

Translating green strategic intent into green process innovation performance: the role of green intellectual capital

The role of
green
intellectual
capital

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Abstract

Purpose – Many firms struggle to implement strategies that can successfully enhance the environmental sustainability of their processes. Drawing on the theories of green intellectual capital and complementary assets, this study develops a model describing the mechanism whereby firms can translate a green (i.e., environmental) strategy into a superior green process innovation performance (GPIP).

Design/methodology/approach – Regression analysis of multi-source survey data collected from 514 managers at 257 firms (257 top management members and 257 safety or environmental managers) was used to test the hypotheses.

Findings – A firm's green strategic intent has positive effects on the three aspects of green intellectual capital (i.e., human, organizational and relational capital). In turn, these three aspects have positive effects on GPIP. Moreover, green organizational capital positively moderates the effect of green relational capital on GPIP, whereas it negatively moderates the effect of human capital on GPIP.

Research limitations/implications – In order to implement a green strategy successfully, especially in polluted industries such as the chemical industry, managers need to develop not only the firm's tangible resources but also its intangible resources. The more they invest in green organizational capital, the higher the level of GPIP that can be achieved. On average, a firm's green human capital is more important than its organizational and relational capital. Moreover, its organizational capital helps capture the benefits of its relational capital, but it impairs the creativity of its human capital.

Originality/value – The authors contribute to the literature on green strategy implementation by suggesting that green intellectual capital plays a mediating role in the relationship between a firm's green strategic intent and GPIP.

Keywords Green strategy implementation, Green strategic intent, Green intellectual capital, Green process innovation performance

Paper type Research paper

1. Introduction

In order to face the increasing pressure from stakeholders and reduce any negative impact on the natural environment (Herremans *et al.*, 2016; Lee and Min, 2015), firms adopt green strategies (Tsai and Liao, 2017) that aim at improving their green (i.e., environmental) performance (Shu *et al.*, 2016; Song and Yu, 2018) mainly through green innovation (Weng *et al.*, 2015). Firms that succeed in implementing green strategies can achieve a

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sustainable competitive advantage (Chen *et al.*, 2006; Leonidou *et al.*, 2017), strengthen their core competence (Chen, 2008a), enhance their green image (Chen, 2008a), take advantage of new market opportunities (Babiak and Trendafilova, 2011; Berrone and Gomez-Mejia, 2009) and improve their financial performance (Gallego-Alvarez *et al.*, 2015; Iwata and Okada, 2011). Moreover, they can enhance their customers' satisfaction, value perceptions and purchase intentions (Frank, 2018, 2021; Herbas Torrico *et al.*, 2018). Therefore, the successful implementation of green strategies has become an important goal for many firms.

A review of the literature on green strategy reveals the following gaps. First, while there has been a considerable amount of research on the drivers (Aragón-Correa *et al.*, 2008; Huang *et al.*, 2016) and consequences (Chen *et al.*, 2006; Leonidou *et al.*, 2017) of green strategies, little attention has been given to the strategy implementation phase (Verrier *et al.*, 2016; Zhang *et al.*, 2011). While the existing limited studies suggest that firms develop, or otherwise acquire, the necessary tangible and intangible resources to implement their stated strategy (Kamasak, 2017), it remains unclear how firms can develop and use intangible resources, such as intellectual capital, to implement a green strategy (Cheng and Shiu, 2012; Kunapatarawong and Martí nez-Ros, 2016). López-Gamero *et al.* (2011) state that only a few studies have focused on green strategy implementation, which limits our understanding of its mechanism. Consequently, the mechanism underlying successful implementation of a green strategy requires further consideration (Morgan *et al.*, 2009). The lack of clear understanding of green strategy implementation may explain, at least partially, why many firms struggle to operationalize their green strategy into effective green innovation and, consequently, fail to improve their overall green performance (Leonidou *et al.*, 2017; Matus *et al.*, 2012). Although many firms may have similar green strategies, the differences in implementation may possibly provide the answer to why some firms outperform others with regard to green performance (Huang and Li, 2018; King and Lenox, 2001).

Second, most of the literature focuses on green product innovation, rather than on green process innovation (Dangelico *et al.*, 2013; Tariq *et al.*, 2019), despite the latter's significant impact on the environmental and economic performance of a particular firm (Famiyeh *et al.*, 2018). Green process innovation helps a firm to reduce waste, consume less energy and produce less pollution. Therefore, this can significantly improve a firm's green performance (Albort-Morant *et al.*, 2016; Song and Yu, 2018). However, knowledge regarding green product innovation cannot be simply extrapolated to cover green process innovation, because these two distinct types of innovation call for different organizational skills, resources and characteristics (Damanpour and Gopalakrishnan, 2001), which involve different areas and activities within a firm and trigger different performance outcomes (Albort-Morant *et al.*, 2018; Dost and Badir, 2019).

Therefore, the goal of this article is to extend our understanding of the mechanism through which a firm's green strategy is translated into a superior level of green process innovation performance (GPIP). Firms develop and deploy resources in a manner that is consistent with their strategic direction (Choi and Phan, 2014; Reyes-Rodríguez *et al.*, 2016) as these resources, either independently or through their interrelationships, influence innovation performance (Dost *et al.*, 2016; Subramaniam and Youndt, 2005). Thus, we draw on a perspective highlighting the role of firms' resources (Barney *et al.*, 2001; Hart, 1995), namely their green intellectual capital and complementary assets, which allow us to examine the mechanism underlying the implementation of their green strategy.

Research suggests that the ability of firms to implement strategy and innovate is closely tied to their intellectual capital, that is, the ability to utilize knowledge resources (Subramaniam and Youndt, 2005). Firms adopt different approaches to accumulate and utilize their knowledge, and these approaches manifest themselves as the distinct aspects of intellectual capital – namely, human, organizational and relational capital (Davenport and Prusak, 1998; Nahapiet and Ghoshal, 1998). Similarly, due to the popularity of environmentalism (Chang and Chen, 2012), scholars propose the concept of green

intellectual capital, which enables firms to comply with the strict international environmental regulations, satisfy the increasing environmental awareness among the stakeholders and create value for the firms (Huang and Kung, 2011). Although the issue of intellectual capital has been widely discussed during recent decades, the concept of green intellectual capital has only been proposed more recently (Chang and Chen, 2012), and has now emerged as an important field of study (Yong *et al.*, 2019a, b). This article also relies on the perspective of the complementary resources of any particular firm (Christmann, 2000; Teece, 2006), which has also received less attention in the literature (Galbreath, 2016). This perspective suggests that the interaction among two or more resources can offer more value than they would otherwise offer individually (Galbreath, 2016; Teece, 1986).

In this article, we suggest that a firm's long-term commitment to a green strategy, known as its green strategic intent, would result in a higher level of GPIIP when the firm succeeds in developing, possessing, integrating and applying green intellectual capital in its operations. Specifically, we argue that a firm's three aspects of green intellectual capital (green human capital, green organizational capital and green relational capital) mediate the effect of the firm's green strategic intent on its GPIIP. Moreover, from the perspective of the complementary assets of the firm, we also argue that the level of interaction among the three aspects of green intellectual capital influences the firm's GPIIP.

The contribution of this article is fourfold. First, it contributes to the literature on green strategy implementation by suggesting that firms implement green strategy by developing and deploying green intellectual capital for achieving a superior green performance. In other words, green intellectual capital has a mediating role in the relationship between a firm's green strategic intent and its GPIIP. This contribution is original because the current article develops a comprehensive view of the process of strategy implementation (i.e., strategy–operation–performance relationship), which is only discussed partially in the literature. Second, since the three aspects of intellectual capital are conceptually separate and different in how they accumulate and distribute knowledge (López-Gamero *et al.*, 2011; Subramaniam and Youndt, 2005), this article contributes to the literature on green intellectual capital and green innovation by comparing the individual influence of each aspect of green intellectual capital on GPIIP. Third, building on the perspective of the complementary assets of a firm, this article extends the literature by considering the possible interaction among the intellectual capital aspects and how this interaction influences the outcome of innovation. Fourth, this article also extends the literature on green process innovation by highlighting the role of green intellectual capital in achieving a superior GPIIP, especially in polluted industries.

2. Theoretical background and hypotheses

This article builds on the perspectives of green intellectual capital and complementary assets to develop a model that links a firm's strategy, operations and the outcome (see Figure 1).

2.1 Green intellectual capital

In order to explain the strategy implementation (Hitt *et al.*, 2001) and performance differential among firms (Galbreath, 2015), strategy scholars have relied on the resource-based view (RBV) of firms. This view suggests that successful implementation of a firm's strategy to achieve a competitive advantage depends on the development and use of valuable, rare and inimitable tangible and intangible resources (Barney *et al.*, 2001; Grant, 1991; Hart and Dowell, 2011). However, in the current knowledge-based economy, more emphasis is given to the intangible resources (Barney *et al.*, 2001; Kristandl and Bontis, 2007), which are important determinants of a firm's competitive advantage (Chang and Chen, 2012; Chen, 2008b; Grant, 1991). The concept of intellectual capital has been proposed to evaluate these intangible resources (Bontis, 1998). A firm's intellectual capital is defined as the sum of its hidden

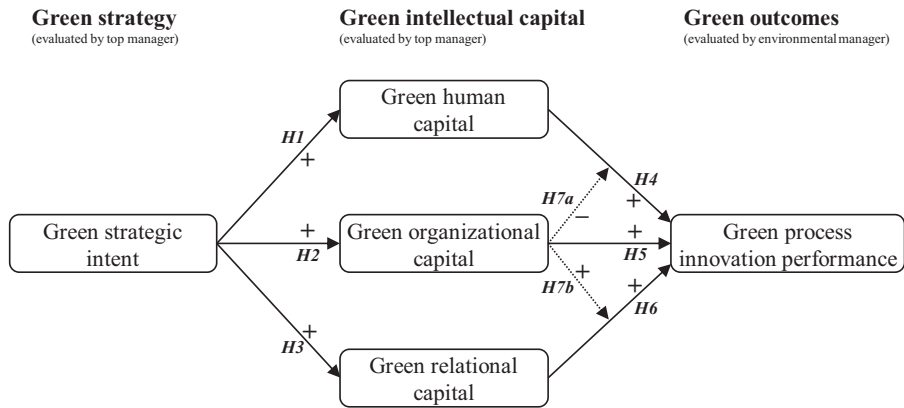


Figure 1.
The conceptual
framework and
hypotheses

resources, which are within the firm’s staff, or as the collection of the firm’s knowledge-based resources (Inkinen, 2015).

The intellectual capital approach has evolved over twenty years and has moved through different stages (Massaro *et al.*, 2018; Secundo *et al.*, 2018). The first stage focused on the importance of intellectual capital in creating and managing a sustainable competitive advantage (Dumay and Garanina, 2013). The Skandia Navigator model visualizes the hidden value of intangible assets through the reporting system (Edvinsson, 1997). This approach has influenced the expansion of the intellectual capital in many countries, including Sweden, USA, UK and Canada (Guthrie *et al.*, 2012).

The second stage emphasized meaning, managing and reporting about intellectual capital. A significant evolution of intellectual capital reporting appeared in Germany (Edvinsson and Kivikas, 2007). The German intellectual capital report introduced a systematized management approach to the hidden knowledge assets within a firm. The report aims to build a process flow that can identify and utilize the firm’s intellectual capital that can lead to the intangible value. The process-flow provides the management platform to prioritize the actions regarding the firm’s intellectual capital with a cost and benefits approach in order to improve future earnings potential (Bornemann and Alwert, 2007; Edvinsson and Kivikas, 2007). System dynamics reporting on intellectual capital, rooted in the MIT (Forrester, 1993), has been refined and applied to understand the interdependent drivers of intellectual capital (Dumay and Edvinsson, 2013). In Japan, the government has supported the publication of the intellectual capital report to raise awareness of the value of intellectual capital to potential investors (Johanson *et al.*, 2006).

The third stage emphasized the measurement of intellectual capital in practice (Dumay and Garanina, 2013). The aim was to investigate the interrelationship between intellectual capital mobilization and management in order to examine the benefits and effects of intellectual capital on value creation (Will and Mertins, 2013). Firms have understood, adapted and applied intellectual capital as a management technology (Guthrie *et al.*, 2012). The fourth stage is to extend the boundary of intellectual capital into the wider ecosystem, such as across countries, cities, communities and specific firms (Dumay and Garanina, 2013; Secundo *et al.*, 2018). The National Intellectual Capital Yearbook observes intangible assets within a nation, which is vital for national competitive advantage (Lin *et al.*, 2019). Research related to this stage also seeks to examine the impact of intellectual capital on society and the environment (Secundo *et al.*, 2018).

With the increase in the stakeholders’ environmental awareness (Chang and Chen, 2012), strategy scholars have realized that the intellectual capital perspective ignores the relationship between a firm and its natural environment (Meadows *et al.*, 1992). The tacit

assumption is that, theoretically, the traditional intellectual capital perspective may not be appropriate to examine environmental issues as it lacks the green dimension. To fix this issue, researchers have extended the traditional intellectual capital perspective to include green elements. Similar to the traditional intellectual capital, green intellectual capital has three main aspects: human, organizational and relational capital. Green human capital is defined as the sum of the employees' knowledge, skills, capabilities, experience, attitude, wisdom, creativity and commitment regarding environmental protection (Chen, 2008b). Green organizational capital refers to the stock of the organizational capability, commitment, operations and knowledge management systems about environmental protection within a firm (Chang and Chen, 2012). Green relational capital relates to the stock of a firm's interactive relationship with its customers, suppliers and the network members and partners concerning corporate environmental management (Chen, 2008b).

The green intellectual capital concept has only recently emerged as an important field of study (Chang and Chen, 2012; Yong *et al.*, 2019a, b). Consequently, relatively less research has been conducted regarding this important domain. This limited research has examined the effects of green intellectual capital on a firm's competitive advantage (Chen, 2008a; Huang and Kung, 2011), green product innovation (Albort-Morant *et al.*, 2016; Delgado-Verde *et al.*, 2016) and business sustainability (Yusoff *et al.*, 2019). No previous research has explored the mediating role of green intellectual capital in translating a firm's green strategic intent into a superior GPIIP.

2.2 *The influence of green strategic intent on green intellectual capital*

Strategic intent refers to the long-term goals that reflect the preferred future direction of a firm as envisioned by its top management (Prahalad and Doz, 1987). As suggested by Hamel and Prahalad (1989), strategic intent envisions the desired leadership position and establishes the criteria firms use to chart progress toward achieving their strategic goals. It informs and shapes how a business defines itself and where it finds its unique strategic advantage (Ice, 2007). Scholars state that strategic intent is the driving force behind strategic aggressiveness, market leadership (Ice, 2007; Mariadoss *et al.*, 2014) and the creation and sustainability of competitive advantage (Ice, 2007). According to Johnson and Sohi (2001), firms with a high level of strategic intent work constantly and energetically towards growth, market dominance, and the achievement of competitive advantage. Since our article deals with green performance, we build on previous studies (Reyes-Rodríguez *et al.*, 2016; Worthington and Patton, 2005) and propose the concept of green strategic intent, which translates into strategic intent in the field of environmental management. A firm's green strategic intent reflects the perception, attitude and long-term goals of the top management regarding the environment.

Previous research suggests that strategic intent has implications for a firm's resource development, acquisition, allocation and ultimately its performance. For instance, strategic intent gives the development processes inside a firm something to aim for; but if absent, decision-making about rival claims to the resources has no legitimate basis (Lovas and Ghoshal, 2000; Mariadoss *et al.*, 2014). Similarly, Johnson and Sohi (2001) postulate that the concept implies that firms view all resources through the lens of strategic goals and will deliberately and explicitly muster all possible resources in pursuit of their goals to win against competitors in the marketplace. Firms with strong strategic intentions build competitive advantage by allocating resources that support proactive action, and they utilize the resources and capabilities effectively (Cheng *et al.*, 2010; Reyes-Rodríguez *et al.*, 2016). Accordingly, in this article, we argue that a firm's green strategic intent will lead it to develop its green intellectual capital.

2.2.1 Green strategic intent and green human capital. A strong green strategic intent by a firm is expected to become part of its image and identity and thus to guide the actions of its employees. Such green intent is likely to influence the human resources policy, in turn

shaping job design, recruitment and selection, training and the employee development system (Russo and Fouts, 1997). Moreover, employees whose knowledge, skills and experience are in line with the organization's strategy are more likely to be promoted to leadership positions (Hitt *et al.*, 2001). When employees see that the top management is concerned with environmental issues and committed to long-term green goals, as reflected in the firm's green strategic intent, they will most likely learn and acquire more knowledge and technical capability regarding environmental protection in order to be in line with the firm's strategy.

We posit that managers who adopt a green strategic intent and perceive environmental issues as opportunities, build green human capital by supporting the development of their employees' environmental capabilities and skills through training, talent management and work engagement (Wirtenberg *et al.*, 2007). They also direct the employees' attention and behavior toward the firm's environmental goals (Ramus and Steger, 2000).

H1. Green strategic intent has a positive effect on green human capital.

2.2.2 Green strategic intent and green organizational capital. A clear strategic intent provides top managers with a rallying point around which to make decisions about the future of their organization and assess the investment options (Ice, 2007). We posit that a firm with a strong green strategic intent will give priority to developing its green resources and capabilities and thus its green organizational capital, which will help the firm to achieve its environmental protection goals. The top management will more likely provide the firm with a superior environmental management system and efficient green operations to ensure that there is no harm to the natural environment.

Studies suggest that besides shaping a firm's green strategic intent, the environmental ethics of the top management play an essential role in pursuing green technology and green operations (Greeno and Robinson, 1992; Schlegelmilch *et al.*, 1996). Managers concerned about environmental issues both influence and support the firm's decision to adopt an advanced environmental management system (Ángel del Brío *et al.*, 2001) and to implement operational sustainability (Hong *et al.*, 2019). A study by Greeno and Robinson (1992) found that environmentally proactive firms bolster their green technology and increase their operational environmental capability. Taken together, these managerial actions reflect the pursuit of green organizational capital.

H2. Green strategic intent has a positive effect on green organizational capital.

2.2.3 Green strategic intent and green relational capital. Generally, the expression of "birds of a feather flock together," which means those of similar taste congregate in groups, is valid in the context of environmental management. We posit that environmentally concerned firms are more likely to build relational capital by interacting and collaborating with customers, suppliers and strategic partners who share their interests and views concerning environmental protection. Such collaboration can help these firms achieve their green strategic goals.

Firms interact with customers to understand their needs (Shih *et al.*, 2010), which provides them with the critical inputs they need to develop and market products that better meet customers' needs (Von Hippel, 2007; Wimalachandra *et al.*, 2014a/b). Similarly, firms with green strategic intent will interact with environmentally concerned customers in order to understand and address their environmental concerns (Schlegelmilch *et al.*, 1996) and thus foster a stronger relationship with them. Moreover, environmentally concerned suppliers play a major role in helping firms to implement their green strategic intent by providing environmentally friendly materials and products. Firms with a strong green strategic intent will add a green dimension to their supplier selection criteria, and only purchase from suppliers that achieve both operational and environmental performance (Handfield *et al.*, 2002;

Hong *et al.*, 2019). Strategy scholars (Cronin *et al.*, 2011) state that firms can achieve their environmental goals by utilizing alliances and partnerships that support their environmental operations. These environmental alliances and partnerships reflect the development of green relational capital.

H3. Green strategic intent has a positive effect on green relational capital.

2.3 The influence of green intellectual capital on GPIIP

Green process innovation is defined as improvement of the existing production processes, or the addition of new processes aimed at minimizing the firm's environmental impact (Cheng *et al.*, 2014; Tariq *et al.*, 2017). Similarly, Qi *et al.* (2012) define green process innovation as a set of instruments that improve a firm's environmental management process, such as innovations related to saving energy, preventing pollution, recycling waste or eliminating toxicity. In our article, the performance of green process innovation reflects the effectiveness of innovation in order to minimize energy consumption, hazardous emissions and the use of raw materials in the production process and the recycling of waste or emissions from production (Chang and Chen, 2013; Chen *et al.*, 2006). Whereas the literature reports the effect of intellectual capital on product innovation, an effect of green intellectual capital on green innovation, specifically on GPIIP, has not yet been covered.

2.3.1 *Green human capital and GPIIP.* Human capital is considered the primary foundation for organizational innovation (Dost *et al.*, 2016) because the employees' skills, competence and expertise in their roles and functions all stimulate innovation (Kuczmarrski, 1996). Hayton (2005) found that human capital influences innovation among high-technology new ventures. Similarly, Bontis *et al.* (2000) argues that human capital is an important source of innovation and strategic renewal. There is a consensus among scholars that a firm's human capital facilitates the generation of innovation because such capital is the repository of the employees' diverse skills, knowledge sets and learning abilities that become the source of sustained competitive advantage (Coff and Raffiee, 2015) and innovation (Dost and Badir, 2019).

Prior research (Russo and Fouts, 1997) has shown that a certain level of environmental expertise and skills by the employees is required in order to produce and use green technology effectively in business operations. When a firm has a high level of green human capital, its employees are expected to have adequate green skills and competence, and are more likely to actively and productively contribute to the environmental protection efforts. In doing so, these employees will try to improve the firm's processes, operations and manufacturing facilities in order to reduce waste and hazards, thereby improving the firm's GPIIP.

H4. Green human capital has a positive effect on GPIIP.

2.3.2 *Green organizational capital and GPIIP.* Organizational capital is the institutionalized knowledge and codified experience embedded in the structures, management systems, knowledge management and operations that influence a firm's innovation capability (Delgado-Verde *et al.*, 2011). Aramburu and Sáenz (2011) found that the organizational structure, culture, policies and guidelines foster innovation-related competences that lead to improve innovation activities. Similarly, firms build organizational capital to develop their organizational learning capability (Ulrich *et al.*, 1993), which improves their innovation performance (Hsu and Fang, 2009).

Scholars have found that the implementation of environmental management systems (e.g., ISO 14001) affects environmental performance through organizational citizenship behavior for the environment (Paillé *et al.*, 2014). Accordingly, we suggest that a superior level of green management techniques and practices, continuous investment in environmental

protection facilities, and sharing best practices and experience on how to protect the environment by the employees can incentivize them to find new and more effective means to reduce hazardous emissions and waste from business operations, all of which improve the firm's GPIIP. Firms also implement knowledge transformation and exploitation to improve their GPIIP (Albort-Morant *et al.*, 2018). Moreover, investment in environmental projects and sharing the results and best practices among all the business units, functions and plants (Lanoie *et al.*, 2011) may also improve a firm's overall GPIIP. Therefore, we propose that green organizational capital can increase the performance level of a firm's green process innovation.

H5. Green organizational capital has a positive effect on GPIIP.

2.3.3 Green relational capital and GPIIP. The strategic relationships of a firm, including its strategic alliances and relationships with the customers and suppliers, drive the firm to achieve the intended innovation performance (Badir and O'Connor, 2015; Capello and Faggian, 2005). A close relationship with the customers enables a firm to gain a more diverse perspective, competency and experience that fosters product and process innovation (Bonner and Walker, 2004; Wimalachandra *et al.*, 2014a/b). In addition, many firms have established closer relationships with their suppliers in order to utilize their skills, capabilities, information and resources to influence their own innovation performance (Walter, 2003). Alliance partners facilitate knowledge sharing, and firms absorb and utilize such knowledge to increase their innovation performance (Wu *et al.*, 2007).

When a firm's relationships are built on a green basis, we expect that these relationships will lead to green innovation. Strong relationships with environmentally aware customers may motivate a firm not only to produce green products (Borin *et al.*, 2013), but likely also to innovate green processes that can satisfy these green customers. Also, relationships with green suppliers are likely to provide a firm with green technology (Chiou *et al.*, 2011) that facilitates and supports green process innovation. Overall, a firm's collaboration with environmentally friendly stakeholders may help the firm reduce both waste and energy consumption, which will enhance its GPIIP (Sharma and Vredenburg, 1998; Wu, 2013).

H6. Green relational capital has a positive effect on GPIIP.

2.4 Moderating effects of green organizational capital

The limited past research on green intellectual capital examines the performance impact of individual, isolated aspects of a firm's green intellectual capital. This view, however, limits our understanding of the power of green intellectual capital because these aspects coexist in a firm and are likely to interact. Our article builds on the perspective of the complementary resources of a firm (Foss, 1998; Galbreath, 2016) to suggest the existence of a strong complementary relationship among individual aspects of green intellectual capital. Their clustering and interaction may facilitate or hinder achievement of a superior GPIIP.

Earlier, in *H4*, we hypothesized that a high level of green human capital leads a firm's employees to contribute more positively to the firm's GPIIP. We expect, however, that this relationship is influenced by the firm's organizational capital.

According to the organization theory, to align a firm's collective efforts with its strategy (Hannan and Freeman, 1984) and to direct its employees' behavior toward goals such as environmental protection, the firm must develop and repeatedly use environmentally related rules, routines, knowledge management systems and operational procedures (Chang and Chen, 2012). However, excessive use of these practices may lead to undesirable consequences (Gilbert, 2005), including lower innovation performance (Zhou and Wu, 2010). For example, highly knowledgeable and skilled employees may feel difficulties in changing the organization's rigid formal processes, which discourages them from acting upon their own creative ideas.

H7a. Green organizational capital negatively moderates the effect of green human capital on GPIP.

Earlier, in [H6](#), we suggested that a firm's green relational capital is likely to improve its GPIP. However, we also argue that this relationship can be strengthened by the firm's ability to internalize, document, share and use the new knowledge gained from such external entities. For example, when a firm cooperates and interacts with its customers, suppliers and strategic partners who share the same green values, it acquires more updated knowledge about best practices concerning environmental protection and may also learn different ways to reduce its environmental footprint (e.g., less waste and the consumption of resources). A well-developed organizational capital facilitates and supports the process of leveraging the knowledge acquired from these relationships into a better GPIP. For instance, the existence of an effective knowledge management system within the firm facilitates documenting the newly acquired knowledge and promotes sharing it among the employees ([King and Marks, 2008](#)). Several studies ([López-Nicolás and Meroño-Cerdán, 2011](#)) suggest that knowledge sharing helps the employees to innovate.

H7b. Green organizational capital positively moderates the effect of green relational capital on GPIP.

3. Method

3.1 Sample and data collection

To test our hypotheses, we targeted firms in the chemical and plastics industries, where environmental problems are widespread and the GPIP level is a relevant and important objective of their operations ([North and Halden, 2013](#)). The sample group was selected from firms certified with the "Green Industry Accreditation" by the Ministry of Industry, Thailand. All the firms in the sample have adopted environmental management systems and achieved ISO14001 certification.

We collected data from two groups of respondents at different management levels within each firm; the top and middle management levels. The respondents at the top management level were members of the Board of Directors, and the respondents at the middle management level were representatives from the Environmental Department or Safety Management Division. In order to increase the valid response rate of the surveys, we telephoned each sampled company to explain the objectives of the study and the content of the questionnaires, and we asked them to confirm their name and job title before sending them the relevant questionnaire.

After two pretests, for the main survey, we telephoned and sent emails to 554 companies, and 278 returned both questionnaires. After discarding any invalid questionnaires, we obtained a valid sample of completed paired responses from the top management members and the environmental managers from 257 firms. As shown in [Table 1](#), the average firm size is 518 employees, and the average firm age is 22.73 years. Hence, the sample group comprised mostly medium-sized and larger enterprises. This sample structure is representative of the chemical and plastics industries, where the high fixed cost for expensive facilities leads to economies of scale; thus, creating more favorable conditions for larger firms. As environmental concerns are critical to the chemical and plastics industry, the stakeholders have expectations for environmentally sustainable practices.

3.2 Measures

To measure the constructs of our study, we developed a questionnaire survey targeted at managers. To prevent common method variance in predicting GPIP, which is the final

dependent variable of our study, we developed two separate questionnaires to measure different sets of variables. We operationalized the variables as reflective constructs and measured them with a seven-point Likert-type multi-item scale. The first questionnaire contained the scale for green strategic intent from [Johnson and Sohi \(2001\)](#), and the scale for green human capital, green organizational capital, and green relational capital from [Chen \(2008a\)](#). The second questionnaire contained the scale for GPIIP from [Chen and Chang \(2013\)](#). We targeted environmental managers who are experts in evaluating environmental performance characteristics in detail. [Appendix](#) lists the constructs, all the scale items, and their literature sources. In addition, the surveys inquired about objective information on each firm's size (number of employees) and age (years since establishment), which we later cross-checked with public databases and telephone calls to avoid any errors. Correspondingly, the mean values of all the environmental effect variables, calculated by averaging all the non-standardized items in the multi-item scales, ranged between 5 and 6 on the 7-point scale, which reflects a high level of environmental activity (see [Table 1](#)).

Although we adopted questionnaire items from previous studies, we tested their content validity by interviewing three experts and two scholars in the first pretest. Subsequently, for the second pretest, we sent the questionnaire randomly to five directors and ten managers in the manufacturing, safety and environmental protection departments of different companies. They were asked to verify all the questions regarding their meaning and any potential ambiguities. After several revisions, the questionnaires achieved a high level of content validity.

4. Results

To test our hypotheses, we used regression analysis, which allows for a quantitative investigation of the hypothesized multivariate relationships between the variables of our conceptual framework: green strategic intent, green human capital, green organizational capital, green relational capital and GPIIP. Unlike the alternative method of structural equation modeling, regression analysis allows for the inclusion of control variables.

| Variables | Correlations | | | | | | |
|---|--------------|-------|-------|-------|-------|-------|------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| <i>Control variables (single-item, objective measures)</i> | | | | | | | |
| 1 Firm size (number of employees) | | | | | | | |
| 2 Firm age (number of years since foundation) | 0.19* | | | | | | |
| <i>Effect variables (multi-item, survey-based measures)</i> | | | | | | | |
| 3 Green strategic intent | 0.08 | 0.00 | | | | | |
| 4 Green human capital | -0.05 | -0.02 | 0.49* | | | | |
| 5 Green organizational capital | 0.01 | 0.01 | 0.52* | 0.66* | | | |
| 6 Green relational capital | 0.06 | -0.06 | 0.50* | 0.59* | 0.64* | | |
| 7 Green process innovation performance | -0.02 | 0.02 | 0.37* | 0.47* | 0.44* | 0.41* | |
| <i>Descriptive statistics</i> | | | | | | | |
| Mean | 517.85 | 22.73 | 5.46 | 5.21 | 5.45 | 5.62 | 5.77 |
| Standard deviation | 706.43 | 12.40 | 0.68 | 0.86 | 0.73 | 0.75 | 0.83 |
| Cronbach's α | Single item | | 0.87 | 0.90 | 0.85 | 0.88 | 0.83 |
| Composite reliability | Single item | | 0.88 | 0.90 | 0.86 | 0.89 | 0.84 |
| Average variance extracted | Single item | | 0.51 | 0.61 | 0.51 | 0.64 | 0.58 |

Table 1. Correlations and descriptive statistics of the constructs

Note(s): * $p < 0.05$ (two-sided). See [Appendix](#) for scale information and coding of control variables. For standardized factors, descriptive statistics for mean score across non-standardized items. Sample size: 257 firms (multi-source data from 257 top managers and 257 environmental managers)

The regression model applied single-item control variables, the firm’s size and age, as it was done in previous studies with similar objectives (Dzenopoljac *et al.*, 2017; Scafarto *et al.*, 2016). Since additional analyses using ordinary least squares and generalized least squares led to the same conclusions (significance, coefficient order of magnitude), we reported the results based on ordinary least squares. In each of our analyses, the variance inflation factors were below 5, which indicates that multicollinearity is not a concern in our study (Mason and Perreault, 1991). An inspection of the residuals of each analysis does not indicate a departure from the assumption of multivariate normal distribution.

To test H1–H3, we conducted three regression analyses with green human capital (H1), green organizational capital (H2) and green relational capital (H3) as the dependent variables. These analyses share the same independent variables: green strategic intent (H1–H3) as the effect variable, and the firms’ size and age as the control variables. As shown in Table 2, green strategic intent exerts significantly ($p < 0.001$) positive effects on green human capital (H1), green organizational capital (H2) and green relational capital (H3), which supports H1–H3. The control variables do not have any significant effect. The adjusted R^2 values are between 23.6 and 25.8%, which indicates that green intellectual capital depends on more than merely strategic intent, and is likely due to the effect of organizational behavior (e.g., leadership, group processes, resistance to change) on strategy implementation (Barney and Zajac, 1994).

To test our hypotheses H4–H7b, we performed a regression analysis with GPIIP as the dependent variable. The independent variables included the control variables (each firm’s size and age), green human capital (H4), green organizational capital (H5), green relational capital (H6) and the interaction terms calculated by multiplying the green organizational capital by the green human capital (H7a) and the green relational capital (H7b). We standardized all the variables before calculating the interaction terms. Since we obtained the dependent variables (as reported by the environmental or safety managers) and the independent variables (as reported by the top management members) from separate data sources, common method variance is not a concern in predicting our outcome variable. As reported in Table 3, green human capital (H4) exerts the strongest positive effect on GPIIP, followed by the positive effects of green relational capital (H6) and green organizational capital (H5). The significant interaction effects indicate that a high level of green organizational capital strengthens the influence of green relational capital (H7b), and weakens the influence of green human capital (H7a) on GPIIP. As visualized in Figure 2, these moderating effects are so strong that green relational capital only influences GPIIP when green organizational capital actively absorbs the benefits of any green relational capital

| Independent variables | Dependent variables | | |
|--------------------------------------|---|--|--|
| | Green human capital (H1: +) β | Green organizational capital (H2: +) β | Green relational capital (H3: +) β |
| <i>Control variables</i> | | | |
| Firm size | −0.087 | −0.040 | 0.032 |
| Firm age | −0.003 | 0.015 | −0.067 |
| <i>Green strategy</i> | | | |
| Green strategic intent (H1–H3: +) | 0.494*** | 0.518*** | 0.498*** |
| <i>Fit statistics</i> | | | |
| Adjusted R^2 | 0.236 | 0.258 | 0.246 |

Note(s): * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ (two-sided). Sample size: 257 firms (257 top managers)

Table 2.
The effects of green strategic intent on green intellectual capital

(H7b). Also, green human capital influences GPIIP only in the absence of green organizational capital, whereas green organizational capital redirects a firm's green innovation processes away from each individual employee's effort toward the institutionalized organizational effort (H7a). In summary, these analyses support H4–H7b. A firm's size and age, which serve as the control variables, do not appear to influence GPIIP. The adjusted R^2 value of 27.6% is low, which reflects both the presence of unobserved drivers of GPIIP, and the use of multi-source data with the respondents' different response styles.

In order to examine whether green strategic intent has an additional direct (non-mediated) effect on GPIIP, we added green strategic intent to our regression model as an independent variable. However, this additional direct effect is not significant ($p > 0.05$). Also, we conducted the Sobel test for multiple mediators (Preacher and Hayes, 2008), which confirms ($p < 0.05$)

| Independent variables | Dependent variable Green process innovation performance β |
|---|---|
| <i>Control variables</i> | |
| Firm size | -0.034 |
| Firm age | 0.024 |
| <i>Green intellectual capital</i> | |
| Green human capital (H4: +) | 0.263*** |
| Green organizational capital (H5: +) | 0.177* |
| Green relational capital (H6: +) | 0.200** |
| Green organizational capital \times Green human capital (H7a: -) | -0.389*** |
| Green organizational capital \times Green relational capital (H7b: +) | 0.413*** |
| <i>Fit statistics</i> | |
| Adjusted R^2 | 0.276 |

Table 3.
The effects of green intellectual capital on GPIIP

Note(s): * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ (two-sided). Sample size: 257 firms (257 top managers evaluating green operations, and 257 environmental managers evaluating green process innovation performance)
All variables were standardized before calculating the interaction terms

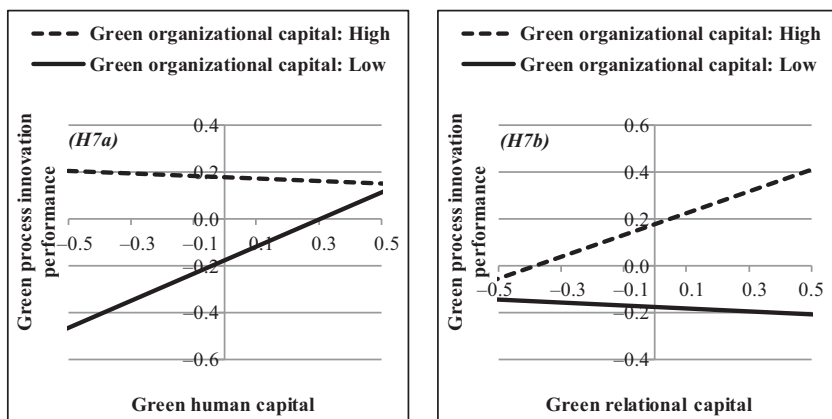


Figure 2.
The moderating effect of green organizational capital

Note(s): Two contrasting degrees of green organizational capital as a moderator. The dashed line represents a high degree of green organizational capital. The solid line represents a low degree of green organizational capital

that green intellectual capital mediates the effect of green strategic intent on GPIIP, as suggested by our conceptual model (see [Figure 1](#)). Hence, a firm can implement its green strategic intent by building green intellectual capital in order to influence its GPIIP, especially in an innovation context where the outcome consists not of any mental attitude but of implemented engineering work.

5. Discussion

In this article, we draw on the perspectives of green intellectual capital and complementary assets to develop and test a model of the mechanism through which a firm's green strategic intent is translated into a superior GPIIP. Overall, our findings provide strong support for the premise that the three aspects of a firm's intellectual capital (i.e., organizational, relational and human capital) fully mediate the relationship between the firm's strategic intent and GPIIP.

Specifically, we found that green strategic intent has a positive effect on the three aspects of green intellectual capital. These results support the proposition of the natural resources-based view that in order to implement green strategy and achieve a better environmental performance, firms must allocate and deploy resources in line with their green strategy ([Hart and Dowell, 2011](#)). [Ling \(2019\)](#) indicates that green strategic intent by the top management is vital in directing green management with the support of green competencies. Our findings also extend the results of two previous and related studies. First, in studying accounting practices, [Massaro et al. \(2015\)](#) found that strategic intent has a significant positive effect on intellectual capital, which in turn enhances a firm's service diversification. We extend this argument to a green and non-service context based on the premise that green strategic intent enables the employees to have the same strategic posture to start environmental action ([Aragón-Correa and Sharma, 2003](#); [Reyes-Rodríguez et al., 2016](#)). Second, [Ramus and Steger \(2000\)](#) found that the strength of the signal (e.g., well-communicated environmental policies) from the managers regarding the protection of the natural environment positively influences the employees' willingness to promote green initiatives. We extend their finding by explaining how these policies may translate into actual innovation (e.g., GPIIP).

This study is unique in examining the performance impact of the three aspects of green intellectual capital on GPIIP. Our findings show that all aspects of green intellectual capital positively relate to GPIIP, and that among the three, a firm's green human capital has the strongest effect on GPIIP. This is in line with [Russo and Fouts \(1997\)](#), who found that green human capital addresses the knowledge and skills of the employees regarding environmental protection, and that these employees play a significant role in enhancing the firm's profitability from green activities. As for green organizational capital, a prior study ([Roome and Wijen, 2006](#)) suggests that firms must improve their structure, processes, operations and new product development in order to improve their environmental performance (e.g., GPIIP). Lastly, green relational capital involves both primary and secondary tier suppliers in the environmental management process that aims for greater progress ([López-Gamero et al., 2011](#)). By extending such past studies, our findings suggest that firms which employ multiple aspects of green intellectual capital in parallel enjoy additional improvements in GPIIP, and that green human capital plays the most crucial role. However, this is not obvious, because organizational capital is organized and implemented by humans and is based on relationships, and separate types of green intellectual capital might cannibalize each other's effects. However, we show that they have true separate effects without such cannibalization.

Relying on the perspective of the complementary assets of firms, this study demonstrates the moderating effect of green organizational capital. The contribution of green organizational capital is important for any sustainably oriented business that supports the process of employing organizational resources ([Yusoff et al., 2019](#)). Firstly, we found that

green organizational capital positively moderates the effect of green relational capital on GPIIP. That is, the more that firms invest in green organizational capital, the higher is the GPIIP that they can achieve from interacting and cooperating with their stakeholders regarding environmental protection. This finding resembles a previous study about how environmentally aware firms increase green linkages with their networks, suppliers, partners and customers by implementing effective environmental management systems (Chang and Chen, 2012), which positively affect green process innovation (Chang, 2011). However, unlike that study, we show that a firm's green organizational capital not merely increases its relational capital, but also enhances its effectiveness; thus, allowing the firm to exploit its external relationships more effectively.

As hypothesized, green organizational capital has a negatively moderating effect on the relationship between human capital and GPIIP. This result suggests that stronger management systems and more deeply rooted operations create stronger organizational routines that can lead to organizational rigidity. Prior studies argue that strong organizational routines and rigidity may influence innovative efforts negatively (Dooley, 2018; Zhou and Wu, 2010), as a rigid system locks creative employees into the existing routines, thereby precluding any variation from the established process architecture (McKinley *et al.*, 2014).

6. Implications, limitations and future research

This research has important theoretical implications. It builds on the limited literature regarding green strategy implementation. We have answered the research calls by Kunapatarawong and Martí nez-Ros (2016), López-Gamero *et al.* (2011) and Cheng and Shiu (2012) to highlight the mechanism underlying successful green strategy implementation. Our research sheds light on the strategy implementation process along the causal path from green strategy, via green operations, toward green performance. The investment in tangible assets, such as machines, operation processes and facilities, is required to achieve environmental goals. However, firms also need capabilities, such as the tacit capacities developed from management systems, employee commitment, expertise and networks with external partners to support the usage of invested tangible assets. Firms that fail to develop their intangible assets, therefore, may forego environmental performance. The empirical result depicts that firms implement green strategy by developing green intellectual capital, which in turn influences GPIIP. This finding is consistent with Massaro *et al.* (2015), who concluded that strategic intent influences the development of intellectual capital, which positively relates to service diversification. We extend their research in the context of both environmental management and non-service industries.

This study highlights the different effect of the three aspects of green intellectual capital on GPIIP. Our results show that green human capital has the strongest effect on GPIIP. The competence of the environmental managers and staff helps build knowledge, and then utilizes this knowledge to reduce the environmental impact of the firm's operations.

We advance the literature on green innovation by integrating the perspective of the complementary assets to reveal the interactive nature of the mechanism within the three aspects of green intellectual capital. We examine the moderating role of green organizational capital in linking green human capital and green relational capital on GPIIP. The results show that the value of green relational capital is tied to green organizational capital. In order to leverage green relational capital effectively, it is imperative that a firm develops its green organizational capital in order to provide the necessary management process which helps to organize the external relationships and acquire external knowledge from the firm's stakeholders. In practice, environmental management systems encourage firms to share green reports with the public. The disclosure of green information and performance is necessary to build a green image and social accountability towards customer, suppliers and

partners (Azzone *et al.*, 1997; Noci, 2000). Firms share green reports with their suppliers in the value chain in order to let them know how the firms' production process reduces the environmental impact and why they seek support from their suppliers (Massaro *et al.*, 2018). Therefore, the relationship between the stakeholders and GPIIP is strengthened through green reporting, and this mechanism boosts GPIIP. As anticipated, green organizational capital has a negative moderating effect on the relationship between human capital and GPIIP. This is in line with Bontis (1998) who argued that human capital does not affect a firm's financial performance without the supportive structure of the organization (i.e., organizational capital) that utilizes and nurtures human skills.

In the literature on an organization's environmental performance, scholars have debated the relationship between green initiatives and financial performance. Their studies indicate mixed and opposing results (Clarkson *et al.*, 2011; Hart and Ahuja, 1996; King and Lenox, 2001). This phenomenon may be explained by green strategy implementation. Green strategic intent only indirectly influences GPIIP, but there is a mechanism linking green strategy and performance. We suggest that building adequate green intellectual capital not only supports the implementation of green strategy, but may also improve a firm's financial performance. This is because, as our model shows, the firm's green intellectual capital can improve its GPIIP. In the innovation literature, there is a consensus (Ar and Birdogan, 2011; Frishammar *et al.*, 2012) that process innovation reduces both the costs and the time to market and allows improved product quality, all of which enhance financial performance.

This study also contributes to the literature on the antecedents of green process innovation by providing new insights into the configuration of intangible assets. Our results show that, in the green context, the three aspects of intellectual capital, individually and interactively, support the development of process innovation performance. Out of these three, the human capital seems to have the strongest influence on process innovation performance. The knowledge and experience embedded in the employees both facilitate knowledge development and dissemination in the firm, improving the process innovation performance. Moreover, green organizational capital positively moderates the effect of green relational capital on GPIIP, whereas it negatively moderates the effect of human capital on GPIIP.

The results of this study expand the systematic management of thinking and utilizing green intellectual capital. Previous studies in Germany and Austria (Edvinsson and Kivikas, 2007; Leitne and Warden, 2004) have visualized the process flow from the perspective of the firm's goals and strategies to develop and utilize intellectual capital that can improve the firm's intangible value. With a dynamic system approach (Bornemann and Alwert, 2007; Forrester, 1993), feedback loops are applied to intellectual capital management that explain the pattern of interaction among the aspects of intellectual capital to achieve business outputs. Hence, a firm may seek a pattern of relationships between the three green intellectual capital aspects in order to decide the management actions that it seeks to build or develop. These management actions must aim to improve GPIIP.

In order to face the increasing pressure from stakeholders to improve the environmental performance (Karra and Affes, 2014), a firm should focus on improving its intellectual capital, particularly its human capital. When a firm's employees are more knowledgeable, experienced and aware of potential environmental problems, they may produce innovations that help to mitigate environmental hazards, consequently increasing the health and safety of people, and thus benefiting society at large (Yusliza *et al.*, 2020).

Our research also has important implications for managers. It suggests that firms, especially those operating in polluting industries, should pay more attention to the development and management of green intellectual capital since it has a significant influence on GPIIP. Managers should devote substantial effort to improve their employees' knowledge and skills regarding environmental protection and management, which may lead to a superior GPIIP. We also suggest that managers should make adequate investments in

environmental protection facilities and design and apply knowledge management systems focusing on environmental issues, all of which facilitate the development of green process innovation. The existing standard operating procedures, routines and manuals provide the guideline for employees to conduct environmental management. An effective knowledge management system offers opportunities for sharing and utilizing knowledge and information to improve green production. Moreover, in forming strategic alliances and initiating other forms of interfirm cooperation, managers should consider the partner's green performance as an important selection criterion.

This study has several limitations, such as the limited net sample size after pairing multiple responses per firm. A larger sample size enhances the power of statistical tests. However, this study focused on two key informants in each firm (top management members and the managers in charge of environmental management), which helps to reduce any common method variance and enhance the external validity of the surveys' responses. It is difficult to collect data from different managerial levels within the same firm. Another limitation is our holistic, rather than detailed, perspective in measuring green intellectual capital. The measurement of green intellectual capital is perceptual, and the responses provided by top managers, who have the vantage point to view the overall activity of the firm, may differ from those provided by middle managers. These middle managers see different aspects of green intellectual capital because they are involved in front-line operations and might thus know more details than the executive level staff. We intentionally selected top management members to measure green intellectual capital because they can best assess each aspect of green intellectual capital as a whole and rate each aspect against the same standard of comparison, which matches our objective.

This study was conducted in a developing country, Thailand. While the results of the study may be applicable to other developing countries, they may not, necessarily, apply to more developed countries. Previous studies have shown that firms in developing countries still tend to lack advanced technical knowledge and capabilities (Badir *et al.*, 2020), which may limit their innovation opportunities. However, our study suggests that firms in developing countries may focus on enhancing the role of cooperation (green relational capital) and management involvement (green organizational capital) because individual employees might lack knowledge compared with employee in firms in more developed countries (Yamauchi, 2007; Yong *et al.*, 2019a, b).

The low R^2 in this research model depicts the nature of strategy formulation and implementation according to various factors (Edvinsson and Kivikas, 2007; Engert and Baumgartner, 2016). Future studies may consider other drivers and control variables in analyses of the strategy management process. Separate surveys of multiple respondents generally reduce the R^2 value. Survey measures always include a certain amount of measurement error that is unexplained by the dependent variables and does not have any explanatory power by independent variables (Bogers *et al.*, 2018; Zhou *et al.*, 2005).

To conclude, our study provides a framework simultaneously linking green strategic intent and the various aspects of green intellectual capital with the focus on GPIP. This framework shows how green strategic intent enhances GPIP by utilizing green human capital, green organizational capital, and green relational capital and by exploiting the interactions between these subdimensions of green intellectual capital. It also provides a structure for future research by highlighting the crucial role of strategic management in the approach to green innovation.

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Questionnaire for top managers

Green strategic intent (7 points; strongly disagree/agree; Johnson and Soli, 2001)

At the top management level, your company . . .

- (1) . . . is strategically aggressive in environmental management
- (2) . . . seeks competitive dominance through environmental management
- (3) . . . systematically builds competitive advantages through environmental management
- (4) . . . seeks market leadership through environmental management
- (5) . . . sets and pursues strategic targets and goals in environmental management
- (6) . . . strengthens its environmental management ability to build competitive advantage
- (7) . . . seeks to win in the marketplace through environmental management

Green organizational capital (7 points; strongly disagree/agree; Chen, 2008a)

Compared to major competitors, your company . . .

- (1) . . . has a superior management system for environmental protection
- (2) . . . has formed a committee to make progress on key issues in environment protection
- (3) . . . makes an adequate investment in environmental protection facilities
- (4) . . . has a high percentage of employees working on environmental management
- (5) . . . smoothly runs operations in environmental protection
- (6) . . . systematically accumulates and shares knowledge of environmental management

Green human capital (7 points; strongly disagree/agree; Chen, 2008a)

Compared to major competitors, the employees of your company . . .

- (1) . . . contribute strongly to, and are productive in, environmental protection
- (2) . . . are adequately competent in environmental protection
- (3) . . . perform well in pursuing environmental product/service performance
- (4) . . . cooperate well and work in teams to ensure environmental protection

Green relational capital (7 points; strongly disagree/agree; Chen, 2008a)

Compared to major competitors, your company . . .

- (1) . . . designs its products/services in compliance with its customers' environmental desires
- (2) . . . successfully satisfies its customers with the provided level of environmental protection
- (3) . . . cooperates persistently with upstream suppliers on environmental protection
- (4) . . . cooperates persistently with downstream clients/channels on environmental protection
- (5) . . . cooperates persistently with strategic partners on environmental protection

Questionnaire for environmental managers

Green process innovation performance (7 points; strongly disagree/agree; Chang and Chen, 2013)

Now and recently, your company effectively has been . . .

- (1) . . . reducing hazardous emissions/waste in manufacturing
- (2) . . . recycling waste and treated/reused emissions in manufacturing
- (3) . . . reducing the consumption of water, electricity, coal and oil in manufacturing
- (4) . . . reducing the use of raw materials in manufacturing

Table A1.
Construct scales and
the literature sources

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