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Two are Better Than One: The Link Between Management Systems and Business Performance

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ABSTRACT
Little is known about the complementary performance benefits associated with facilities' combined use of both quality management systems (QMSs) and environmental management systems (EMSs), and how these performance benefits might differ from those associated with facilities' use of only one of these management systems (or neither). We suggest that complementarities arise because each management system fosters the development of internal capabilities that facilitates the adoption and routine operationalization of the other, while maintaining differentiated goals that enhance strategic value. We examine these relationships using a sample of 2619 manufacturing facilities operating within six OECD countries, while controlling for self-selection issues. Our findings support the idea of complementarity, in that facilities that adopt both QMS and EMS are more associated with positive business performance than facilities that adopt either a QMS or an EMS on its own, or no management system. Copyright © 2014 John Wiley & Sons, Ltd and ERP Environment

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Introduction

Quality management systems (QMSs) and environmental management systems (EMSs) are continual improvement procedures designed to enhance a facility's overall operating efficiency. QMSs are designed to continually improve a facility's operational and product quality, whereas EMSs focus on improving a facility's environmental performance. By 2011, approximately 1 110 000 facilities (a 30% increase over the previous five years) had certified their QMSs to ISO 9001, the international QMS standard (ISO, 2011), and many more had adopted other sorts of QMSs. Similarly, by 2011 nearly 250 000 facilities (a 56% increase over the previous five years) had certified their EMSs to ISO 14001, the international EMS standard (ISO, 2011), while many more had adopted uncertified EMSs.

Increasing private sector adoption of QMSs and EMSs has encouraged numerous scholars to examine the business performance benefits that might accrue to adopting facilities. Performance benefits have been attributed to opportunities to improve internal efficiencies (King and Lenox, 2001; Sroufe, 2003), and enhance routine internal

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processes that foster innovation (Darnall and Edwards, 2006; Pil and Rothenberg, 2003; Simpson and Samson, 2010; Sroufe, 2003). However, the decision to adopt one of these management systems does not preclude adoption of the other, and many facilities elect to adopt both. We suggest that facilities that adopt both management systems do so because the socially complex internal capabilities required to adopt one management system facilitate the adoption and routine operationalization of the other. Adopting both can therefore further embed these capabilities deep within the organization, which previous management strategy scholars (e.g. Barney, 1991; Wernerfelt, 1984) note can lead to competitive advantage. Additionally, because each management system has different goals, adopting both may enhance the facility's strategic value further than can be achieved by adopting one management system alone.

Several studies suggest that business performance is positively related to quality management practices (e.g. Corredor and Goñi, 2011; Easton and Jarrell, 1998; Hendricks and Singhal, 1997; Kaynak, 2003; Powell, 1995; Sharma, 2005; Zhang and Xia, 2013), and others suggest that a similar relationship exists for facilities that adopt proactive environmental management practices (e.g. Darnall *et al.*, 2008a; González-Benito and González-Benito, 2005; Hart and Ahuja, 1996; Klassen and McLaughlin, 1996; Russo and Fouts, 1997). However, as yet we know little about facilities' adoption of both QMSs and EMSs, and how adopting both relates to business performance. This issue is particularly important since in practice many QMS adopters also adopt EMSs, and, while several studies have assessed the connection between quality management and environmental management (e.g. King and Lenox, 2001; Pil and Rothenberg, 2003; Sroufe, 2003; Welford, 1992), to the best of our knowledge none have considered the collective link between quality management, environmental management and business performance.

Hence, the objective of this study is to analyze whether facilities that adopt both QMSs and EMSs are associated with greater business performance than facilities that implement one or neither management system. To examine these issues, we draw on survey data collected by the Environmental Directorate of the Organization for Economic Co-operation and Development (OECD) for 2619 manufacturing facilities located in Canada, France, Germany, Japan, Norway, and the United States of America (USA). We control for selection bias related to facilities' decision to adopt QMS and EMS by simultaneously estimating the adoption decision using multivariate probit and Heckman regression techniques. Our results suggest that facilities that adopt both QMSs and EMSs are associated with positive business performance to a greater degree than facilities that adopt either QMS only, EMS only or neither management system. Combined, our findings suggest that complementarities arise from adopting both management systems that are not achieved by adopting only one.

Quality Management Systems and Business Performance

Quality management is defined as a governing philosophy that promotes continuous quality improvement within all activities of an organization (Kaynak, 2003). A QMS institutionalizes this philosophy through a formalized structure, procedure and process (Casadesús *et al.*, 2005). It involves an organization-wide commitment to continually improve internal process and product quality, to measure quality constantly and to undertake appropriate corrective action whenever defects occur (Corbett *et al.*, 2005; Heras-Saizarbitoria, 2010; Powell, 1995). In order to implement these corrective actions, QMS adopters must undergo extensive monitoring of organizational resources, constraints, production capabilities and processes (ISO, 2001). QMS adopters must also engage their employees across multiple operational units and develop extensive tacit knowledge regarding their internal operations, since quality concerns affect many aspects of an organization (Darnall and Edwards, 2006).

There are several reasons why the adoption of quality management practices is related to improvements in overall business performance. The first relates to improving internal efficiencies (see, e.g., Corredor and Goñi, 2011; York and Miree, 2004) arising from continuous improvements in product design and processes. Quality management practices can also reduce process variations which lead to both fewer defective products and increases in productivity (see, e.g., Adams, 1999; Corredor and Goñi, 2011; Garvin, 1994; Zhang and Xia, 2013). Each of these factors can lower production costs and improve overall business performance (Adam and Foster, 2000; Corredor and Goñi, 2011; Hendricks and Singhal, 2001; Kaynak, 2003; Powell, 1995; Sharma, 2005; Zhang and Xia, 2013).

In addition to increasing internal efficiencies, QMSs can also enhance a facility's goodwill benefits from customers and buyers. Since product quality is so closely related to customer and buyer satisfaction (see, e.g., Choi

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and Eboch, 1998), QMSs necessarily encourage facilities to engage their customers and buyers directly (Easton and Jarrell, 1998) to determine which quality features are perceived to be more important than others. By enhancing specific quality features, QMS adopters can increase customer and buyer satisfaction (Choi and Eboch, 1998; Das *et al.*, 2000; Forza and Filippini, 1998; Lakhal and Pasin, 2008; Rungtusanatham *et al.*, 1998; York and Miree, 2004). This sort of engagement can enhance the goodwill benefits among customers and buyers, who subsequently bestow preferential treatment towards businesses that utilize quality management practices (Corbett, 2006). As such, facilities that adopt QMSs can benefit from customers' increased loyalty (Corredor and Goñi, 2011; Nilsson *et al.*, 2001), preferential contracts and extended purchasing contracts (Deming, 1986; Ruzevicius *et al.*, 2004). These benefits may also lead to improved image, enhanced reputational standing among industry peers (Ruzevicius *et al.*, 2004), in addition to increased customer referrals. Each of these factors may increase the facility's market share and revenues (Corredor and Goñi, 2011; York and Miree, 2004). Consequently, in addition to the efficiency benefits gained from QMS adoption, goodwill benefits may improve a facility's business performance.

Environmental Management Systems and Business Performance

Like quality management, environmental management is an organizational governance philosophy, which is based on continual improvement principles. An EMS ratifies this philosophy by way of formalized structures, procedures and processes that require facilities to implement an environmental policy, undertake internal environmental assessments, establish environmental goals, monitor goal attainment and undergo management review (Netherwood, 1998). However, rather than focusing on improving product and process quality, an EMS seeks to continually reduce the environmental impact of a facility's internal processes and products (Guoyou *et al.*, 2012).

Similar to the adoption of a QMS, the positive association between EMS adoption and positive business performance are related to enhancements to internal efficiencies as well as goodwill benefits. Internal efficiencies arise because EMSs require facilities to undertake internal assessments that incorporate source reduction into product design, thus institutionalizing pollution prevention programs and extending them throughout the organization (Guoyou *et al.*, 2012; Takahashi and Nakamura, 2010; USDOE, 1998). These activities help EMS adopters reduce their environmental impacts by eliminating unnecessary materials purchases (Christmann, 2000; Guoyou *et al.*, 2012), energy consumption and the use of toxic product inputs (Hart and Ahuja, 1996). They also create avenues for EMS adopters to reduce their material costs by substituting costly toxic inputs for environmentally friendly ones (Sroufe, 2003), and decrease production costs by eliminating expensive regulated processes altogether (Darnall and Edwards, 2006; Darnall, 2009). For example, as part of their EMS, some enterprises may implement life-cycle cost analysis and assess their activities at each step of their value chain – from raw materials access to disposition of used products (Allenby, 1991; Fiksel, 1993). The focus on continuous improvement processes allows organizations to eliminate environmentally hazardous production activities (Guoyou *et al.*, 2012; Simpson and Samson, 2010; Takahashi and Nakamura, 2010), redesign existing product systems to reduce life-cycle impacts and develop new products with lower life cycle costs (Hart, 1995). These efficiency improvements can reduce a facility's operational costs and lead to improved business performance (see, e.g., Darnall *et al.*, 2008a; Hart and Ahuja, 1996; Klassen and McLaughlin, 1996). Consequently, while EMSs are tools to improve environmental compliance (García-Rodríguez *et al.*, 2013; Sarkis, 1995), there is also strong evidence suggesting that the adoption of EMSs encourages facilities to proactively reduce their environmental impacts beyond regulatory expectations (Darnall and Kim, 2012; Potoski and Prakash, 2005).

Additionally, similarly to QMS adopters, facilities can derive goodwill benefits from adopting an EMS. Related to customers and buyers, some place a high value on environmental quality, and may offer preferential purchasing contracts and extended purchasing contracts to businesses that share a similar operating philosophy (Arimura *et al.*, 2011; Darnall *et al.*, 2000; Darnall *et al.*, 2001; Fineman and Clarke, 1996; Henriques and Sadorsky, 1999; González-Benito and González-Benito, 2005). Facilities that yield to these preferences can enhance their competitive advantages (Curkovic and Sroufe, 2011) to the extent that they fully integrate their EMS throughout their organization and supply chain (Curkovic and Sroufe, 2011; Darnall *et al.*, 2008b). Goodwill benefits can also extend beyond customers and buyers to regulators, communities and environmental groups. Regulatory benefits include

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expediting EMS adopters' operating permits or monitoring adopters less frequently (Darnall *et al*., 2010). In some cases, regulators may give facilities with EMSs greater latitude when a permitting discrepancy is discovered (Darnall *et al*., 2010). Regulator goodwill may also facilitate collaborative relationships with regulators towards achieving greater environmental improvements and shared learning (Potoski and Prakash, 2005). Related to the goodwill benefits bestowed by community and environmental groups, facilities that adopt an EMS may be in a better position to communicate information about their environmental proactiveness and integrate environmental stakeholder concerns in product design and process development, thus reducing operational costs (Hart, 1995) and avoiding the cost of environmental legal liabilities (Sharma and Vredenburg, 1998). These factors can help EMS adopters avoid negative environmental publicity, and foster useful information exchange and dialogue in broader society (Darnall *et al*., 2009; Gould *et al*., 1996). Adopting an EMS may therefore bolster a facility's social license to operate and improve its overall external legitimacy with critical stakeholders (González-Benito and González-Benito, 2008; Henriques and Sadorsky, 1999). Combined, facilities that adopt an EMS may strategically improve their business performance.

Complementary Capabilities, Management Systems and Business Performance

We extend these arguments by examining whether adopting both management systems is related more to positive business performance than the adoption of either a QMS or EMS on its own. We suggest that this possibility exists because these management systems are complementary in that the tacit and socially complex internal capabilities required to adopt one management system complement and facilitate the routine operationalization of the other. Further embedding these capabilities within the organization can lead to competitive advantage (Barney, 1991; Wernerfelt, 1984). Additionally, because each management system has different goals, adopting both may further enhance the facility's strategic value.

Capabilities involve complex patterns of coordination among people and between people and other resources (Grant, 1991). Perfecting such coordination requires learning through repetition and enacting routines (Grant, 1991). Related to the capability complementarities of QMSs and EMSs, both QMSs and EMSs require facilities to implement formal routines and procedures to assess their internal operations for opportunities to continually enhance internal efficiency (King and Lenox, 2001; Pil and Rothenberg, 2003; Sroufe, 2003). For instance, QMS adopters develop routines for determining what aspects of the organization affect product and process quality, and then determine which of these aspects have significant impacts, prior to establishing detailed performance requirements for high priority impacts (Black and Porter, 1996; Scholtes and Hacquebord, 1988). Similarly, adopting an EMS requires that facilities establish routines to determine what aspects of the organization affect the natural environment, and then assess which of these aspects have significant impacts on the natural environment (Netherwood, 1998). Like QMS adopters, EMS adopters establish detailed performance requirements based on high priority impacts by undertaking a similar ranking procedure. As a consequence, facilities that implement one of these management systems must develop tacit capabilities related to establishing routines for monitoring performance, which require employee training, knowledge development, and work in teams (King and Lenox, 2001; Pil and Rothenberg, 2003). Because of their similar governance structures, the routines established by one management system therefore complement those established in the other, and further embed these capabilities deep within the organization, thus facilitating competitive advantage. For instance, during the routine operationalization of QMSs and EMSs, facilities must persistently improve their internal operations around a common goal (Falk, 2002). Such improvements rely on extensive internal knowledge, production capabilities and processes, and the monitoring of organizational resources (González-Benito and González-Benito, 2005; Sroufe, 2003). For both management systems, facilities invest in capabilities that allow them to strategically plan for the long-term and develop a capacity towards assessing their progress toward achieving desired outcomes (Black and Porter, 1996; García-Rodríguez *et al*., 2013; Kitazawa and Sarkis, 2000). They also develop a culture that embraces continuous internal evaluations, which helps facilities achieve greater organizational efficiencies (Lawrence and Morell, 1995; Simpson and Samson, 2010; Welford, 1992). These combined efficiencies can increase organizational competitiveness and profitability (García-Rodríguez *et al*., 2013). Further, due to the cross-functional nature of quality and environmental issues (Pil and Rothenberg, 2003), the combined use of QMSs and EMSs can foster inter-functional coordination among employees, thus

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encouraging information and knowledge sharing among units (King and Lenox, 2001; Pil and Rothenberg, 2003). For these reasons, the routine operationalization of one management system can facilitate the implementation of the other, while creating additional competitive advantage opportunities.

Other opportunities for improved business performance relate to the fact that QMSs and EMSs have different goals. This uniqueness can enhance the strategic value to facilities that adopt both. QMSs focus on client satisfaction and quality improvement (Deming, 1986), whereas EMSs emphasize environmental improvements (Netherwood, 1998). This fundamental difference creates opportunities for facilities that adopt both management systems to improve their business performance to a greater extent than if they adopt either management system on its own. We suggest that these complementary benefits exist because facilities can derive greater efficiency gains, thus reducing costs. That is, while facilities that choose to only adopt QMSs may optimize their product quality, because QMS goals differ from those of EMSs they may overlook important efficiency enhancing opportunities related to environmental waste (King and Lenox, 2001; Klassen, 2000; Simpson and Samson, 2010). These missed opportunities are likely to further reduce facilities' costs and increase productivity (Simpson and Samson, 2010).

Additionally, facilities that adopt both management systems may be able to derive greater goodwill benefits than can be achieved by adopting only one management system. For instance, while facilities that adopt only QMSs may enhance their goodwill benefits with buyers that value product quality, they may also forego prospects to enhance their goodwill benefits with buyers that value environmental quality (González-Benito and González-Benito, 2005), and with regulators, communities and environmental groups that place importance on environmental stewardship (Hart, 1995). Similarly, facilities that decide to only adopt EMSs may fail to operationalize important opportunities related to improved product quality and customer satisfaction because EMSs have a different strategic focus. Additionally, these facilities may miss opportunities to enhance goodwill with buyers who place greater value on product quality. For these reasons, we hypothesize that, compared with facilities that adopt no management system, facilities that adopt both QMSs and EMSs are more likely to be associated with positive business performance than facilities that adopt only one of these management systems or neither management system.

> Hypothesis: *Compared with facilities that adopt no management system, facilities that adopt both QMSs and EMSs are more likely to be associated with positive business performance than facilities that adopt only one (or neither) management system.*

Methodology

Data

To empirically assess our research hypothesis, we drew on a subset of survey data obtained from the OECD Environment Directorate, which examined publicly and privately owned facilities from manufacturing industries in Canada, France, Germany, Japan, Norway and the USA. Prior to data collection, the OECD pre-tested its survey in France, Canada and Japan before it was translated into each country's official language and then back-translated to validate the accuracy of the original translation (Johnstone *et al.*, 2007). The OECD coordinated with academic researchers within each country to collect the data. Surveys were sent to individuals responsible for the facility's environmental activities. These individuals typically have expertise and knowledge about environmental regulations as well as production and operations (King, 1995; Simpson and Samson, 2010). The OECD sent two follow-up mailings to prompt additional responses (Johnstone *et al.*, 2007). The survey's overall response rate was 24.7 percent (4186 responses); however, the subset of the OECD data that we used excluded Hungary because of item non-response issues. The resulting response rate was 20.0 percent (3681 responses), which is consistent with the response rate in previous studies of facilities' environmental practices (e.g. Christmann, 2000; Melnyk *et al.*, 2003).[1]

[1]Response rates were 20.1% and 10.4% respectively.

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Several biases can arise when using survey techniques, one of which is common method variance. Common method variance refers to the amount of spurious covariance shared among variables, and is assessed by relying on Harman's single factor test. Undertaking this test involves factor analyzing all indicators used in the study (Podsakoff and Organ, 1986). The emergence of a single common factor is an indication of common method variance. We performed this test on the OECD data and our results revealed that no single factor accounted for the majority of variance in variables, thus reducing concern about common method variance.

A second bias that often arises in survey research is social desirability bias. OECD researchers addressed issues related to social desirability bias in part by ensuring respondents' anonymity. Additionally, the six-section, 12-page survey (containing 42 questions) assessed a wide range of topics related to facilities' environmental management tools, relationships with stakeholders, and perceptions about environmental policies, environmental measures, and environmental innovations/performance. Survey questions related to QMS (on page 2) were separated from questions related to EMS (page 4) and those related to business performance (page 10). By assessing a wide variety of topics and separating questions of interest, we were able to reduce some concern related to social desirability bias.

A third bias that arises from survey research, non-response bias, was addressed by assessing the industry representation and facility size of the sample relative to the distribution of facilities in the broader population (Johnstone *et al.*, 2007). The OECD made such an assessment and found no statistically significant differences with respect to facility size. Additionally, there was no statistical difference among industry representation across Canada, France, Germany, Japan and Norway. However, the USA was an exception, in that the data showed that facilities within certain USA industries were either over- or under-represented (Darnall *et al.*, 2010). Following standard practice for addressing response bias, we weighted the USA portion of the sample to reflect actual industry representation using USA census data for the year in which the survey was administered. Since the OECD data included a large number of manufacturing facilities (both publicly and privately owned) that spanned multiple countries, generalizability was less of a concern.

Dependent Variable

Prior literature has assessed business performance using self-reported subjective and objective measures (Franco-Santos *et al.*, 2007). Subjective measures have included managerial perceptions related to the relative position of the organization compared with its competitors (see, e.g., González-Benito and González-Benito, 2005; Martínez-Costa and Martinez-Lorente, 2008), and managers' perceptions of their facilities' overall business performance (Darnall *et al.*, 2008a, 2008b; Darnall, 2009). Self-reported objective measures have included variables obtained in financial statements, such as return on assets, sales or income, and earnings before interest (see, e.g., González-Benito and González-Benito, 2005; Grolleau *et al.*, 2013; Hendricks and Singhal, 2001; Martínez-Costa and Martínez-Lorente, 2008; Hart and Ahuja, 1996). In our case, we follow the approach used by Darnall *et al.* (2008a) and Darnall (2009) by assessing business performance using data from an OECD survey question that asked facility managers how they would assess their facility's overall business performance over the past three years. Using a five-point Likert scale, respondents indicated whether revenues had (1) 'been so low as to produce large losses', (2) 'been insufficient to cover costs', (3) 'allowed us to break even', (4) 'been sufficient to make a small profit' or (5) 'been well in excess of costs'. We then evaluated these responses in two ways. First, because the focus of our analysis was the relationship between facilities' management systems and positive business performance, we estimated positive business performance as a dichotomous scale (i.e. having or not a positive business performance). This variable was created by combining facilities that reported having positive business performance (categories 4 and 5; coded 1), and comparing them with those facilities that broke even or incurred business losses (categories 1–3; coded 0). Second, as a robustness check, we also estimated facility responses to this question using the five-point scale to account for a progression of positive business performance.

Explanatory Variables

Our explanatory variables consisted of the adoption of three types of management approach: *QMS and EMS*, *QMS only*, and *EMS only*. We developed our *QMS and EMS* variable by relying on two OECD survey questions, one of which asked managers 'Has your facility implemented a QMS?' and the other of which asked facility managers

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'Has your facility actually implemented an EMS?'. Respondents who answered 'yes' to both questions were coded 1, and all other facilities were coded 0.

To develop our second management system variable, *QMS only*, we relied on the OECD survey question that asked managers 'Has your facility implemented a QMS?'. Facility managers that answered 'yes', and had not also adopted an EMS, were coded 1, otherwise 0. Similarly, our third management system variable, *EMS only*, was developed by asking facility managers 'Has your facility actually implemented an EMS?'. Facility managers who answered 'yes', and had not also adopted a QMS, were coded 1, otherwise 0. By coding our QMS only and EMS only variables in this manner, we were able to isolate the relationship between each management system and business performance. Table 1 shows descriptive statistics of our explanatory variables.

Control Variables

To address issues related to facility heterogeneity, this study included multiple control variables. We controlled for differences in facilities' primary customers by relying on data derived from an OECD question that asked managers 'How would you, in general, classify the primary customers for your facility's products?'. We coded three responses: households, wholesalers or retailers, and other manufacturing facilities or other facilities within the firm. This last group served as our omitted reference category.

Since facilities operating in industries with a smaller number of competitors may have greater opportunities to improve their business performance arising from monopolistic competition (Chamberlin, 1986), we included a set of dummies to account for market concentration. We relied on data from an OECD question that asked managers to report the number of competitors the facility competed with for its most commercially important product within the past three years. Managers responded by indicating either 'less than 5', '5–10' or 'greater than 10'. The first category ('less than 5') was our omitted reference category.

We also accounted for whether facilities were part of a publicly traded firm, since publicly traded and privately owned firms differ significantly in their overall organizational structure (Darnall and Edwards, 2006; Mascarenhas, 1989). For instance, compared with facilities of publicly traded companies, privately owned enterprises tend to have greater concerns for their short-term economic viability, which often leads to management decisions that are a response to supply chain requirements (Bianchi and Noci, 1998) or networks of similar companies (Gilmore *et al.*, 2001) rather than proactive strategic decisions (Darnall and Edwards, 2006). Since these factors may be related to a facility's business performance, we included data derived from an OECD survey question that asked facility managers 'Is your firm listed on a stock exchange?'.

Larger facilities are often suggested to have more access to resources and capabilities (Bianchi and Noci, 1998), which may be leveraged towards achieving greater business performance. We thus accounted for facility size by taking the natural logarithm of the number of employees per facility. Finally, we included industry sector dummies, in addition to country of operation dummies. Our reference sector dummy was the petroleum, chemicals and rubber product industries and our excluded country dummy was the USA. Table 2 shows correlations and descriptive statistics for all variables used in this study.

Category	*N*	Percentage	Mean business performance	Standard deviation
Both QMS and EMS	1108	42.31	3.50	0.94
QMS only	852	32.53	3.42	0.97
EMS only	185	7.06	3.49	1.03
Neither QMS nor EMS	474	18.10	3.24	1.02
Total facilities	2619	100.00	3.43	0.97

Table 1. Categories of management system adopters and their business performance

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	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1. Business performance	1.0																								
2. Households	0.01	1.0																							
3. Wholesalers	0.07	−0.20	1.0																						
4. Customer at beginning of supply chain	−0.07	−0.39	−0.82	1.0																					
5. Market concentration (<5)	0.06	−0.05	−0.03	0.05	1.0																				
6. Market concentration (5–10)	0.01	−0.02	−0.03	0.03	−0.44	1.0																			
7. Market concentration (>10)	−0.06	0.06	0.05	−0.08	−0.46	−0.59	1.0																		
8. Publicly traded	0.10	−0.01	0.00	0.00	0.06	0.05	−0.09	1.0																	
9. Ability to compete on quality	0.08	−0.01	−0.03	0.04	−0.04	−0.04	0.07	0.05	1.0																
10. Government encouragement of EMS	0.05	−0.02	−0.01	0.03	−0.01	0.01	−0.01	0.15	0.05	1.0															
11. Importance of natural resource use	0.01	0.01	−0.06	0.05	0.00	0.02	−0.03	0.08	0.06	0.08	1.0														
12. Market scope	0.13	−0.12	−0.07	0.13	−0.01	0.03	−0.02	0.17	0.18	0.06	0.06	1.0													
13. Firm's head office in foreign country	0.10	−0.03	−0.01	0.03	0.05	0.02	−0.07	0.30	0.05	0.11	0.04	0.20	1.0												
14. Size	0.08	0.04	0.00	−0.03	−0.04	0.02	0.01	0.33	0.12	0.12	0.19	0.26	0.14	1.0											
15. USA	0.06	−0.05	0.03	0.00	0.02	0.03	−0.04	0.29	0.07	0.20	0.02	0.14	0.06	0.18	1.0										
16. Germany	0.08	0.12	−0.06	−0.02	−0.12	−0.01	0.13	−0.11	0.08	−0.12	0.02	0.30	0.08	0.04	−0.21	1.0									
17. Japan	−0.24	−0.01	−0.09	0.08	0.03	−0.01	−0.02	−0.15	−0.13	−0.07	0.03	−0.43	−0.25	−0.13	−0.28	−0.50	1.0								
18. Norway	0.06	−0.06	0.09	−0.05	0.03	0.00	−0.03	−0.02	−0.03	0.05	−0.16	0.00	0.07	−0.13	−0.10	−0.18	−0.24	1.0							
19. France	0.03	−0.04	0.02	0.01	0.11	0.00	−0.10	0.03	0.02	0.00	0.13	0.07	0.00	0.05	−0.09	−0.16	−0.22	−0.08	1.0						
20. Canada	0.15	−0.04	0.11	−0.09	0.00	−0.01	0.00	0.12	0.05	0.05	−0.07	0.07	0.19	0.06	−0.10	−0.17	−0.23	−0.08	−0.08	1.0					
21. Food, beverage, textiles	−0.01	0.11	0.24	−0.30	−0.05	−0.06	0.10	−0.09	0.00	−0.04	0.02	−0.17	−0.10	−0.05	−0.13	0.00	0.05	0.00	0.07	−0.01	1.0				
22. Pulp, paper, print	0.01	0.00	0.15	−0.14	−0.06	−0.02	0.07	−0.03	−0.01	0.02	−0.07	−0.06	−0.01	−0.09	−0.06	−0.05	−0.09	0.21	−0.02	0.12	−0.09	1.0			

23. Petroleum, chemicals, rubber	−0.02	0.13	−0.02	−0.05	−0.05	−0.05	0.09	−0.06	−0.03	−0.03	0.02	−0.14	0.01	−0.03	−0.09	0.06	0.01	0.02	−0.04	0.01	−0.12	−0.07	1.0		
24. Nonmetallic minerals, metals	0.07	−0.08	0.02	0.02	0.05	−0.01	−0.04	0.06	−0.04	0.01	0.06	0.03	0.09	0.00	−0.10	0.04	−0.01	−0.02	0.05	0.04	−0.20	−0.11	−0.14	1.0	
25. Machinery, media equipment	0.00	−0.04	−0.16	0.18	0.00	0.03	−0.02	−0.09	0.00	0.00	0.02	0.00	−0.04	−0.05	−0.09	0.06	0.01	0.00	0.01	−0.02	−0.22	−0.12	−0.16	−0.26	1.0
26. Transport equipment	−0.08	−0.04	−0.15	0.16	0.05	0.06	−0.10	−0.01	0.02	−0.07	−0.07	0.14	−0.01	0.05	−0.19	0.02	0.15	−0.05	−0.03	−0.02	−0.24	−0.13	−0.17	−0.28	−0.31
Mean	0.56	0.09	0.29	0.62	0.26	0.35	0.39	0.18	2.82	0.21	1.94	2.75	0.11	5.04	0.10	0.26	0.42	0.08	0.07	0.07	0.14	0.05	0.08	0.18	0.21
Standard deviation	0.50	0.28	0.45	0.48	0.44	0.48	0.49	0.38	0.39	0.41	0.67	1.06	0.31	1.05	0.30	0.44	0.49	0.27	0.25	0.26	0.35	0.21	0.28	0.38	0.40
Minimum	0	0	0	0	0	0	0	0	1	0	1	1	0	.69	0	0	0	0	0	0	0	0	0	0	0
Maximum	1	1	1	1	1	1	1	1	3	1	3	4	1	.13	1	1	1	1	1	1	1	1	1	1	1

Table 2. Correlations and descriptive statistics†

†Correlations > |0.065| and |0.085| are significant at the 5% and 1% level of significance, respectively.

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Predicting Management System Adoption

Prior to estimating the relationship between management system adoption and business performance, it was first essential to consider whether facilities that adopted both management systems (or either on its own) did so because of observed or unobserved characteristics that may be correlated with their business performance. The origin of the concern relates to the fact that management system adoption is subject to selection bias. Selection bias refers to the possibility that statistical distortion exists resulting from some members of the population being less likely to be included than others (Heckman, 1979). If this statistical distortion exists, it must be addressed empirically (Heckman, 1979). To deal with this potential problem, we simultaneously accounted for the factors that might affect facilities' adoption decisions. Related to QMS adoption, facility managers were asked to indicate the importance of product quality to their competitive strategy since it is likely an important factor that would motivate QMS adoption (Kurapatskie, 2012). More specifically, we relied on data derived from an OECD survey question that asked facility managers to 'Please assess product quality in your facility's ability to compete on the market for its most important product within the past three years'. Respondents answered 'not important' (1), 'moderately important' (2), or 'very important' (3).

Related to facilities' decisions to adopt an EMS, prior literature suggests that if facilities know of government programs that are designed to encourage EMS adoption then they are more likely to adopt them (Arimura *et al.*, 2008, 2011). This relationship is independent of whether or not facilities actually participate in these assistance programs. To measure this circumstance, we relied on data derived from an OECD survey question that asked facility managers 'Do the regulatory authorities have programs and policies in place to encourage your facility to use an EMS?'. Respondents answered either 'yes' (1) or 'no' (0).

We also included several control variables that may be related to facilities' management system adoption. First, we considered managers' perception about the potential negative environmental impacts related to their use of natural resources (energy, water, etc.) in their products and processes (Darnall *et al.*, 2008a, 2008b). Respondents answered whether they had either 'no negative impacts' (1), 'moderately negative impacts' (2) or 'very negative impacts' (3). Market scope was measured by incorporating OECD survey data that asked respondents whether the facility's market was primarily at a local, national, regional or global level. Responses were coded 1–4 respectively. Additionally, we accounted for whether the facility's head office was in a foreign country, the degree of the facility's market concentration and whether the facility was part of a publicly traded company. Finally, we controlled for manufacturing sector and country of operation. Our excluded industry dummy was the petroleum, chemicals and rubber product industries and our excluded country dummy was the USA.

Empirics

We assessed the relationship between management system adoption and business performance using two techniques to account for selection bias: multivariate probit estimation and Heckman estimation. Multivariate probit estimation belongs to the general class of simultaneous equation models known as selection models, which attempt to control for correlations between the error terms (Greene, 2011) in the equations related management systems adoption and in the principal equation assessing business performance. If these correlations exist, a standard probit model will offer inconsistent results (Maddala, 1983). Similarly, Heckman regression is a two-stage least square estimation. Like multivariate probit, the first stage of a Heckman selection model estimates the probability of belonging to the sample, and the second stage simultaneously analyzes the factors that affect business performance. Both estimations assume that a facility's business performance and the variables that explain both QMS and EMS adoption are separate, but interrelated. This interrelation takes place through a correlated error structure (Greene, 2011).

In estimating interrelationship of the errors, a multivariate probit model produces 'rho', which if statistically different from zero ($\alpha = 0.05$) would indicate that the errors are correlated. In such instances, there would be at least a 95% probability that an endogenous relationship exists between the factors associated with management system adoption and those associated with business performance, such that simultaneous estimation procedures are needed. Similarly, the Heckman model produces a 'Mills' lambda', which if statistically different from zero ($\alpha = 0.05$) indicates that the errors are correlated. For both estimations, model significance is determined using a Wald chi-square test.

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The main difference between multivariate probit and Heckman regression models relates to the treatment of the dependent variable. Multivariate probit estimation treats the dependent variable (i.e. business performance) as a dichotomous measure (positive business performance or not), while Heckman estimation treats the dependent variable as a continuous measure (degree of business performance). Because our dependent variable is constructed from a five-point Likert scale, it was possible to create a dichotomous variable suitable for multivariate probit analysis.[2] Related to the Heckman model, the five-point scale violates the continuous distribution assumption required for Heckman regression analysis. Additionally, the Heckman regression analysis does not allow for the simultaneous estimation of multiple first-stage equations (i.e. both *QMS and EMS*, *QMS only*, *EMS only*). For these reasons, we include the Heckman model merely as a robustness check to our multivariate probit regression.

In executing our multivariate probit model, we estimated four equations simultaneously. Equation (1) examines the association between management system adoption (both *QMS and EMS*, *QMS only*, *EMS only*) and our binary dependent variable – business performance. The error term is represented by ε_{i1}.

$$(\text{prob business performance} = 1) = f(\text{both}\, QMS\ and\ EMS, QMS\ only, EMS\ only, \text{ control variables}, \varepsilon_{i1}). \quad (1)$$

The remaining three equations assess the factors associated with management system adoption. More specifically, Equation (2) considers the factors related to facility adoption of both QMS and EMS. Equation (3) assesses the factors related to the adoption of QMS only, and Equation (4) considers the factors related to the adoption of EMS only. The error terms are represented by ε_{i2}, ε_{i3} and ε_{i4}, respectively.

$$(\text{prob both QMS and EMS} = 1) = f(\text{importance of quality, government encourages EMS, control vars}, \varepsilon_{i2}) \quad (2)$$

$$(\text{prob QMS only} = 1) = f(\text{importance of quality, control vars}, \varepsilon_{i3}) \quad (3)$$

$$(\text{prob EMS only} = 1) = f(\text{government encourages EMS, control vars}, \varepsilon_{i4}). \quad (4)$$

By estimating the four equations jointly, the model accounts for correlations among them. A likelihood ratio test evaluating the null hypothesis – that the correlations among the four error terms (ε_{i1}–ε_{i4}) are jointly equal to zero – was used to offer support for whether a multivariate probit was an appropriate specification for the data. A rejection of the null hypothesis would provide evidence of selection bias among our explanatory variables, and verify the need for our two-stage estimation approaches.

In executing our Heckman model, we estimated two equations simultaneously. Equation (1) examines the association between management system adoption (both *QMS and EMS*, *QMS only*, *EMS only*) and business performance as a continuous dependent variable, while Equation (2) examines the factors that relate to facility adoption of both management systems.

Results

Results from the multivariate probit model are shown in Tables 3 and 4. Table 3 contains the findings from estimating Equation (1), and considers the relationship between management system adoption and business performance. Table 4 shows the results related to estimating Equations (2)–(4). Model fit statistics in both of these tables are

[2]A two-stage multinomial probit analysis would have been a more appropriate model to use given the nature of our dependent variable. However, this specific two-stage estimation approach was not available using existing statistical software.

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Equation (1). Dependent variable: positive business performance	Coefficient	Std error
Explanatory variables[†]		
Both QMS and EMS	0.625***	0.143
QMS only	0.269**	0.133
EMS only	−0.139	0.310
Control variables		
Households	0.138	0.095
Wholesalers	0.169**	0.062
Market concentration (5–10)	−0.172**	0.066
Market concentration (>10)	−0.244***	0.067
Publicly traded	0.019	0.084
Size	0.026	0.028
Germany	0.079	0.118
Japan	−0.583***	0.110
Norway	0.107	0.143
France	−0.143	0.142
Canada	0.513***	0.143
Food, beverage, textiles	−0.033	0.101
Pulp, paper, print	−0.003	0.147
Petroleum, chemicals, rubber	−0.132	0.114
Nonmetallic minerals, metals	−0.139*	0.083
Transportation equipment	−0.296***	0.080
Constant	0.089	0.177
Overall model statistics		
rho_{12}		−0.154*
rho_{13}		0.243
rho_{14}		0.047
rho_{23}		−0.255***
rho_{24}		−0.859***
rho_{34}		−0.099**
Likelihood ratio test $rho_{12} = rho_{13} = rho_{14} = rho_{23} = rho_{24} = rho_{34} = 0$		1137.91***
Wald test χ^2		936.28***
N		2619

Table 3. Predicting positive business performance (multivariate probit)[†]

[†]This model was assessed using multivariate probit regression with simultaneous estimation of four equations. Equation (1) estimates the relationship between the adoption of management systems (QMS and EMS, QMS only and EMS only) and business performance. Our comparison category consists of facilities that adopt no management system. The excluded supply chain dummy is other manufacturing facilities or other facilities within the firm; excluded market concentration dummy is <5 competitors; excluded country dummy is the USA; excluded industry dummy is nonmetallic minerals and metals.

*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

equivalent since all four equations were estimated simultaneously. The Wald chi-square statistic (936.28) is statistically significant ($p < 0.01$), indicating sufficient model fit.

Rho estimates the correlations between the estimated errors in each of the four equations. Six rho statistics are derived from the four equations, and indicate the correlation between the individual estimation errors. The likelihood ratio test assessing whether each of the rhos is jointly equal to zero is rejected ($p < 0.01$), indicating significant overall correlation between the error terms of the four equations, and the importance of our two-stage estimation approach.

In considering the relationship between management system adoption and business performance, our results indicate that the estimated coefficient of both *QMS and EMS adoption* is positive and statistically significant (0.625; $p < 0.01$). These findings suggest that facilities that adopt both QMS and EMS also are more likely to have positive business performance over facilities that do not adopt either (or no) management system. In considering the estimated coefficient of *QMS only*, it too is positive and statistically significant (0.269; $p < 0.05$), indicating that facilities that adopt *QMS only* are more likely to have positive business. By contrast, the estimated coefficient for *EMS only*

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	Equation (2): both QMS and EMS		Equation (3): QMS only		Equation (4): EMS only	
Variable	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Ability to compete on quality	0.224***	0.062	0.017	0.067	−0.142	0.096
Government encouragement of EMS	0.479***	0.059	−0.379***	0.070	0.156*	0.092
Importance of natural resource use	0.337***	0.038	−0.193***	0.040	0.068	0.061
Market scope	0.294***	0.087	−0.030	0.029	−0.070	0.043
Firm's head office in foreign country	0.154***	0.028	−0.178*	0.099	−0.126	0.146
Market concentration (5–10)	0.082	0.063	0.029	0.068	−0.168	0.102
Market concentration (>10)	0.143**	0.064	−0.100	0.069	−0.066	0.100
Publicly traded	0.506***	0.072	−0.351***	0.084	−0.228**	0.117
Germany	−0.225**	0.102	0.655***	0.120	−0.834***	0.154
Japan	0.416***	0.101	0.175	0.120	−0.807***	0.146
Norway	−0.085	0.124	0.613***	0.143	−0.843***	0.198
France	0.235*	0.126	0.327**	0.147	−0.732***	0.196
Canada	−0.136	0.123	0.437***	0.144	−0.361**	0.173
Food, beverage, textiles	−0.632***	0.087	−0.003	0.094	0.097	0.143
Pulp, paper, print	−0.374**	0.127	−0.347**	0.145	0.430**	0.188
Petroleum, chemicals, rubber	−0.296**	0.101	−0.220*	0.115	0.277*	0.159
Nonmetallic minerals, metals	−0.132*	0.079	0.157*	0.084	−0.138	0.139
Transportation equipment	−0.044	0.078	0.070	0.083	−0.109	0.137
Constant	−2.186***	0.216	−0.247	0.238	−0.313	0.327
Overall model statistics						
rho_{12}					−0.154*	
rho_{13}					0.243	
rho_{14}					0.047	
rho_{23}					−0.255***	
rho_{24}					−0.859***	
rho_{34}					−0.099**	
Likelihood ratio test ($rho_{12} = rho_{13} = rho_{14} = rho_{23} = rho_{24} = rho_{34} = 0$)					1137.91***	
Wald test χ^2					936.28***	
N					2619	

Table 4. Predicting management system adoption (multivariate probit)†† This model was assessed using multivariate probit regression with simultaneous estimation of four equations. Equations (2)–(4) estimate the factors related to both QMS and EMS adoption, the adoption of QMS only, and the adoption of EMS only. The excluded supply chain dummy is other manufacturing facilities or other facilities within the firm; excluded market concentration dummy is <5 competitors; excluded country dummy is the USA; excluded industry dummy is nonmetallic minerals and metals
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

(−0.139) is not statistically significant, suggesting that adopters of EMS have a reported business performance that is not significantly different from that of non-EMS adopters. These latter findings were a potential concern since they contradicted prior EMS research. However, earlier scholarship also has not assessed the relationship between EMS adoption and business performance in a way that omits the possible influence of QMS. This issue is important since many facilities adopt both management systems. To investigate the issue further, we pooled *EMS only* adopters with facilities that adopted both *QMS and EMS* to examine the collective relationship with business performance. Our comparison category was no EMS. Consistent with the findings of prior research (e.g. Darnall *et al.*, 2008a), we found that EMS adopters (of all sorts, including those that also adopt a QMS) are positively associated ($p < 0.01$) with business performance.

To assess the relative difference between the sizes of our coefficients of interests, we performed a post-hoc χ^2 test. The results indicate that the difference in the size of the estimated coefficient for both *QMS and EMS* adopters (0.625) was statistically significant and larger ($\chi^2 = 5.16$; $p < 0.01$) than the estimated coefficient for adopters of *QMS only* (0.269). Similarly, the difference in the size of the estimated coefficient for both *QMS and EMS* adopters

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Dependent variable: improved business performance	Coefficient	Std error
Explanatory variables†		
Both QMS and EMS	0.284***	0.058
QMS only	0.173***	0.056
EMS only	0.187**	0.082
Control variables		
Households	0.138**	0.069
Wholesalers	0.144***	0.044
Market concentration (5–10)	−0.123**	0.049
Market concentration (>10)	−0.217***	0.050
Publicly traded	0.071	0.055
Size	0.009	0.019
Germany	0.098	0.085
Japan	−0.374***	0.093
Norway	0.094	0.111
France	−0.023	0.102
Canada	0.427***	0.100
Food, beverage, textiles	−0.090	0.071
Pulp, paper, print	−0.202*	0.109
Petroleum, chemicals, rubber	−0.130	0.082
Nonmetallic minerals, metals	−0.071	0.061
Transportation equipment	−0.195***	0.059
Constant	3.496***	0.154
Predicting management system adoption		
Ability to compete on quality	0.443***	0.075
Government encouragement of EMS	0.110	0.127
Importance of natural resource use	−0.040	0.74
Market scope	0.067	0.051
Firm's head office in foreign country	−0.264*	0.144
Market concentration (5–10)	0.081	0.123
Market concentration (>10)	0.055	0.127
Publicly traded	0.024	0.132
Germany	0.416**	0.176
Japan	0.824***	0.176
Norway	0.789**	0.273
France	0.358	0.220
Canada	0.348	0.271
Food, beverage, textiles	0.147	0.201
Pulp, paper, print	2.004	2.621
Petroleum, chemicals, rubber	−0.043	0.211
Machinery, media equipment	−0.046	0.162
Transportation equipment	−0.182	0.156
Overall model statistics		
Mills lambda		−0.841*
Wald test χ^2		281.96***
N		2.699

Table 5. Predicting improved business performance (Heckman model)†

†This model was assessed using Heckman regression with simultaneous estimation of the relationship between the adoption of management systems (QMS and EMS, QMS only and EMS only) and business performance. The excluded supply chain dummy is other manufacturing facilities or other facilities within the firm; excluded market concentration dummy is <5 competitors; excluded country dummy is the USA; excluded industry dummy is nonmetallic minerals and metals.

*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

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was statistically significant and larger ($\chi^2 = 3.74$; $p < 0.10$) than the estimated coefficient for adopters of *EMS only*. Combined, these findings offer support for our central hypothesis, which states facilities that adopt both *QMS and EMS* are more likely to be associated with more positive business performance than facilities that adopt only one of these management systems, or neither management system.

With respect to the control variables associated with Equation (1), compared with facilities that market their products to other facilities or other facilities within the firm, wholesalers are associated with more positive business performance. Facilities that report having between 5 and 10 (and greater than 10) competitors are not as likely as facilities that reported having fewer than 5 competitors to have positive business performance. Additionally, compared with facilities operating in the USA, facilities that operated in Japan are less likely to report positive business performance.

Related to the factors associated with management system adoption (Table 4), the estimated coefficient of 'Ability to compete on quality' is positive and statistically significant (0.224; $p < 0.01$) for Equation (2), as is the estimated coefficient for 'Government encouragement of EMS' (0.479; $p < 0.01$). The coefficient for 'Ability to compete on quality' for QMS adopters (Equation (3)) was not statistically significant. Finally, related to Equation (4), facilities' knowledge that government programs exist to encourage EMS adoption is associated with their adoption of EMS only (0.156; $p < 0.1$).

Results from the Heckman model are shown in Table 5. The Wald chi-square statistic (281.96) was statistically significant ($p < 0.01$), indicating sufficient model fit. Further, the Mills lambda test was statistically significant ($p < 0.10$), indicating the appropriateness for controlling for selection bias.

Like the results for our multivariate probit model, our Heckman model results indicate that the estimated coefficient of *QMS and EMS* adoption was positive and statistically significant (0.284; $p < 0.01$), suggesting that facilities that adopt both QMS and EMS also are more likely to have stronger business performance. Additionally, the estimated coefficients of *QMS only* and *EMS only* were positive and statistically significant (0.173, $p < 0.01$ in the case of QMS only; 0.187, $p < 0.05$ in the case of EMS only). The results of our post hoc χ^2 test indicate that the difference in the size of the estimated coefficient for both *EMS and QMS* adopters was statistically significant and larger ($\chi^2 = 5.89$; $p < 0.05$) than the estimated coefficient for adopters of *QMS only*, although there was no statistical difference for *EMS only*. Combined, these findings offer some additional support for our hypothesis that stated that facilities that adopt both *QMS and EMS* are more likely to be associated with positive business performance than facilities that adopt *QMS only*, *EMS only* or neither management system.

In sum, combined, our findings offer evidence about the robustness of our approach – that multivariate probit analysis is appropriate to use when estimating the relationship between adopting both QMS and EMS and positive business performance, and that facilities that adopt both QMS and EMS are more likely to be associated with more positive business performance. Further, our findings appear robust to different model specifications, although the multivariate probit model is the best fit for our data.

Discussion and Conclusions

While QMS and EMS adoption has been increasing worldwide, many questions remain about the extent to which these management systems relate to positive business performance. Prior literature suggests that quality management on its own is related to stronger business performance (e.g. Corredor and Goñi, 2011; Easton and Jarrell, 1998; Hendricks and Singhal, 1997; Kaynak, 2003; Powell, 1995; Sharma, 2005; Zhang and Xia, 2013), and a similar case appears to exist for environmental management (see, e.gDarnall *et al.*, 2008a, 2008b; González-Benito and González-Benito, 2005; Hart and Ahuja, 1996; Klassen and McLaughlin, 1996; Russo and Fouts, 1997). However, we lack sufficient understanding of the business performance benefits associated with the concurrent use of both QMS and EMS. Additionally, as yet, the performance benefits related to both QMS and EMS adoption (compared with QMS only, EMS only and neither management system) have not been well understood.

This study addresses these concerns by analyzing whether facilities that adopt both QMS and EMS have stronger business performance than facilities that adopt one or neither management system. Using a cross-country sample, our results offer novel empirical evidence indicating that facilities that adopt both management systems are more

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likely to be associated with positive business performance than facilities that adopt only one of these management systems. We argue that stronger business performance is due to complementarities in the capabilities required of each, which leads to greater competitive advantage opportunities. Each management system facilitates the other during adoption and throughout routine operationalization. Moreover, both management systems emphasize continual improvement that can enhance organizational efficiencies as well as goodwill benefits with critical stakeholders. Additionally, these management systems also have unique goals that taken together can enhance a facility's strategic value. As a consequence, adoption of the second management system can assist with further imbedding continual improvement principles deeper within the organization, thereby enhancing business performance in a way that may not be achieved by adopting one management system alone.

These findings offer several contributions to scholarship and practice. First, they offer critical evidence for the position that has been put forward by prior researchers who advocate for facilities' concurrent adoption of QMS and EMS (e.g. Harrington *et al.*, 2008; Molina *et al.*, 2009; Pil and Rothenberg, 2003; Sroufe, 2003; Zeng *et al.*, 2005). By way of anecdote or suggestion, these scholars submit that performance benefits may exist for facilities that integrate both quality management and environmental management. This study extends this research by offering some of the first large sample evidence that improved business performance indeed appears to be associated with the concurrent adoption of both management systems. It articulates specific arguments for why strategic complementarities exist between these management systems and why these complementarities relate to stronger business performance. Moreover, by controlling for the selection bias associated with the adoption of these management systems, we improve significantly on earlier research examining the relationship between management systems and business performance.

A second important contribution of this research relates to the finding that *EMS only* adopters are no more likely to have a positive business performance. These findings are likely due to the fact that our *EMS only* variable excludes facilities that adopt both an EMS and a QMS. That is, when we pooled *EMS only* adopters with facilities that adopted both *QMS and EMS* to assess the collective relationship of EMS with business performance, consistent with the findings of prior research, we found that EMS adopters (of all sorts) are positively associated with business performance. The fact that *EMS only* adopters are not associated with positive business performance benefits raises important questions about the extent to which they have sufficiently embedded continual improvement routines into their overall management strategy. If not, competitive advantage opportunities are likely to be lessened, as are the opportunities for facilities to improve their environmental performance (Curkovic and Sroufe, 2011).

Another explanation for the inconclusive findings related to *EMS only* adopters may be due to the fact that the facilities in our sample have indeed embedded their continual improvement routines into their overall management strategy, but that the goals associated with these routines are not sufficiently ambitious. That is, *EMS only* adopters may be strategically focusing their EMSs to address 'lower-order sustainability issues' that affect existing products and processes, while ignoring 'higher-order sustainability issues' that affect communities and human well-being (Kurapatskie and Darnall, 2013). This issue is important, because in comparing the two the business performance benefits associated with higher-order sustainability activities tend to be greater (Kurapatskie and Darnall, 2013). However, developing these activities requires that facilities work closely with their external stakeholders. Facilities that adopt both QMS and EMS may be better positioned to do so, since QMS adoption requires facilities to develop stronger relationships with stakeholders in their supply chain, and also address their particular concerns. As a consequence, facilities that adopt both QMS and EMS are likely to attend to concerns expressed by other stakeholders – such as regulatory stakeholders and community stakeholders – who support the adoption higher-order sustainability practices.

However, prior studies assessing the environmental performance benefits of EMSs (e.g. Darnall and Kim, 2012; García-Rodríguez *et al.*, 2013; Potoski and Prakash, 2005) have not distinguished between *EMS only* adopters and facilities that adopt both *QMS and EMS*. They also have not made distinctions between lower- and higher-order sustainability activities and how the implementation of one over the other might differ for facilities that have QMSs in place. Future research would benefit from considering these issues further. It could be that the complementary capabilities and strategic goals of QMSs are what help organizations imbed the operational routines of EMSs into their management strategy so that greater environmental and business performance can be achieved.

This research offers other important implications for future studies that attempt to analyze the performance benefits associated with QMS and EMS adoption. It raises questions about the optimal sequence of implementing

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management practices (Karapetrovic and Willborn, 1998). That is, for facilities that adopt both management systems, does it matter whether QMS is adopted first and then EMS, or do facilities benefit more from adopting an EMS first and then implementing a QMS? Alternatively, do facilities accrue the greatest gains by adopting both management systems concurrently as opposed to sequentially? Several scholars have suggested that environmental management facilitates the efficacy in the adoption of quality management practices (Pil and Rothenberg, 2003; Sroufe, 2003). However, other studies posit that quality management practices are the foundation upon which environmental management initiatives should be developed (Angell, 2001; King and Lenox, 2001; Zhang and Xia, 2013). It therefore remains uncertain whether adopting QMS first or concurrently with EMS may be a more optimal sequence of implementing these management practices. Prospective research should consider this issue.

Finally, this research offers important contributions to practice in that many managers who have an existing management system may question the strategic advantages of adopting another. Our findings suggest that adopting two management systems are likely to be better than one. Further, they offer managers a strong rationale for why additional benefits are likely accrue – that facilities can reap additional internal efficiencies and goodwill benefits from stakeholders by expanding their management system approach because each management system has distinct strategic goals.

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References

Adam EE, Foster ST. 2000. Quality improvement approach and performance: multisite analysis within a firm. *Journal of Quality Management* **5**: 143–158. DOI: 10.1016/S1084-8568(01)00018-9

Adams M. 1999. Determinants of ISO accreditation in the New Zealand manufacturing sector. *Omega* **27**(2): 285–292. DOI: 10.1016/S0305-0483(98)00046-2

Allenby B.1991. Design for environment: a tool whose time has come. *SSA Journal* **September**: 5–10.

Angell LC. 2001. Comparing the environmental and quality initiatives of Baldrige Award Winners. *Production and Operations Management* **10**(3): 306–326. DOI: 10.1111/j.1937-5956.2001.tb00377.x

Arimura TH, Darnall N, Katayama H. 2011. Is ISO 14001 a gateway to more advanced environmental action? The case for green supply chain management. *Journal of Environmental Economics and Management* **61**(2): 170–182. DOI: 10.1016/j.jeem.2010.11.003

Arimura TH, Hibiki A, Katayama H. 2008. Is a voluntary approach an effective environmental policy instrument? A case for environmental management system. *Journal of Environmental Economics and Management* **55**(3): 281–295. DOI: 10.1016/j.jeem.2007.09.002

Barney JB. 1991. Firm resources and sustained competitive advantage. *Journal of Management* **17**: 99–120. DOI: 10.1177/014920639101700108

Bianchi R, Noci G. 1998. 'Greening' SMEs' competitiveness. *Small Business Economics* **11**(3): 269–281. DOI: 10.1023/A:1007980420087

Black S, Porter L. 1996. Identification of the critical factors of TQM. *Decision Sciences* **27**(1): 1–21. DOI: 10.1111/j.1540-5915.1996.tb00841.x

Casadesús M, Heras I, Merino J. 2005. Calidad Práctica. Prentice Hall–Financial Times Editorial: Madrid.

Chamberlin EH. 1986. Monopolistic competition. In Organizational Economics, Barney JB, Ouchi WG (eds). Jossey-Bass: San Francisco; 396–408.

Choi TY, Eboch K. 1998. The TQM paradox: relations among TQM practices, plant performance, and customer satisfaction. *Journal of Operations Management* **17**(1): 59–75. DOI: 10.1016/S0272-6963(98)00031-X

Christmann P. 2000. Effects of best practices of environmental management on cost advantage: the role of complementary assets. *Academy of Management Journal* **43**(4): 663–680. DOI: 10.2307/1556360

Corbett CJ. 2006. Global diffusion of ISO 9000 certification through supply chains. *Manufacturing and Service Operations Management* **8**(4): 330–350. DOI: 10.1287/msom.1060.0120

Corbett CJ, Montes-Sancho M, Kirsch D. 2005. The financial impact of ISO 9000 certification in the United States: an empirical analysis. *Management Science* **51**(7): 1046–1059. DOI: 10.1287/mnsc.1040.0358
Corredor P, Goñi S. 2011. TQM and performance: is the relationship so obvious? *Journal of Business Research* **64**(8): 830–838. DOI: 10.1016/j.jbusres.2010.10.002
Curkovic S, Sroufe R. 2011. Using ISO 14001 to promote a sustainable supply chain strategy. *Business Strategy and the Environment* **20**(2): 71–93. DOI: 10.1002/bse.671
Darnall N. 2009. Regulatory stringency, green production offsets and organizations' financial performance. *Public Administration Review* **69**(3): 418–434. DOI: 10.1111/j.1540-6210.2009.01988.x
Darnall N, Edwards D. 2006. Predicting the cost of environmental management system adoption: the role of capabilities, resources and ownership structure. *Strategic Management Journal* **27**(4): 301–320. DOI: 10.1002/smj.518
Darnall N, Gallagher DR, Andrews RNL. 2001. ISO 14001: Greening management systems. In Greener Manufacturing and Operations, Sarkis J (ed.). Greenleaf: Sheffield; 178–190.
Darnall N, Gallagher DR, Andrews RNL, Amaral D. 2000. Environmental management systems: opportunities for improved environmental and business strategy. *Environmental Quality Management* **9**(3): 1–10. DOI: 10.1002/1520-6483(200021)9:3<1::AI
Darnall N, Henriques I, Sadorsky P. 2008a. Do environmental management systems improve business performance in an international setting? *Journal of International Management* **14**(4): 364–376. DOI: 10.1016/j.intman.2007.09.006
Darnall N, Jolley GJ, Handfield R. 2008b. Environmental management systems and green supply chain management: complements for sustainability? *Business Strategy and the Environment* **17**(1): 30–45. DOI:10.1002/bse.557
Darnall N, Kim Y. 2012. Which types of environmental management systems are related to greater environmental improvements? *Public Administration Review* **72**(3): 351–365. DOI: 10.1111/j.1540-6210.2011.02503.x
Darnall N, Potoski M, Prakash A. 2010. Sponsorship matters: assessing business participation in government- and industry-sponsored voluntary environmental programs. *Journal of Public Administration* **20**(2): 283–307. DOI: 10.1093/jopart/mup014
Darnall N, Seol I, Sarkis J. 2009. Perceived stakeholder influences and organizations' use of environmental audits. *Accounting, Organizations and Society* **34**(2): 170–187. DOI: 10.1016/j.aos.2008.07.002
Das A, Handfield RB, Calantone RJ, Ghosh S. 2000. A contingent view of quality management: the impact of international competition on quality. *Decision Science* **31**(3): 649–690. DOI: 10.1111/j.1540-5915.2000.tb00938.x
Deming WE. 1986. Out of the Crisis. MIT Press: Cambridge.
Easton GS, Jarrell SL. 1998. The effects of total quality management on corporate performance: an empirical investigation. *Journal of Business* **71**(2): 253–307. DOI: 10.1086/209744
Falk M. 2002. Endogenous organizational change and the expected demand for different skill groups. *Applied Economics Letters* **9**(7): 419–423. DOI: 10.1080/13504850110088141
Fiksel J. 1993. Design for environment: the new quality imperative. *Corporate Environmental Strategy* **1**: 49–55.
Fineman S, Clarke K. 1996. Green stakeholders: industry interpretations and response. *Journal of Management Studies* **33**(6): 715–730. DOI: 10.1111/j.1467-6486.1996.tb00169.x
Forza C, Filippini R. 1998. TQM impact on quality conformance and customer satisfaction: a causal model. *International Journal of Production Economics* **55**(1): 1–20. DOI: 10.1016/S0925-5273(98)00007-3
Franco-Santos M, Kennerley M, Micheli P, Martínez V, Mason S, Marr B, Gray D, Neely A. 2007. Towards a definition of a business performance measurement system. *International Journal of Operations and Production Management* **27**(8): 784–801. DOI: 10.1108/01443570710763778
García-Rodríguez FJ, García-Rodríguez JL, Castilla-Gutiérrez C, Major SA. 2013. Corporate social responsibility of oil companies in developing countries: from altruism to business strategy. *Corporate Social Responsibility and Environmental Management* **20**(6): 371–384. DOI: 10.1002/csr.1320
Garvin DA. 1994. Reading in Total Quality Management. Dryden: Boston, MA.
Gilmore A, Carson D, Grant K. 2001. SME marketing in practice. *Marketing Intelligence and Planning* **19**(1): 6–11. DOI: 10.1108/02634500110363583
González-Benito J, González-Benito O. 2005. Environmental proactivity and business performance: an empirical analysis. *Omega* **33**(1): 1–15. DOI: 10.1016/j.omega.2004.03.002
González-Benito J, González-Benito O. 2008. Operations Management practices linked to the adoption of ISO14001: an empirical analysis of Spanish manufacturers. *International Journal of Production Economics* **113**(1): 60–73. DOI: 10.1016/j.ijpe.2007.02.051
Gould K, Schnaiberg A, Weinberg A. 1996. Local Environmental Struggle: Citizen Activism in the Treadmill of Production. Cambridge University Press: Cambridge.
Grant RM. 1991. The resource-based theory of competitive advantage: implications for strategy formulation. *California Management Review* **33**(3): 114–135.
Greene WH. 2011. Econometric Analysis, 7th edn. Prentice Hall: Upper Saddle River, NJ.
Grolleau G, Mzoughi N, Pekovic S. 2013. Is business performance related to the adoption of quality and environmental-related standards? *Environmental and Resource Economics* **54**(4): 525–548. DOI: 10.1007/s10640-012-9604-0
Guoyou Q, Saixing Z, Xiaodong L, Chiming T. 2012. Role of internalization process in defining the relationship between ISO 14001 certification and corporate environmental performance. *Corporate Social Responsibility and Environmental Management* **19**(3): 129–140. DOI: 10.1002/csr.258
Harrington DR, Khanna M, Deltas G. 2008. Striving to be green: the adoption of total quality environmental management. *Applied Economics* **40**(23): 2995–3007. DOI: 10.1080/00036840600994005
Hart SL. 1995. A natural-resource-based view of the firm. *Academy of Management Review* **20**(4): 986–1014. DOI: 10.2307/258963

Hart SL, Ahuja G. 1996. Does it pay to be green? An empirical examination of the relationship between pollution prevention and firm performance. *Business Strategy and the Environment* **5**(1): 30–37. DOI: 10.1002/(SICI)1099-0836(199603)5:1<30::AID-BSE38>3.0.CO;2-Q
Heckman J. 1979. Sample selection bias as a specification error. *Econometrica* **47**(1): 153–161. DOI: 10.2307/1912352
Hendricks KB, Singhal VR. 1997. Does implementing an effective TQM program actually improve operating performance? Empirical evidence from firms that have won quality awards. *Management Science* **43**(9): 1258–1274. DOI: 10.1287/mnsc.43.9.1258
Hendricks KB, Singhal VR. 2001. Firm characteristics, total quality management, and financial performance. *Journal of Operations Management* **19**(3): 269–285. DOI: 10.1016/S0272-6963(00)00049-8
Henriques I, Sadorsky P. 1999. The relationship between environmental commitment and managerial perceptions of stakeholder importance. *Academy of Management Journal* **42**(1): 87–99. DOI: 10.2307/256876
Heras-Saizarbitoria I. 2010. Internalization of ISO 9001 and cost efficiency: a study based on cases. *Spanish Journal of Finance and Accounting* **29**(148): 609–636.
International Organization for Standardization (ISO). 2001. ISO 9000 – Selection and Use. ISO: Geneva.
International Organization for Standardization (ISO). 2011. The ISO Survey of Certifications. ISO: Geneva.
Johnstone N, Serravalle C, Scapecchi P, Labonne J. 2007. Project background, overview of the data and summary results. In Environmental Policy and Corporate Behavior, Johnstone N (ed.). Elgar: Northampton; 1–33.
Karapetrovic S, Willborn W. 1998. Integration of quality and environmental management systems. *TQM Magazine* **10**: 204–213.
Kaynak H. 2003. The relationship between total quality management practices and their effects on firm performance. *Journal of Operations Management* **21**(4): 405–435. DOI: 10.1016/S0272-6963(03)00004-4
King A. 1995. Innovation from differentiation–pollution control departments and innovation in the printed-circuit industry. *IEEE Transactions on Engineering Management* **42**(3): 270–277. DOI: 10.1109/17.403745
King A, Lenox MJ. 2001. Lean and green? An empirical examination of the relationship between lean production and environmental performance. *Production and Operations Management* **10**(3): 244–256.
Kitazawa S, Sarkis J. 2000. The relationship between ISO 14001 and continuous source reduction programs. *International Journal of Operations and Production Management* **20**(2): 225–248. DOI: 10.1108/01443570010304279
Klassen RD. 2000. Exploring the linkage between investment in manufacturing and environmental technologies. *International Journal of Operations and Production Management* **20**(2): 127–147. DOI: 10.1108/01443570010304224
Klassen RD, McLaughlin CP. 1996. The impact of environmental management on firm performance. *Management Science* **42**(8): 1199–1214. DOI: 10.1287/mnsc.42.8.1199
Kurapatskie B. 2012. Environmental Sustainability Practices and their Complex Relationships with Business Performance and Production and Transaction Costs. George Mason University: Fairfax, VA.
Kurapatskie B, Darnall N. 2013. Which corporate sustainability activities are associated with greater financial payoffs? *Business Strategy and the Environment* **11**(1): 49–61. DOI: 10.1002/bse.1735
Lakhal L, Pasin F. 2008. The direct and indirect impact of product quality on financial performance: a causal model. *Total Quality Management and Business Excellence* **19**(10): 1087–1099. DOI: 10.1080/14783360802264293
Lawrence AT, Morell D. 1995. Leading edge environmental management: motivation, opportunity, resources and processes. *Research in Corporate Social Performance and Policy Supplement* **1**: 99–126.
Maddala GS. 1983. Limited-Dependent and Qualitative Variables in Econometrics. Cambridge University Press: New York.
Martínez-Costa M, Martínez-Lorente R. 2008. Sistemas de gestión de la calidad y resultados empresariales: una justificación desde las teorías institucional y de recursos y capacidades. *Cuadernos de Economía y Dirección de la Empresa* **34**(Marzo): 7–30.
Mascarenhas B. 1989. Domains of state-owned, privately held, and publicly traded firms in international corporations. *Administrative Science Quarterly* **34**(4): 582–597. DOI: 10.2307/2393568
Melnyk SA, Sroufe RP, Calantone RL. 2003. Assessing the impact of environmental management systems on corporate and environmental performance. *Journal of Operations Management* **21**(3): 329–351. DOI: 10.1016/S0272-6963(02)00109-2
Molina JF, Tarí JJ, Claver E, López MD. 2009. Quality management environmental management and firm performance: a review of empirical studies and issues of integration. *International Journal of Management Reviews* **11**(2): 197–222. DOI: 10.1111/j.1468-2370.2008.00238.x
Netherwood A. 1998. Environmental management systems. In Corporate Environmental Management, Welford R (ed.). Earthscan: London; 37–60.
Nilsson L, Johnson MD, Gustafsson A. 2001. The impact of quality practices on customer satisfaction and business results: product versus service organizations. *Journal of Quality Management* **6**(1): 5–27. DOI: 10.1016/S1084-8568(01)00026-8
Pil F, Rothenberg S. 2003. Environmental performance as a driver of superior quality. *Production and Operations Management* **12**(3): 404–415. DOI: 10.1111/j.1937-5956.2003.tb00211.x
Podsakoff PM, Organ DW. 1986. Self-reports in organizational research: problems and prospects. *Journal of Management* **12**(4): 531–544. DOI: 10.1177/014920638601200408
Potoski M, Prakash A. 2005. Covenants with weak swords: ISO 14001 and facilities' environmental performance. *Journal of Policy Analysis and Management* **24**(4): 745–769. DOI: 10.1002/pam.20136
Powell TC. 1995. Total quality management as competitive advantage: a review and empirical study. *Strategic Management Journal* **16**(1): 15–37. DOI: 10.1002/smj.4250160105
Rungtusanatham M, Forza C, Filippini R, Anderson JC. 1998. A replication study of a theory of quality management underlying the Deming method: insights from Italian context. *Journal of Operations Management* **17**(1): 77–95. DOI: 10.1016/S0272-6963(98)00032-1
Russo MV, Fouts PA. 1997. A resource-based perspective on corporate environmental performance and profitability. *Academy of Management Journal* **40**(3): 534–559. DOI: 10.2307/257052

Ruzevicius J, Adomaitiene R, Sirvidaite J. 2004. Motivation and efficiency of quality management systems implementation: a study of Lithuanian organizations. *Total Quality Management and Business Excellence* **15**(2): 173–189. DOI: 10.1080/1478336032000149018
Sarkis J. 1995. Manufacturing strategy and environmental consciousness. *Technovation* **15**(2): 79–97. DOI: 10.1016/0166-4972(95)96612-W
Scholtes P, Hacquebord H. 1988. Beginning the quality transformation. *Quality Progress* **21**(7): 28–33.
Sharma DS. 2005. The association between ISO 9000 certification and financial performance. *The International Journal of Accounting* **40**: 151–172. DOI: 10.1016/j.intacc.2005.01.011
Sharma S, Vredenburg H. 1998. Proactive corporate environmental strategy and the development of competitively valuable organizational capabilities. *Strategic Management Journal* **19**(8): 729–753. DOI: 10.1002/(SICI)1097-0266(199808)19:8<729::AID-SMJ967>3.3.CO;2-W
Simpson D, Samson D. 2010. Environmental strategy and low waste operations: exploring complementarities. *Business Strategy and the Environment* **19**(2): 104–118. DOI: 10.1002/bse.626
Sroufe R. 2003. Effects of environmental management systems on environmental management practices and operations. *Production and Operations Management* **12**(3): 416–431. DOI: 10.1111/j.1937-5956.2003.tb00212.x
Takahashi T, Nakamura M. 2010. The impact of operational characteristics on firms' EMS decisions: strategic adoption of ISO 14001 certifications. *Corporate Social Responsibility and Environmental Management* **17**(4): 215–229. DOI: 10.1002/csr.199
United States Department of Energy (USDOE). 1998. Environmental Management Systems Primer for Federal Facilities. USDOE, Office of Environmental Policy and Assistance, DOE/EH-0573, and USEPA, Federal Facilities Enforcement Office: Washington, DC.
Welford R. 1992. Linking quality and the environment: a strategy for the implementation of environmental management systems. *Business Strategy and the Environment* **1**(1): 25–34. DOI: 10.1002/bse.3280010105
Wernerfelt B. 1984. A resource-based view of the firm. *Strategic Management Journal* **5**(2): 171–180. DOI: 10.1002/smj.4250050207
York KM, Miree CE. 2004. Causation or covariation: an empirical re-examination of the link between TQM and financial performance. *Journal of Operations Management* **22**(3): 291–311. DOI: 10.1016/j.jom.2004.02.001
Zeng SX, Tian P, Shi JJ. 2005. Implementing integration of ISO 9001 and ISO 14001 for construction. *Managerial Auditing Journal* **20**(4): 394–407. DOI: 10.1108/02686900510592070
Zhang GP, Xia Y. 2013. Does quality still pay? A reexamination of the relationship between effective quality management and firm performance. *Production and Operations Management* **22**(1): 120–136. DOI: 10.1111/j.1937-5956.2012.01341.x