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Green practices-IS alignment and environmental performance: The mediating effects of coordination

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Abstract The problem of environmental sustainability has been growing in recent years with an interest from both researchers and practitioners. A major gap that exists is the absence of empirical studies that addressed business value of green IS (information systems). Thus, drawing on the resource-based view of the firm and IT (information technology) business value literature, this study aims to develop a comprehensive research model of green practice-IS alignment, the key cross-functional coordination of green practices with manufacturing and marketing functions, and firm performance. The study provides a better understanding of the relationship between green practice-manufacturing coordination and green practice-marketing coordination, and how both variables mediated the relationship between green practices-IS alignment and environmental performance. The data used in this study were collected from manufacturing firms. The results show that a firm's green practices-IS alignment had a positive effect on both green practices-manufacturing coordination and green practices-marketing coordination. In turn, both green practices-manufacturing coordination and green practices-marketing coordination are the significant predictors of environmental performance. Meanwhile, green practices-IS alignment had an indirect effect on environmental performance via both green practices-manufacturing coordination and green practices-marketing coordination. Moreover, the findings of this study show that environmental performance is an important predictor of economic performance.

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1 Introduction

Environmental sustainability (ES) has increasingly become important to business research and practice over the past decade as a response to a rapid depletion of natural resources by developed countries and corporate social responsibility (Dao et al. 2011). Both researchers and practitioners have investigated why firms respond to the environmental issues, whether incorporating environmental practices into their business processes can lead to increased performance, and if so, what strategies are needed to achieve the goals (Melville 2010). Also, though previous studies have proposed that organizations are the key players in reducing the environmental footprints (e.g., Melville 2010), the integration of various functions in organization to improve both environmental performance (i.e., reducing environmental footprints) and firm performance remains underresearched.

There is a growing body of evidence showing that green practices directly or indirectly enable a firm to sustain competitive advantages. The extant researches in green management literature have advanced our understanding of the role of green practices in various contexts, such as green information systems (IS) (Bengtsson and Ågerfalk 2011; Steger 2000; Ziegler and Seijas Nogareda 2009), green supply chain management (Zhu and Sarkis 2004, 2007; Zhu et al. 2008), green manufacturing (Ellram et al. 2008; Klassen and Whybark 1999; Routroy 2009), and green marketing (Polonsky and Rosenberger III 2001; Sharma et al. 2010). Moreover, operation researchers have investigated lean production and environmental performance (King and Lenox 2001) and sustainable supply chains (Klassen and Vachon

2003); marketing scholars have examined consumer adoption of green products and the marketing of sustainable business initiatives (Collins et al. 2007).

Furthermore, the increased role of IS in amplifying firms' business sustainability gives rise to the research concern on the role of alignment between green practices and green IS (Bernardo et al. 2009; Dao et al. 2011). As is well known, the literature on information technology (IT) provides that there is a positive relationship between IT and firm performance (Melville et al. 2004; Mukhopadhyay et al. 1995; Zhu 2004). In the green IS stream, Melville (2010, 1–2) define green IS as "IS for environmental sustainability as IS-enabled organizational practices and processes that improve environmental and economic performance." It addresses the development and implementation of green IS that contribute to sustainable business process, consistent with IT business value literature (Watson et al. 2011).

However, few empirical studies have examined the impacts of green IS on a firm's environmental and economic performance. A major gap that exists is the absence of empirical studies that addressed business value of green IS. Specifically, relatively few studies have attempted to address new dimensions of the *alignment* between green practices and green IS and the cross-functional *coordination* between green practices and other business functions (e.g., manufacturing and marketing functions) (Bharadwaj et al. 2007). The integration of those elements into a single empirical research study based on a complementary perspective of green practices and other business functions has not yet been reported (Dao et al. 2011).

Thus, drawing on the resource-based view of the firm (RBV) and IT business value literature, this study aims to develop a comprehensive research model of green practice-IS alignment, the key cross-functional coordination of green practices with manufacturing and marketing functions, and firm performance. Specifically, this study addressed two research questions: (1) how green practices-IS alignment affects both green practices coordination and a firm's environmental performance and (2) how green practices coordination along with other business functions affects a firm's environmental performance.

Before moving to the central part of our argument, the preliminary comments seem necessary in order to provide a proper setting for what we have to conduct an empirical study on green IS. Although green IS area still remains far from fully investigated empirically (Chen et al. 2008), there are a lot of empirical researches in environmental management literature, as reference disciplines of IS discipline (De Giovanni and Esposito Vinzi 2012). According to the work of Elliot (2011) reviewing 140 works from 12 reference disciplines, many studies at empirical levels already were conducted plentifully. To advance theory for green IS stream, researchers are encouraged to take a transdisciplinary approach for developing a deeper understanding of green IS (Elliot 2011; Melville 2010). Also, investigating empirically the potentials of green IS has become increasingly important for researchers and practitioners to advancing green IS research (Jenkin et al. 2011). Thus, the empirical study of this topic is timely and necessary to better help organizations in the green IS principles. To conduct this study and close the research gaps in green IS literatures, this study aims to examine empirically the effects of green practices-IS alignment on both environmental and economic performance. Following the suggestion of Elliot (2011) and Jenkin et al. (2011), we adopted measures from the more well-established disciplines such as environmental management and supply chain management and modified them to green IS context to advance green IS research discipline.

The remainder of this paper proceeds as follows. The next section reviews the relevant theories of green practice and IS and identifies the business value of green IS that may lead to increased environmental performance. And then we develop theoretical hypotheses and research model. Next, the study describes our research methods, followed by the results of the analysis used to validate the hypotheses. Finally, the article closes by discussing the results and their implications.

2 Theoretical backgrounds

2.1 Status Quo of IS research on green IS

Environmental technology is the foremost notion defined by Shrivastava (1995). This concept refers to "production equipment, methods and procedures, product designs, and product delivery mechanisms that conserve energy and natural resources, minimize environmental load of human activities, and protect the natural environment". Such environmental technologies include both hardware such as pollution control equipment and operating methods such as waste management practices.

Drawing on these two dimensions of environmental technologies, terms such as "Green IT" and "Green IS" in IS research and practice are used to frame undertakings that associate IS with environmental sustainability. On the one hand, green IT refers to the use of hardware and software addressing energy consumption and waste reduction (Watson et al. 2010). Examples of "green IT" include green data centers, virtualization software, etc. On the other hand, green IS refers to the development and use of information systems to support or enable environmental sustainability initiatives (Watson et al. 2010). Examples of "green IS" include environmental information systems and green supply chain management systems, etc.

In this paper, we adopt a view of green IS derived from the Watson et al. (2010). In our view, IS as a discipline has an excellent opportunity to contribute to environmental sustainability IT in the larger context of business and social

activity by triggering a socio-technical view of sustainable development and Green IT. Put otherwise, green IS could contribute to such a discourse by focusing on how business processes can and must be re-engineered with the help of green IS as a change enabler in green practices innovation because it incorporates a greater variety of possible initiatives to support sustainable business processes (Watson et al. 2010).

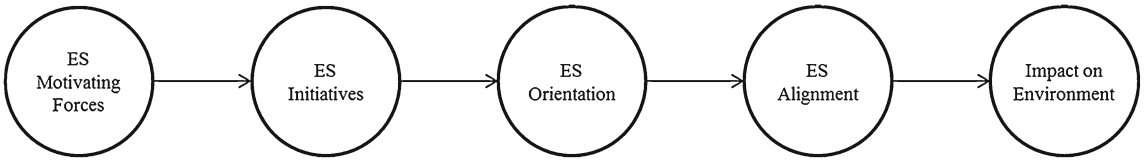
Numerous studies suggest that the potential of green IS to incorporate environmental initiatives into business operations, and thereby enhance firm's environmental and economic performance (Elliot 2011; Melville 2010; Shrivastava 1995; Watson et al. 2010) (Table 1). In recent, Jenkin et al. (2011) suggested green IS framework provides the existing research gaps and implications for green IS research. This green IS framework informs our choices concerning which constructs to include and how to model their interrelationships for conducting and advancing the green IS research. The framework, as shown in Fig. 1, reveals that (1) ES motivating forces: the impacts of ES motivating forces such as laws and social norms on ES initiatives; (2) ES initiatives: the ES initiatives play a role in developing the overall environmental strategies and the resulting technologies (e.g., green IS adoption); (3) ES orientation: other organizational factors such as environmental attitudes, cognitions, and behaviors at both employee and organization levels interact with green IS, whether as mediator or moderator, termed here as ES orientation which is similar to organizational climate or culture, one of complementary organizational resources in IT business value literature; (4) ES alignment: the fit between green practices and green IS and the coordination between green practices and other function's practices (e.g., manufacturing and marketing), consistent with the IT business value perspective; and (5) Impact on environment: the way how to disaggregate the green IS impact construct into meaningful subcomponents and how to measure environmental impact for assessing a firm's environmental performance.

2.2 Green practices and green IS

Although there is no consensus as to a clear and unified framework for green practices (GP), we defined here GP as "environmentally-friendly cooperative activities among the members of an organization to address environmental issues, to reduce environmental impact, and then to capture added value that can

Table 1 Previous empirical study on green IS

Categories	Antecedents	Dependent variables	Research methodology	Previous studies
ES motivating forces	Eco-efficiency motive Eco-effectiveness motive	Adoption of green IT & IT for green	Survey method	(Molla and Abareshi 2012)
	Eco-responsiveness motive			
	Eco-legitimacy motive			
	Personal values Environmental attitudes	Corporate environmental responsiveness	Survey method	(Papagiannakis and Lioukas 2012)
	Subjective norms			
	Self-efficacy			
	Monetary cost-benefit assessment			
	Environmental regulation			
ES initiatives	Ubiquity Uniqueness	Environmental strategic initiatives	Case study	(Watson et al. 2011)
	Unison			
	Universality			
	The capacity of a company's information system	Corporate environmental responsibility	Case study	(Andrea and Marisa 2004)
ES orientation	The environmental sustainability of implementing Information systems	Environmental sustainability	Case study	(Haigh and Griffiths 2008)
	IS implementation to measure key environmental outputs and inputs	Environmental performance	Case study	(Goodman 2000)
ES alignment				N/A
Environmental impacts	The quality of corporate environmental information collection, management, and communication	Environmental impact reduction	Case study	(Erlandsson and Tillman 2009)
	The informating capabilities of green IS (i.e., the capabilities of communication and knowledge sharing within and across functions)	Environmental compliance management performance	Case study	(Tom 2011)



Note 1: ES: Environmental Sustainability.
Note 2: This framework are adopted from Jenkin et al. (2011).

Fig. 1 Green IS research framework

emerge from these activities" (De Giovanni and Esposito Vinzi 2012; Vachon and Klassen 2006). Despite the existence of a contradictive perspective about the effect of green practices on firm performance, most researches in recent green management literature linked green practices to more positive perception of firm performance (Aragon-Correa 1998; Klassen and Whybark 1999; Russo and Fouts 1997). That is because pursuing environmental sustainability is no longer forsaking economically-friendly thinking (Watson et al. 2010).

As this paper seek to study green IS value, we first draw on the resource-based view of the firm (RBV) on how the business value of information technology (IT) is created (Hitt and Brynjolfsson 1996). RBV suggests that unique resources and capabilities represent the main determinants of firm performance relative to rival firms (Barney 1996). In the context of green management, compatible with RBV, some researchers have investigated green issues through the lens of RBV (Christmann 2000; Dowell et al. 2000; Hart 1995). Hart (1995) argues that firms can develop environmentally responsible sustainable strategy to gain profit and shareholder returns. Hart (1995) also proposes that the characteristics of green strategies such as pollution prevention, product stewardship, and sustainable development are identical with those of general resources in that they are valuable, nonsubstitutable, firm-specific and difficult to imitate since they must be bundled into capabilities to perform specific value-added activities. To the same extent, Klassen and Whybark (1999) and Judge and Douglas (1998) find a positive relationship between environmental technology investment and firm performance, leading to the creation of environmental competitive advantages.

Furthermore, based on the arguments of RBV, IT business value research argues that IT influences other resources or processes and capabilities which, in turn, lead to competitive advantage (Wade and Hulland 2004). To gain sustainability capabilities, a firm should have the firm's capabilities to align green practices with green IS (Dao et al. 2011). Green practices-IS alignment refers to the degree to which the IT function supports the goals and priorities of green practices (Tiwana and Konsynski 2010). Such Green practices-IS alignment ensures that organizational green IS activities support a firm's environmental sustainability objectives. In light of this logic, this study would like to argue for the relationship of green IS to a firm's performance. Namely, such green practices should be integrated with environmentally-friendly technologies like green IS to optimize the existing business process from the green perspective (Handfield et al. 1997).

Surprisingly, however, the potential of green IS to advance sustainable practices is often noted but rarely studied in the vast IS literature (Chen et al. 2008). Thus, by extending such line of research, this study will examine the role of green IS, when aligned with green practices, in enabling firms increase environmental performance.

2.3 Coordination of green practices

As discussed above, from the RBV perspective, green practices is regarded as the strategic resources that have a positive impact on environmental product and process innovations and in turn promote environmental performance (Klassen and Whybark 1999; Ziegler and Seijas Nogareda 2009). However, in environmental management, green practices are often difficult to separate from firms' other productive business processes (Hart 1995). Thus, in order to develop capabilities to address environmental sustainability, a firm needs to incorporate green practices and other wide activities by changing business culture and redesigning business processes (Hart 1995; Porter and Kramer 2006).

Besides, since green practices are often regarded as detached from regular business process (Christmann 2000), it is important for organizations to encourage business practices to be congruent and compatible with their initiatives for environmental responsibility (Jenkin et al. 2011). It is a sufficient challenge for most firms to adopt environmentally-friendly business process or to integrate primary business process with green practices. But close coordination of such efforts with significant business process innovation is needed. Correspondingly, organizations are laboring to implement environmentally responsible business practices in order to respond to increasing pressure for environmental responsiveness (Henriques and Sadorsky 1999; Ramus and Steger 2000).

Despite the important role of green practices in increasing firm performance, however, the coordination of green

practices and the focal firm's primary functions such as manufacturing, marketing, and supply chain has never been empirically investigated (Sharma et al. 2010). According to Whang (1995), there are three types of coordination: (a) coordination within operations, (b) cross-functional coordination, such as between manufacturing and marketing, and (c) interorganizational coordination, such as that with supply chain partners. This study focuses on a firm-level environmental performance, and therefore we examine the key cross-functional coordination between green practices as the focal function and other units. Specifically, prior studies on coordination between functions in a firm and its effects on performance basically focused on the coordination with both the manufacturing and the marketing functions as well as the coordination with IS capability (Bharadwaj et al. 2007).

Thus, we identified two major coordination types: (a) green practice's coordination with manufacturing, which refers to the extent to which the green practices and manufacturing functions develop a mutual understanding of each other's capabilities and align their respective goals and activities based on such understanding and (b) green practice's coordination with marketing, which refers to the extent to which the green practices and marketing functions develop a mutual understanding of each other's capabilities and align their respective goals and activities based on such understanding. Consistent with RBV, we argue that green practices-manufacturing and green practices-marketing coordination enable firms develop environmental sustainability capabilities and then enhance environmental sustainability performance.

Furthermore, based on our careful review on the IT business value literature, a growing majority of these studies provide empirical evidences that IT resources enable the firm to generate superior business process performance only when integrated with other business/organizational capabilities. In other words, instead of having a direct effect, IT is likely to have an indirect impact on business process performance through increased coordination among other business activities (Clemons and Row 1991; Devaraj et al. 2007; Melville et al. 2004; Pavlou and El Sawy 2006; Tanriverdi 2005). For example, Melville et al. (2004) suggest that an integrative process-based model of IT value. They posit that IT business value at a firm level is created when IT is deployed properly in conjunction with complementary organizational resources within processes. It assumes that IT will improve business process performance, which in turn leads to superior organizational performance. Thus, this study also proposes that green practices-IS alignment will acts as an enabler of green practices-manufacturing and green practices-marketing coordination affecting environmental performance, not having a direct effect on environmental performance.

In the following section, we will develop our hypotheses. Before we close this section, let us pause to note the boundaries of the present study. As shown Fig. 2, this paper will be limited to consideration of the path from green practices-IS alignment (termed as ES alignment in the Fig. 2) to impacts on environmental performance (termed as impact on environment in the Fig. 2) since we specifically focus on the business value of green IS which has never been examined.

3 Research model and hypotheses

Drawing from RBV and IT business value literature, we developed an integrative model of environmental performance. Figure 3 illustrates our proposed model that posits the relationships among green practices-IS alignment, green practices-manufacturing coordination, and green practices-marketing coordination and the potential impacts of them on environmental performance.

The model proposes that green practices-IS alignment will act as an enabler of green practices-manufacturing coordination and green practices-marketing coordination. We also indicated that there are positive effects of green practices-manufacturing coordination and green practices-marketing coordination on environmental performance. In turn, environmental performance influences economic performance which refers to the decrease of cost for materials purchasing and energy consumption, fee for waste treatment and waste discharge, and fine for environmental accidents.

3.1 Green practices-IS alignment and green practices coordination

A business's capability to comply with the mounting demands of different environmental groups and government regulations and take actions to reduce its environmental impacts might affect its competitiveness (Molla et al. 2009). An initiative such as purchasing green IS is one of the most visible statements any firm can make about its environmental responsiveness. To achieve this capability, various types of green IS have been implemented in the firms (Bernardo et al. 2009) due to the capability of the green IS in improving the environmental practice of a company (Watson et al. 2010).

Meanwhile, IT business value literature suggests that IT can influence performance either directly or indirectly, through the promotion of the effectiveness and efficiency of inter-firm activities such as integration (Clemons and Row 1991; Devaraj et al. 2007; Melville et al. 2004; Pavlou and El Sawy 2006; Tanriverdi 2005). However, the interaction between IS and green practices has received a special attention from few IS scholars (for except, Melville 2010; Molla et al. 2009; Watson et al. 2010). Traditionally, IT

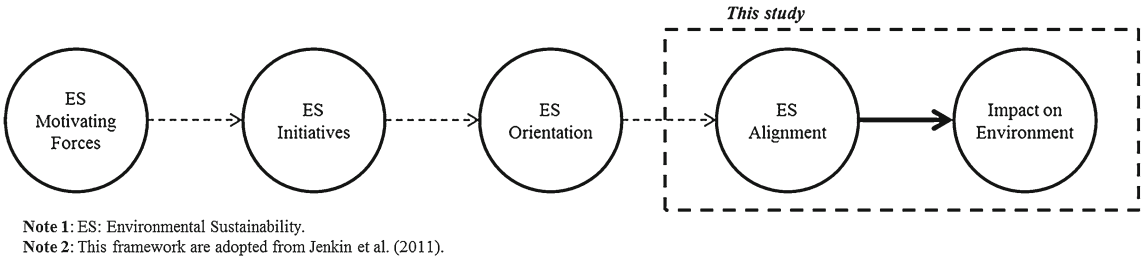


Fig. 2 Boundaries of the present study

alignment is the extent to which a firm's information technology is compatible with its activities which IS support (Kearns and Sabherwal 2006; Wu et al. 2006). Likewise, in the context of green IS, green practices-IS alignment refers to the extent to which the green practices is associated with IS functions in order to develop and strengthen goals and activities based on sustainability perspective.

To interrelate green practice-IS alignment with the coordination between green practice and other business processes, we draw on the RBV perspective that specifies the role of the coordination among business processes. As many firms have accepted the necessity to do no harm to the environmental sustainability, they move toward cleaner products and production processes. However, in spite of a growing awareness of the necessity of the business logic for greening, many firms usually regard green practices as detached from routine business processes. In recent, after reviewing the recent research on green practices, Dao et al. (2011) assert that IT resources enable firms to develop sustainability capabilities via its integration with other resources and/or functions.

Building on IT business value literature, firms with ample alignment between green practices and IS have the potential to be substantial using green IS to support the coordination between green practices and other business processes (Melville et al. 2004). In the absence of the green practice-IS alignment, the firm's activities may have only limited impacts on the environmental initiatives. Various scholars have represented that IT can facilitate the cross-functional coordination by decreasing coordination costs (Bharadwaj et al. 2007). Although previous studies have not specifically focused on the value of IT alignment between green practices and IS, they implicitly indicated that there is a positive relationship between green practices-IS alignment and the coordination of green practices. Thus, we hypothesized that green practice-IS alignment should help improve the coordination between

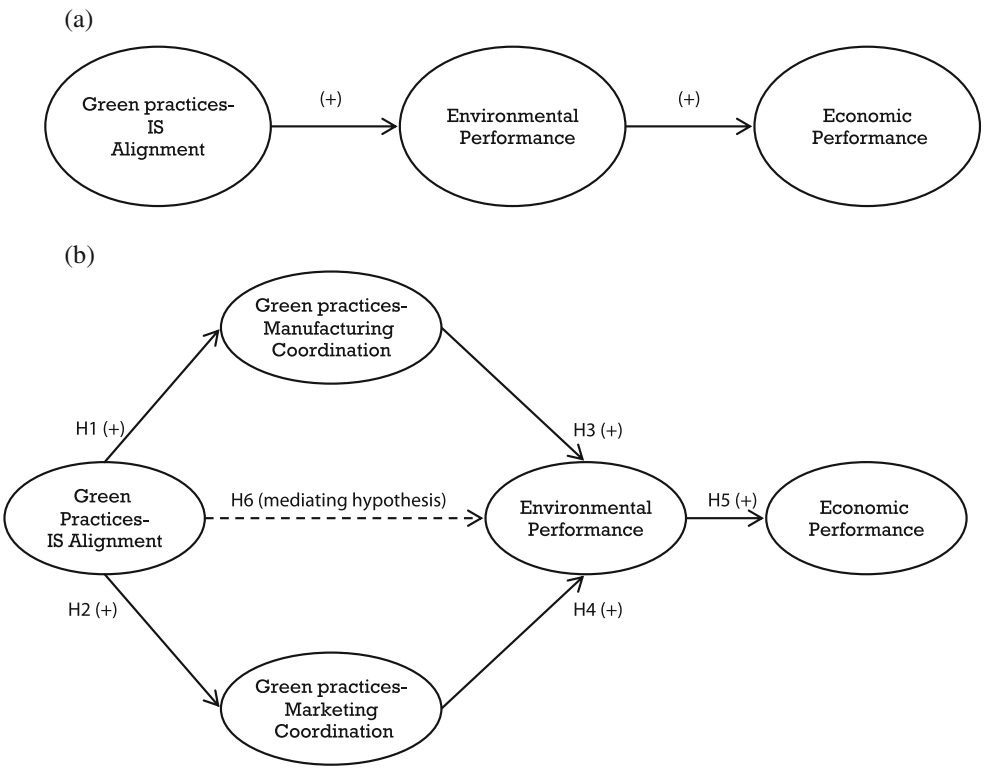


Fig. 3 Theoretical model: **a** initial model, **b** proposed model of mediating effect of green practices-manufacturing coordination and green practices-marketing coordination

green practices and other business processes, specifically manufacturing and marketing processes.

H1: Green Practices-IS alignment has a positive effect on green practices-manufacturing coordination.
H2: Green Practices-IS alignment has a positive effect on green practices-**marketing** coordination.

3.2 Green practices coordination and performance

As firms perceive the value of green practices in terms of competitive advantages, the firms will take the green initiative in this matter (Esty and Porter 1998; Marcus and Geffen 1998). To get the competitive advantages of green practices, firms simultaneously harmonize the green practices with the other resources and available business processes (Bremmers et al. 2009). For example, Zhu et al. (2008) showed that the performance of green supply chain management (SCM) depends on the coordination with their partners' business processes around environmental issues. When SCM partners can develop the coordination between green practices and supply chain practices, they can get jointly benefits from environmental practices including environmentally greater efficiencies in lead time and inventory management (Geffen and Rothenberg 2000; Rao 2002).

Meanwhile, although the researcher pays scant attention on the inter-functional coordination around environmental issues in a firm, it is also critically necessary in some routine processes of inter-functional in a firm as well as inter-firm. The conceptual work of Aragon-Correa and Sharma (2003) posits that cross-functional capabilities around environmental issues increases firms' ability to implement proactive corporate environmental strategies and performance. In recent years, many manufacturing firms have adopted green practices not only to promote internal coordination with manufacturing, but also to facilitate external coordination with other operations (Seuring and Müler 2008). Dowell et al. (2000) assert that innovations in the manufacturing or production process can reduce or eliminate pollution. In the context of such environmentally-friendly innovations in manufacturing functions, firm's conscious effort to heighten the coordination with green practices leads to increased environmental performance such as the reduction of pollution and waste. That is, greater coordination between green practices with manufacturing facilitates the development of sustainable products and environmental performance. Hence, we hypothesized:

H3: Green practices-manufacturing coordination has a positive effect on environmental performance.

Marketing activities relate to production and consumption process–they influence product portfolio and the communication efforts of the producer (Rex and Baumann 2007) . In the era of green paradigm, green marketing also has an important role of "*integrating approach that continually reevaluates how firms can achieve their objectives and meet consumer needs*" (Polonsky and Rosenberger III 2001). The aim of green marketing is to include environmental issues in the marketing efforts. In other words, if we provide consumers with better information about the green properties of the product offered, they are likely to include this information in their purchasing decisions (Rex and Baumann 2007). Like the green practice coordination with manufacturing, green practice coordination with marketing function such as targeting, positioning, promotion based on sustainable paradigm leads the firm into improved environmental performance (Sharma et al. 2010). Hence, we hypothesized:

H4: Green practices-marketing coordination has a positive effect on environmental performance.

Currently, many organizations have an opportunity to deal with sustainable development while improving productivity, reducing costs, and enhancing profitability (Watson et al. 2010). The outcomes of environmentally-friendly organizational practices and processes may be assessed at the organizational and environmental level —e.g., the economic impacts of pollution reduction and the economic costs and environmental benefits such as reducing the energy costs (Melville 2010). Most research in the sustainability literatures have shown many empirical evidences that there is a positive relationship between environmental and economic performance (Klassen and Whybark 1999). Consistent with the previous research, strong environmental performance is associated with a better economic performance (Seuring and Müler 2008). Hence, we hypothesized:

H5: Environmental Performance has a positive effect on Economic Performance.

3.3 Mediation of green practices-IS alignment by green practices coordination

This study posits that there is an indirect impact of green practice-IS alignment on environmental performance through the mediating role of both green practices-manufacturing coordination and green practice-marketing coordination. Following the IT business value literature (Pavlou and El Sawy 2006; Stieglitz and Heine 2007; Tanriverdi 2006), IT alignment does not necessarily lead to an improvement of performance, but it has an indirect impact on the performance by directly improving process-level capabilities and performance (Dong et al. 2009).

Drawing on these arguments, we proposed that the effect of green practice-IS alignment on environmental performance is mediated by green practices-manufacturing coordination and green practices-marketing coordination. We expect firms that possess and control green practices-IS

alignment will develop capabilities related to green practices coordination with other functions more easily, and in turn improve their environmental performance. Hence, we hypothesized:

> H6: (a) Green Practices-Manufacturing Coordination and (b) Green Practices-Marketing Coordination will mediate the relationship between Green Practices-IS alignment and environmental performance.

4 Research methods

4.1 Measures

All constructs were measured using existing validated scales which were adapted to the study context. All variables were measured with multi-item instruments on a five-point Likert scale anchored from "strongly disagree" to "strongly agree". Table 8 of Appendix shows the specific instruments that were used to collect data. To maintain the consistency, an English version of the questionnaire was first translated into the Korean by one of the authors. Then, the Korean version was translated back into English by a professional editor.

In regard with antecedents of environmental performance, green practices-IS alignment refers to the degree to which the IT function supports the goals and priorities of green practices. Items to measure green practices-IS alignment were adapted from Bharadwaj et al. (2007). With regard to mediating factors, green practices-manufacturing coordination refers to the extent to which the green practices and manufacturing functions develop a mutual understanding of each other's capabilities and align their respective goals and activities based on such understanding. Meanwhile, green practices-marketing coordination refers to the extent to which the green practices and marketing functions develop a mutual understanding of each other's capabilities and align their respective goals and activities based on such understanding. Green practices-manufacturing coordination and green practices-marketing coordination were adapted from Bharadwaj et al. (2007).

As dependent variables, environmental performance and economic performance were measured using Zhu and Sarkis (2004)'s scale on environmental performance and operational financial performance. We used a measurement scale for environmental performance based on sustainability perspective as followings: (1) improvements to current processes or creation of new processes, (2) cost efficiencies of energy and materials use, (3) learning about customers and markets for our products, (4) creation of new products, product enhancements, and (5) development of new business opportunities. For economic performance was measured the reduction of cost-related indicators such as cost for materials purchasing, fee for waste treatment, and fine for environmental accidents.

4.2 Sample and data collection

To test the proposed model, the data used in this study were collected by survey methodology. The questionnaire was administered to the employees of manufacturing firms in South Korea. Each respondent is responsible for the environmental management practices of his/her firm, assuring the validity of sample selection in this study. A web-based survey was used over a period of two months. In order to maximize the response rate and ensure the data quality, respondents were offered 5$ incentive to the respondent. A total of 102 were received, however, among those, cases with missing data were excluded. Finally, hypotheses were tested using the final sample of 77. The profile of the respondents and the firms is given in Table 2.

Since this study used a convenience sampling method, nonresponse bias test by comparing the respondents and nonrespondents was not applicable to this study. Thus, nonresponse bias was assessed by verifying that responses on principal constructs did not differ significantly between the early responses (first 25 %, 20 firms) and the late responses (last 25 %, 20 firms). Early respondents were classified by selecting those that responded in the first 3 weeks. As shown in Table 3, the results of t-tests showed no significant differences at a 0.05 level, suggesting that nonresponse bias was low.

5 Data analysis and results

This study used structural equation modeling called Partial Least Squares (PLS) to analysis the research model. PLSGraph3.0 was used to perform statistical analysis. Because PLS enables the researchers to place minimal demands on sample size and

Table 2 Profile of the respondents and the firms

The distribution of sample		Percentage
Respondent profile	Top management	23.4
	Director	22.1
	Manager	45.5
	Other management	9.1
Company profile (employees)	Below 100	23.4
	100–200	6.5
	200–300	2.6
	300–400	2.6
	400–500	1.3
	Over 500	63.6
Company profile (2010 annual sales: billion)	Below 0.01	9.1
	0.01–0.1	5.2
	0.1–1	18.2
	1–10	29.9
	10–100	37.7

Table 3 Analysis of non-response bias

Construct	Early respondents (n=20)	Late respondents (n=20)	Significance (p-value)
GP-IS	3.09	3.32	.431
GP-MF	3.52	3.73	.456
GP-MK	3.24	3.41	.518
ENV	3.53	3.49	.830
ECP	3.31	3.40	.711

residual distribution (Chin 1998) and is most suitable for early studies for theory development (Byrd et al. 2006), it would be a reasonable methodological alternatives for this study.

5.1 Measurement model

For the measurement model, each construct was modeled to be reflective. This study assessed the measurement model by examining reliability, convergent validity, and discriminant validity. First, overall, the reliability of the measurement scales is satisfied with the recommended 0.70 threshold (Gefen et al. 2000). All items except for one item in economic performance exhibit the standardized loadings of 0.75 or higher on their respective constructs, and thus Table 2 shows that the results of the subsequent analyses which are conducted excluding this item.

For establishing convergent validity, we examined the internal consistency for each measure. As illustrated in Table 4, the composite reliability (CR) scores of all constructs exhibited 0.90 or higher, which is very higher than the recommended 0.70 cut-off. Also, the recommended threshold for average variance extracted (AVE) is 0.5, meaning that 50 % or more variance of the indicators is accounted for (Gefen et al. 2000; Straub et al. 2004). As shown in Table 4, all of our constructs in this measurement model exceeded the recommended criteria for AVE, ranged from 0.67 to 0.88. Taken together, these results clearly support the convergent validity of the measures used in this study.

Finally, discriminant validity was assessed in two ways (Gefen et al. 2000): (1) examined whether each indicator loads more highly on its own construct than another constructs; (2) compared the square root of AVEs of each construct from its correlations with the other constructs. First, Table 9 of Appendix exhibits that each measure loaded more highly on their intended construct than other constructs. Second, Table 5 shows that the correlations between the constructs reported in

Table 4 Reliabilities of constructs

Construct	Indicator	Loadings	T-stat. (*p<0.01)	Composite reliability	AVE
Green practices-IS alignment	GP-IS1	0.94	56.82*	0.97	0.88
	GP-IS2	0.93	43.90*		
	GP-IS3	0.94	51.67*		
	GP-IS4	0.96	89.51*		
	GP-IS5	0.92	53.02*		
Green practice-manufacturing coordination	GP-MF1	0.94	56.31*	0.97	0.85
	GP-MF2	0.91	32.44*		
	GP-MF3	0.93	44.66*		
	GP-MF4	0.94	53.77*		
	GP-MF5	0.91	23.76*		
Green practices-marketing coordination	GP-MK1	0.93	46.27*	0.96	0.82
	GP-MK2	0.90	35.08*		
	GP-MK3	0.91	36.86*		
	GP-MK4	0.92	53.31*		
	GP-MK5	0.85	22.23*		
Environmental performance	ENV1	0.77	15.65*	0.91	0.67
	ENV2	0.83	20.97*		
	ENV3	0.83	21.90*		
	ENV4	0.83	20.39*		
	ENV5	0.82	18.44*		
Economic performance	ECP1	0.75	7.60*	0.90	0.74
	ECP2	0.92	42.20*		
	ECP3	0.91	50.89*		

Table 5 Descriptive statistics and latent variable correlation matrix

	Mean	SD	VIF	GP-IS	GP-MF	GP-MK	ENV	ECP
GP-IS	3.36	0.85	2.11	**0.94**				
GP-MF	3.59	0.81	2.45	0.64	**0.92**			
GP-MK	3.31	0.72	2.02	0.65	0.62	**0.91**		
ENV	3.57	0.68	2.14	0.55	0.67	0.52	**0.82**	
ECP	3.36	0.69	1.57	0.46	0.49	0.44	0.57	**0.86**

GP-IS Green Practices-IS Alignment; *GP-MF* Green Practices-Manufacturing Coordination; *GP-MK* Green Practices-Marketing Coordination; *ENV* Environmental Performance; *ECP* Economic Performance

***VIF* Variance inflation factor

***The bold numbers on the leading diagonal are the square root of the variance shared between the constructs and their measures

the lower left off-diagonal elements in the matrix are lower that the diagonal elements which is the square root of AVEs. Summing up, the confirmatory factor analysis and the correlation matrix results provide sufficient evidence for discriminant validity of our measurement model.

Since the data used in this study were collected from a single respondent, this might raise a concern of common method bias. To address this problem, Harman's one-factor test was conducted to analyze the extent to which common method bias might influence our findings (Podsakoff and Organ 1986). The results revealed five factors explaining 81.79 % of the variance in all constructs and the first factor explaining 20.02 % of the total variance, far below the recommended 50 % threshold (Podsakoff and Organ 1986). These results imply that common method bias is not a significant issue in our study.

5.2 Structural model

The results of the PLS analyses for the structural model is reported in Tables 6 and 7 and Fig. 4. The path coefficients *t*-values for the PLS structural model were computed using 300 re-sampling with bootstrapping (Chin et al. 2003). Figure 4(b) shows the explained variances (R^2) values for the full model, in which the R^2 values of green practices-manufacturing coordination, green practices-marketing coordination, environmental performance, and economic performance are 0.41, 0.43, 0.48, and 0.33, respectively.

As shown in Table 7, green practices-IS alignment has a positive effect on both green practices-manufacturing coordination (H1, $t=7.73$, $p<0.001$) and green practices-marketing coordination (H2, $t=7.37$, $p<0.001$). In addition, both the path from green practices-manufacturing coordination to environmental performance (H3, $t=8.12$, $p<0.001$) and the path from green practices-marketing coordination to environmental performance (H4, $t=1.96$, $p<0.05$) turn out to be significant. Furthermore, environmental performance is significantly associated with economic performance (H5, $t=7.35$, $p<0.001$).

Research hypothesis 6 in this study predicts both green practices-manufacturing coordination and green practices-marketing coordination will mediate the effects of green practice-IS alignment on environmental performance. To test this mediating effects of them, we adopted the logic of Baron and Kenny (1986) and followed their three-step procedure. First, this study tested the direct effect of green practices-IS alignment on environmental performance. As shown in Fig. 4 (a), we found green practices-IS alignment has a direct positive effect on environmental performance ($t=7.63$, $p<0.001$). However, the proportion of R^2 for environmental performance decreased from 48.2 % in the full model in Fig. 4(b) to 30.4 % in the initial model in Fig. 4(a). After these mediating variables are added to the initial model, the previously significant direct effect of green practices-IS alignment on environmental performance became insignificant (see Fig. 4(b)).

Also, to determine whether both green practices-manufacturing coordination and green practices-marketing

Table 6 The results of Sobel mediation test

Test	Path	Beta	S.E.	T-stat	*p*-value
GP-IS → GP-Manufacturing → ENV	GP-IS → GP-Manufacturing	0.64	0.08	5.71	0.000
	GP-Manufacturing → ENV	0.57	0.07		
GP-IS → GP-Marketing → ENV	GP-IS → GP-Marketing	0.65	0.07	1.97	0.049
	GP-Marketing → ENV	0.17	0.08		

Table 7 The results of measured research model

Hypothesis		Path coefficient	Outcome
H1	Green Practices-IS → Green Practices-Manufacturing	0.64***	Supported
H2	Green Practices-IS → Green Practices-Marketing	0.65***	Supported
H3	Green Practices-Manufacturing → ENV	0.57***	Supported
H4	Green Practices-Marketing → ENV	0.17*	Supported
H5	ENV → ECP	0.57***	Supported
H6	Mediating Hypothesis:		
	Green Practices-IS → ENV (direct effect)	0.55***	
	Expected non-significant direct effect in the presence of the effects of:	0.16(n.s.)	Supported
	- Green Practices-Manufacturing;		
	- Green Practices-Marketing		

One-tailed significance levels: *$p<0.05$, **$p<0.01$, ***$p<0.001$

coordination fully mediate the relationships between green practices-IS alignment and environmental performance, we formally tested the mediating effect of both green practices-manufacturing coordination and green practices-marketing coordination following the approach recommended by Sobel (1982). The results in Table 6 show that the reported p-values are within ±1.96, the critical values of the test ratio and thus indicate mediation by both green practices-manufacturing coordination and green practices-marketing coordination, respectively. Taken together, green practices-manufacturing coordination and green practices-marketing coordination fully mediate the effects of green practices-IS alignment on environmental performance, supporting H6.

Meanwhile, because Table 5 showed some relatively high correlations among some variables (e.g., a correlation of 0.67 between green practices-manufacturing coordination and environmental performance), we tested all constructs of multicollinearity in our model by examining the variance inflation factor (VIF) values. The resultant VIF values for all of our constructs did not exceed 2.5 (ranged from 1.57 to 2.45), far below the recommended threshold of 10 (Chatterjee and Price 1991). Thus, the results indicate no serious concerns with multicollinearity in the data.

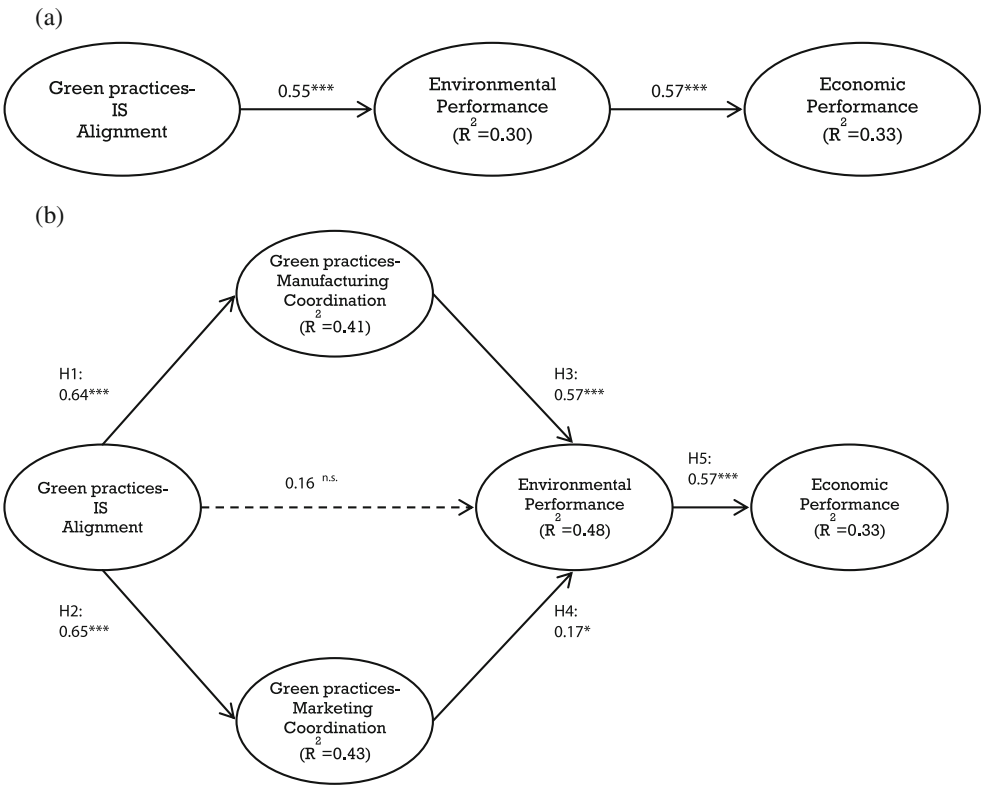


Fig. 4 Results of PLS analysis: **a** initial model, **b** proposed model of mediating effect of green practices-manufacturing coordination and green practices-marketing coordination

6 Discussions

6.1 Discussion of the results

The present study is one of the earliest empirical academic studies on the emerging green IS stream. Drawing on RBV and IT business value literature, this study attempts to describe how green practices-IS alignment affects a firm's environmental performance and how green practices' coordination with manufacturing and marketing affects a firm's environmental performance.

This study contributes to the green IS literature in three primary ways. First, this study explores the underresearched constructs regarding with green IS, which is very important in enhancing environmental performance. Despite the rise of interests in green IS, few have attempted to address empirically the links among green IS alignment with green practices, green practice coordination with other functions, and its consequences on organizational performance (Sharma et al. 2010). To better understand the impacts of green IS, this study developed new instruments to measure three concepts of green practices-IS alignment, green practices-manufacturing coordination, and green practices-marketing coordination, respectively and then validated them empirically. Consistent with IT business value literature, the results of this study support that green practices-IS alignment positively affect outcome variable such as environmental performance via green practices-manufacturing coordination and green practices-marketing coordination.

Second, another significant contribution of this study is its examination of the roles of green practices-manufacturing coordination and green practices-marketing coordination in the sustainability perspective. The study explores the association of green practice coordination with other functions, which is very important in achieving environmental performance. We showed that the coordination of green practices with the other functions are critical, especially to facilitate the potential impact of green IS on environmental performance. Specifically, the results of this study support that green practices-manufacturing coordination and green practices-marketing coordination mediate the relationship between green practices-IS alignment and environmental performance, i.e., green practices-IS alignment positively influences environmental performance, by enhancing green practice-manufacturing coordination and green practices-marketing coordination (Dao et al. 2011).

Finally, this study attempts to examine the relationship between environmental performance and economic performance. Although some studies suggest that following environmentally-friendly business comes with economic costs, contrary to this perspective, recent green IS studies suggest that following environmentally-friendly business makes all stakeholders be satisfied. The results of this study support that environmental performance influences economic performance. This result indicates that economic performance which has been influenced by environmental performance may motivate firms to participate in green practices (Vachon and Klassen 2006).

6.2 Implications

This study offers some implications for researchers and practitioners. First, given the theoretical and practical importance of developing measurement scale regarding with the alignment between a green practices and green IS, we introduced a study based on an empirical survey of manufacturing firms. For researchers, the study provides a reason for researchers to use the IT business value for green IS research as the results showed that green practices-IS alignment were significant. Practically, this measurement is to help manufacturers understand the strength and weakness of the implementation of their green practices-IS alignment. Furthermore, firms should consider aligning IS with green practices to improve environmental performance in the future (Berkhout and Hertin 2004).

Second, this result implies that green practices should be coordinated with other functions in order to achieve optimal environmental performance. However, besides manufacturing and marketing functions shown in this study, such coordination must be extended to other functions in a firm to achieve more improved environmental performance (Bremmers et al. 2009). Theoretically and practically, human resources and supply chain should be coordinated with green practices in order to increase fully environmental performance (Dao et al. 2011).

Finally, this result of the study provides a reasonable answer why organizations should be encouraged to go green. For researchers, the way how to accurately measure environmental and economic performance remains marginal to green IS stream (Jenkin et al. 2011). To develop more accurate and IS-related measures of environmental impacts would give a deeper understanding of the effects of green IS. Practically, the results of this study are to help firms understand the potential values of green practices. Firms should recognize that ES has emerged not only as an important organizational challenge but also opportunity to create competitive advantage (Melville 2010).

6.3 Future research and limitations

Although the present study offered several contributions to the literature concerning green practices, we acknowledge the limitations of this study. First, all of our samples were located in South Korea and the sample is a little skewed toward smaller firms. The characteristics of our sample used in the model were a convenience sample rather than a random sample. Hence, the

interpretation of our results is subject to the constraints of cultural characteristics of smaller firms as well as one country, thus the results of this study should be interpreted with some caution. In order to increase the external validity of the findings of this study, future research incorporating a sample from multiple companies in other countries is needed.

Second, this study did not cover all green practice coordination with other functions, e.g. supply chain (Dao et al. 2011). The omitted green practice coordination may have affected the results of the study. Thus, the findings of this study should be interpreted with some caution, and then future study incorporating these omitted variables is needed.

Third, our sample size only consists of 77 manufacturing firms. Although the number of firms adopting green practices may not be large so far, the sufficient sample size can better validate our research model. Thus, future research should consider the issue of sample size effects to avoid over fitting problems.

Another area of fruitful investigation would be to look into how cross-functional conflicts influence the coordination of green practices with other functions with green IS. Enhancing the positive impacts of green IS, organizations need to resolve conflict issues such as cross-functional asymmetric dependency in integrating green practices, green IS, and other functions business process. Future research could profitably look into how this conflict issues would be solved. Furthermore, given the important role played by green practices-IS alignment, future research should examine the impact of integration of IT technical and human resources with green practices which are critical in enabling firms to develop sustainability capabilities (Bharadwaj et al. 2007).

Appendix

Table 8 Measurement items for key constructs

Construct	Items
Green practices-IS alignment	The green IS aligns with the company's mission, goals, objectives, and strategies based on sustainability perspective.
	The green IS contains quantified goals and objectives based on sustainability perspective.
	The green IS contains detailed action plans/strategies that support company's sustainability direction.
	We invests in green IS to align our technology with green practices.
	Our green IS is well aligned with our green practices.
Green practice-manufacturing coordination	*In our firm, the green practices area coordinates frequently with manufacturing area …
	… to increase manufacturing's understanding of the green practices
	… to help develop an understanding of manufacturing's technical requests for the green practices
	*In our firm, the green practice staff …
	…work with manufacturing staffs to customize the green practices to their needs
	… helps manufacturing staffs obtain information and reports from the green practices relevant to them
	… provide ongoing training on the use of the green practices
Green Practices-Marketing Coordination	*In our firm, the green practice area coordinates frequently with marketing area …
	… to increase marketing's understanding of the green practices
	… to help develop an understanding of marketing's technical requests for the green practices
	*In our firm, the green practice staff …
	… work with marketing staffs to customize the green practices to their needs
	… helps marketing staffs obtain information and reports from the green practices relevant to them
	… provide ongoing training on the use of the green practices
Environmental Performance	Improvements to current processes or creation of new processes based on sustainability perspective
	Cost Efficiencies of energy and materials use based on sustainability perspective
	Learning about customers and markets for our products based on sustainability perspective
	Creation of new products, product enhancements based on sustainability perspective
	Development of new business opportunities based on sustainability perspective
Economic Performance	Decrease of cost for materials purchasing
	Decrease of fee for waste treatment
	Decrease of fine for environmental accidents

Table 9 Item-factor loadings and cross-loadings

Construct	Item	GP-IS	GP-MF	GP-MK	ENV	ECP
Green practices-IS alignment (GP-IS)	GP-IS1	0.94	0.55	0.62	0.50	0.38
	GP-IS2	0.93	0.56	0.60	0.45	0.37
	GP-IS3	0.94	0.61	0.59	0.56	0.46
	GP-IS4	0.96	0.64	0.65	0.52	0.50
	GP-IS5	0.92	0.64	0.60	0.53	0.46
Green practice-manufacturing Coordination (GP-MF)	GP-MF1	0.59	0.94	0.55	0.64	0.51
	GP-MF2	0.55	0.91	0.52	0.62	0.40
	GP-MF3	0.57	0.93	0.56	0.61	0.38
	GP-MF4	0.60	0.94	0.64	0.63	0.47
	GP-MF5	0.65	0.91	0.60	0.61	0.51
Green practices-marketing coordination (GP-MK)	GP-MK1	0.57	0.60	0.93	0.49	0.35
	GP-MK2	0.57	0.59	0.90	0.46	0.38
	GP-MK3	0.54	0.54	0.91	0.49	0.38
	GP-MK4	0.61	0.54	0.92	0.50	0.39
	GP-MK5	0.66	0.54	0.85	0.42	0.47
Environmental performance (ENV)	ENV1	0.53	0.57	0.32	0.77	0.38
	ENV2	0.39	0.54	0.34	0.83	0.43
	ENV3	0.49	0.60	0.54	0.83	0.50
	ENV4	0.46	0.52	0.49	0.83	0.52
	ENV5	0.37	0.53	0.42	0.82	0.51
Economic performance (ECP)	ECP1	0.33	0.36	0.44	0.39	0.75
	ECP2	0.40	0.47	0.41	0.48	0.92
	ECP3	0.44	0.44	0.31	0.59	0.91

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