Early and late adopters of ISO 14001-type standards: revisiting the role of firm characteristics and capabilities

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Abstract Environmental management standards (EMS) are important voluntary management tools that aim at reducing the environmental impact of firms' activities. From ethical motivations through increasingly high pressure from regulatory authorities to expected financial returns, reasons to adopt an EMS are manifold. While they all certainly matter, it is still unclear from the literature which firm-specific organisational capabilities and structural characteristics significantly drive adoption. Using Propensity Score Matching (PSM) on two samples of French firms, we identify firm-specific factors associated with the early or late adoption of ISO 14001-type EMS and we test whether adoption increases labour productivity. We find that adopters are moderately large manufacturing firms that rely on ISO 9001 standards or Total Quality Management. In addition, according to the first sample, early adopters tend to be more technologically complex firms that are active in the European market. These differences are attenuated in the second sample, which may be biased towards more innovative firms. Both samples however concur with the conclusion that, whether early or late, adoption is associated with a higher labour productivity compared to non-adoption. This result still holds when we use fully interacted linear models instead of PSM, and seems to be consistent over time. Thus, implementing EMS might provide win–win opportunities to adopters, without giving any premium to ''early birds''.

Keywords: Environmental management standards, Early and late adoption of environmental standards, Labour productivity.

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1 Introduction

Standardisation and industrial regulations have played a major role in improving the quality, safety and reliability of the goods and services that we use today. Organizations implement increasingly technical industrial standards, which are often imposed by policy-setting institutions or through industry-level agreements. Others, though, are non-manda-tory, which raises the question of the determinants of their adoption. This is the case in particular of environmental management standards (EMS) such as ISO 14001.

The adoption of EMS has been explained from broadly three perspectives. First, it may be driven by firm strategies (Bansal and Hunter 2003), external factors such as regulations and citizen pressures (e.g., Nakamura et al. 2001; Anton et al. 2004; Porter and van der Linde 1995; Lim and Prakash 2014) and the usual economic factors such as cost, finance and market requirements (Ayres and Walter 1991; Kirkpatrick and Pouliot 1996; Khanna and Zilberman 1997; Albertini 2013). Second, adoption may depend on firm characteristics such as size, ownership structure and workforce composition (Harter and Homison 1999; Nakamura et al. 2001; King and Lenox 2001; Welch et al. 2002). A third perspective refers to firm capabilities such as complementary assets, export experience, experience with ISO 9001 or Total Quality Management (TQM), R&D expenditures and technologies (Melnyk et al. 1999; Christmann 2000; Nakamura et al. 2001; Bowen 2002; Lenox and King 2004; Grolleau and Thomas 2007; Grolleau et al. 2007a, b). As Grolleau and Thomas (2007) point out, due to conflicting findings, the roles of firm characteristics and capabilities such as firm size, export experience, ownership structure and R&D expenditures are still unclear.

Furthermore, few studies identify the firm-specific drivers of early and late adoption, despite potential first-mover advantages in cost, learning curve and profitability (Christ-mann 2000; Bansal and Hunter 2003; Grolleau and Thomas 2007; Su et al. 2015). Mori and Welch (2008) study the adoption of ISO 14001 in Japan and show that the timing of the adoption might be affected by an organization's resources and attitude toward environ-mental protection, indicating firm size and capability as possible factors. Su et al. (2015) recently investigated the first-mover advantages of 101 manufacturing companies and found that firms can achieve early-mover advantages through the adoption of ISO 14001 standards. However, they argue that firms' absorptive capacity and the competitive intensity of their industry tend to mediate early-mover advantages (Su et al. 2015). Sim-ilarly, Wakke et al. (2016) used the number of seats at the German Institute of Stan-dardisation as a proxy for participation in standardisation and found that participation in formal standardization is positively related to firm performance in the German manufac-turing sector but not in the service sector. These studies suggest that revisiting the roles of firm characteristics and capabilities can give more insight into firms' decision to be early or late adopters.

The contribution of the present research to the environmental management literature is twofold: First, we identify firm-specific factors (structural characteristics and organisa-tional capabilities) associated with the early or late adoption of an ISO 14001-type EMS.
Second, we test whether early or late adoption increases labour productivity. In identifying the drivers of early or late adoption, we re-examine some popular factors (e.g., firm size, experience with ISO 9001) and investigate a previously unexamined firm characteristic (i.e., being part of a group) as well as several capabilities (i.e., willingness to anticipate changes in the environmental regulation, labelling service, quality-oriented management, delivery service, market exposure, and technological orientation). Our research may thus help policy makers identify firm characteristics and capabilities that are likely to speed up the diffusion of voluntary proactive approaches for environmental protection. It may also give managers a better vision of where their firm stands with regards to environmental regulation.

Using two distinct samples of French firms observed in 2006 and in 2008, we find that adopters are moderately large manufacturing firms that rely on ISO 9001 standards and/or Total Quality Management. In addition, according to the first sample, early adopters tend to be more technologically complex firms that are active in the European market. These differences are attenuated in the second sample, which is likely to comprise more inno-vative firms. Both samples however concur with the conclusion that, whether early or late, adoption is associated with a higher labour productivity compared to non-adoption. This result is robust to a change in the econometric methodology and seems to hold across time as well. Thus, EMS might provide win–win opportunities to adopters, but without giving any premium to ‘‘early birds’’.

The rest of the paper is organized as follows: after providing a brief description of ISO 14001 and related EMS in Sect. 2, we state our research hypotheses in Sect. 3. Section 4 is dedicated to the description of the data and empirical methodology. We present our results in Sect. 5 and conclude in a final section.

2 Adoption and expected impact of ISO 14001-type standards

2.1 A brief description of ISO 14001

EMS provide firms with a management structure and framework to minimise the envi-ronmental impact of their activities, ensure compliance with environmental regulation, and reduce wasteful uses of natural resources. Among EMS, ISO 14001 is one of the most well-known, if not the most binding. Implementing EMS such as ISO 14001 generally involves organisational change and an internally motivated environmental self-regulation (Anton et al. 2004). ISO 14001 is part of ISO's broader environmental management standards family (ISO 14000). According to the ISO survey,[1] the number of ISO 14001 certifications in 2015 totalled 319,324 in 171 countries worldwide (including 6847 in France). ISO 14001 standards prescribe principles for firms to form their own internal environmental management systems. They are considered as efficient tools to support market-based instruments (i.e., tradable permits, emission taxes, subsidies etc.). They do not impose environmental performance requirements (Khanna and Damon 1999; Albertini and Segerson 2002), and neither do they prescribe how to improve the adopters' business performance. Nonetheless, according to ISO, these standards may help firms improve their existing products or product lines, reduce their carbon footprint and inputs cost, and increase employee, consumer, investor, shareholder and insurer trust by reflecting an environmentally friendly image. This 'greener' image may provide substantial marketing advantages and help capture additional market shares. It may also provide access to ''green'' markets, reduce insurance charges and input costs, which in turn may have a significant impact on a firm's business performance.

The adoption of an ISO 14001 standard requires several steps to be taken and a suc-cessful implementation of the standard depends on how well the 'Plan, Do, Check, Act (PDCA)' model is applied. This feature of ISO 14001 standards ensures that organisations are responsible for setting their own environmental targets, which makes the standards applicable to a wide range of organisations. The ISO 14001 standards cover: (1) envi-ronmental policy, (2) performance goals (objectives and targets), (3) environmental pro-grams (action plans to meet objectives), (4) roles and responsibilities, (5) training and awareness, (6) internal and external communication, (7) documentation of the system, (8) monitoring, measurement and record keeping,

[1] Available online at www.iso.org

(9) procedures for corrective and preventive action, (10) Environmental Management System audits and (11) management reviews.[2]

These steps make sure that organisations identify and minimise the potentially negative environmental effect of their operations, comply with existing laws and continually improve in this direction. ISO 14001 certification also involves an extensive third-party auditing process. In the absence of experienced and knowledgeable managers, firms may have to hire additional staff to plan and monitor their environmental management process. Therefore, the expected time and cost for the implementation can vary considerably across organisations.

Firms often adopt ISO 14001 on a voluntary basis to reduce their environmental impact, facilitate sustainable development and foster international trade (Bansal and Hunter 2003; Simpson et al. 2012). Thus, adoption can be relevant to a large variety of organisations. Some firms, however, tend to be more proactive than their competitors and to adopt the standards earlier. This may be the case in particular if the managers of the former consider that adoption is likely to improve the quality of their products and services enough to derive substantial competitive advantages. For instance, Bansal and Hunter (2003, p. 290) show that ‘‘firms reinforcing their current strategy are more likely to look for the com-petitive advantage associated with being a first mover with ISO 14001.’’

2.2 Empirical evidence

So far, the literature on the adoption of ISO 14001-type standards has focused on such firm characteristics as size and ownership structure. Most existing studies (Melnyk et al. 1999; Nakamura et al. 2001; King and Lenox 2001; Welch et al. 2002) find firm size positively associated with ISO 14001 adoption. By contrast, Harter and Homison (1999) do no report any significant link and Bowen (2002) found that the association between firm size and adoption disappears when one controls for visibility and organizational slack. This con-trasted evidence implies that re-examining the role of firm size is a requirement in our study.

Research on the influence of ownership is rather scarce. According to Melnyk et al. (1999), foreign-owned manufacturing firms in the USA are more likely to adopt ISO 14001 certification. Publicly owned firms are also more likely to pursue ISO 14001 certification in order to attain a variety of environmental objectives (Melnyk et al. 2003). By contrast, Nakamura et al. (2001) suggest that the structure of ownership is

[2] These 11 points are described in ISO 14001:2015 Environmental Management Systems, Requirements with Guidance for Use, Available at http://www.iso.org/iso/catalogue_detail?csnumber=60857.

not a relevant driver of ISO 14001 adoption in Japan. To the best of our knowledge, there is no convincing empirical evidence suggesting that firm size and the structure of ownership may help distinguish early from late adopters.

Some studies argue that the pre-existence of some specific complementary capabilities may help reduce both the time and the cost of implementation. Such capabilities would allow firms to innovate and modify their production process (Christmann 2000). Examples of these capabilities include prior experience in ISO 9001 and/or TQM, which has been found to be positively correlated with the adoption of ISO 14001 (Melnyk et al. 1999; Harter and Homison 1999; Nakamura et al. 2001; King and Lenox 2001). Experience in exporting products appears as a significant driver of adoption in Japan (Nakamura et al. 2001) but does not seem to matter in the USA (Melnyk et al. 1999). The influence of R&D is still dubious, as the literature reports both positive and negative associations with adoption (Nakamura et al. 2001). Bansal and Hunter (2003) argue that firms without existing environmental legitimacy and capability are better off becoming followers and adopt ISO 14001-type standards later. In the light of these arguments, it is thus interesting to try and find out which capabilities, if any, may differentiate early and late adopters of these standards.

3 Hypotheses

3.1 Firm characteristics

Following our survey of the literature, we argue that the decision to apply standardisation earlier or later depends on specific firm characteristics such as firm size and the structure of ownership. Firm size is one of the most commonly examined firm characteristics. Medium and large firms are virtually the primary target for voluntary industrial standards since they are more likely to operate in highly polluting industries (Simpson et al. 2012; Bansal and Roth 2000; Darnall 2006; Delmas and Montes-Sancho 2010; Murillo-Luna et al. 2008). Due to higher public visibility, these firms also experience significant pressure from stakeholders to demonstrate environmental performance improvement (Henriques and Sadorsky 1999; Brammer and Millington 2008).

Even though in theory any type of firm can participate in voluntary standardisation, the cost of the standardisation process is not proportional to firm size (Colombo et al. 2006). Blind (2006) reports that the participation cost for the formal standardisation process constitutes a sizable financial burden for small and medium manufacturing firms in Ger-many. In the same vein, most empirical studies find that the probability of implementing environmental standards increases with firm size and that large firms could lower the cost of adoption through economies of scales and learning (Arora and Cason 1995; King and Lenox 2001; Nakamura et al. 2001; Grolleau et al. 2007a, b; Delmas and Montiel 2009; Wakke et al. 2015). In addition, Montiel and Husted (2009) argue that many large firms tend to be a part of smaller industry associations and that those firms have more economic, intellectual, and political resources to adopt a voluntary EMS. These firms may act as institutional entrepreneurs and not only certifying early but also playing an active role in the promotion of voluntary EMS. In doing so, larger firms could virtually set new barriers to entry for small entrants, which could help the former consolidate their strategic position within the industry. All these elements suggest that larger firms have more incentives and financial resources to adopt EMS. Accordingly, we state Hypothesis 1 as follows.

Hypothesis 1 Large firms are likely to adopt an EMS earlier than smaller firms.

Previous research presents the structure of ownership as a potentially important factor that shapes organizational strategy and institutional entrepreneurship (Mascarenhas 1989; Gedajlovic 1993; Darnall 2003; Darnall and Edwards 2006). In this research, we pay particular attention to the role of being a subsidiary or part of a group. Firms that are members of a group have access to larger financial resources to develop their internal environmental expertise (Bowen 2002; Russo and Fouts 1997; Zyglidopoulos 2002; Pekovic 2010). By sharing financial resources and other firm-specific assets (such as managerial and organisational capabilities) with the parent company, a subsidiary may also take advantage of economies of scale and reduce the cost of standardisation.

Even though members of a group are able to share firm-specific assets (Bloom and Van Reenen 2010; Dachs and Peters 2014), the environmental competencies of the parent company and organisational challenges within the group may also play an important part in the adoption of an EMS (Henriques and Sadorsky 1996; Hart 1995; Russo and Fouts 1997; Christmann 2000). Companies that are part of a group traditionally share one source of control, and a group may have several sibling companies that engage in relevant and/or irrelevant businesses. Siblings are heterogeneous in their development of complementary capabilities or resources (Darnall and Edwards 2006). If the parent company and its sibling companies align in favour of environmental protection strategies, then we might expect a group-wide adoption. However, such an alignment might take some time to realize. Mismatches between parent and siblings' environmental strategies may hinder group-wide adoption of the EMS. In this case, not being part of a group may mean swifter decisions. We therefore propose the following Hypothesis 2.

Hypothesis 2 Firms are more likely to be late adopters of an EMS when they are part of a group than when they are not.

3.2 Firm capabilities

Firms' complementary capabilities may have an impact on a firm's decision to adopt an EMS early. Boiral (2011) states that ISO 9001 and ISO 14001 share similar objectives and follow identical compliance procedures, which makes them compatible with each other. Implementing ISO 9001-type TQM standards can enhance firms' absorptive capacity and help them acquire new capabilities and managerial skills. These can help them adopt EMS earlier. Conversely, EMS have the potential to improve the overall quality of processes, products and even management. Evidence of this complementarity can be found for instance in Benavides-Velasco et al. (2014) who, in an empirical investigation of 141 Spanish hotels, find that TQM can favour the development of Corporate Social Respon-sibility (CSR). Additionally, Karapetrovic and Casadesu´s (2009) find that most of ISO 14001-registered firms are also certified in accordance with the ISO 9001 standard, which suggests that firms may adopt an EMS to expand TQM practices towards CSR.

ISO 9001 is one of the most widely used TQM standards in the world today. It provides guidance and tools for organizations to ensure that their products and services consistently meet customer requirements and that quality is consistently improved. The costs of implementing ISO 9001 standards are a good indicator of the costs that can be expected if ISO 14001 standards are adopted (Hormozi 1997). In addition, Darnall and Edwards (2006) find that experience with quality management and inventory control management systems reduce the cost of EMS adoption. This may be because the existing experience helps organisations acquire crucial knowledge-based processes with fewer resources. Firms that possess such capabilities may also operationalize their EMS within a shorter time and with much less effort (King and Lenox 2001; Delmas 2003; Lo´pez-Gamero et al. 2009) and may even reduce the cost of implementing the standards (Bansal and Hunter 2003; Nakamura et al. 2001). Based on these considerations, we posit that having ISO 9001 standards or similar TQM practices provide a good basis for the early adoption of ISO 14001-type standards, and formulate Hypothesis 3 as follows.

Hypothesis 3 Firms with previous experience in implementing TQM are more likely to adopt an EMS earlier than those without such experience.

Expectations from foreign customers may also affect a firm's adoption decision (Corbett and Kirsch 1999; Bansal and Hunter 2003; Blind and Mangelsdorf 2013; Wakke et al. 2015). This form of external pressure can be a stronger driver to adopt environmental standards than the technical capacity to use these standards (Simpson et al. 2012). The increasing worldwide effort to reduce carbon footprint as well as increasing consumer environmental awareness may press firms to take preventive measures. This pressure becomes more important when a firm intends to enter new markets, e.g., when a US firm is targeting European markets (Potoski and Prakash 2004b). Entering a new market requires extensive information on this market, on factors that affect customers' consumption choices and on regulations and standards in the target country. Wakke et al. (2015) posits that idiosyncratic national standards can raise a firm's compliance costs and hamper business activities in foreign countries. Accordingly, voluntary EMS can help firms all over the world to have comparable environmental goals and achievements and overcome compliance problems while ensuring the sustainability of the business activities in the export market. In addition, Wojan and Bailey (2000) argue that when domestic environmental regulations are in place, customers might have greater confidence in their domestic suppliers whereas in the absence of proof of environmental compliance, foreign suppliers might struggle to obtain acceptance. When this is the case, an internationally recognized certification such as ISO 14001 can help firms overcome legitimacy problems, generate trust (Zucker 1986) and ensure better relationships with customers, regulators and gov-ernments (Bansal and Hunter 2003). Based on this argument, we posit that being active in foreign markets is more likely to lead to early adoption of EMS and we propose the following Hypothesis 4.

Hypothesis 4 Firms with a wider international scope are more likely to adopt an EMS earlier than those with a narrower, more local scope.

Firms' technological complexity is yet another factor that may influence the adoption decision. Technologically complex firms are generally R&D-intensive firms that rely heavily on innovation. They tend to operate in complex environments that involve the adaptation and creation of cutting-edge knowledge and technology, as well as sophisticated production processes. These processes may rely on energy-intensive technologies and may require rare materials as well as possibly toxic or harmful substances. For such firms, adopting voluntary environmental standards may be a way to gain market shares by developing social and technical capabilities that competitors cannot easily challenge. Benner and Veloso (2008) argue that firms with a very low technological complexity benefit less than other firms from the adoption of industry standards. By contrast, firms that rely on technologically and organisationally complex production processes may find it important to adopt industry standards. For example, Bansal and Hunter (2003) state that the ISO 14001 requirements of (1) documenting all relevant environmental regulations and (2) developing a plan to meet them may help firms improve their internal coordination. By adopting EMS, technologically complex firms may also be able to stay ahead of regulations and thus gain legitimacy in the eyes of external stakeholders (Meyer and Rowan 1977; Di Maggio and Powell 1983). EMS may also endow their products with unique characteristics (Mueller et al. 2009; Jamali 2010) that make them marketable as greener products. Therefore, the adoption of an EMS may be positively associated with technological complexity. We formulate this intuition as Hypothesis 5.

Hypothesis 5 Technologically more complex firms are more likely to adopt EMS earlier than those with lower technological complexity.

3.3 Firm performance

EMS are not designed to directly improve firms' business performance. However, their link to firm performance is a legitimate research question as they have potential advantages to all industries. These advantages may be one of the most significant drivers of the adoption decision. Lim and Prakash (2014) assert that properly designed voluntary programs can support both environmental and economic objectives, an opinion that goes back to Porter and van der Linde (1995). It relies on the assumption that, if successfully implemented, EMS may provide substantial financial returns through different channels. The adoption of EMS has indeed been found to be positively associated with financial performance (Melnyk et al. 1999; King and Lenox 2002; Su et al. 2015; Wakke et al. 2016), but this finding is challenged by the work of Nakamura et al. (2001), Frondel et al. (2007) and Delmas and Pekovic (2013). The latter studies nevertheless show that adopting EMS may reduce input costs (i.e., costs of raw materials, energy, water and labour), mitigate envi-ronmental liability and create a sustainable brand image that can attract new customers and/or reduce trade barriers to reach certain markets. In addition, Delmas and Pekovic (2013) find that the ‘‘sustainable brand’’ image has a positive impact on the employees’ work attitude. Similarly, Ambec and Lanoie (2008) state that employees who are proud of their company’s good reputation are (1) more likely to have a higher job satisfaction and (2) more likely to disseminate this good reputation during their daily encounters. In turn, and even though EMS do not specifically try to achieve such an objective, this may result in increased productivity, which could provide an important incentive to adopt ISO 14001-type EMS standards early. Compared to late adopters and non-adopters, early adopters are in a unique position to achieve productivity gains since early adoption may even out rapidly the cost of implementing EMS. This leads to Hypothesis 6.

Hypothesis 6 Firms that adopt EMS early have a higher productivity than late adopters.

4 Empirical analysis

4.1 Data

This study provides a unique perspective on the issues of EMS adoption and of the relationship between adoption and firm performance, by analysing two distinct samples of French firms, drawn from the same population at approximately the same time. The first sample is derived from the national ‘‘Organisational Change and ICT Use’’ survey con-ducted in 2006 (COI 2006) and covering the period 2003–2006. The second sample comes from the French component to the 2008 Community Innovation Survey (CIS 2008), which includes a one-shot module on environmental innovation and provides retrospective information on the period 2006–2008. Both samples provide similar variables that allow us not only to apply the same econometric methodology but also to compare the results. In the social sciences, having two distinct samples of the same population, taken at two very close points in time and that allow researchers to address the same issue, is a very rare opportunity.

Both surveys cover French manufacturing and services firms of 10 employees or more and (despite differences in the questionnaire and in the structure of the data) yield similar variables on EMS adoption, firm characteristics, capabilities and performance. They bear on two samples of different size (7700 firms for COI 2006 and 20,114 for CIS 2008), which are further described below. Besides the obvious differences in size and sampling sche-me/time, the main caveat for our study is that, due to the structure of the underlying survey,[3] the CIS 2008 sample may be biased towards more innovative firms. This possible bias is not a definitive flaw, as long as we keep it in mind when interpreting our results. In addition, our methodology partly addresses selection biases.

4.1.1 COI 2006 sample

The COI survey, which results from the joint efforts of the INSEE (National Statistical Institute), DARES (Direction for Research, Ministry of Labour) and CEE (Centre for Employment Studies), provides a unique insight on organisational changes among French firms. So far, two waves of the survey have been conducted, the first in 1997 and the second in 2006. The latter remains, to this day, our best source and most recent of information on this topic and its wealth has yet to be fully plumbed. Due to recent changes in the regulations that govern the collection of public data and their availability for research in France, it is still uncertain whether a new wave will take place in 2017.

A first strength of COI 2006 lies in an overall higher response rate, of about 85% (Greenan et al. 2010), which makes the data very comprehensive compared to those generally used in related studies. The main component of the COI survey is addressed to a large, representative sample of French firms. It can be matched with a second component addressed to small groups of employees randomly sampled within each firm. In the present study, we focus on the firm-level information provided by the main component of the survey. The survey bore on a representative sample of 7700 firms with 10 employees or more, covering all industries except agriculture, forestry and fishing. These firms filled in a questionnaire on their organisational practices (and ICT use) in 2003, in 2006 and over the period in between—thus providing retrospective information that allows researchers to observe the organizational changes that occurred between 2003 and 2006. The question-naire includes a question dedicated to the introduction of ISO 14001-type standards, in 2003 and/or in 2006.

Another strength of the survey is that it can easily be matched with administrative data. In the present study, we merged the COI 2006 survey with administrative data from the French Yearly Enterprise Survey (EAE) to obtain information on value added, number of employees and some other accounting variables. This merger yielded a balanced 2-year panel of 11,168 observations (5584 firms observed in 2003 and in 2006) after an additional clean up. Following standard clean-up procedures, we

[3] A significant part of the questionnaire is addressed only to innovative firms.

eliminated outliers by excluding firms with less than 10 employees and with more than 100% annual growth rate (in terms of totals sales). In Columns (1) and (2) of Table 1, we present pre- and post-merger summary statistics for key variables, together with the p value of a test of differences in means. Overall, the test is not significant, which indicates that merging datasets did not lead to severe selection biases.

Table 1 Summary statistics of key variables in COI 2006 and CIS 2008

Variables	Data source						
	(1) COI 2006		(2) COI 2006 ? EAE			(3) CIS 2008	
	Mean	SD	Mean	SD	p value	Mean	SD
Firm size	691.8	3739.8	653.7	3735.8	0.29	244.8	1967.1
Firm size (year t - 2)	–	–	–	–	–	274.6	2593.6
Turnover	168,558.5	1,132,874	152,650.1	1,034,387	0.21	80,249.3	775,340.4
Turnover (year t - 2)	–	–	–	–	–	75,684.7	727,694.4
EMS adopter (year t)	0.05	0.22	0.05	0.23	0.87	0.11	0.32
EMS adopter (t - 3 in COI, t - 2 in CIS)	0.15	0.36	0.16	0.36	0.65	0.07	0.26
Part of a group (year t)	0.34	0.48	0.35	0.48	0.38	0.45	0.50
Part of a group (year t - 3)	0.36	0.48	0.36	0.48	0.37	–	–
Main market (year t): local/regional	0.13	0.34	0.13	0.34	0.48	0.58	0.49
Main market (year t): National	0.3	0.46	0.3	0.46	0.24	0.33	0.47
Main market (year t): European	0.54	0.5	0.53	0.5	0.25	0.05	0.22
Main market (year t): International	0.64	0.48	0.64	0.48	0.41	0.03	0.18
Main market (year t - 3): local/regional	0.14	0.34	0.14	0.34	0.46	–	–
Main market (year t - 3): National	0.31	0.46	0.3	0.46	0.20	–	–
Main market (year t - 3): European	0.55	0.5	0.55	0.5	0.26	–	–
Main market (year t - 3): International	0.65	0.48	0.65	0.48	0.39	–	–
ISO 9001 (year t)	0.49	0.5	0.47	0.5	0.1	–	–
ISO 9001 (year t - 3)	0.53	0.5	0.52	0.5	0.08	–	–
Quality-oriented practices (TQM)	–	–	–	–		0.26	0.44
Labelling (year t)	0.35	0.48	0.36	0.48	0.25	–	–
Labelling (year t - 3)	0.32	0.47	0.33	0.47	0.24	–	–
Delivery (year t)	0.68	0.47	0.69	0.46	0.23	0.17	0.38
Delivery (year t - 3)	0.68	0.47	0.70	0.47	0.02**	–	–
Anticipate environmental regulation	–	–	–	–		0.10	0.30
High-tech. manufacturing	0.03	0.18	0.04	0.19	0.27	0.02	0.15
High-medium tech. manufacturing	0.09	0.29	0.1	0.29	0.16	0.07	0.26
Low-medium tech. manufacturing	0.1	0.3	0.1	0.31	0.14	0.12	0.33

Table 1 continued

Variables	Data source						
	(1) COI 2006		(2) COI 2006 ? EAE			(3) CIS 2008	
	Mean	SD	Mean	SD	p value	Mean	SD
Low-tech manufacturing	0.14	0.35	0.15	0.36	0.08	0.13	0.34
Knowledge intensive services	0.18	0.39	0.18	0.38	0.32	0.17	0.38
Other services	0.46	0.50	0.44	0.5	0.02**	0.35	0.48

4.1.2 CIS 2008 sample

The CIS is a harmonised survey conducted every four years in every EU Member State by national statistical agencies under the coordination of Eurostat. The survey follows the guidelines of the so-called Oslo Manual[4] and comprises two parts. The first is the core questionnaire, common to all EU countries, on which we focus in the present study. The second part of the CIS is a complementary questionnaire, the contents of which may vary across countries depending on national priorities. The core questionnaire provides firm-level information on innovative activities, including R&D, product and process innova-tions, and abandoned innovations. It also contains information on firm capabilities (such as reliance on Total Quality Management) and characteristics (e.g., size and turnover). Most of this information is expressed in terms of variation, occurrence or accruement over the last three years (for instance, CIS 2008 will give retrospective information on the period 2006–2008), with the notable exception of the R&D variable, which is defined in the year of the survey.

CIS 2008 is uniquely relevant to the present study, because it was divided in five modules, one of which was specifically dedicated to environmental innovation. This module was introduced in the CIS for the first time in 2008, and was not carried over to the subsequent waves of the survey, such as CIS 2012. It includes a question dedicated to the adoption of ISO-14001 types standards, which makes CIS 2008 a complementary source to COI 2006 for the study at hand. As can be seen in Table 1, we were able to recover in CIS 2008 variables that are almost identical to those sourced from COI 2006, with two visible exceptions.

The first concerns Total Quality Management practices, which CIS 2008 captures as such (i.e., in a broad way), whereas COI 2006 focuses only on ISO 9001 certification. To try and compensate for this difference, we will also rely on an indicator of reliance on quality labelling sourced from COI 2006. The second visible

[4] https://www.oecd.org/sti/inno/2367580.pdf

exception is a variable that indicates whether a firm has an innovation strategy that anticipates changes in environ-mental regulation. This variable is available only in the CIS 2008 sample, and we will use it as a control variable in the econometric analysis based on this sample.

A third (and not so noticeable) exception to the similarities between CIS 2008 and COI 2006 concerns labour productivity, which is computed using turnover in the former and using value added for the latter (thanks to the merger with administrative data mentioned in Sect. 4.1.2). This difference is not a huge hindrance for our analysis, as our purpose is to use productivity as a proxy for firm performance. We will simply have to keep it in mind when interpreting our results.

With a response rate of more than 80% in France, CIS 2008 yielded a sample of 20,114 firms. Following the same standard clean-up procedures as those used with COI 2006, we excluded firms with less than 10 employees and with more than 100% annual growth rate (in terms of totals sales). This clean-up led to a final sample of 19,030 firms. Tests of differences in means (the results of which are available upon request) did not reveal any significant bias after cleaning. Column (3) of Table 1 present summary statistics for key CIS 2008 variables.

4.2 Methodology

Our empirical objective is twofold. We want (1) to identify firm-specific characteristics and capabilities associated with early or late adoption of EMS (Hypotheses 1 to 5) and (2) to estimate the effect of early and late adoption on the adopters' performance, as measured by productivity (Hypothesis 6). Propensity Score Matching (PSM) appears as an elegant framework to tackle both objectives. PSM (Rosenbaum and Rubin 1983; Heckman et al. 1997, 1998) is a non-parametric alternative to Instrumental Variable (IV) and Heckman-type models for estimating a causal effect net of endogeneity and selectivity biases.

To estimate the impact of adoption on productivity, one needs to compare the average productivity of these firms to the average productivity they would have achieved had they not adopted EMS. However, the latter is an unobserved counterfactual, since only one outcome is observed. In other words, if Y_i denotes the productivity of firm i and if D_i is a binary variable equal to 1 if firm i adopted EMS and to 0 otherwise, we only observe Y_{i1} if firm i is an adopter ($D_i = 1$) and Y_{i0} if it is an non-adopter ($D_i = 0$). What we would like to observe is the counterfactual ''$Y_{i1} \mid D_i = 1$''.

More precisely, considering the adoption of EMS as a treatment,[5] we want to estimate the ATT (average effect of the treatment on the treated), which is defined as the expected difference between Y_1 and Y_0 conditional on D = 1 and on a set of observed control variables X:

$$\Delta TT = E(Y1 - Y0 \mid X, D = 1) = E(Y1 \mid X, D = 1) - E(Y0 \mid X, D = 1) \qquad (1)$$

However, since $E(Y_0 \mid X, D = 1)$ is unobserved, we must estimate this counterfactual. This is possible if one relies on the Conditional Independence Assumption (CIA), which states that selection occurs only on observables and is eliminated when X is accounted for. Under the CIA, $E(Y_0 \mid X, D = 1) = E(Y_0 \mid X, D = 0)$, and thus we can use the latter expectation rather than the former to estimate the counterfactual.

However, conditioning on all pre-treatment variables X is a computational burden. Rosenbaum and Rubin (1983) propose to alleviate this burden by using the propensity score, which is simply the probability to receive treatment conditional on the control variables, which we can denote P(X) = Pr(D = 1 | X). This probability is estimated using a standard Probit or Logit model. Individuals are then matched based on their propensity score, using a nonparametric algorithm. To implement PSM, though, one has to have a large enough common support, i.e., to have enough firms among the non-treated (or ‘‘control’’) group with characteristics similar to those of the treated firms. It is therefore usual practice, after matching, to check the size of the common support.

In our application, computing the propensity score allows us to check Hypotheses 1–5, while estimating the ATT helps us test Hypothesis 6. Several matching algorithms are available, such as nearest neighbour, 5-nearest neighbour and kernel. Our preference goes to the kernel estimator,[6] because the large-sample properties of nearest neighbour esti-mators have not been fully established (Abadie and Imbens 2006), and when they have, are not very attractive (for instance, these estimators in a sample of size n are not $n^{1/2}$ con-sistent). By contrast, Heckman et al. (1998) have

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[5] We are aware that, since EMS are generally adopted on a voluntary basis, they are not a treatment in the fully conventional sense of the term. However, this is not a major issue in our investigation, since we are less interested in estimating a pure causal impact of EMS on productivity than in determining whether adoption is associated with a higher productivity, controlling inasmuch as possible for endogeneity biases.

[6] In a nutshell, the kernel estimator attributes weights to control observations according to their relative proximity to the treated observation. Good matches get a large weight and poor matches get a small weight.

developed a sampling theory for kernel-based matching estimators and established their large-sample properties (in particular, they are consistent and $n^{1/2}$ consistent).

As a sensitivity analysis of sort, we have estimated the ATT using Fully Interacted Linear Matching (FILM) as an alternative to PSM. FILM consists in estimating is a fully interacted linear regression model in which the treatment dummy is interacted with each one of the control variables.[7] FILM allows the impact of adoption to vary for each observable factor and to test for the presence of heterogeneous effects. This test (which is specified as a Fisher test) allows one to determine whether the treatment effect is only driven by a specific set of control variables.

4.3 Definition of the treated/controls groups and of the dependent variables

As explained in Sect. 4.2, PSM is a two-step methodology: In the first step, one estimates the propensity score (i.e., the probability to be in the treated group) using a Probit or Logit model, and in the second step one estimates the ATT by matching the treated with indi-viduals from the control group based on the propensity score. Therefore, each step has a specific dependent variable: A treatment indicator in the first step, and a measure of the outcome in the second step.

Our outcome variable is straightforward: To test Hypothesis 6, we need a measure of productivity (our proxy for firms' economic performance). We use labour productivity, defined as the ratio of Value Added (VA) to firm size in COI 2006 and as the ratio of turnover to firm size in CIS 2008. Our treatment indicator is not a simple binary indicator as is usually the case in the literature (and as was the case, in particular, in Rosenbaum and Rubin 1983). Indeed, we want to distinguish between early and late adopters of voluntary EMS according to the timing of adoption. This is possible in both samples: In COI 2006, we have two observations, at different point in time (2003 and 2006), for each firm. In CIS 2008, the question relative to the adoption of ISO-14001-type standards distinguishes between adoption before 2006 and adoption between 2006 and 2008. We thus define ''early adopters'' as firms that had already adopted a voluntary EMS and obtained the certification in 2003 for COI 2006 and in 2006 for CIS 2008. By contrast, ''late adopters'' are firms that did not have the certification between 2003 and 2006 in COI 2006 and between 2006 and 2008 in CIS 2008. By contrast, non-adopters are firms that had not implemented any

7 We implemented FILM using the FILM module for Stata proposed by Leuven and Sianesi (2004) and available at http://www.ifs.org.uk/publications/2712.

EMS certificate at the time of the survey.[8] In Table 2, we present the distribution of firms in each sample according to their adoption behaviour: Early adopters, late adopters and non-adopters.

To distinguish between early and late adopters, we have to build our treatment indicator as a three-category variable, which calls for a specific model to estimate the propensity score. We experimented with a Multinomial Logit, but the IIA hypothesis was rejected (as is often the case with this type of model). A Bivariate Probit was not a valid alternative, because it would have required a significant number of firms to be EMS adopters in 2003 and non-adopters in 2006, which by construction could not be the case in our sample (see Footnote 11). We ended up estimating two distinct simple Probit[9] models, one for the year 2003 (contrasting early adopters to non-adopters) and one for the year 2006 (contrasting late adopters to non-adopters).

We will thus obtain two propensity scores (one for early adopters and the other for late adopters), which will let us estimate two ATTs: The average effect of early adoption (versus non-adoption) on the one hand and the average effect of late adoption (versus non-adoption) on the other. This is interesting because, according to the literature, one may assume that a certain amount of time is required before the standards can have a significant effect on firms' performance. For instance, Hart and Ahuja (1996) assert that there may be a positive relationship between emissions reductions and financial performance but that firms may have to wait for as long as two years before they can see any significant financial return. In addition, Ambec et al. (2013) claim that researchers often regress productivity on proxies of environmental regulation using a simultaneous specification (i.e., one in which both variables are observed at the same date), which does not reflect the time it takes for the environmental innovation process to occur. By identifying distinct effects for early and late adoption, we avoid this pitfall. Based on the aforementioned literature, we may expect the effect of early adoption—if any—to be stronger than that of late adoption, as stated in Hypothesis 6.

4.4 Explanatory variables

In this sub-section, we briefly list and describe the explanatory variables of the Probit models that allow us to estimate the propensity score, i.e., the X vector in Eq. (1). Our

[8] In COI 2006, 11 firms reported an EMS in 2003 but not in 2006, which probably correspond to mistakes in the reporting. We treated them as outliers and thought they were best left out of the sample. This problem did not occur in CIS 2008, thanks to the structure of the dedicated question.

[9] Estimating a Logit rather than a Probit specification did not qualitatively affect our results.

first explanatory variable is firm size, measured by the number of employees in both samples.[10] This variable will allow us to test Hypothesis 1. Our models will also include the square of size among the regressors, to consider a possible nonlinearity in the relationship between size and the probability of adoption.

The second variable is a binary indicator equal to 1 if a firm is part of a group and to 0 otherwise, which allows us to test Hypothesis 2. To test Hypothesis 3, we include an indicator of ISO 9001 certification in the model estimated on the COI 2006 sample, and an indicator of TQM use in the model estimated on the CIS 2008 sample. To consider the degree of openness to international markets and customers (and their related requirements), we include a categorical variable indicating whether a firm is primarily active in the local/ regional market, in its national market (i.e., France), in the European market or in the international market, taking the first category (local/regional market) as the category of reference. This allows us to test Hypothesis 4.

Table 2 Sample distribution of firms according to adoption behaviour

	(1) COI 2006 ? EAE		(2) CIS 2008	
	Number	Share (%)	Number	Share (%)
Early EMS adopters	873	16	1318	7
Late EMS adopters	300	5	2033	11
Non-adopters	4411	79	16,763	83
Total	5584	100	20,114	100

Finally, our explanatory variables also include industry dummy variables. We created these dummy variables following the OECD ‘‘technological level’’ classification. Our reasons for using OECD technological levels rather than simply including NACE or ISIC codes in the Probit regressions are twofold. First, the COI 2006 sample lacks a measure of R&D intensity, while the COI 2008 sample only provides one for the year 2008.[11] The OECD tech levels give us a proxy of the technological level of a firm, based on the tech level of the environment in which it operates. This will help us test Hypothesis 5. Second, using NACE codes would make for many industries dummy variables, some of which will be equal to 0 for most firms. This creates an imbalance that may endanger the common support required for the matching process, in the second step of the PSM procedure.

[10] In our estimations, we express size in thousands of employees in order to avoid a scaling problem.

[11] In the CIS 2008 sample, the existence of a measure of R&D intensity for the year 2008 allows us to test an alternative specification of the Probit model for late adopters only.

The OECD tech level classification identifies industries based on their level of R&D intensity (ratio of R&D expenditures to VA). This classification distinguishes between: (1) high technology industries (where R&D intensity is above 5% on average), (2) medium– high technology industries (where R&D intensity is between 3 and 5%), (3) medium–low technology industries (where R&D intensity is between 0.09 and 3%, (4) low technology industries (where R&D intensity is between 0 and 0.09%) and (5) knowledge-intensive services. For the econometric analysis, we use conventional (non knowledge-intensive) services industries as the category of reference. The correspondence between tech levels and two-digit ISIC codes can be found on the OECD website[12] for manufacturing industries. A full correspondence table is also available upon request from the authors.

We add a few control variables in the Probit regressions. In the COI 2006 sample, we control for the reliance on customer-related services (namely, labelling and just-in-time type delivery), using dedicated indicators equal to one if a firm relies on the specific customer service (labelling or delivery), and to 0 otherwise. In the CIS 2008 sample, we control for reliance on just-in-time delivery and for anticipated changes in the environ-mental regulation, again using dedicated binary indicators. We provide summary statistics on our explanatory and control variables in Columns (2) and (3) of Table 1 for the COI 2006 sample (augmented with the administrative EAE data) and CIS 2008 samples, respectively.

5 Results and discussion

In this section, we first present the estimates of the Probit models we used to compute our propensity scores, and use these estimates to test Hypotheses 1–5. We then proceed with the matching per se, examine the ATT and test Hypothesis 6. We conclude the section with some standard post-estimation statistical tests and with a complementary analysis on two of our main findings, pertaining to Hypotheses 3 and 6.

5.1 Firm characteristics, capabilities and adoption

In Table 3, we present the marginal effects of the Probit models used to compute the Propensity Scores for early and late adopters in COI 2006 sample [Column (1)] and in the CIS 2008 sample [Column (2)]. The first result pertains to firm size: In both

[12] http://www.oecd.org/sti/ind/48350231.pdf at the time of this writing.

samples, the relationship between firm size and the adoption of an EMS can be described by an inverted U-shape, as the coefficient associated with size is significantly positive whereas the coefficient associated with the square of size is significantly negative. This is the case for both early and late adoption. This result only partially supports our Hypothesis 1 as we formulated it. It would be more accurate to say that moderately large or ‘‘medium sized’’ firms are those that are more likely to adopt ISO 14001-type standards. Our result is consistent with the finding of some studies. Simpson et al. (2007) and Mueller et al. (2009) point out that some large firms, such as Toyota, have developed their own EMS or used independently designed EMS because ISO 14001-type standards were not adequate for their specific requirements. Another reason why medium-sized firms are the most likely adopters might be found in the implementation problems that large firms have to deal with. The adoption of ISO 14001-type standards involves extensive employee participation and training as well as an extensive documentation of the organisation’s processes. This can lead implementation costs to increase with firm size (Kollman and Prakash 2001).

Our second result concerns firms that are part of a group. Table 3 reveals that being part of a group is negatively associated with the adoption of ISO 14001-type EMS in the COI 2006 sample, but positively associated with adoption in the CIS 2008 sample. In other words, we only find mixed evidence and partial support for Hypothesis 2. The negative relationship that we find in the COI 2006 sample suggests that subsidiaries may shy away from adopting EMS because not only of the financial burden, but also of the organisational burden associated with the adoption. It may also reflect the dependence of French sub-sidiaries on their parent company to undertake strategic facility-level decisions (Oliver 1991). Subsidiaries may adopt ISO 14001-type standards only if the parent encourages facility-level adoption, e.g., through the corporate culture it promotes (Darnall 2006). The contradictory positive relationship we find in the CIS 2008 sample might be explained by a bias towards innovative firms in this sample. If innovative firms are more drawn to environmental innovation than non-innovative ones, then the corporate culture at the level of a group may reflect this, and group members may be encouraged to adopt ISO 14001-type standards.

Our third result regards experience in implementing ISO 9001 standard or TQM, which is positively associated with both early and late adoption in both samples. This result brings partial support to our Hypothesis 3, in the sense that experience with ISO 9001 standards or TQM encourages not only early adoption, but also late adoption.

Nevertheless, this result, which is consistent with those of the related literature, is an important one to our eyes. It implies that ISO 9001 standards and TQM are important complementary assets that can help firms operationalize other types of management standards, such as the ISO 14001-type standards we are interested in. In Sect. 5.4, we examine the relationship between ISO 9001 and ISO 14001 at a more macroeconomic level over the last two decades to shed another light on the robustness of this finding.

Regarding the primary market, we observe in the COI 2006 sample that firms that are active in national markets are significantly less likely to adopt ISO 14001-standards, whereas those that are active in the European market are more likely to be early adopters. Although the marginal effect of being active on the international market is not significant, this may merely reflect the fact that foreign markets for French firms are primarily European markets. These results are corroborated and expanded by those obtained in the CIS 2008 sample, where all primary business markets are associated with a higher prob-ability of adoption than the local/regional market. The main differences are that (1) the higher probability of adoption concerns both early and late adopters and (2) being active on the national market is associated positively rather than negatively with adoption. The first difference may arise from the already-mentioned bias towards innovative firms in the CIS 2008 sample, while the second difference may be due to the fact that the CIS 2008 sample is larger and comprises more small firms than the COI 2006 sample.

Overall, these results give partial support to our Hypothesis 4. They indicate that the adoption of ISO 14001-type standards is becoming increasingly important to conduct business in wider markets, especially at the European and international levels. This is consistent with the findings of the related literature. Nishitani (2009) shows that countries exporting more to environmentally conscious European countries such as Finland, Ger-many, Sweden, Denmark and the UK are more likely to have a higher number of ISO 14001 adoptions. This is because the environmental preferences of customers in these countries, and the related pressure it exerts on providers of goods and services, are stronger. Accordingly, customers in these countries are more likely to prefer both domestic and foreign suppliers that have adopted ISO 14001. Moreover, while formal and informal regulations in France may be sufficient to operate in several international markets (Grol-leau et al. 2007b), French firms may have to adopt ISO 14001-type standards when they compete in eco-sensitive or environmentally proactive European markets (Potoski and Prakash 2004a; Chang and Kristiansen 2006).

Table 3 Marginal effects of Probit models

Dep. Var.: adoption of EMS	(1) COI 2006 ? EAE		(2) CIS 2008	
	Early adopter versus non-adopter	Late adopter versus non-adopter	Early adopter versus non-adopter	Late adopter versus non-adopter
Constant	-0.29*** (0.02)	-0.18*** (0.01)	-0.19*** (0.01)	-0.28*** (0.004)
Characteristics				
Size (in thousands of employees)	0.016*** (0.0024)	0.005** (0.002)	0.008*** (0.001)	0.02*** (0.002)
Size^2	-0.0001*** (0.00003)	-0.00008** (0.00002)	-0.00005*** (0.00001)	-0.0002*** (0.00003)
Being part of a group	-0.04*** (0.01)	-0.013** (0.006)	0.05*** (0.003)	0.07*** (0.004)
Capabilities				
Having ISO 9001 certification	0.18*** (0.01)	0.06*** (0.01)	–	–
Using quality-oriented practices (TQM)	–	–	0.03*** (0.003)	0.08*** (0.005)
Main market (ref. local/regional)				
National	-0.02** (0.01)	-0.014** (0.007)	0.02*** (0.003)	0.03*** (0.005)
European	0.024** (0.012)	0.01 (0.01)	0.06*** (0.005)	0.06*** (0.009)
International	0.015 (0.011)	0.01 (0.01)	0.04*** (0.007)	0.05*** (0.01)
Industry (ref. other services)				
High-tech. manuf.	0.04** (0.02)	0.003 (0.013)	0.03*** (0.008)	0.02* (0.01)
High-medium manuf.	0.07*** (0.01)	-0.02 (0.01)	0.04*** (0.005)	0.02*** (0.01)
Low-medium manuf.	0.01 (0.01)	0.005 (0.008)	0.03*** (0.004)	0.002 (0.01)
Low-tech manuf.	0.02 (0.01)	0.01 (0.01)	0.02*** (0.004)	0.02*** (0.01)
KIS	-0.06*** (0.01)	-0.02** (0.01)	-0.05*** (0.005)	-0.05*** (0.01)
Control variables				
Using product labeling	0.035*** (0.008)	0.001 (0.01)	–	–
Anticipating environmental regulation	–	–	0.07*** (0.004)	0.13*** (0.006)
Using binding delivery	0.02** (0.01)	0.01 (0.01)	0.003 (0.004)	0.02*** (0.005)
N	5455	4867	17,076	17,862
Treated	867	265	1271	2020
Untreated	4588	4602	15,805	15,842
Pseudo R^2	0.21	0.10	0.26	0.21

Table 3 continued

Dep. Var.: adoption of EMS	(1) COI 2006 ? EAE		(2) CIS 2008	
	Early adopter versus non-adopter	Late adopter versus non-adopter	Early adopter versus non-adopter	Late adopter versus non-adopter
LR v^2 (13)	990.42***	194.2***	2405.23***	2605.81***
Log likelihood	-1893.54	-931.83	-3321.76	-5001.06

Marginal effects computed at sample mean

Standards errors in parentheses

Significance: * significant at 10%, ** significant at 5%, *** significant at 1%

Last but not least, our analysis suggests that firms operating in industries where the average R&D intensity is high enough are likely to be early adopters of ISO 14001-type standards. More precisely, with the COI 2006 sample, we find that operating in high-tech or in high/medium-tech manufacturing industries is associated with a higher probability of operating in the manufacturing industries have a higher probability of being early adopters of ISO 14001-type standards, regardless of the tech level. We also find that firms operating either in high/medium-tech or in low-tech manufacturing industries have a higher probability of being late adopters. This is probably because the CIS 2008 is biased towards more innovative firms. Indeed, adding R&D intensity in 2008 as an additional control variable in the Probit model for late adopters versus non-adopters makes the effect of the manufacturing industries indicators altogether disappear, even though R&D intensity itself is not significant.

Overall, these findings support our Hypothesis 5 and give us evidence that technological complexity and R&D intensity matter in the voluntary adoption of EMS. But, as a caveat, Table 3 also displays another result on which both samples concur: Firms operating in knowledge-intensive services (KIS) sectors are less likely to be adopters. This could be because ISO 14001 standards primarily target the potential environmental damage that may come from the production processes of tangible goods. By definition, services firms may feel less concerned and are less prone to adopt ISO 14001 standards, which they may not need to perform their business.

5.2 EMS adoption and firm performance

In the second step of our empirical analysis, we estimate the ATT that measures the impact of the early or late adoption of ISO 14001-type environmental standards on labour pro-ductivity, as explained in Sect. 4.2. These results are presented in Table 4, the upper panel being dedicated to the COI 2006 sample, and the lower panel to the

CIS 2008 sample. As explained in Sect. 4.2, we present, as a sensitivity analysis, ATT estimated using FILM in addition to those estimated using PSM. As can be seen in Table 4, for a given sample and a given type of adopter, both estimates are very close, with a strong overlap in the 95% confidence intervals. We will therefore focus our comments on the ATT that we estimated with PSM (the FILM estimates would call for basically the same comments).

The estimated ATT are significantly positive in both samples and for both types of adopters. The magnitude of the ATT is noticeably higher in the CIS 2008 sample than in the COI 2006 sample, but this is only because the outcome variable, labour productivity, is computed using turnover in the former and VA in the latter. When comparing both samples, it is therefore wiser to simply examine the sign of the effect rather than its magnitude.

Overall, our findings provide only partial support for Hypothesis 6. On the one hand, they do indicate that the adoption of EMS is associated with a higher labour productivity. On the other, both early and late adoptions are associated with a higher labour produc-tivity,[13] which suggests that what matters is primarily adoption rather than the timing of adoption. It could be that the distance in time we use to define early adopters is too small to reflect what early adoption actually is in the real world. But our result could also mean that the ‘green signal’ sent by the early adoption of ISO 14001-type standards matters less than the implementation of these standards.

Our findings provide evidence that ‘‘win–win’’ situations may indeed occur, i.e., situ-ations in which voluntary EMS appear as effective tools that both decrease firms’ environmental liabilities and enable them to obtain productivity gains. Since increasing a firm’s labour productivity is not the primary aim of ISO 14001-type standards, one may assume that these productivity gains are derived from the very adoption of these standards. Indeed, it may be that a lower environmental liability, reduced input costs, improved production processes, an environmentally-friendly image and increased stakeholders and shareholders’ trust actually enable firms to increase their productivity.

[13] Although the coefficient associated with late adoption is slightly higher than the one associated with early adoption, its standard error is higher too, so confidence intervals overlap and one can only conclude that both early and late adoptions have a positive effect of a similar magnitude.

Table 4 Average treatment effect on the treated (ATT) obtained from PSM and FILM

Dep. var.: log of labour productivity	Propensity Score Matching (PSM)		Fully Interacted Linear Matching (FILM)	
	Early adopter versus non-adopter	Late adopter versus non-adopter	Early adopter versus non-adopter	Late adopter versus non-adopter
(1) COI 2006 ? EAE				
ATT	0.05** (0.025)	0.073* (0.04)	0.055** (0.023)	0.063* (0.038)
Untreated (On support)	4588	4602	4711	5284
Treated (On support)	867	264	873	299
Treated (Off support)	0	1	0	1
N	5455	4867	5584	5584
(2) CIS 2008				
ATT	0.26*** (0.03)	0.18*** (0.03)	0.25*** (0.03)	0.18*** (0.03)
Untreated (On support)	158,085	15,842	16,763	16,763
Treated (On support)	1271	2020	1313	2183
Treated (Off support)	0	0	5	3
N	17,076	17,862	18,081	18,904

Standards errors in parentheses—standard errors of PSM-estimated ATT are bootstrapped

Significance: * significant at 10%, ** significant at 5%, *** significant at 1%

This result is important because, in order to reach a certain level of global environmental effectiveness, the number of adopting firms should be augmented rapidly. This number has actually increased from 2008 until today, as will be shown in Sect. 5.4. To keep on encouraging adoption, policy makers may communicate on the economic advantages that can be derived from voluntary EMS. As a caveat, it remains possible that the productivity gains derived from adoption erode after a certain number of firms have adopted the standards, which would ultimately limit the effect of such a communication. We shed a light on this issue in Sect. 5.4, using macroeconomic time series on France.

5.3 Statistical tests

After using a matching method such as PSM, it is usual to check whether the ‘‘balancing property’’ is achieved, i.e., whether the propensity score effectively balances characteris-tics between the treatment and comparison group. If this balancing property is achieved, we are confident that the bias associated with observable characteristics is reduced. Table 5 presents standard balancing tests (t tests for comparisons in means) that are performed before and after matching for the treatment and control groups. For simplicity, we have pooled both early and late adopters in a single treatment group (which is more reasonable since both types of adopters display a very similar ATT, as explained in Sect. 5.2). We present the tests conducted on the COI 2006 sample in the upper panel of Table 5, and those conducted on the CIS 2008 sample in the lower panel.

Table 5 Summary statistics on explanatory variables before and after matching

Adopter versus non-adopter Variables	Before matching			After matching			
	Treated (adopter)	Control (non-adopter)	t test	Treated (adopter)	Control (non-adopter)	t test	% reduction in bias
(1) COI 2006 ? EAE							
ISO 9001	0.90	0.42	27.8***	0.9	0.89	0.69	98
Group	0.16	0.38	-12.4***	0.17	0.18	-0.46	96
Delivery	0.84	0.65	11.05***	0.84	0.84	-0.05	99.5
Size	1590	464	8.5***	1590	1270	1.06	72
Size^2	0.01	0.01	3.45***	0.005	0.004	0.56	66
Labelling	0.56	0.30	15.44***	0.56	0.58	-0.87	92
National	0.82	0.69	7.66***	0.82	0.81	0.59	91
European	0.68	0.43	13.66***	0.68	0.67	0.35	97
International	0.57	0.32	13.98***	0.57	0.57	-0.15	98.5
High-tech	0.06	0.02	6.34***	0.06	0.06	0.03	99
High-medium	0.23	0.07	14.62***	0.23	0.25	-0.77	90
Low-medium	0.15	0.10	4.26***	0.15	0.14	0.82	72
Low-tech	0.17	0.16	0.50	0.17	0.17	-0.15	61
KIS	0.08	0.18	-7.07***	0.08	0.086	-0.19	97
(2) COI 2008							
Anticipation	0.33	0.05	51.28***	0.33	0.33	0.22	99
Group	0.75	0.39	39.10***	0.75	0.74	1.62	95
Delivery	0.33	0.14	26.83***	0.33	0.34	-1.17	93
Size	0.82	0.15	15.96***	0.82	0.88	-0.48	91
Size^2	22.7	1.27	5.03***	22.7	28.3	-0.53	73.5
Quality	0.54	0.20	41.54***	0.54	0.55	-0.92	97
National	0.45	0.31	15.44***	0.45	0.45	-0.08	99
European	0.13	0.04	22.32***	0.13	0.12	1.71*	85
International	0.07	0.02	13.16***	0.07	0.07	-0.12	98
High-tech	0.05	0.02	11.03***	0.05	0.05	-0.28	95
High-medium	0.16	0.06	21.78***	0.16	0.15	1.34	89
Low-medium	0.15	0.12	5.85***	0.15	0.14	1.66*	61
Low-tech	0.15	0.13	4.30***	0.15	0.15	0.33	89
KIS	0.10	0.18	-11.8***	0.10	0.11	-1.52	86

Significance: * significant at 10%, ** significant at 5%, *** significant at 1%

In addition to mean values and t statistics, we also report in Table 5 the ‘standardised difference’, defined as the size of the difference in means of a conditioning variable (between the treatment and control groups) scaled by (or as a percentage of) the square root of the average of their sample variances. Before-matching results show an imbalance between the treated and the control groups in both samples. All t statistics are highly significant, which indicates that the null hypothesis of joint equality of means in the matched sample is rejected. By contrast, after-matching results clearly show that differ-ences are no longer statistically significant (except at the 10% level for a couple of industry indicators in the CIS 2008 sample). We can therefore be confident that our matching procedure has significantly reduced the bias associated with the observables.

5.4 Complementary analyses

Quality survey data on environmental innovation has become scarce after 2008: The COI survey has not been re-conducted to this day and post-2008 waves of the CIS have abandoned the module on environmental innovation. In this sub-section, we shed a light on two of our main results: The positive association between the implementation of ISO 9001 standards and the adoption of ISO 14001-type standards on the one hand, and the positive effect of adoption on labour productivity on the other. Simple econometric estimations on time series allow us to identify a dominant trend in France from 1999 to 2015 on each of these two results.

To remain consistent with our main analysis, we focus only on France, but our esti-mations could easily be conducted in most countries. For the sake of concision, we briefly describe our analysis (which is textbook standard) and display only one key estimate (and its standard error) for each association. Full tables of results are available in an online appendix.

5.4.1 Dynamic relationship between ISO 9001 and ISO 14001

Our aim is to examine the time consistency of the positive association we observe between the implementation of ISO 9001 quality standards and the adoption of ISO 14001-type standards. The publicly available ISO surveys[14] provide us with the yearly number of ISO 9001 certifications officially registered from 1993 to 2015 and with the yearly number of ISO 14001 certifications registered from 1999 to 2015. We present the chronograms of these two series in Fig. 1. Both series clearly follow an ascending trend over their

[14] Available at www.iso.org

respective time period, and both reach a plateau after 2010. DF-GLS and/or KPSS tests allow us to reject at the 1% level of confidence the null hypothesis that the series are non-stationary. We can therefore conclude that each series is stationary around a deterministic trend.

In order to determine whether the positive association between ISO 9001 and ISO 14001 holds over time, we estimate a simple Distributed Lags (DL) model of the form:

$$Y_t = \delta_0 + \delta_1 \Delta X_t + \delta_2 \Delta X_{t-1} + \cdots + \delta_p \Delta X_{t-p} + \delta_{p+1} \Delta X_{t-p} + \varepsilon_t \qquad (2)$$

where Y_t is the number of ISO 14001 certifications in year t, X_t the number of ISO 9001 certifications in year t, D the first-difference operator and e_t a random error. In model (2), our coefficient of interest is δ_{p+1} the so-called cumulative dynamic multiplier, which measures the cumulative effect of a unit change in X on Y over p periods. In our

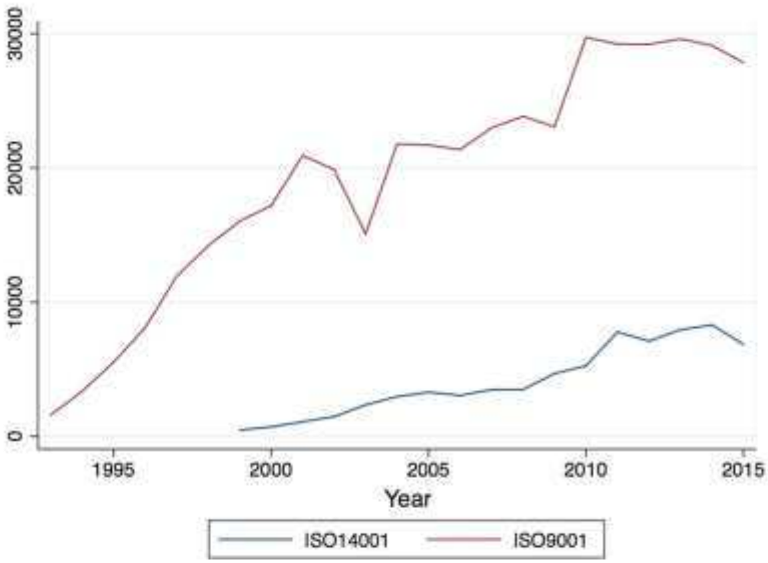

Fig. 1 Number of ISO 9001 and ISO 14001 certifications per year in France, 1993–2015. Source: www.iso.org, authors' own representation

application, since the ISO 9001 series starts six years before the ISO 14001 series, we can let p go from 1 to 6 without losing any further observation (besides the one lost from first-differencing X_t). Using the Bayesian Information Criterion (BIC), we determined that the best value of p for our data was p = 2. We estimated Model (2) for this value of p using an Heteroskedasticity and Autocorrelation Consistent (HAC) variance estimator.

This overall fit was very good (the Fisher test was significant at the 1% level and the R^2 was equal to 0.93) and the estimated cumulative dynamic multiplier was equal to 0.52 with a HAC standard error of 0.02 (which implies that the estimate is significantly different from zero at the 1% level). In other words, 100 new ISO 9001 certifications in France in any given year will lead to 52 new ISO 14001 certifications over the next two years. We therefore have found evidence that the positive association between both types of ISO standards in France is a result that has been consistent over time, including in the recent years.

5.4.2 Dynamic relationship between ISO 14001 and labour productivity

We now want to examine the time consistency of the positive effect of the adoption of ISO 14001-type standards on labour productivity that we ascertained in Sect. 5.2. To do so, we use a time series of labour productivity in France computed by the OECD[15] and measured in US dollars (constant prices 2010 purchasing power parity). The series is available until 2015, and we cut it back in 1993 so that it fits with our ISO survey data. We present the corresponding chronogram in Fig. 2. After checking that the series is stationary using DF-GLS and KPSS tests, we estimated a variant of Model (2) in which Y_t is the natural log of labour productivity in year t and X_t the natural log of the number of ISO 14001 certifications in year t. Using the logged variables allows us to interpret the cumulative dynamic multiplier as an elasticity.

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[15] This series is publicly Available at https://stats.oecd.org/Index.aspx?DataSetCode=PDB_LV.

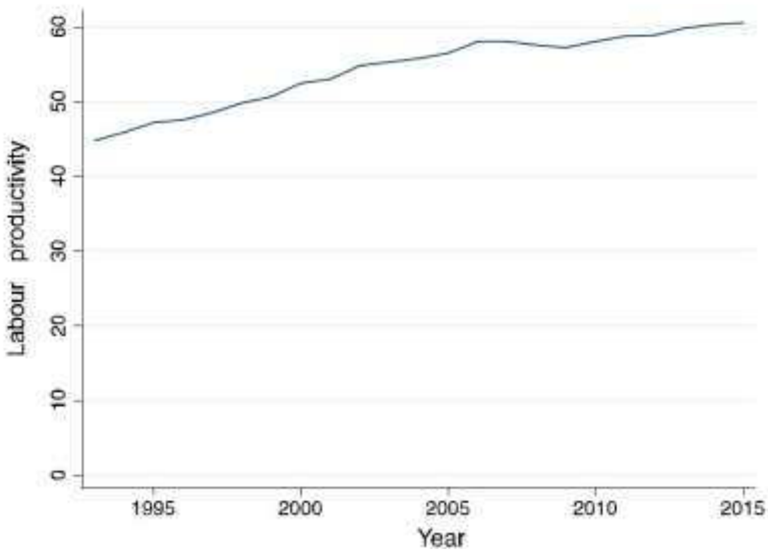

Fig. 2 Labour productivity in France in US dollars (constant price, 2010 PPP), 1993–2015. Source: OECD, authors' own representation

The BIC criterion suggests a model estimated with p = 1, and this model yields an estimate of the cumulative dynamic multiplier equal to 0.045 with an HAC standard error of 0.002 (which makes the estimate significantly different from 0 at the 1% level). In other words, the 1-year elasticity of labour productivity with respect to the number of ISO 14001 certifications is equal to 0.045. Although this value is lower than 1, it nevertheless provides some evidence that the effect of ISO 14001 adoption on labour productivity has been consistent over time, including over the recent years.

6 Conclusion

This research contributed to the literature on the adoption and economic effect of voluntary EMS from an empirical perspective, using two large samples of French firms observed in 2003 and 2006 and over 2006–2008, respectively. Our contribution was twofold. First, we have identified the structural characteristics and organisational capabilities that have an impact on a firm's early or late adoption decision. Few empirical studies in the literature have been able to make a distinction between early and late adoption, although some theoretical reflections suggest that the timing of adoption may matter. Second, we have provided evidence that adopting voluntary EMS of the ISO 14001 type is associated with labour productivity gains.

As regards our first contribution, we have found that adopters are typically moderately large manufacturing firms that rely on ISO 9001 standards or on TQM. In addition, early adopters typically operate in high-tech or medium/high-tech industries and are primarily active in the European or international markets. These differences are more clear-cut in the first sample than in the second one, which is more biased towards innovative firms. Highlighting these profiles of adopters may be important for policymakers should they wish to accelerate the diffusion of voluntary proactive approaches for environmental protection. These profiles give a starting point regarding which firms to target first when promoting ISO 14001-type EMS.

Our second contribution was to show that adoption is associated with labour produc-tivity gains. The timing of adoption does not seem to matter. In other words, there is no premium to 'early birds', and it could well be that productivity increases through more cost-effective and waste-reducing production processes. This finding has important policy implications, as policy makers may communicate on the economic effectiveness of EMS in order to convince more firms to become adopters. Moreover, while voluntary EMS such as ISO 14001 are hardly credible substitutes for governmental intervention through envi-ronmental regulation, they may be a good complement for market-based instruments (such as tradable permits, taxes, subsidies etc.) and 'command and control' mechanisms. Simple complementary analyses on time series suggest that two of our main results (the positive association between the implementation of ISO 9001 standards and the adoption of ISO 14001-type standards on the one hand, and the positive effect of adoption on labour productivity on the other) have been consistent over time, including in the recent years.

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References

Abadie, A., & Imbens, G. W. (2006). Large sample properties of matching estimators for average treatment effects. Econometrica, 74(1), 235–267.

Albertini, E. (2013). Does environmental management improve financial performance? A meta-analytical review. Organization and Environment, 26(4), 431–457.

Albertini, A., & Segerson, K. (2002). Assessing voluntary programs to improve environmental quality. Environmental & Resource Economics, 22(1–2), 157–184.

Ambec, S., Cohen, M. A., Elgie, S., & Lanoie, P. (2013). The porter hypothesis at 20: Can environmental regulation enhance innovation and competitiveness? Review of Environmental Economics and Policy, 7(1), 2–22.

Ambec, S., & Lanoie, P. (2008). Does it pay to be green? A systematic overview. The Academy of Management Perspectives, 22(4), 45–62.

Anton, W. R. Q., Deltas, G., & Khanna, M. (2004). Incentives for environmental self-regulation and implications for environmental performance. Journal of Environmental Economics and Management, 48, 632–654.

Arora, S., & Cason, T. N. (1995). An experiment in voluntary environmental regulation: Participation in EPA^{0}s 33/50 program. Journal of Environmental Economics and Management, 28(3), 271–286.

Ayres, R. U., & Walter, J. (1991). The greenhouse effect: Damages, costs and abatement. Environmental & Resource Economics, 1(3), 237–270.

Bansal, P., & Hunter, T. (2003). Strategic explanations for the early adoption of ISO 14001. Journal of Business Ethics, 46(3), 289–299.

Bansal, P., & Roth, K. (2000). Why companies go green: A model of ecological responsiveness. Academy of Management Journal, 43, 717–736.

Benavides-Velasco, C. A., Quintana-Garcı´a, C., & Marchante-Lara, M. (2014). Total quality management, corporate social responsibility and performance in the hotel industry. International Journal of Hospitality Management, 41, 77–87.

Benner, M. J., & Veloso, F. M. (2008). ISO 9000 practices and financial performance: A technology coherence perspective. Journal of Operations Management, 26(5), 611–629.

Blind, K. (2006). Explanatory factors for participation in formal standardisation processes: Empirical evidence at firm level. Economics of Innovation and New Technology, 15(2), 157–170.

Blind, K., & Mangelsdorf, A. (2013). Alliance formation of SMEs: Empirical evidence from standardization committees. IEEE Transactions on Engineering Management, 60(1), 148–156.

Bloom, N., & Van Reenen, J. (2010). Why do management practices differ across firms and countries? Journal of Economic Perspectives, 24, 203–224.

Boiral, O. (2011). Managing with ISO systems: Lessons from practice. Long Range Planning, 44(3), 197–220.

Bowen, F. E. (2002). Does size matter? Organisational slack and visibility as alternative explanations for environmental responsiveness. Business and Society, 41, 118–124.

Brammer, S., & Millington, A. (2008). Does it pay to be different? An analysis of the relationship between corporate social and financial performance. Strategic Management Journal, 29(12), 1325.

Chang, H. S. C., & Kristiansen, P. (2006). Selling Australia as ‘clean and green’. The Australian Journal of Agricultural and Resource Economics, 50, 103–113.

Christmann, P. (2000). Effects of the ‘Best Practices’ of environmental management on cost advantage: The role of complementary assets. Academy of Management Journal, 43(4), 663–680.

Colombo, M. G., Grilli, L., & Piva, E. (2006). In search of complementary assets: The determinants of alliance formation of high-tech start-ups. Research Policy, 35(8), 1166–1199.

Corbett, C. J., & Kirsch, D. A. (1999). International diffusion of ISO 14000 certification. Production and Operations Management, 10, 327–342.

Dachs, B., & Peters, B. (2014). Innovation, employment growth, and foreign ownership of firms: A European perspective. Research Policy, 43(1), 214–232.

Darnall, N. (2003). Motivations for participating in a voluntary environmental initiative: The multi-state working group and EPA’s EMS pilot program. In S. Sharma & M. Starik (Eds.), Research in corporate sustainability (pp. 123–154). Boston: Edward Elgar.

Darnall, N. (2006). Why firms mandate ISO 14001 certification. Business & Society, 45(3), 354–381.

Darnall, N., & Edward, D. (2006). Predicting the cost of environmental management system adoption: The role of capabilities, resources and ownership structure. Strategic Management Journal, 27, 301–320.

Delmas, M. (2003). In search of ISO: An institutional perspective on the adoption of international management standard. Stanford Graduate School of Business Working Paper, 1784.

Delmas, M. A., & Montes-Sancho, M. J. (2010). Voluntary agreements to improve environmental quality: Symbolic and substantive cooperation. Strategic Management Journal, 31(6), 575–601.

Delmas, M., & Montiel, I. (2009). Greening the supply chain: When is customer pressure effective? Journal of Economics and Management Strategy, 18(1), 171–201.

Delmas, M. A., & Pekovic, S. (2013). Environmental standards and labor productivity: Understanding the mechanisms that sustain sustainability. Journal of Organizational Behaviour, 34, 230–252.

Di Maggio, P. J., & Powell, W. W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. American Sociological Review, 48(2), 147–160.

Frondel, M., Horbach, J., & Rennings, K. (2007). End-of-pipe or cleaner production? An empirical comparison of environmental innovation decisions across OECD countries. Business Strategy and the Environment, 16(8), 571–584.

Gedajlovic, E. (1993). Ownership, strategy and performance: Is the dichotomy sufficient? Organization Studies, 14, 731–752.

Greenan, N., Guillemot, D., & Kocoglu, Y. (2010). Pre´sentation du dossier'' Informatisation et changements organisationnels dans les entreprises''. Re´seaux, 28(162), 9–32.

Grolleau, G., Mzoughi, N., & Pekovic, S. (2007a). The characteristics of chemical firms registering for ISO 14001 or Responsible Care. Economic Bulletin, 12(29), 1–13.

Grolleau, G., Mzoughi, N., & Thomas, A. (2007b). What drives agrifood firms to register for an Environmental Management System? European Review of Agricultural Economics, 34(2), 233–255.

Grolleau, G., & Thomas, A. (2007). Adoption of environmental management systems by farmers: An empirical application to ISO 14001. Journal of Agricultural and Applied Economics, 39(3), 523–540.

Harter, C. L., & Homison, R. (1999). Factors affecting Pennsylvania firms' intentions concerning ISO 14001. Pennsylvania Economic Review, 7(1), 16–27.

Hart, S. (1995). A natural-resource-based view of the firm. Academy of Management Review, 20, 986–1014. Hart, S. L., & Ahuja, G. (1996). Does it pay to be green? An empirical examination of the relationship between emission reduction and firm performance. Business Strategy and the Environment, 5(1), 30–37.

Heckman, J., Ichimura, H., & Todd, P. (1997). Matching as an econometric evaluation estimator: Evidence from evaluating a job training program. Review of Economic Studies, 64(4), 605.

Heckman, J., Ichimura, H., & Todd, P. (1998). Matching as an econometric evaluation estimator. The Review of Economic Studies, 65, 261–294.

Henriques, I., & Sadorsky, P. (1996). The determinants of an environmentally responsive firm: An empirical approach. Journal of Environmental Economics and Management, 30, 381–395.

Henriques, I., & Sadorsky, P. (1999). The relationship between environmental commitment and managerial perceptions of stakeholder importance. Academy of Management Journal, 42(1), 87–99.

Hormozi, A. M. (1997). ISO 14001: The next focus in standardization. SAM Advanced Management Journal, 62(3), 32–41.

Jamali, D. (2010). MNCs and international accountability standards through an institutional lens: Evidence of symbolic conformity or decoupling. Journal of Business Ethics, 95(4), 617–640.

Karapetrovic, S., & Casadesu´s, M. (2009). Implementing environmental with other standardized management systems: Scope, sequence, time and integration. Journal of Cleaner Production, 17(5), 533–540.

Khanna, M., & Damon, L. A. (1999). EPA's voluntary 33/50 program: Impact on toxic releases and economic performance of firms. Journal of Environmental Economics and Management, 37(1), 1–25.

Khanna, M., & Zilberman, D. (1997). Incentives precision technology and environmental protection. Ecological Economics, 23, 25–43.

King, A., & Lenox, M. (2001). Who adopts management standards early? An examination of ISO 14001 certifications. In D. Nagao (Ed.), Best paper proceedings: Fifty-ninth meeting of the Academy of Management (pp. A1–A6). Washington, DC: Academy of Management.

King, A., & Lenox, M. (2002). Exploring the locus of profitable pollution reduction. Management Science, 48(2), 289–299.

Kirkpatrick, D., & Pouliot, C. (1996). Environmental management, ISO 14000 offers multiple rewards. Pollution Engineering, 28(6), 62–65.

Kollman, K., & Prakash, A. (2001). Green by choice? Cross-national variations in firms' responses to EMS-based environmental regimes. World Politics, 53, 399–430.

Lenox, M., & King, A. (2004). Prospects for developing absorptive capacity through internal information provision. Strategic Management Journal, 25(4), 331–345.

Leuven, E., & Sianesi, B. (2004). FILM: Stata module to perform 'fully interacted linear matching'. Software. Institute for Fiscal Studies. http://www.ifs.org.uk/publications/2712.

Lim, S., & Prakash, A. (2014). Voluntary regulations and innovation: The case of ISO 14001. Public Administration Review, 74(2), 233–244.

Lo´pez-Gamero, M. D., Molina-Azorı´n, J. F., & Claver-Cortes, E. (2009). The whole relationship between environmental variables and firm performance: Competitive advantage and firm resources as mediator variables. Journal of Environmental Management, 90(10), 3110–3121.

Mascarenhas, B. (1989). Domains of state-owned, privately held, and publicly traded firms in international corporations. Administrative Science Quarterly, 34, 582–597.

Melnyk, S. A., Calantone, R., Handfield, R., & Tummala, R. L. (1999). ISO 14001: Assessing its impact on corporate effectiveness and efficiency. Tempe, AZ: Report, Center for Advanced Purchasing Studies, National Association of Purchasing Management.

Melnyk, S. A., Sroufe, R. P., & Calantone, R. (2003). Assessing the impact of environmental management systems on corporate and environmental performance. Journal of Operations Management, 21, 329–351.

Meyer, J., & Rowan, B. (1977). Institutionalized organizations– formal structure as myth and ceremony. American Journal of Sociology, 83(2), 340–363.

Montiel, I., & Husted, B. W. (2009). The adoption of voluntary environmental management programs in Mexico: First movers as institutional entrepreneurs. Journal of Business Ethics, 88, 349–363.

Mori, Y., & Welch, E. W. (2008). The ISO 14001 environmental management standard in Japan: Results from a national survey of facilities in four industries. Journal of Environmental Planning and Management, 51(3), 421–445.

Mueller, M., dos Santos, V., & Seuring, S. (2009). The contribution of environmental and social standards towards ensuring legitimacy in supply chain governance. Journal of Business Ethics, 89(4), 509–523.

Murillo-Luna, J. L., Garces-Ayerbe, C., & Rivera-Torres, P. (2008). Why do patterns of environmental response differ? A stakeholders' pressure approach. Strategic Management Journal, 29(11), 1225–1240.

Nakamura, M., Takahashi, T. and Vertinsky, I. (2001). Why Japanese Firms Choose to Certify: A Study of Managerial Responses to Environmental Issues. Journal of Environmental Economics and Management, 42, 23-52.

Nishitani, K. (2009). An empirical study of the initial adoption of ISO 14001 in Japanese manufacturing firms. Ecological Economics, 68(3), 669–679.

Oliver, C. (1991). Strategic responses to institutional pressures. Academy of Management Journal, 16, 145–179.

Pekovic, S. (2010). The determinants of ISO 9000 certification: A comparison of the manufacturing and service sectors. Journal of Economic Issues, 44, 895–914.

Porter, M. E., & Van der Linde, C. (1995). Toward a new conception of the environment-competitiveness relationship. The Journal of Economic Perspectives, 9(4), 97–118.

Potoski, M., & Prakash, A. (2004a). Regulatory convergence in nongovernmental regimes? Cross-national adoption of ISO 14001 certifications. The Journal of Politics, 66, 885–905.

Potoski, M., & Prakash, A. (2004b). Green clubs and voluntary governance: ISO 14001 and firms' regu-latory compliance. American Journal of Political Science, 49, 235–248.

Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. Biometrika, Biometrika Trust, 70, 41–55.

Russo, M., & Fouts, P. (1997). A resource-based perspective on corporate environmental performance and profitability. Academy of Management Journal, 40(3), 534–559.

Simpson, D., Power, D., & Klassen, R. (2012). When one size does not fit all: A problem of fit rather than failure for voluntary management standards. Journal of Business Ethics, 110(1), 85–95.

Simpson, D., Power, D., & Samson, D. (2007). Greening the automotive supply chain: A relationship perspective. International Journal of Operations and Production Management, 27(1), 28–48.

Su, H. C., Dhanorkar, S., & Linderman, K. (2015). A competitive advantage from the implementation timing of ISO management standards. Journal of Operations Management, 37, 31–44.

Wakke, P., Blind, K., & de Vries, H. (2015). Driving factors for service providers to participate in standardization: Insights from the Netherlands. Industry and Innovation, 22, 299–320.

Wakke, P., Blind, K., & Ramel, F. (2016). The impact of participation within formal standardization on firm performance. Journal of Productivity Analysis, 45(3), 317–330.

Welch, E. W., Mori, Y., & Aoyagi-Usui, M. (2002). Voluntary adoption of ISO 14001 in Japan: Mecha-nisms, stages and effects. Business Strategy and the Environment, 11(1), 43–62.

Wojan, T. R., & Bailey, T. (2000). International quality control certification: Signal or heuristic?. Lex-ington: Department of Agricultural Economics, College of Agriculture, University of Kentucky.

Zucker, L. G. (1986). Production of trust: Institutional sources of economic structure, 1840–1920. Research in Organizational Behavior, 8, 53–111.

Zyglidopoulos, S. C. (2002). The social and environmental responsibilities of multinationals: Evidence from the Brent Spar case. Journal of Business Ethics, 36, 141–151.