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Zhaojun Yang
Xidian University, zhaojunyang@xidian.edu.cn

Jun Sun
University of Texas Rio Grande Valley, jun.sun@utrgv.edu

Yali Zhang
Northwestern Polytechnical University, zhangyl@nwpu.edu.cn

Ying Wang
University of Texas Rio Grande Valley

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Zhaojun Yang, School of Economics and Management, Xidian University, Xi'an, China, zhaojunyang@xidian.edu.cn

Jun Sun, College of Business and Entrepreneurship, University of Texas Rio Grande Valley, Edinburg-Brownsville-Harlingen, Texas, USA., jun.sun@utrgv.edu

Yali Zhang, School of Management, Northwestern Polytechnical University, Xi'an, China, zhangyl@nwpu.edu.cn

Ying Wang, College of Business and Entrepreneurship, University of Texas Rio Grande Valley, Edinburg-Brownsville-Harlingen, Texas, USA, ying.wang01@utrgv.edu

Abstract

Contemporary organizations recognize the importance of green innovation for their competitive advantages in the long run, and most existing studies focus on its impacts on organizational performances. Based on the resource-based view, this study examines the roles that green information systems (IS) infrastructure and green culture play in green innovation as tangible and intangible resources. In addition to their direct impacts, green IS infrastructure and green culture may have indirect relationships with green innovation through the alignment between two as well as their alignments with green innovation. The hypothesized triadic relationships among green IS infrastructure, green culture and green innovation effectiveness were tested with survey observations collected from organizations in China. The statistical analyses supported all the direct relationships as hypothesized, but yielded mixed results on the mediating relationships. The alignment between GIS and green innovation had positive effect, the alignment between green IS and green culture had insignificant effect, and the alignment between green culture and green innovation had negative effect. In addition, each aspect of alignment played somewhat different roles across organizations of different sizes.

Keywords: Green Information Systems, Green Innovation, Green Culture, Perceived Alignment.

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1 INTRODUCTION

In the current global advocacy of green economy, each country faces the environmental challenge to keep up in the "green race" (Fankhauser et al., 2013). In this context, green innovation at the organizational level is widely regarded as the essential means to the end of ecological competitiveness (Abimbola, Hillestad, Xie, & Haugland, 2010; Chang, 2011; Chen, 2008). A considerable number of studies have confirmed that the implementation of green innovation not only helps the environment, but also contributes to organizational performance, competitiveness, and corporate green image or brand (Ar, 2012; Chen, 2007; Chiou, Chan, Lettice, & Chung, 2011; Tseng, Wang, Chiu, Geng, & Lin, 2013).

Among the studies that examined the organizational performance related to green innovation, some include its adoption drivers as the antecedents (Bernauer, Engels, Kammerer, & Seijas, 2007; Qi, Shen, Zeng, & Jorge, 2010; Weng & Lin, 2011). For those organizations that have decided to adopt or are in the process of implementing green innovation, however, it is also important to understand what existing factors and conditions may affect green innovation practice and effectiveness. Researchers identify the relevant factors and conditions as follows: absorptive capacity (Gluch, Gustafsson, & Thuvander, 2009), stakeholders and culture (Guoyou, Saixing, Chiming, Haitao, & Hailiang, 2013), green organizational identity (Chang & Chen, 2013), corporate environmental ethics (Chang, 2011), and green intellectual capital (Chen, 2007). In particular, the emergence of green information systems (GIS) is seen as an important organizational resource that contributes to the well development and functioning of green innovation (Bengtsson & Ågerfalk, 2011; Faucheux & Nicolaï, 2011; Melville, 2010).

Based on a case study, Cabrera, Cabrera and Barajas (2001) suggested that that the success of organizational innovations depends on the mutual alignment between new technologies and pre-existing conditions like organizational culture and structure. Though researchers have examined green culture and green IS quite extensively, there is a lack of empirical findings on the alignment between them. Thus the main purpose of this study is to investigate the synergetic effect of technological and cultural factors on green innovation.

As Russo and Fouts (1997) pointed out, organizations need to assemble and integrate capabilities/resources into manageable bundles. And such organizational capabilities cannot be evaluated in isolation as their values manifest through mutual integration and interplay (Collis & Montgomery, 1995). In addition, organizational innovation research reveals that organizational culture also plays an important role (Büschgens, Bausch, & Balkin, 2013; Claver, Llopis, Garcia, & Molina, 1998; Khazanchi, Lewis, & Boyer, 2007; Naranjo-Valencia, Sanz-Valle , & Jiménez-Jiménez, 2010). Despite the presence of a few studies on green culture (Porter-O'Grady & Malloch, 2010; Wirtenberg, 2014), it has not been examined together with other organizational capabilities, especially Green IS.

From a holistic perspective, this study aims to investigate the relationships among green innovation, GIS and green culture. In addition to the direct effects that GIS and green culture may have on green innovation, there are potential indirect effects through the mediation of the alignments between two of them. Based on literature review, this study develops a research model and tests it with empirical observations collected from organizations. The findings may enrich the green innovation literature by examining the roles of GIS and green culture together, and provide helpful insights for organizations to integrate their cultural, technological and innovative efforts in their green endeavour.

2 KEY COMPONENTS OF GREEN ENDEAVOUR

2.1 Green Innovation

In recent years, green innovation has captured the attention of researchers and practitioners as an emerging organizational innovation. The appearance of the term can be traced back to the concept of

eco-innovation concept that describes "new products and processes which provide customer and business value but significantly decrease environmental impacts" (Fussler & James, 1996). Since then, there have been quite a few studies on the topic with the same or similar terms like environmental innovation and sustainable innovation (Brunnermeier & Cohen, 2003; Geffen & Rothenberg, 2000; Carrion-Flores & Innes, 2010; Verghese & Lewis, 2007; Oltra & Saint Jean, 2009; Theyel, 2000; Horbach, 2008; Foxon & Pearson, 2008; Schiederig, Tietze, & Herstatt, 2012). Largely synonymous and interchangeable, these terms can be categorized under the umbrella term of "green innovation".

In a classical publication that redefines organizational innovation, Rennings (2000) pointed out three kinds of changes towards sustainable development: technological innovation, organizational, and social/institutional innovation. For organizational innovation, in particular, Hellström (2007) suggested that green innovation requires the integration of "hardware and software" resources as well as new and existing technologies in an organization to cope with different innovation types (e.g radical vs. incremental) and modes (e.g. component vs. architectural). Therefore, green innovation is a complex organizational endeavour that has been examined in different contexts, such as green research and development (Bartlett & Trifilova, 2010; Pujari, 2006), green supply chain management (Lee, Ooi, Chong, & Seow, 2014), green corporate image (Amores-Salvadó, Castro, & Navas-López, 2014) and green organizational identity (Chang & Chen, 2013).

Researchers mainly investigate green innovation from three aspects: its own components (i.e. construct dimensions), antecedents (i.e. explanatory variables), and consequences (i.e. outcome variables). The primary challenge for empirical studies is in construct measurement, especially for the multi-dimensional construct of green innovation. In addition to the direct ecological effort, the success of green innovation also depends on the necessary changes in products, processes, and organizational structures (Arundel & Kemp, 2010; Cheng & Shiu, 2012). Thus, it is not appropriate to measure green innovation as a unidimensional construct. For instance, Arundel and Kemp (2010) argued that eco-innovation measurement should include four aspects: input, intermediate output, direct output and indirect impact. Similarly, Carrillo-Hermosilla, del Río and Könnölä (2010) has developed an analytical framework to explore the diversity of eco-innovations along several key dimensions including design, user, product service and governance. Despite the difference in details, it is clear that green innovation is a multidimensional concept including technical and non-technical elements.

In addition, researchers are interested in the factors that affect green innovation, or its antecedents. Green innovation may involve the factors at different levels, and organization-level factors play a fundamental role in comparison with industry-, region-, and country-level factors. Organizational factors deserve close attention because the green innovation effort is never purely policy-driven, but a result of balancing between short-term profitability and long-term sustainability in managerial praxis (Bernauer et al., 2007; Schiederig et al., 2012). For instance, Bernauer et al. (2007) suggested that organizations need to get ready internally for green innovation to embrace the external challenges and opportunities of environmental regulations and market demands. Empirical evidence confirmed that a firm's internal initiatives, environmental regulations and market demands are all important to its green innovation success (Qi et al., 2010; Zailani et al., 2015). Based on the Technology-Organization-Environment (TOE) framework, Weng and Lin (2011) found that the technical characteristics such as complexity, compatibility and relative advantage also affect green innovation adoption in addition to organizational, market and regulatory factors.

Green innovation is likely to have different implications on the consequences from general innovation as well. Most existing studies treated green innovation as one subtype of general organizational innovation without paying much attention to its unique features and impacts, such as multi-dimensional performances (e.g. economic, environmental and social), technology support (e.g. green supply chain management and green information systems), and cross-sector collaboration (e.g. suppliers, customers, stakeholders). This makes it difficult for existing green innovation research to highlight its difference with existing organizational innovation research. However, green innovation differs from general innovation from innovation process and driving factors to consequences and performance (Jakobsen, 2014; Cuerva, Triguero-Cano, & Córcoles, 2014; Jakobsen & Clausen, 2015).

Because innovation processes within firms with higher environmental goals has some peculiarities not shared by innovation processes motivated by other objectives, environmental innovation process will often be more complex and challenging than the non-environmental innovation process (Jakobsen & Clausen, 2015).

Therefore, green innovation is a complex organizational endeavour that requires the design and implementation of eco-friendly products, green supply chain management and green information systems. In addition to the "hardware", the effort requires the support of "software", especially the organizational culture related to green innovation, or "green culture". The success of green innovation largely depends on the alignment between such hardware and software (Hellström, 2007).

2.2 Green Culture

Extant literature examines the relationship between organizational culture and green innovation from different aspects. First, it is found that green culture affects employee awareness related to green innovation. Fok, Zee, Susan and Hartman (2012) studied the relationships among individuals' green orientation, employee perceptions of organizational commitment to the green movement, and organizational culture. Employees in organizations of which culture is aligned with the green movement are likely to participate in sustainability effort, and enhance relevant organizational performance and positive environmental impact.

In terms of the relationship between green culture and organizational strategy, researchers found that strong environmental culture helps organizations implement green strategy (Fraj, Martínez and Matute, 2011). Moreover, how well environmental values are integrated into organizational culture influences the effect of green strategy on ecological and business performance (Moreton et al., 2005).

Sugita and Takahashi (2015) found that organizational culture comprises different aspects that play different roles in environmental management or sustainability management, and organizations need to cultivate green culture to guide employee behaviour in different aspects of their collective effort. Based on a case study of nine companies in various industries, Wirtenberg (2014) analysed how they defined, developed, and integrated sustainability into organizational culture and strategy as well as employees' mentality, and gave a practical guidance on how organizations build green culture by taking advantage of their unique capabilities, knowledge and purposes to cater to both long-term sustainability goal and short-term profitability requirement. In the healthcare field, for another example, Porter-O'Grady and Malloch (2010) found that the transformation of organizational cultures is inseparable from the involvement of individuals, the work of innovation, an infrastructure for significant cultural change, and new decision-making models.

The theories of organizational innovation suggest that organizations' internal factors are essential to green innovation. According to the resource-based view, such internal factors include strategy, structure, and core capabilities (Fagerberg, Mowery, & Nelson, 2005). In addition, intangible factors like personnel-based resources also play the role that cannot be ignored (Bernauer et al., 2007). As an intangible resource, organizational culture is related to the internal climate that supports or impedes organizational creativity and innovation (Claver, Llopis, Garcia, & Molina, 1998; McLean, 2005; Qin, Zhao, & Yao, 2013; Steiber & Alänge, 2013). On one hand, an organizational culture proactive to green innovation often leads to competitive advantage ("AU Optronics Corporation leads in green innovation," 2013). On the other, bad or mismatched culture may negatively affect the organization's environmental management, green innovation and relevant performance (Sugita & Takahashi, 2015).

From the theoretical perspective, the existing studies highlight the importance of organizational culture to sustainable development and environmental management. Yet there is still a lack of empirical studies on the relationship between organizational culture and green innovation. Based on the current literature of organizational culture, therefore, this study will investigate the research question whether and how green culture may affect green innovation?

2.3 Green IS Infrastructure

Whereas organizational culture can be regarded as an intangible "software" resource that provides necessary environment for environmental management, green information system (IS) can be regarded as a tangible "hardware" resource that provides the necessary technical infrastructure and support to green innovation. Based on the resource-based view, Tarafdar and Gordon (2007) found that six IS competencies can differentially affect the conception, development and implementation of process innovations, and they are: knowledge management, collaboration, project management, ambidexterity, IT/innovation governance, and business-IS linkages.

There are a few empirical studies on the relationship between general IS and business innovation. In an exploratory case study, Anaya, Dulaimi and Abdallah (2015) examined the roles that enterprise information systems play in within-organization innovation. For cross-organization innovation, IS may also facilitate the effort by enhancing the communication with other organizations like suppliers and clients (Ganotakis, Hsieh, & Love, 2013), as well as the quality of service through service innovation (Chaparro-Pel áez, Pereira-Rama, & Pascual-Miguel, 2014).

Nevertheless, there is still a lack of empirical studies on the relationship between green IS and green innovation. Although green IS and green innovation sharing the common goal of sustainable development, they play different roles in organizations. In addition to the resource-based view that treats green IS as a "hard" resources, the general IT alignment literature have also investigated the relationship between system characteristics and organizational characteristics (e.g. strategy and culture) in terms of how to implementing technology to facilitate and support long-term endeavour (Gallivan & Srite, 2005; Cui et al., 2015).

3 MUTUALITY AMONG KEY COMPONENTS

The above literature review suggests that green culture and green IS can be regarded as the soft (i.e. intangible) and hard (i.e. tangible) resources that facilitate the strategic endeavour of green innovation. Regarding the relationships between organizational resources and strategic activities, the general alignment theory provides an overarching framework. There are generally six perspectives of alignment: fit-as-moderation, fit-as-mediation, fit-as-matching, fit-as-gestalts, fit-as-profile-deviation, and fit-as-covariation (Venkatraman, 1989). Green culture and green IS provides the social environment and technological infrastructure necessary for green innovation, the success of which largely depends on how well the two types of resources meet its requirement. In this sense, fit-as-matching gives appropriate theoretical mechanism and analytical scheme to conceptualize and operationalize the alignment among them, as depicted in Figure 1.

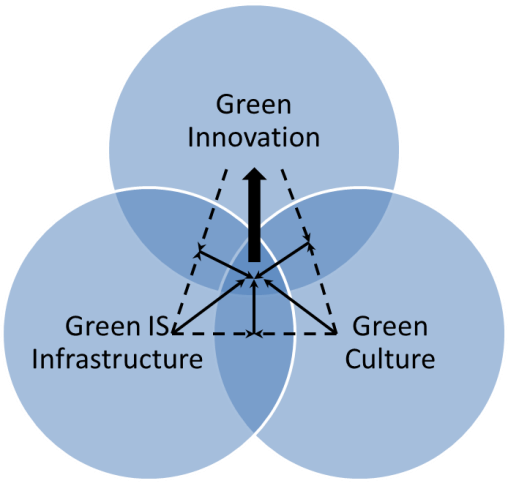

Figure 1. Conceptual Framework

3.1 Organizational Innovation and IS Infrastructure

For organizations, the implementation of information systems is increasingly seen as the key enabler of organizational innovation rather than just for cost-efficiency consideration (Ashurst et al., 2012). Information technology may promote innovation as an intellectual technology that interacts with the intellect of the human users (Lee, 1999). The technology extends the intellects of its users, leading to an ongoing cycle of organizational innovation and change (Ashurst et al, 2012).

From the perspective of knowledge management, Pellissier (2008) believes that organizations may facilitate process-, product-, service-, technology- and management-related aspects of innovation by aligning technology with innovation. From an IT capability view, organizations may utilize technological advances to innovate and differentiate, leading to IT-enabled business value (Carcary et al., 2015). Thus, the implementation of IT promotes the process, service and management innovation in organizations (Al-Mashari, 2006; Müller et al, 2012; Chae, 2014).

Information technology supports organizational innovation through the complex interaction among different factors, rather than a simple technology adoption or diffusion process. Based on the resource-based view, for instance, Huang & Liu (2000) found that the interaction between innovation and IT capital has a positive effect on firms' performance. At the strategic level, Cui et al.'s (2015) findings also confirmed that alignment between IT strategy and open innovation strategy enhances organizational performance.

To summarize, researchers suggest that organizations need to align technology capability with innovation requirement to achieve optimal resource allocation and competitive advantage. Although there are not many studies on Green IS and Green Innovation, the existing literature concerning the relationship between general IS and corporate innovation still provides a theoretical basis.

3.2 Organizational Innovation and Organizational Culture

Similarly, there are not many studies on the relationship between green innovation and green culture. Yet researchers have also confirmed the important role that organizational culture plays in organizational innovation (Ahmed, 1998; Jaruzelski, Loehr & Holman, 2011). The consensus is that organizations should establish a supportive cultural environment conducive to the promotion of innovation (Khazanchi, Lewis & Boyer, 2007; Naranjo-Valencia, Jiménez-Jiménez & Sanz-Valle, 2011). Nevertheless, a number of studies found that different types of organizational endeavour call for different strategies of cultural cultivation (Herzog & Leker, 2010). For instance, Naranjo-Valencia, Jiménez-Jiménez & Sanz-Valle (2011) found that adhocracy culture fosters the pioneer strategy to lead the market (e.g. developing new products) and hierarchical culture promotes the imitator strategy to follow a pioneer.

Furthermore, organizational culture is a multi-dimensional construct. It is found that the mission and consistency dimensions ensure stability and direction, whereas adaptability and involvement dimensions allow change and flexibility (Denison and Mishra, 1995). This dual nature requires the cultivation of organizational culture through internal integration and external adaptation (Schein, 1990), leading to ambidextrous organizational culture (Wang & Rafiq, 2014). In terms of organizational innovation, ambidextrous organizational culture affects the development of new products, services and processes through contextual ambidexterity (Wang & Rafiq, 2014).

Green culture is also likely to have this dual characteristics, namely internally integration of shared vision, and external adaptation to the changes in policy and market. Naturally green culture can be considered as moderating factors that can significantly promote green innovation if they can be aligned with each other through mutual and dynamic adjustment.

3.3 IS Infrastructure and Organizational Culture

Following a values-based approach, Leidner and Kayworth (2006) reviewed the literature on the linkage between IT and culture, and it is found that the existing research have examined culture's impact on IT, IT's impact on culture, and IT culture. In addition, they developed a theory that there is a mutual influence between organizational culture and IT as well as a potential conflict of values. It suggests that the reconciliation of the conflict results in a reorientation of values, which requires organizations to appropriately address the relationship between IT value and culture fit.

From the fragmentary perspective, Gallivan and Srite (2005) presented a more holistic view of culture, and identified four stages of theory development regarding the relationship between IT infrastructure and organizational culture: 1) technological determinism that IT impacts organizational and their cultures; 2) the organizational imperative to change organizations and their cultures; 3) the interactionist view of IT and culture; 4) IT-culture fit as an emergent process. Although country-level culture is considered relatively stable, organizational culture is considered malleable. Both stages 3) and 4) suggest the importance of interaction and integration between IT infrastructure and organizational culture for their alignment optimal to corporate performances.

For green innovation, the same logic may apply: green culture and green IS may interact and align with each other through mutual influence and accommodation. In the long run, the implementation and adoption of green IS will shape organizational culture to be more eco-friendly, which will in turn enhance green IS usage at different levels in an organization.

4 RESEARCH MODEL AND HYPOTHESES

Green innovation, green culture and green IS in organizations are closely related to each other, and researchers must examine their relationships in a holistic system rather than separately. The alignment between green innovation and green IS, or innovation-GIS fit, captures how well GIS implementation support the accomplishment of green innovation goal. Once an organization establishes the strategy of green innovation, it needs to implement appropriate GIS functionalities to facilitate the endeavour. A mismatch is likely to prevent employees from fully utilizing GIS to fulfil green innovation. The alignment between green culture and green innovation, or culture-innovation fit, indicates how green innovation is in line with green culture. For example, an organization of a stronger green culture faces less resistance from employees in the adoption of green innovation approaches like paperless office and teleconferencing. Meanwhile, such green innovation endeavour may as well strengthen green culture in the long run. Similarly, the alignment between green culture and green IS, or culture-IS fit, reflects the degree of cohesion between GIS implementation and green culture. If an organization has a relatively weak green culture, for instance, it probably needs to take effort to justify GIS expenditure and persuade employees to use the newly implemented functionalities.

As the two different types of foundations, GIS infrastructure and green culture are likely to have direct impacts on green innovation. In addition, there may be indirect effects through the mediation of alignments among the three components of green endeavour. The premise is that if the components are aligned with each other, the supportive roles that green IS infrastructure and green culture play will be optimized in terms of green innovation effectiveness as the outcome variable. The direct and indirect relationships are hypothesized in the research model as shown in Figure 2.

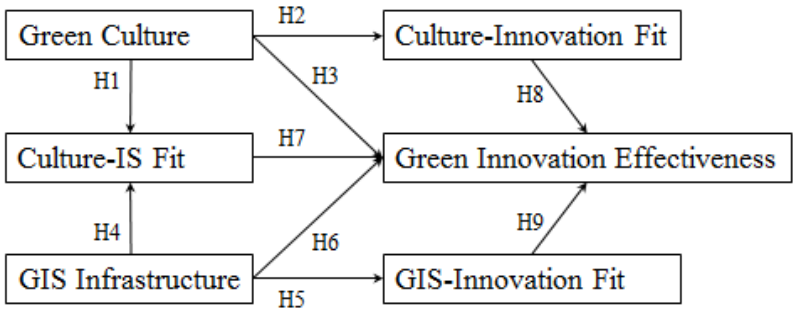

Figure 2. Research Model

Compared with the traditional organizational innovation, green innovation emphasizes sustainable development and may not necessarily bring competitive advantage in the short run. Thus the two types of innovation require somewhat different ways of outcome assessment. In addition to economic indicators like cost and revenue, broader-scope measures may be used to evaluate environmental and social impacts of green innovation. Thus this study uses green innovation effectiveness to capture the multi-dimensional outcome of such organizational endeavour.

4.1 Green Culture-Related Hypotheses

Organizational culture has been considered an important factor for the success of an organization, especially in the IT-driven global environment (Cameron & Quinn, 2011). For sustainable-development-oriented organizations, the establishment of a good green culture enhances environmental management and performance. Choo et al. (2008) found that IS-related organizational culture will affect system usage and user behaviour. Organizations that establish green culture and implement green IS, therefore, need to pay attention to the alignment between two.

Similarly, organizational culture in many studies is also seen as an important factor that influences organizational innovation (McLean, 2005; Qin, Zhao, & Yao, 2013; Steiber & Alänge, 2013). Yang & Hsu (2010) study found certain aspects of organizational culture can significantly affect organizational innovation. This requires innovation-driven organizations to consider the impact of organizational culture and pay attention to aligning organizational culture with innovation activities.

Organizational culture comprises multiple dimensions in terms of adaptability, consistency, involvement, and mission, which play somewhat different roles in organizational effectiveness (Denison, 1990; Denison and Mishra, 1995). The same dimensions of green culture also pertain to green innovation (Porter-O'Grady and Malloch, 2010). An organization of relatively high level of adaptability tends to change its operation, technology and structure to survive the ecological tide. Consistency and involvement largely determine the efficiency of collective effort of organizational members in green endeavour, as the two dimensions indicate agreement and participation. Finally, mission provides direction and guidance to the collective effort, such as GIS implementation and use, as it is related to an organization's purpose as shared by employees.

In an organization with a good green culture, therefore, employees are more receptive to green concepts and practices, and more active in green innovation activities. In addition, the organization is more likely to seriously examine and continuously adapt its culture to green innovation. Hence the following hypotheses:

H1：Green Culture has a positive effect on Culture-IS Fit.

H2：Green Culture has a positive effect on Culture-Innovation Fit

H3：Green Culture has a positive effect on Green Innovation Effectiveness

4.2 GIS-Related Hypotheses

In an organization, information system infrastructure and organizational culture are closely related with each other. Claver et al. (1990) suggested that system implementation and adoption shape relevant organizational culture in terms of informatic culture and informational culture. The former is a material symbol of the culture that entails the acceptance of using IT as a critical organizational activity, whereas the latter also concerns how employees capture and utilize information and data through organizational behavior.

Southern and Murray (1994) believed that the use of IS contributes to a better organizational culture. Meanwhile, Silvius, Smit and Driessen (2010) also found that certain aspects of organizational culture like "governance" and "partnership" play an important role in the implementation and adoption of information systems. According to Claver et al.'s (1990) point of view, information systems and green culture may combine and form green informational culture, which can be seen as an organizational resource as well as an organizational capacity. When an organization has better IS infrastructure, therefore, it is more likely to achieve the desired alignment between GIS and Green Culture.

From the resource-based view, information systems provide necessary infrastructure for organizational innovation (Tarafdar & Gordon, 2007; Anaya, Dulaimi, & Abdallah, 2015). For cross-organization innovation, information systems facilitate service innovation by enhancing communication and quality of service (Ganotakis, Hsieh, & Love, 2013; Chaparro-Peláez, Pereira-Rama & Pascual-Miguel, 2014). Green innovation usually involves the collaboration within and cross organizations to accomplish ecological goals, which requires green IS to provide necessary technical support. Therefore, green IS infrastructure is critical to Green Innovation, as indicated in the following hypotheses:

H4: Green IS Infrastructure has a positive effect on Culture-IS Fit

H5: Green IS Infrastructure has a positive effect on GIS-Innovation Fit

H6: Green IS Infrastructure has a positive effect on Green Innovation Effectiveness

4.3 Alignment-Related Hypotheses

The basic premise of resource-based view is that an organization must effectively integrate various resources to achieve its managerial goals. Based on the ecological modernization theory, Huang and Li (2014) found that environmental innovation strategy and resource alignment between partners are positively related to green innovation performance, and resource alignment plays a moderating role in the relationship between environmental innovation strategy and green innovation performance. The three aspects of green innovation, including product innovation, green process innovation and green management innovation, all require the effective integration of organizational resources (Chen et al., 2006; Chiou et al., 2011; Damanpour et al., 2012).

Researchers also found that cultural factors as intangible resources make a difference in organization creativity and innovation (Claver, Llopis, Garcia, & Molina, 1998; McLean, 2005; Qin, Zhao, & Yao, 2013; Steiber & Alänge, 2013). Therefore, the establishment of environment-friendly culture consistent with sustainable development objectives facilitates green innovation.

Organizational culture can be defined as the values, principles, traditions and conventions shared by the members of an organization that regulate their behaviour (Denison & Mishra, 1995). Compared with other tangible organizational resources, therefore, green culture is unique in that it provides a common context for all employees to participate in green activities. For the same ecological goal, the alignment between green culture and green IS reflects the integration of two tangible and intangible resources, the alignment between green culture and green innovation reflects the integration of intangible resources and business operations, and the alignment between green IS and green innovation reflects the integration of tangible resource and business operations. The degree of alignment or misalignment affects how employees utilize organizational resources and carry out

business operations, leading to different levels of performance. Therefore, all aspects of alignment contribute to green innovation in organizations, as hypothesized below:

H7: Culture-IS Fit has a positive effect on Green Innovation Effectiveness

H8: Culture-Innovation Fit has a positive effect on Green Innovation Effectiveness

H9: GIS-Innovation Fit has a positive effect on Green Innovation Effectiveness

5 METHODOLOGY

To test the research model, this study collected survey observations from organizations that pursue ecological goals in their operations. The target population is the employees of those organizations in China. Known as the "world's factory", this largest emerging economy faces the challenge of environment protection and embraces the opportunity sustainable development.

5.1 Measurement

From the perspective of employees, the survey questionnaire captures the constructs in the research model. Green IS Infrastructure were measured with items adapted from Gholami et al. (2013)'s study. Measures of Green Culture were adapted from Denison and Mishra (1995)'s items. Measurement of Green Innovation came from Chen et al.(2006), Chiou et al.(2011) and Damanpour et al.(2012)'s study. Measures of different aspects of alignment were derived from Lin & Huang (2008)'s scales. All the measurement items were measured with 5-point Likert scale in the questionnaire.[1]

5.2 Survey Method and Sample

Online and on-site survey questionnaires were sent to the contacts of 500 companies. Altogether, 368 valid responses were obtained, of which 194 were from the on-site survey (53%) and 174 were from the on-line survey (47%). Among the respondents, 7% were at the senior management level, 32 % were at middle level, 61% were at the operational level, and 0.3% (only one case) was not reported. In terms of organizational size, 48% respondents were from big enterprises that had over 1000 employees, 13% between 500 and 1000, 19% between 100 and 500, and 20% below 100.

Possible response bias due to different data collection methods was assessed. The MANOVA test comparing on-site versus online responses showed no significant difference (Wilks' lambda=0.827, p=0.196). On-site responses were typically obtained immediately, but online responses usually take some time from several hours to a few weeks after emailed invitations. As the responses were not sensitive to response time, nonresponse bias is not a big concern (Armstrong and Overton, 1977).

This study also conducted Harman's one-factor test to evaluate common method bias (Podsakoff et al., 2003; Podsakoff et al., 2012). A factor analysis on all the measurement items suggest that the first unrotated factor explained 25.248% of total variance, whereas all factors with Eigen value larger than 1 explained 62.176% of total variance. Thus the majority of the variance was not commonly shared.

6 RESULTS

Table 1 gives reliability coefficients and descriptive statistics of each construct. All the reliability coefficients were above the threshold of 0.7, indicating that the responses are internally consistent. Also the descriptive statistics suggest that responses were generally quite positive. The variance inflation factors (VIF) were all below 5, indicating that the multi-collinearity issue is not a big concern.

[1] Due to the space limit, the measurement items cannot be listed here, but will be included in conference presentation.

Construct	Dimension	Items	Alpha	Mean	S.D.	VIF
Green Culture	Adaptability	3	0.73	3.79	0.69	2.85
	Consistency	3	0.81	3.65	0.77	2.35
	Involvement	3	0.79	3.63	0.82	2.14
	Mission	3	0.83	3.72	0.75	2.50
Green IS	Pollution prevention	3	0.88	3.77	0.80	2.72
	Product stewardship	3	0.86	3.77	0.78	3.41
	Sustainable development	4	0.86	3.84	0.74	2.58
Green Innovation Effectiveness	Product innovation	5	0.85	3.68	0.72	2.21
	Process innovation	5	0.85	3.80	0.66	3.08
	Managerial innovation	6	0.88	3.73	0.70	2.81
GIS-Culture-Fit		5	0.90	3.75	0.68	
Culture-Innovation-Fit		5	0.91	3.76	0.69	
GIS-Innovation-Fit		5	0.91	3.72	0.68	

Table 1. Reliability Coefficients and Descriptive Statistics

The main statistical analysis tool used is partial least square (PLS-SEM) to accommodate the reflective-formative higher-order nature of latent constructs (Wetzels, Odekerken-Schröder & van Oppen, 2009; Hair, Hult, Ringle & Sarstedt, 2013). Following the common practice of item packaging when reliability coefficients are all acceptable, the index score of each dimension of Green Culture, Green IS and Green Innovation Effectiveness was calculated based on the average of item responses, and used as a formative indicator.

Table 2 reports the estimates of path coefficients for the overall sample, as well as the split samples across organization sizes. For the overall sample, the direct effects of both GIS Infrastructure (β = 0.477, $p < 0.01$) and Green Culture (β = 0.376, $p < 0.01$) on Green Innovation Effectiveness were significantly positive as hypothesized. Each of the two exogenous variables also contributed to the alignment between them (Culture->GIS-Culture-Fit: β = 0.313, $p < 0.01$; GIS->GIS-Culture-Fit: β = 0.48, $p < 0.01$) as well as their alignments with Green Innovation in a positive way (Culture->Culture-Innovation-Fit: β = 0.637, $p < 0.01$; GIS->GIS-Innovation-Fit: β = 0.648, $p < 0.01$). The effects of three alignment variables, however, were quite mixed. In terms of their effects on Green Innovation Effectiveness, GIS-Innovation-Fit (β = 0.152, $p < 0.05$) was positive and significant, GIS-Culture-Fit (β = 0.025, ns) was positive but not significant, and Culture-Innovation-Fit (β= -0.117, $p < 0.1$) was negative and marginally significant, indicating the suppression effect of Culture-Innovation-Fit (cf. Hair et al., 2013). Together, the results suggest partial mediation for GIS-Innovation-Fit and Culture-Innovation-Fit, but no mediation for GIS-Culture-fit.

Path	Overall	Big	Small-Med	Diff
Control：Size->Green Innovation Effectiveness	-0.028	/	/	/
Control：Age->Green Innovation Effectiveness	0.065*	0.051	0.026	0.024
Culture->Culture-Innovation-Fit	0.637***	0.634***	0.659***	0.025
Culture->GIS-Culture-Fit	0.313***	0.315***	0.298**	0.017
Culture->Green Innovation Effectiveness	0.376***	0.371***	0.354***	0.017
Culture-Innovation-Fit->Green Innovation Effectiveness	-0.117*	0.011	-0.198**	0.209*
GIS->GIS-Culture-Fit	0.48***	0.543***	0.436***	0.106
GIS->GIS-Innovation-Fit	0.648***	0.68***	0.619***	0.061
GIS->Green Innovation Effectiveness	0.477***	0.365***	0.534***	0.17
GIS-Culture-Fit->Green Innovation Effectiveness	0.025	0.212*	-0.058	0.269**
GIS-Innovation-Fit->Green Innovation Effectiveness	0.152**	-0.002	0.227***	0.229**

Table 2. Estimates of Path Coefficients (*Note: *-Sig. at 0.1 level; **- Sig. at 0.05 level; ***-Sig. at 0.01 level)*

In terms of the mediating effects, Green IS's alignment with Green Innovation was more important than its alignment with Green Culture to the dependent variable (GIS -> Green Innovation Effectiveness's indirect effect: β= 0.111, t value: 2.515, p = 0.012; Culture -> Green Innovation Effectiveness's indirect effect: β= -0.067, t value: 1.595, p = 0.111). It seems that organizations should focus on aligning Green IS with Innovation rather than aligning it with Green Culture. Though culture counted in its direct effect on green innovation, their alignment with each other had even a negative effect on the dependent variable. So organizations may found it important to nurture the culture for long-term support, but it is not worth the effort to adjust the culture to green innovation endeavour.

Table 2 also reports the results of a multi-group analysis based on organization size. First, the path between Culture-Innovation-Fit and Green Innovation Effectiveness varied across large and small/medium organizations (βdiff = 0.209, p <0.1). Whereas the path was significant for small and medium enterprises (β = -0.198, p <0.05), it was not for larger ones (β = 0.011, ns). The second path that yielded distinct estimates between two groups was between GIS-Culture-Fit and Green Innovation Effectiveness (βdiff = 0.269, p <0.05). It was more significant for large enterprises (β = 0.212, p <0.01) than for small and medium enterprises (β = -0.058, ns). Finally, organization size made a difference in the path between GIS-Innovation-Fit and Green Innovation Effectiveness (βdiff = 0.229, p <0.05). This time, it was more significant for small and medium enterprises (β = 0.227, p <0.01) than for large enterprises (β = -0.002, ns).

The results suggest that large and small/medium enterprises have their own advantages and disadvantages in green innovation endeavor. Bigger companies are more capable of integrating intangible cultural resource and tangible IS resource to promote green innovation. Smaller companies have the upper hand to quickly adopt GIS to support green innovation, yet are more susceptible to the negative effects of possible misalignment. Compared with large organizations, small and medium organizations are usually more agile and flexible to embrace new technology but also easier to run the risk of bleeding edge as one form of misalignment.

Compared with green culture, green IS is more flexible and closely related to green innovation, and GIS-innovation fit makes more sense to organizations. It is possible that the effort to align green IS with green innovation takes less time to show effects, whereas it takes longer for culture-innovation fit: when organizational culture is adjusted to green innovation, the endeavour may already switch in its focus activity. Actually, aligning culture to either green IS or green innovation can be somewhat meaningless or even counter-productive. Yet, culture is something that the organization should cultivate from the very beginning to provide the supporting environment for both green IS and green innovation. Therefore, it supports the notion that organizational culture is an intangible resource that provides a relatively stable context for green efforts.

7 CONCLUSION AND IMPLICATIONS

This study examines the roles that green IS infrastructure and green culture play in green innovation. Based on the literature review, a research model was developed to capture the triadic relationships involving the direct effects of green IS infrastructure and green culture on green innovation as well as their indirect effects through the mediation of mutual alignments among the three. The hypothesized relationships were tested using survey observations collected from organizations in China. The results supported most of the hypotheses, and suggested that the relationships may vary across organizations of different sizes.

The major limitation of this study is that the observations were collected from a single country sample. In China, most organizations either voluntarily or are forced to embrace the opportunity of green innovation and green technology to sustain competitive advantages and comply with regulatory requirements. In this sense, the observations were valid. Yet organizational culture may somewhat depends on national culture, which may vary significantly from one country to another. Future studies may conduct cross-country analyses by collecting observations from multiple countries and regions.

Despite the limitations, this study yields some interesting and useful insights for researchers and practitioners. First of all, it examines the major components of green organizational endeavour and their relationships. Existing studies on organizational innovation based on the alignment perspective typically include two factors and the fit between them. Yet, green innovation depends on the tangible technological resource as well as intangible cultural resource. This study incorporates both types of resources and investigates their effects on green innovation through triadic relationships. The findings may contribute to the literature by providing a more comprehensive understanding of how different components interact with each other in green organizational endeavour.

The findings suggest that green innovation is indeed an extremely complex phenomenon. For an organization to succeed in achieving the ecological goals, it must establish sufficient green IS infrastructure, and align it with the endeavour. In addition, it must consider the existing organizational culture and cultivate new green culture. Organizations of different sizes may pursue different strategies to align green culture with green innovation and green IS infrastructure.

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