Global Governance in New Public Environmental Management: An International and Intertemporal Comparison of Voluntary Standards' Impacts

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Abstract

The aim of this paper is to analyse the indirect effects of environmental management system implementation and certification. Specifically, the paper comprehensively assesses the effects of ISO 14001 and EMAS certification as well as experience with implementing environmental management systems on 1) organizational activities outside the scope of environmental management systems, 2) pollution prevention, and 3) product stewardship. This is done by applying multivariate regression analysis to a large multi-country and multi-period dataset. The analysis finds heterogeneous effects that are limited specifically as concerns pollution prevention and product stewardship, and cannot establish clear links to national business systems. Given this and the differences between environmental management system standards, implications for global governance in the context of new public environmental management and the role of national governments in implementing sustainability, even beyond environmental protection, are discussed. Ultimately, the paper evidences on potential limitations of the major international environmental management system standards ISO 14001 and EMAS in supporting the diffusion of advanced practices such as pollution prevention and product stewardship that are necessary for sustainable development. In doing so, it highlights that government-led public environmental management remains crucial for organising governance, especially in the context of voluntary standards that are applied internationally.

Keywords

international, global governance, environmental management, voluntary standard, ISO 14001, EMAS

Introduction

Increasingly, new public management and the role of governance systems in guiding private firms are being analysed empirically based on theories drawn from organisation studies, and especially institutional approaches such as the national business system concept (Whitley, 1999). This paper relates this trend to the context of voluntary governance and self-regulation in the area of environmental sustainability (Lenox, 2006), which commenced with a first wave of command-and-control based public management and regulation (Ghosal, 2015) which started in 1973 after the publication of the first report of the Club of Rome and lasted to around 1983. This initial phase was followed by a second wave of applying more market-based instruments, which has been superseded by a third wave from 1993 onwards characterised by voluntary initiatives (Prakash, 2001; Delmas & Toffel, 2004), where new public management and related deregulation made standardisation based on voluntary environmental management standards pivotal (Delmas, 2002; Testa, Heras-Saizarbitoria, Daddi, Boiral & Iraldo, 2016). As part of this third wave, standards for environmental management systems (EMS), especially the European Union (EU) Eco-Management and Auditing Scheme (EMAS) and the International Organisation for Standardisation (ISO) 14001 standard, have become increasingly relevant since the late 1990s in all EU member states (Glachant, Schucht, Bültmann & Wätzold, 2002; Montobbio & Solito, 2018; Papagiannakis, Voudouris, Lioukas & Kassinis, 2019). Therefore, the remainder of the paper focuses on these main voluntary environmental management standards used today, taking into account their differing origin as private decentralised (ISO) and public (EMAS) institutions (King, Lenox & Terlaak, 2005).

As part of the trend described above, the ISO 14001 and EMAS standards for EMS can be seen as means by which firms can continuously improve their environmental performance while (at least) not jeopardising their economic performance, based on arguments applying the resource-based view and theories of organisational learning (Argote, 1999). This means that firms would be able to create win-win situations in which private and societal interests are aligned, which immediately raises the question of whether such a proposition is supported by empirical evidence? An alternative perspective holds that ISO 14001 and EMAS are examples of rational myths (Boiral, 2007). This would suggest more limited or even no positive (direct or indirect) effects of EMS implementation and certification as well as the possibility of effect differences across standards (Testa et al., 2014).

This paper therefore analyses the influence of ISO 14001 and EMAS certification, and temporal EMS implementation experience, on the environmental performance of (compared to services) higher polluting manufacturing firms in several EU countries and over time. Since, by definition, voluntary initiatives always allow firms to safeguard their economic performance, our analysis can shed light on the win-win proposition, which would imply increased social welfare.

EMS have become increasingly relevant over the last two decades as a foundation stone of corporate sustainability management (Fanasch, 2019), as evidenced by their high corporate adoption across many industries (ISO, 2015; Eurostat, 2016; Papagiannakis et al., 2019). That popularity can at least partly be attributed to the ability of EMS to reduce costs, increase sales, and induce innovation, particularly if the systems are externally audited and certified (Heras-Saizarbitoria, Arana & Boiral, 2016).

Other research has echoed concerns with regard to the environmental benefits of EMS (Hertin, Berkhout, Wagner & Tyteca, 2008) and the reasons for EMS adoption and the benefits flowing from that adoption have been researched with regard to the differing views (win-win vs. trade-off) as concerns direct benefits (Delmas & Montes-Sancho, 2011). Nevertheless, there is far less research directed at illuminating the indirect benefits and spillovers of EMS (Boiral, Guillaumie, Heras-Saizarbitoria & Tayo Tene, 2018) and that creates a research gap. Furthermore, environmental protection goes well beyond addressing climate change (Rockström et al., 2009), which imposes a requirement to consider indirect effects and spillovers of EMS for the full set of environmental aspects and effects that matter for manufacturing firms, which equally presents a research gap, even when accounting for the recent literature (Wright & Nyberg 2017). Finally, most studies to date could not address these issues in a comparative manner involving different countries and standards from a longitudinal perspective, which constitutes a third gap in the extant literature (Boiral et al., 2018).

This paper improves on this state by specifically analysing the indirect effects of EMAS and ISO 14001 certification, as well as those from the duration of implementation and resulting experience with EMS in general, over time and across different countries. Focusing in this way on indirect effects enables a more comprehensive assessment and thus constitutes an important contribution to the body of knowledge on voluntary standards as an instrument for (global) environmental governance. In doing so, this analysis also provides answers to questions raised by the research agenda developed by Heras-Saizarbitoria and Boiral (2013).

The remainder of the paper first reviews extant literature and, based on that review, derives a set of hypotheses. Subsequently, the data and analytical methods used to test those hypotheses are introduced before the results of the empirical analysis are presented. The paper provides a discussion and conclusions in its last section.

Literature review and hypotheses

Standardisation and the corresponding use of voluntary standards such as EMS standards have been explored in many different contexts in the past. For example, this concerns EMAS (e.g., Heras-Saizarbitoria et al., 2016; Montobbio & Solito, 2018; Testa, Iraldo & Daddi, 2018a; Testa, Boiral & Iraldo, 2018b) and ISO (e.g., Heras-Saizarbitoria, Molina-Azorin & Dick, 2011; Boiral et al., 2018) separately, or in combination (e.g., Neugebauer, 2012; Testa, Rizzi, Daddi, Gusmerotti, Iraldo & Frey, 2014). These and other studies also reveal that over time, ISO 14001 with its global scope has become relatively more dominant than EMAS.

This extant work can be linked to the notion of standards markets (Reinecke, Manning & van Hagen, 2012) suggesting that public authorities, social movements, and industry bodies simultaneously introduce competing voluntary standards, which differ in their stringency and flexibility. This is also true for EMS standards, where ISO 14001 was mainly developed by ISO itself and industry bodies, whereas EMAS was largely promoted by the EU and the European Commission as governmental actors, supported by non-profit non-governmental organisations endorsing EMAS as a more stringent EMS standard than ISO 14001 (Moon, 2002; Neugebauer, 2012).

Beyond adoption, the literature has also discussed several possible economic and environmental benefits of EMS implementation and certification (De Jong, Paulraj & Blome, 2014; Heras- Saizarbitoria et al., 2011; Boiral et al., 2018). Specifically, this concerns direct benefits in terms of environmental performance improvements derived from activities required by an EMS standard (Van Dijken et al. 1999; Boiral, 2007; Wagner, 2009; Testa et al., 2014; Montobbio & Solito, 2018; Papagiannakis et al., 2019; Testa et al., 2018a).

For example, De Jong et al. (2014) show that EMS implementation and certification offers mostly financial, rather than ecological, benefits. Van Dijken et al. (1999) find that the EMS implementation to be associated with environmental innovations within the implementing firm. Similarly, Montobbio and Solito (2018) and Papagiannakis et al. (2019) find some evidence of EMS certification having positive effects on environmental innovation.

Based on case studies in Canadian firms, Boiral (2007) shows that ISO 14001 implementation can lead to ceremonial behaviour that can be decoupled from daily practices. He therefore concludes that adoption of ISO 14001 has a doubtful association with environmental performance and direct factors related to it. Testa et al. (2018a) and Heras- Saizarbitoria et al. (2011) suggest that the equivocal evidence may be partly reconciled by taking a contingency approach.

Alongside the above, environmentally related indirect benefits can be distinguished, such as heightened uptake of activities improving environmental performance that are not required by any EMS standard. Similarly, indirect benefits that are not environmentally related, such as improved staff satisfaction and recruitment, or general innovation benefits might exist (Rennings, Ziegler, Ankele & Hoffmann, 2006; Arimura, Darnall & Katayama, 2011; Grolleau, Mzoughi & Pekovic, 2012).

Rennings et al. (2006) provide an early evaluation of EMAS effects on innovation. Based on a survey and case data, the study identifies information spillovers from the environmental statements under EMAS for innovation in other firms. Furthermore, the study suggests that learning through information spillovers from EMS implementation is more limited for technical activities than for other organisational activities. To illustrate, addressing ISO 14001, Arimura et al. (2011) find that EMS implementation mainly supports employee co-operation and teamwork within the firm.

The above review of the literature again clarifies that research to date has rarely addressed the indirect effects from a heightened uptake of activities improving environmental performance that are not required by any of the EMS standards. The hypotheses development in the current research will therefore focus on them.

Building on institutional, spillover, and learning theories permits the identification of several hypotheses on various indirect effects of EMS implementation (Argote, 1999). To start with, institutional theory suggests that EMS implementation certification could generate misleading signals owing to asymmetric information enabling and incentivising opportunistic behaviour of weaker or reactive firms pursuing institutional isomorphism and organisational mimicry across firms or within industries (King, Lenox & Terlaak, 2005; Testa et al., 2018b).

To credibly signal the opposite, firms that invested proactively in EMS certification as a club good to differentiate themselves in the market or to signal the existence of strong sustainability-related capabilities (Kollman & Prakash, 2002; Wernerfelt, 1984) have incentives to pursue further technical and organisational environmental activities to maintain a credible signal and mitigate information asymmetries (Grolleau, Mzoughi & Pekovic, 2007). This leads to the following three hypotheses concerning EMS certification in general (e.g., EMAS or ISO 14001):

H1a: EMS certification positively associates with the extent of organisational environmental activities beyond the scope of EMS.
H1b: EMS certification positively associates with the extent of technical activities related to pollution prevention.
H1c: EMS certification positively associates with the extent of technical activities related to product stewardship.

In terms of spillover effects, ISO certification is more strongly oriented towards cross-referencing (Johnstone & Labonne, 2009), since several other ISO standards relate directly to the EMS specification standard ISO 14001. Key examples of those standards are ISO 14000 on environmental management principles, systems, and supporting techniques, as well as several auditing-related standards, namely ISO 14010 on principles, ISO 14011 on procedures, ISO 14012 on auditor qualification and ISO 14013/15 on reviews and assessments, but there are also others with more indirect links (ISO, 2015). Examples of the latter include ISO 14020/23 on environmental labelling, ISO 14031 on environmental performance evaluation, ISO 14040/43 on life-cycle analysis, ISO 50001 on energy management and ISO 14060 on environmental aspects in product standards as well as ISO 26000 on social responsibility. Given that ISO 14001 frequently only provides generic requirements (Testa et al., 2018a), spillovers from the involvement of cross-referenced ISO standards can be expected. In contrast to this position, EMAS is a stand-alone standard, and therefore cannot trigger organisational activities due to structural or other similarities in the same way as ISO 14001 can.

Furthermore, the majority of requirements of EMAS and ISO 14001 refer to organisational aspects that are closely related to production technologies and internal processes (Grolleau et al., 2007). These organisational aspects are more strongly linked to technical activities related to pollution prevention within the existing production system (Könnölä & Unruh, 2007), but have only limited associations with technical activities related to product stewardship, which typically extend beyond the boundaries of the firm. This situation prompts the following two differential hypotheses:

H2a: The positive association of ISO 14001 certification with organisational environmental activities beyond the scope of EMS is stronger than that of EMAS certification.
H2b: The positive association of EMS certification with technical activities related to pollution prevention is stronger than that with technical activities related to product stewardship.

According to Llerena (1999), EMS implementation experience can lead to activities beyond the direct requirements of a standard owing to organisational mechanisms oriented towards exploration (March, 1991), such as higher order learning (Argyris & Schön, 1978). Similarly, EMS implementation benefits exploitation, where learning-by-doing (Argote, 1999) and disciplined problem solving (Levitt & March, 1988) have been suggested as the most relevant mechanisms. Therefore, temporal implementation aspects are expected to have effects beyond those of EMS certification on the adoption of further organisational environmental activities (Yin & Schmeidler, 2009). On the one hand, this is because specific competencies and capabilities needed for such activities are developed and refined in firms over time through the exploration and exploitation mechanisms described above (Heras-Saizarbitoria et al., 2016). On the other hand, performance feedback on implementation effects also accumulates over time, suggesting that complementarities and new commercial opportunities that can be realised based on EMS implementation unfold in a process, which is distinct and therefore has an effect independent of any certification (Melnyk, Sroufe & Calantone, 2003). Accordingly, we propose the following hypotheses:

H3a: EMS implementation experience positively associates with organisational environmental activities beyond the scope of EMS.
H3b: EMS implementation experience positively associates with adoption of technical activities related to pollution prevention.
H3c: EMS implementation experience positively associates with adoption of technical activities related to product stewardship.

Data and method

The empirical data used for our analysis were collected in the context of a larger research project during four waves of the German Sustainability Barometer survey (2001 when it was integrated into the European Business Environment Barometer (EBEB), 2006, 2011, and 2016). For 2001, integration in the EBEB allowed us to utilise a large multinational dataset to compare evidence across different countries and to establish a baseline. The three additional waves that cover further time periods in Germany permit the adoption of an intertemporal and longitudinal perspective. Heras-Saizarbitoria and Boiral (2013) call for both longitudinal and cross-country comparative studies; and combining both perspectives can contribute particularly well to that research plea. For Germany and the remaining European countries, 832 and 1492 manufacturing firm observations, respectively, could be included in the analysis. Based on statistics from the German Federal Labour Office and the Organisation for Economic Co-operation and Development, a minor firm size bias in the data should be acknowledged, in that for Norway, Switzerland, the United Kingdom, and Germany smaller firms are underrepresented. However, this is a persistent issue in empirical management studies in general, since smaller firms inherently have fewer resources available to devote to participating in surveys (Armstrong & Overton, 1977). Beyond size however, response bias in the data is unlikely since there is considerable variation across the responses in all countries and survey waves, indicating that in terms of environmental management, less active firms did respond to the survey.

The survey generally aimed to assess the state of environmental management across space and time. The questionnaire asked firms to self-assess their adoption of organisational activities beyond the scope of EMS standards and also to report their adoption of technical activities with regard to pollution prevention and product stewardship. Finally, a number of questions elicited corporate responses on important explanatory variables such as EMS certification and implementation experience, industry membership, firm size, existence of a quality management system, ownership, and market conditions. In the survey, several procedural and statistical methods were used to counter common method bias. Specifically concerning procedures, respondents were guaranteed anonymity, the question order was counter-balanced, scale items were improved following a pre-test, and different response formats were used. This action furthermore reduced item ambiguity and social desirability issues. To test the hypotheses formulated earlier, several variables were constructed from the survey data based on prior literature, and complemented with a comprehensive set of control variables to account for important firm-, country- and sector-level contingencies (Boiral et al., 2018).

For the first dependent variable, an index was calculated to gauge if organisational action not required by the EMS was undertaken in the three years prior to the relevant survey period (i.e., 1998–2000, 2003–2005, 2008–2010, and 2013–2015) using a set of binary coded items (see Table 1 for details). Those items were aggregated to gauge the number of organisational activities undertaken by the firm beyond those required by its EMS. The index (hereafter referred to as NEMS) ranges from zero to 1, and corresponds to the ratio of actually implemented to possible activities. With regard to the other dependent variables, pollution prevention and product stewardship, two separate indices (abbreviated as PP and PS) were equally constructed based on relevant survey items as detailed in Table 1 (as before, these referred to the activity being undertaken in the last three years). These items were also combined into aggregated indices, again ranging from 0 to 1, with the interpretation as above.

** insert Table 1 about here **

EMS certification is measured by evaluating whether a firm is certified or verified according to ISO 14001 or EMAS respectively. If there is a certification according to one of the schemes, the corresponding indicator is 1, otherwise it is zero. The EMS experience variable is coded as the time passed since the first implementation of an EMS standard. To avoid endogeneity with activities in the three-year periods surveyed (i.e., the activity could be implemented before certification was achieved), implementation time was calculated until 1997 (for the period 1998–2000), 2002 (for the period 2003–2005), 2007 (for the period 2008–2010) and 2012 (for the period 2013–2015). For example, for the 2011 survey (referring to 2008–2010) if the EMS was implemented first in 2007, that counted as one year of EMS experience). EMS certification was corrected the same way for all years and countries (e.g., the EMAS/ISO dummies only assume unity in the 2001 survey if certification took place before 1998 to avoid endogeneity issues, and the same is the case for 2006, 2011, and 2016 in Germany).

Several control variables are included in the analyses, such as firm size, which is measured as the logarithm of the number of employees, because the untransformed employee data is rightward-skewed. This control was included because the implementation of activities beyond the scope the EMS depends on resource availability and large firms have more scope to spread fixed costs such as those of the EMS (George, 2005). In addition, because a quality management system (QMS) in accordance with ISO 9001 complements environmental standards (Christmann, 2000), the presence of a QMS was included as a binary dummy variable (with "yes" coded as 1, and "no" as 0). Furthermore, firm type was included in the analysis because structures, processes, and strategies of parent firms can require the implementation of activities beyond those required by environmental management standards (Wagner, 2010). Accordingly, we created a dummy variable and coded the firm as 1 if it was fully independent, and 0 if it was a subsidiary, or in some other way not completely independent. In addition to these control variables, a binary dummy for a firm's main industry was included, based on the following sectors: consumer goods, chemical products, materials, machinery and equipment, electric and electronic devices. This accounts for institutional effects related to industry membership. Finally, growth in the main market was measured to account for possible effects of munificence and slack resources (Dess & Beard, 1984). The measurement used a 5-point scale anchored with "considerably decreasing" (coded as 5) and "considerably increasing" (coded as 1).

To test the hypotheses, the data were analysed using OLS regression with robust (and, as appropriate, firm-clustered) standard errors as well as Welch and F-tests to compare coefficients. In a variant estimation we also used a more detailed industry classification based on two-digit NAICS categories, but the coefficients always had the same sign and significance as with the broad industry classification, except for a small deviation in Germany where H1c and H2b were additionally confirmed for ISO 14001 in 2001 and in the case of H3c in 2016. Accordingly, it was considered adequate to report only conservative results based on the broad industry classification in order to ensure parsimony. Tables A1 and A2 in the appendix provide descriptive statistics and correlations for the full sample.

Results

In the following, results are presented from aggregated (and thus economically more relevant) to disaggregated (and thus managerially more important) levels. To start, Table 2 summarises results for the joint EU data (except for those on Germany, for which four periods are available that are therefore analysed separately). The results clearly indicate support for Hypotheses H1a, H1b, and partly for H1c in the joint EU sample. H2a is not supported, as the coefficient difference is not significant, whereas H2b, based on the Welch test ($t=-20.9$; $p<0.0005$), is only confirmed for ISO certification. Finally, H3a is supported in the joint EU sample, whereas H3b and H3c are not.

** insert Table 2 about here **

To better gauge variation and institutional effects (especially as concerns any unsupported hypotheses in the pooled EU sample), models were also estimated for each country separately. For these estimations (see Tables 3 to 5), H1a is partly confirmed (for 7 out of 15 possible cases), whereas H1b is not supported (because no significant association was found) and H1c partially confirmed (in 4 out of 15 possible cases). H2a is confirmed for Sweden and Switzerland, which suggests that in some countries the spillover effects across ISO norms may be better enabled by national regulation. Likely, for similar reasons, significantly positive learning effects are found for Belgium, Hungary and Switzerland (for pollution prevention) as well as for France and Switzerland (for product stewardship).

** insert Table 3-5 about here **

We could not use the Welch test to evaluate H2b with regard to Sweden, the Netherlands, France, and Belgium owing to overall insignificant models for at least one dependent variable. For other countries it is not applicable because all individual coefficients are not significant.[i] Furthermore, the Welch test could only be calculated meaningfully for countries where the association was consistent with the hypothesised direction (i.e., where the association for PP was more positive (or less negative) than for PS), and when at least one of the two coefficients was significant. This scenario only arose for Hungary, where H2b is supported in that certification to the ISO 14001 standard has a significantly less negative association with PP than with PS ($t=-12.50$; $p<0.0005$). Finally, H3a is confirmed for the Netherlands, United Kingdom, Hungary, and Belgium (see Table 3). H3b is confirmed for Sweden, Hungary, and Belgium (see Table 4), and H3c for Sweden and Hungary (see Table 5).

As summarised in Table 6, the overall picture for the EU in general is basically reproduced at the country level. Specifically and as a robust implication for managers, the majority of significant associations relate to organisational activities beyond the scope of the EMS (13 significant associations, of which two are negative). For PS activities, seven significant associations were found, of which one was negative. This is consistent with the situation found for the detailed analysis by year in Germany that follows below. Finally, as reported for Germany below, PP activities record the lowest number of significant associations in the other EU states (i.e., four, of which one is negative).

** insert Table 6 about here **

Estimations with the pooled sample across all periods in Germany are summarised in Table 7. H1a is confirmed for ISO 14001 and EMAS, whereas H1b and H1c are not supported in the German data. Furthermore, H2a is not supported in the pooled estimations for Germany, since regarding the organisational activities not required by an EMS standard the coefficient for ISO 14001 is significantly smaller than for EMAS ($F=5.20$; $p<0.01$). Concerning H2b, because none of the relevant coefficients was significant in the regression estimations, the Welch test could not be implemented meaningfully. Although H2b could not be confirmed, the hypothesised effect would appear plausible for EMAS certification since the estimated coefficient for PP here was larger than for PS. Finally, H3a is supported, while H3b and H3c could not be confirmed in the pooled estimations for Germany. The German results correspond largely to the findings in the pooled EU sample in Table 2 and thus corroborate the continued economic and managerial importance of the latter.

** insert Table 7 about here **

Tables 8 to 10 summarise the results for Germany when estimating the models separately for the four time periods of 2001, 2006, 2011, and 2016. For organisational activities not forming part of an EMS they corroborate the results for EMAS from the initial estimations with the pooled sample in all periods except 2011. Also, for ISO 14001, the results for the pooled estimations are confirmed for most of the time periods.

** insert Tables 8–10 about here **

For individual years in Germany, H1a is confirmed in five of eight possible cases, whereas H1b and H1c are not supported because no significant association is found. Furthermore, H2a is not confirmed because there are no significant differences or the coefficient for EMAS is larger than for ISO 14001. There is also no support for H2b where there is no significant association for any year, which means the Welch test cannot be meaningfully calculated. Finally, H3a is confirmed for 2016 and H3b for 2001, whereas H3c is not supported since no significant association was found for any year.

Table 11 sums up the effects by year for Germany across all dependent variables. The full set of estimations for all individual countries and time periods reveal that industry- and firm-specific factors are not uniquely driving the heterogeneous indirect EMS effects either, since no other dominating factor could be identified, even though such factors may well have a situational influence on indirect effects.

** insert Table 11 about here **

Discussion and conclusions

EMS can potentially complement government regulation of firms as part of a new perception of global governance in the environmental and sustainability contexts that particularly developed in new public management thinking. This raises the question of whether empirical evidence supports the contention that EMS implementation and certification contribute to sustainability.

This study contributes to answering this question by extending prior work focused on EMAS (e.g., Montobbio & Solito, 2018; Testa et al. 2018a; 2018b), and also including ISO-certified firms alongside firms without certification in a comparative multi-country and partly longitudinal analysis of indirect effects and spillovers, with all of former aspects having been identified as important research gaps (Boiral et al., 2018).

Given the cross-sectional effects in Europe as well as longitudinal trends in Germany found in this study, as an important insight for managers and policy makers, the initially positive evaluation of ISO 14001 and EMAS certifications as voluntary instruments may have been too optimistic.

Specifically, the findings for Germany reveal mainly EMAS effects, which decrease over time. In contrast, across the other EU countries, ISO effects are stronger and only one significant negative effect was found across all tests, indicating that EMS certification generally has no clearly disadvantageous effect on environmental management activities beyond those required by EMS standards. However, it also has a positive effect in only about 50% of cases which should caution the overall economic significance of such standards, since it indicates that several country-, industry- and firm-specific factors equally matter for EMS to achieve an ultimately positive impact.

In addition, there are consistently far more limited EMS certification effects on PP and on PS for both Germany and other European countries which may well be indicative for a limited reach of EMS standards. Finally, in Germany there are comparatively more limited experience effects, namely for PS in 2001 and NEMS in 2016; however, whilst somewhat more learning from experience can be identified across the other EU countries.

All these findings provide at least partial support for the suggestion of Boiral (2012) that ISO 14001's effectiveness is overstated since it frequently decouples formal structures from actual organisational processes, and this also highlights the continued relevance of critical and more diverse approaches to the study of EMS effects (Boiral et al., 2018). As well, the effectiveness issues found in this study help explaining the limited usage of EMAS for communication that has been observed in related contexts (Heras-Saizarbitoria, Boiral, Allur & García, 2019).

Furthermore, institutional arguments based on the varieties of capitalism and national business systems concepts would suggest differing complementarity with regard to EMS implementation and certification (Whitley, 1999). Although the sample countries do not easily lend themselves to being categorised as liberal or constitutional market economies, a classification based on the national business systems approach is possible. More specifically, based on a detailed and carefully validated country taxonomy by Hotho (2014), a distinction can be drawn between four groups that together encompass all the countries studied here. The first group is made up of Norway and Sweden and can be described as a Nordic business system combining centralised wage negotiations and high unionisation with low levels of market regulation and state dominance. The second group is characterised by a compartmentalised business system and includes the UK and Switzerland. The third group corresponds to a state-organised business system and consists of the sample countries France and Hungary. The fourth group corresponds to a collaborative business system and includes Belgium, Germany, and the Netherlands.[ii] The distinct characteristics of national business systems would suggest differences across the groups that imply greater effectiveness of specific EMS standards for certain groups, which equates to stronger and more consistent associations with the dependent variables, and persistent and significant differences of the effects from ISO 14001 versus the EMAS standard between the groups.

However, Tables 6 and 11 reveal that no such pattern can be identified. This suggests that institutional complementarity does not play a major role in supporting the indirect benefits of voluntary EMS standards. One possible explanation for this phenomenon is that the rapid globalisation of economic activity has quickly led to international convergence in the field of EMS standards and that their voluntary governance approach was therefore less influenced by business system differences.

Given that this interpretation is derived based on a comprehensive model that beyond the hypothesised EMS variables also incorporates important firm-level causes (such as firm size or legal form) and sectoral determinants affecting indirect effects and spillovers it further highlights the relevance of incorporating firm- and industry-specific conditions in any analysis of how EMS standards impact.

Finally, with regard to the emergence of standards markets (Reinecke et al., 2012), the analysis sheds some light on tensions between government, firms, and non-governmental organisations, such as standardisation bodies, especially in terms of the rivalry between ISO 14001 and EMAS. In this respect, the (inter-)governmental initiative for EMAS by the European Commission (simultaneously introducing a competing voluntary standard to that of the standardisation body ISO) was initially driven by the concerns of several EU member states that ISO would not adequately take account of public interests aimed at maximising social welfare, but mainly those of profit-oriented private firms. The data in Table 12 suggest that EMAS was ultimately less successful in the standards market than ISO 14001. Based on secondary data, the same table shows the ratio of organisations certified according to ISO 14001 to those registered under EMAS for the years 2000, 2005, 2010 and 2015; the last year for which activities were measured in each survey wave (for example, a value of nine means that for each firm certified to EMAS, nine firms had ISO 14001 certification).[iii]

It is evident that over time the ratio in all countries increasingly tilts in favour of ISO 14001, indicating the ISO standard is quantitatively more successfully diffused than EMAS, which is likely due in part to the limited applicability of EMAS to the EU. Qualitatively however, in terms of indirect effects across all countries and time periods, EMAS performs slightly better than ISO 14001 for NEMS, but not for PS and PP (where, as detailed above, the effects of both standards are very limited).

** insert Table 12 about here **

Given that sustainability for the purposes of our analysis can be conceptualised as a bundle of public goods, while public management can be defined as activities by public administrators contributing to this bundle, for example in the realm of environmental protection, our findings also offer insights on the success determinants of new public environmental management. While evidence for actual performance improvements is challenging to measure in a comparative manner across countries, and thus scarce (Tyteca, Carlens, Berkhout, Hertin, Wehrmeyer & Wagner, 2002), a necessary precondition for such improvements is that the implementation and certification of EMS as voluntary instruments triggers corporate activities (such as the ones listed in Table 1) that improve performance. The evidence found in this study for activities not required by EMS standards (especially the globally predominant ISO 14001 and EMAS schemes) suggests that this is often not the case and is also not easily linkable to institutional differences between countries, nor to other firm- or industry-level factors (Knudsen, Moon & Slager, 2015). This can explain why over the last two decades our empirical data finds less progress towards sustainability than was predicted in the literature on new public environmental management (Schaltegger, Kubat, Hilber & Vaterlaus, 1996) and voluntary instruments, such as EMS standards (Koehler, 2007), which also cautions about the economic significance of such approaches.

More generally, the findings may indicate that private and public initiatives in the field of environmental management failed to adequately promote the implementation of voluntary standards, given the limited dynamic efficiency and spillover effects of those standards. This suggests that voluntary standards such as ISO 14001 are too weak to make sufficient contributions to (environmental) sustainability. The results also reveal that the issue is aggravated by a lack of spillovers from EMS particularly to more advanced practices, such as PP and PS that relate more to technological innovation.

To rectify this situation, more stringent performance targets seem necessary to foster sustainability, which also suggests a need to move back to more mandatory regulation that should however include better provision for flexible implementation choices than it did in the past. However, as the comparison with EMAS shows, the actual design of such voluntary instruments, for example in terms of their spatial scope and the management of their temporal evolution, is also crucial for their effectiveness, an insight that future initiatives need to take into account more than was done in the past.

In conclusion, this study contributes to an improved and more nuanced understanding of global governance aspects in new public environmental management, specifically as concerns voluntary (EMS) standards. At the same time, the analysis has some limitations that suggest some important areas for future research.

First, given that the indirect performance effect of voluntary EMS standards is found to be relatively weak, it is important to ascertain their direct benefits. Accordingly, more systematic evaluation research on those direct benefits is needed. Such research might for example take the form of dedicated panel studies repeatedly surveying the same firms over time to generate more comprehensive evidence on direct effects. Similarly, a more widespread use of release inventories -as has long been practised in the U.S.A. with its Toxic Release Inventory- could help to reliably ascertain tangible and lasting improvements in actual environmental performance (Gerde & Logsdon, 2001). Such inventories would also facilitate linking actual emissions and reduction to EMS implementation and certification, as well as public sustainability targets.

Second, this study is consistent with theoretical arguments (Wijen, 2014) in identifying a trade-off between the success of flexible standards in terms of diffusion and the success of more stringent (but potentially less flexible) standards in terms of performance effects (given that for the more flexible standard, ISO 14001, indirect performance effects are more limited). In line with the suggestions by Heras-Saizarbitoria and Boiral (2013), future research should therefore investigate how such a trade-off might be surmounted, and as part of that effort, could move beyond the EMS context or integrate it further with other approaches. For example, regional embeddedness could be a contextual factor affecting the above trade-off, and future research might therefore expand on this study by investigating its role in affecting the use and implementation of voluntary instruments.

Third, while an integrated comparative analysis of EMS certification and implementation effects across different countries such as that reported here is only possible in Europe, it must be acknowledged as a limitation, that this represents only a minority of global ISO certifications (Boiral et al., 2018), albeit the limitation was unavoidable in a study seeking to present a direct comparison of EMAS and ISO. Therefore, future research might focus more comprehensively on emerging economies to compensate for this imbalance.

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Appendix

Table A1. Descriptive statistics.

Variable name	Variable mean	Standard deviation
NEMS	0.33	0.29
PP	0.67	0.26
PS	0.62	0.30
Firm fully independent	0.40	0.49
QMS	0.73	0.44
Munificence	3.35	0.96
Paper, wood & printing	0.13	0.33
Chemicals	0.15	0.36
Glass, ceramics & metal processing	0.23	0.42
Machinery & transport equipment	0.09	0.29
Electric & electronic equipment	0.06	0.24
Other manufacturing	0.17	0.38
ISO 14001 certification	0.23	0.42
EMAS certification	0.05	0.22
Time since EMS implementation started	1.16	2.13
Firm size	5.34	1.36

Table A2. Correlations.

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. NEMS	1.00														
2. PS	0.28***	1.00													
3. PP	0.28***	0.62***	1.00												
4. Firm fully independent	-0.14***	0.04†	0.04†	1.00											
5. QMS	0.16***	-0.06*	-0.03	-0.21***	1.00										
6. Munificence	0.06*	0.03	0.04*	-0.05*	0.08***	1.00									
7. Paper, wood & printing	0.08***	0.02	0.03	0.05*	-0.16***	-0.08***	1.00								
8. Chemicals	0.08***	-0.03	-0.01	-0.07***	0.08***	0.03	-0.16***	1.00							
9. Glass, ceramics & metal processing	-0.04†	-0.04*	-0.02	-0.02	0.13***	0.01	-0.21***	-0.23***	1.00						
10. Machinery & transport equipment	-0.07**	-0.04	-0.05*	-0.03	0.05*	0.01	-0.12***	-0.13***	-0.17***	1.00					
11. Electric & electronic equipment	0.01	-0.004	0.02	-0.03	0.10***	0.08***	-0.10***	-0.11***	-0.14***	-0.08***	1.00				
12. Other manufacturing	0.01	0.08***	0.04†	-0.004	-0.02	0.01	-0.17***	-0.19***	-0.25***	-0.14***	-0.12***	1.00			
13. ISO certification	0.44***	0.05*	0.09***	-0.18***	0.27***	0.07**	0.02	0.08***	-0.01	-0.02	0.07**	0.01	1.00		
14. EMAS certification	0.26***	0.09***	0.05*	0.02	0.06**	-0.01	0.04†	0.03	-0.05*	-0.02	0.01	0.02	0.24***	1.00	
15. Time since EMS implementation	0.41***	0.08***	0.10***	-0.14***	0.21***	0.02	-0.01	0.09***	-0.04*	-0.004	0.04†	0.01	0.53***	0.37***	1.00
16. Firm size	0.23***	0.05*	0.10***	-0.11***	0.19***	0.07**	-0.08***	0.02	-0.07**	0.04†	0.09***	0.08***	0.24***	0.19***	0.32***

significance levels are † $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 1. Items for dependent variables.

Organisational actions beyond the scope of EMS (NEMS): taking environmental performance into account when selecting suppliers; placing demands on suppliers to undertake environmental actions; environmental/health/safety data in the annual report; use of environmental performance indicators; benchmarking; eco-labelling; informing consumers on environmental effects of products and production processes; market research on the potential of "green" products; implementation of life-cycle analysis
Technical actions related to pollution prevention (PP): reduced water use in production; material recycling within the firm; use of waste streams of other firms; measures to reduce emissions to air; measures to reduce emissions to surface water; measures to reduce solid waste; implementation of cleaner technology
Technical actions related to product stewardship (PS): 'green' design of a new product; using less material per unit of product; substitution of non-renewable materials; substitution of hazardous inputs; product recycling; packaging recycling; using less packaging per unit of production

Table 2. Pooled estimations for Europe in 2001.

Variables	Coeff., NEMS	Coeff., PS	Coeff., PP
Firm fully independent	-0.07 (0.01)***	-0.01 (0.02)	-0.00 (0.02)
QMS	0.05 (0.02)**	-0.03 (0.02)	-0.02 (0.02)
Munificence	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Paper, wood & printing	0.09 (0.03)***	0.02 (0.03)	0.05 (0.02)†
Chemicals	0.05 (0.02)*	-0.01 (0.03)	0.01 (0.02)
Glass, ceramics & metal processing	-0.00 (0.02)	-0.00 (0.02)	0.02 (0.02)
Machinery & transport equipment	-0.07 (0.03)**	-0.02 (0.03)	-0.03 (0.03)
Electric & electronic equipment	-0.01 (0.03)	-0.04 (0.04)	0.01 (0.03)
Other manufacturing	0.03 (0.02)	0.02 (0.03)	0.02 (0.02)
ISO 14001 certification	0.17 (0.03)***	0.01 (0.03)**	0.06 (0.03)**
EMAS certification	0.10 (0.05)**	0.12 (0.05)*	0.01 (0.05)
Time since EMS implementation started	0.02 (0.01)**	0.002 (0.01)	0.005 (0.01)
Firm size	0.04 (0.01)***	0.000003 (0.01)	0.01 (0.01)*
Sweden (2)	0.14 (0.02)***	-0.10 (0.02)***	-0.05 (0.02)**
Switzerland (3)	0.04 (0.03)	-0.00 (0.03)	0.03 (0.03)
Great Britain (4)	0.01 (0.02)	0.03 (0.03)	0.02 (0.03)
Hungary (5)	0.04 (0.03)	0.01 (0.03)	0.06 (0.03)**
France (6)	-0.01 (0.03)	-0.03 (0.04)	-0.05 (0.04)
Belgium (7)	0.09 (0.02)***	0.03 (0.02)	0.03 (0.02)†
Norway (8)	0.18 (0.03)***	0.00 (0.03)	-0.00 (0.03)
Constant	-0.02 (0.04)	0.60 (0.05)***	0.56 (0.04)***
Number of observations	1474	1485	1492
R^2	0.22	0.04	0.03
F	27.09***	3.45***	2.57***

significance levels are † $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; robust standard errors in parentheses; industry relative to consumer goods and country relative to Netherlands (1) as base category

Table 3. Estimations by country (Ctry.; identifier no. as in Table 2) for NEMS, 2001.

Variables	Coeff. (Ctry.=1)	Coeff. (2)	Coeff. (3)	Coeff. (4)	Coeff. (5)	Coeff. (6)	Coeff. (7)	Coeff. (8)
Firm fully independent	-0.06 (0.03)*	-0.04 (0.04)	-0.10 (0.05) †	-0.04 (0.05)	-0.09 (0.06)	-0.10 (0.07)	-0.05 (0.04)	-0.10 (0.05)*
QMS	0.06 (0.03)	0.05 (0.04)	-0.05 (0.08)	0.07 (0.05)	0.04 (0.05)	0.07 (0.07)	0.11 (0.04)**	-0.001 (0.06)
Munificence	0.03 (0.01)†	0.01 (0.02)	0.05 (0.03)	0.01 (0.03)	0.002 (0.03)	0.02 (0.03)	0.01 (0.02)	-0.01 (0.03)
Paper, wood & printing	0.10 (0.05)*	-0.01 (0.05)	0.17 (0.13)	0.11 (0.08)	0.18 (0.10)†	0.26 (0.30)	0.14 (0.07)†	0.15 (0.07)*
Chemicals	0.09 (0.05)†	-0.07 (0.05)	-0.06 (0.10)	0.05 (0.07)	0.13 (0.07)†	0.12 (0.12)	0.05 (0.05)	-0.01 (0.08)
Glass, ceramics & metal processing	-0.01 (0.04)	-0.03 (0.05)	-0.12 (0.10)	0.13 (0.08)†	0.10 (0.07)	-0.10 (0.10)	-0.04 (0.05)	0.03 (0.07)
Machinery & transport equipment	-0.04 (0.04)	-0.19 (0.06)**	-0.24 (0.10)*	-0.03 (0.08)	0.04 (0.07)	-0.11 (0.11)	-0.12 (0.08)	0.20 (0.12)†
Electric & electronic equipment	0.01 (0.07)	-0.07 (0.08)	-0.17 (0.10)†	0.08 (0.11)	-0.01 (0.08)	-0.12 (0.13)	0.14 (0.11)	0.17 (0.12)
Other manufacturing	0.003 (0.01)	0.004 (0.01)	-0.02 (0.01)	0.01 (0.01)	0.03 (0.02)†	0.01 (0.02)	-0.01 (0.01)	0.01 (0.01)
ISO 14001 certification	0.19 (0.05)***	0.18 (0.05)***	0.40 (0.08)***	0.14 (0.11)	-0.38 (0.12)**	0.18 (0.13)	-0.08 (0.11)	0.21 (0.06)***
EMAS certification	multicollinear	0.11 (0.06)†	0.05 (0.09)	0.20 (0.16)	0.51 (0.14)***	0.34 (0.14)**	0.03 (0.15)	0.07 (0.06)
Time since EMS implementation started	0.02 (0.01)*	-0.01 (0.01)	-0.004 (0.02)	0.04 (0.02)*	0.38 (0.05)***	0.02 (0.02)	0.06 (0.02)***	-0.02 (0.01)†
Firm size	0.04 (0.01)**	0.06 (0.02)***	-0.02 (0.03)	0.05 (0.02)*	0.03 (0.03)	0.01 (0.02)	0.02 (0.01)	0.07 (0.02)**
Constant	-0.12 (0.09)	0.06 (0.11)	0.36 (0.18)†	-0.13 (0.11)	0.02 (0.22)	0.08 (0.13)	0.11 (0.10)	0.07 (0.14)
Number of observations	333	267	105	153	163	75	247	131
R^2	0.24	0.24	0.33	0.25	0.18	0.31	0.17	0.20
F	9.79***	9.83***	45.50***	61.16***	96.82***	3.66***	7.62***	4.64***

significance levels are † $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; robust standard errors in parentheses; industry relative to consumer goods as base category

Table 4. Estimations by country (Ctry.. identifier no. as in Table 2) for PP, 2001.

Variables	Coeff. (Ctry.=1)	Coeff. (2)	Coeff. (3)	Coeff. (4)	Coeff. (5)	Coeff. (6)	Coeff. (7)	Coeff. (8)
Firm fully independent	0.03 (0.03)	0.0005 (0.04)	-0.06 (0.06)	0.05 (0.05)	0.02 (0.06)	0.02 (0.08)	-0.03 (0.04)	-0.11 (0.05)*
QMS	-0.01 (0.04)	-0.03 (0.05)	-0.15 (0.07)*	0.08 (0.06)	-0.03 (0.06)	0.18 (0.11)	-0.06 (0.04)	-0.10 (0.07)
Munificence	0.004 (0.01)	0.003 (0.02)	0.06 (0.04)†	0.03 (0.03)	0.01 (0.02)	-0.06 (0.04)	0.02 (0.02)	-0.004 (0.02)
Paper, wood & printing	0.03 (0.05)	0.07 (0.06)	-0.15 (0.11)	0.10 (0.11)	0.07 (0.09)	0.11 (0.11)	0.10 (0.06)†	0.10 (0.08)
Chemicals	0.002 (0.05)	0.03 (0.06)	-0.22 (0.08)**	0.05 (0.12)	0.04 (0.07)	0.03 (0.15)	0.06 (0.05)	-0.01 (0.08)
Glass, ceramics & metal processing	0.03 (0.04)	0.05 (0.05)	-0.15 (0.09)	0.10 (0.11)	-0.01 (0.07)	-0.07 (0.14)	0.02 (0.05)	0.05 (0.07)
Machinery & transport equipment	-0.03 (0.05)	-0.03 (0.06)	-0.21 (0.10)*	-0.07 (0.13)	-0.06 (0.10)	0.03 (0.15)	0.02 (0.08)	0.21 (0.15)
Electric & electronic equipment	-0.04 (0.09)	0.15 (0.07)*	-0.07 (0.09)	0.07 (0.11)	-0.23 (0.13)†	-0.23 (0.17)	0.06 (0.10)	0.09 (0.11)
Other manufacturing	-0.0005 (0.007)	0.005 (0.01)	-0.02 (0.02)	0.02 (0.01)	-0.01 (0.02)	-0.003 (0.02)	0.004 (0.01)	-0.01 (0.02)
ISO 14001 certification	0.07 (0.05)	0.03 (0.07)	0.06 (0.08)	-0.02 (0.09)	-0.05 (0.14)	-0.13 (0.14)	0.05 (0.10)	0.19 (0.14)
EMAS certification	multicollinear	0.03 (0.07)	-0.03 (0.07)	-0.02 (0.12)	-0.07 (0.12)	0.04 (0.17)	-0.49 (0.18)**	0.03 (0.14)
Time since EMS implementation started	-0.004 (0.01)	0.01 (0.03)	0.03 (0.01)*	0.01 (0.01)	0.13 (0.06)*	0.003 (0.02)	0.05 (0.01)***	-0.02 (0.01)
Firm size	0.02 (0.01)	0.03 (0.01)*	-0.04 (0.02)†	0.02 (0.02)	0.02 (0.03)	0.04 (0.03)	-0.001 (0.01)	0.01 (0.02)
Constant	0.55 (0.10)***	0.40 (0.11)**	0.94 (0.14)***	0.33 (0.14)*	0.56 (0.17)**	0.46 (0.20)*	0.63 (0.09)***	0.70 (0.15)***
Number of observations	333	267	105	155	170	74	257	131
R^2	0.02	0.06	0.18	0.09	0.06	0.17	0.07	0.12
F	0.85	1.46	2.57**	5.29***	4.05***	1.12	2.05*	2.04*

significance levels are † $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; robust standard errors in parentheses; industry relative to consumer goods as base category

Table 5. Estimations by country (Ctry., identifier no. as in Table 2) for PS, 2001.

Variables	Coeff. (Ctry.=1)	Coeff. (2)	Coeff. (3)	Coeff. (4)	Coeff. (5)	Coeff. (6)	Coeff. (7)	Coeff. (8)
Firm fully independent	0.05 (0.04)	-0.06 (0.04)	-0.08 (0.06)	0.11 (0.05)*	-0.12 (0.06)†	0.13 (0.09)	-0.01 (0.04)	-0.10 (0.06)†
QMS	-0.04 (0.04)	-0.01 (0.05)	-0.13 (0.08)†	0.10 (0.06)†	-0.07 (0.07)	0.10 (0.11)	-0.02 (0.05)	-0.05 (0.07)
Munificence	0.02 (0.02)	0.0005 (0.02)	0.04 (0.04)	0.03 (0.03)	-0.001 (0.03)	-0.08 (0.05)	0.02 (0.02)	-0.04 (0.03)
Paper, wood & printing	0.07 (0.06)	-0.10 (0.06)	-0.10 (0.11)	-0.005 (0.09)	0.05 (0.10)	0.14 (0.25)	0.09 (0.07)	0.08 (0.09)
Chemicals	0.06 (0.06)	-0.17 (0.06)**	-0.06 (0.10)	-0.07 (0.10)	-0.02 (0.09)	0.02 (0.16)	0.02 (0.06)	-0.10 (0.11)
Glass, ceramics & metal processing	0.06 (0.05)	-0.12 (0.06)*	-0.10 (0.10)	-0.02 (0.10)	-0.04 (0.08)	0.0000003 (0.15)	0.02 (0.05)	0.05 (0.07)
Machinery & transport equipment	0.03 (0.07)	-0.16 (0.06)**	-0.11 (0.12)	-0.02 (0.13)	-0.16 (0.11)	0.15 (0.14)	0.01 (0.09)	0.27 (0.11)*
Electric & electronic equipment	-0.08 (0.10)	-0.05 (0.09)	-0.05 (0.11)	-0.13 (0.13)	-0.15 (0.13)	-0.13 (0.16)	0.11 (0.11)	0.04 (0.14)
Other manufacturing	-0.0002 (0.01)	-0.01 (0.01)	-0.002 (0.02)	0.02 (0.01)	-0.03 (0.01)†	-0.01 (0.02)	0.01 (0.01)	-0.01 (0.02)
ISO 14001 certification	-0.05 (0.05)	0.21 (0.06)***	0.08 (0.10)	0.13 (0.07) †	0.22 (0.14)	0.10 (0.16)	-0.01 (0.12)	0.11 (0.08)
EMAS certification	multicollinear	0.02 (0.08)	0.22 (0.10)*	0.12 (0.15)	-0.25 (0.14)†	0.28 (0.15)†	-0.07 (0.12)	0.09 (0.10)
Time since EMS implementation started	0.003 (0.01)	-0.01 (0.01)	0.03 (0.02)†	-0.02 (0.02)	0.12 (0.05)*	-0.03 (0.02)	0.02 (0.03)	-0.01 (0.02)
Firm size	0.002 (0.01)	0.02 (0.01)	-0.03 (0.03)	0.02 (0.02)	-0.01 (0.03)	0.01 (0.03)	-0.03 (0.01)*	0.04 (0.03)
Constant	0.51 (0.12)***	0.50 (0.12)***	0.78 (0.17)***	0.27 (0.14) †	0.81 (0.21)***	0.70 (0.22)**	0.70 (0.11)***	0.59 (0.16)***
Number of observations	333	267	106	155	160	76	257	131
R^2	0.03	0.12	0.12	0.17	0.10	0.16	0.05	0.10
F	1.05	2.80***	16.82***	8.89***	5.55***	1.89*	1.19	2.75**

significance levels are † $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; robust standard errors in parentheses; industry relative to consumer goods as base category.

Table 6. Summary of hypothesis testing for EU (without Germany).

Country	EMAS, NEMS	ISO, NEMS	Time, NEMS	EMAS-ISO difference, NEMS	EMAS, PP	ISO, PP	Time, PP	EMAS-ISO difference, PP	EMAS, PS	ISO, PS	Time, PS	EMAS-ISO difference, PS
Norway	+	+***	-†	n/s	+	+	-	n/s	+	+	-	n/s
Sweden	+†	+***	-	** (ISO>EMAS)	+	+	+	n/s	+	+***	-	n/s
Switzer-land	+	+***	-	** (ISO>EMAS)	-	+	+*	n/s	+**	+	+†	n/s
United Kingdom	+	+	+*	n/s	-	-	+	n/s	+	+†	-	n/s
Hungary	+***	-**	+***	** (EMAS>ISO)	-	-	+*	n/s	-†	+	+*	** (ISO>EMAS)
France	+**	+	+	n/s	+	-	+	n/s	+†	+	-	n/s
Belgium	+	-	+***	n/s	-**	+	+***	** (ISO>EMAS)	-	-	+	n/s
Nether lands	n/a	+***	+*	n/a	n/a	+	-	n/a	n/a	-	+	n/a

n/a: not available (due to multicollinearity); n/s: not significant; significance levels are † $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 7. Pooled estimations for Germany, 2001-2016.

Variables	Coeff., NEMS	Coeff., PP	Coeff., PS
Firm fully independent	-0.03 (0.02)†	0.01 (0.02)	0.02 (0.02)
QMS	0.02 (0.02)	0.04 (0.02)	0.06 (0.02)*
Munificence	0.01 (0.01)†	0.02 (0.01)**	0.03 (0.01)***
Paper, wood & printing	0.03 (0.04)	0.05 (0.03)	0.06 (0.04)
Chemicals	-0.03 (0.03)	0.07 (0.03)*	0.03 (0.03)
Glass, ceramics & metal processing	-0.07 (0.03)*	0.03 (0.03)	-0.05 (0.03)
Machinery & transport equipment	-0.06 (0.03)†	0.01 (0.03)	0.06 (0.04) †
Electric & electronic equipment	-0.06 (0.03)	-0.02 (0.03)	0.09 (0.03)*
Other manufacturing	-0.04 (0.03)	-0.004 (0.03)	-0.07 (0.03)*
ISO 14001 certification	0.05 (0.03)*	-0.001 (0.02)	0.02 (0.03)
EMAS certification	0.14 (0.02)***	0.02 (0.02)	0.01 (0.02)
Time since EMS implementation started	0.01 (0.002)**	0.003 (0.002)*	0.002 (0.002)
Firm size	0.03 (0.004)***	0.04 (0.004)***	0.03 (0.005)***
2006	0.06 (0.02)**	0.11 (0.03)***	0.10 (0.02)***
2011	0.16 (0.03)***	-0.05 (0.02)*	-0.12 (0.03)***
2016	0.08 (0.03)**	0.05 (0.02)*	0.08 (0.03)**
Constant	0.09 (0.04)*	0.07 (0.04)	0.08 (0.04)†
Number of observations	801	832	830
R^2	0.36	0.24	0.26
F	29.48***	16.00***	23.19***

significance levels are † $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; firm-clustered robust standard errors in parentheses; industry relative to consumer goods as base category.

Table 8. Estimations for NEMS by year, Germany.

Variables	Coeff. (2001)	Coeff. (2006)	Coeff. (2011)	Coeff. (2016)
Firm fully independent	-0.07 (0.03)*	-0.03 (0.05)	0.03 (0.05)	-0.004 (0.03)
QMS	0.02 (0.03)	0.05 (0.06)	-0.001 (0.06)	-0.05 (0.04)
Munificence	0.03 (0.01)*	-0.02 (0.02)	0.03 (0.02)	0.02 (0.01)
Paper, wood & printing	-0.03 (0.06)	-0.03 (0.13)	0.03 (0.08)	0.09 (0.06)
Chemicals	-0.01 (0.05)	-0.04 (0.10)	-0.18 (0.08)*	0.002 (0.06)
Glass, ceramics & metal processing	-0.07 (0.05)	-0.09 (0.10)	-0.10 (0.09)	-0.07 (0.06)
Machinery & transport equipment	-0.07 (0.05)	0.04 (0.09)	-0.11 (0.07)	-0.03 (0.07)
Electric & electronic equipment	-0.11 (0.06)†	0.03 (0.08)	-0.12 (0.09)	-0.02 (0.06)
Other manufacturing	-0.06 (0.05)	-0.02 (0.08)	0.03 (0.07)	-0.09 (0.06)
ISO 14001 certification	0.10 (0.05)*	0.15 (0.06)*	0.01 (0.06)	0.03 (0.04)
EMAS certification	0.11 (0.04)**	0.21 (0.08)**	0.07 (0.05)	0.13 (0.03)***
Time since EMS implementation started	0.01 (0.01)	0.01 (0.01)	0.004 (0.01)	0.01 (0.003)**
Firm size	0.04 (0.01)***	0.02 (0.01)*	0.01 (0.01)	0.03 (0.01)***
Constant	0.03 (0.06)	-1.81 (0.12)***	0.40 (0.11)**	0.17 (0.08)*
Number of observations	298	131	156	216
R^2	0.23	0.41	0.13	0.36
F	9.77***	10.86***	1.96*	8.19***

significance levels are † $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; robust standard errors in parentheses; industry relative to consumer goods as base category.

Table 9. Estimations for PP by year, Germany.

Variables	Coeff. (2001)	Coeff. (2006)	Coeff. (2011)	Coeff. (2016)
Firm fully independent	-0.01 (0.03)	0.01 (0.04)	0.07 (0.04)*	-0.002 (0.03)
QMS	0.02 (0.03)	0.03 (0.07)	0.02 (0.05)	0.04 (0.05)
Munificence	0.03 (0.01)*	-0.01 (0.02)	0.02 (0.02)	0.03 (0.02)†
Paper, wood & printing	0.01 (0.05)	0.09 (0.09)	0.02 (0.06)	0.13 (0.06)*
Chemicals	0.09 (0.05)†	0.09 (0.07)	0.00 (0.06)	0.08 (0.05)
Glass, ceramics & metal processing	0.08 (0.05)†	0.13 (0.10)	-0.06 (0.06)	-0.02 (0.06)
Machinery & transport equipment	-0.02 (0.05)	0.06 (0.07)	0.03 (0.06)	0.07 (0.06)
Electric & electronic equipment	-0.06 (0.05)	0.03 (0.07)	-0.02 (0.06)	-0.02 (0.05)
Other manufacturing	-0.02 (0.06)	-0.01 (0.07)	-0.01 (0.06)	0.01 (0.05)
ISO 14001 certification	0.07 (0.05)	0.02 (0.05)	-0.05 (0.04)	0.05 (0.04)
EMAS certification	-0.07 (0.05)	-0.09 (0.06)	0.06 (0.04)	-0.003 (0.04)
Time since EMS implementation started	0.03 (0.01)**	0.01 (0.01)	0.003 (0.004)	0.003 (0.003)
Firm size	0.06 (0.01)***	0.04 (0.01)***	0.04 (0.01)***	0.03 (0.01)***
Constant	-0.04 (0.07)	0.29 (0.11)**	0.05 (0.09)	0.15 (0.08)†
Number of observations	295	133	188	216
R^2	0.25	0.27	0.19	0.24
F	9.11***	3.51***	3.10***	5.81***

significance levels are † $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; robust standard errors in parentheses; industry relative to consumer goods as base category.

Table 10. Estimations for PS by year, Germany.

Variables	Coeff. (2001)	Coeff. (2006)	Coeff. (2011)	Coeff. (2016)
Firm fully independent	-0.02 (0.03)	-0.01 (0.04)	0.12 (0.04)**	0.04 (0.03)
QMS	0.04 (0.04)	0.04 (0.07)	0.01 (0.05)	0.05 (0.05)
Munificence	0.04 (0.02)*	0.04 (0.02)†	0.03 (0.02)*	0.03 (0.02)†
Paper, wood & printing	0.04 (0.06)	-0.11 (0.15)	0.04 (0.07)	0.12 (0.07)†
Chemicals	0.06 (0.06)	-0.04 (0.06)	-0.03 (0.07)	0.02 (0.07)
Glass, ceramics & metal processing	-0.005 (0.05)	-0.21 (0.07)**	-0.05 (0.08)	-0.08 (0.07)
Machinery & transport equipment	0.13 (0.06)*	-0.04 (0.07)	0.08 (0.08)	-0.02 (0.07)
Electric & electronic equipment	0.10 (0.06)†	0.11 (0.06)†	0.05 (0.08)	-0.01 (0.07)
Other manufacturing	-0.06 (0.06)	-0.07 (0.07)	-0.09 (0.06)	-0.10 (0.06)†
ISO 14001 certification	0.08 (0.05)	0.03 (0.06)	0.01 (0.05)	0.04 (0.05)
EMAS certification	-0.01 (0.04)	0.02 (0.06)	-0.001 (0.04)	-0.04 (0.04)
Time since EMS implementation started	0.002 (0.01)	0.01 (0.01)	0.0005 (0.005)	0.01 (0.004)
Firm size	0.05 (0.01)***	0.03 (0.01)**	0.03 (0.01)**	0.03 (0.01)**
Constant	-0.02 (0.07)	0.24 (0.11)*	0.02 (0.10)	0.19 (0.09)*
Number of observations	294	132	188	216
R^2	0.22	0.28	0.21	0.22
F	8.28***	4.34***	3.81***	5.23***

significance levels are † $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; robust standard errors in parentheses; industry relative to consumer goods as base category.

Table 11. Summary of hypothesis testing for Germany.

Explanatory variable	NEMS 2001	NEMS 2006	NEMS 2011	NEMS 2016	PP, 2001	PP, 2006	PP, 2011	PP, 2016	PS, 2001	PS, 2006	PS, 2011	PS, 2016
EMAS	+**	+**	+	+***	-	-	+	-	-	+	+	-
ISO	+*	+*	+	+	+	+	-	+	+	+	+	+
Time	+	+	-	+**	+**	+	+	+	+**	+	+	+
EMAS-ISO difference	n/s	n/s	n/s	† (EMAS >ISO)	† (ISO> EMAS)	n/s	† (EMAS >ISO)	n/s	n/s	n/s	n/s	n/s

n/s: not significant; significance levels are † $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 12. Development of ISO-to-EMAS ratio by country over time.

Country	ISO/EMAS 2000	ISO/EMAS 2005	ISO/EMAS 2010	ISO/EMAS 2015
Belgium	8.0	20.6	16.7	16.0
Germany	1.0	2.7	4.5	6.9
France	27.0	164.5	308.9	195.9
Hungary	33.0	993.0	86.8	97.0
Netherlands	60.0	44.3	213.4	820.3
Sweden	9.0	31.2	192.6	19.6
United Kingdom	29.5	99.3	231.4	379.2
Norway	0.2	16.1	41.6	180.6
Switzerland	24	n/a	n/a	n/a

2005 to 2016 data based on official figures by Eurostat (EMAS) and ISO (ISO 14001); 2000 data estimated from the EBEB 2001 survey and validated based on Kollman and Prakash (2002); Eurostat data not available (n/a) for Switzerland whose ISO certification increased from 1561 (2005) via 2575 (2010) to 3239 (2015)

NOTES

[i] For the Netherlands, the EMAS variable was dropped in the estimations for all three dependent variables due to high multicollinearity, which is likely related to the unique Dutch approach at the time, based on the country's National Environmental Policy Plan and covenants.

[ii] Hotho (2014) based his classification on information for the year 2000, thus linking it to the data analysed here seems appropriate, with the only exception being the Netherlands, which was classified only in 2011. However, since for almost all countries that were classified in 2000 and 2011 the classification did not change, it was deemed appropriate to use the 2011 information for the Netherlands, since its basic parameters did not change between 2000 and 2011.

[iii] While an average ratio over the three-year window used in each wave to measure activities might have been more precise, lack of EMAS data for 1998 to 2004 precluded calculating this measure. However, when calculating the averages for 2008–2010 and 2013–2015 only small deviations compared to the reported values for individual years are found. Furthermore, the ratio trend towards ISO 14001 remains based on calculating ISO-to-EMAS ratios for the 2008–2010 and 2013–2015 ISO and EMAS averages.