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The impact of green supply chain management practices on firm performance: the role of collaborative capability

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Abstract This study attempts to contribute to the growing research on green supply chain management (GSCM) strategies by relying on the Natural Resource Based View (NRBV) and relational view. Specifically, this study investigates the role of collaborative capability in moderating the effects of GSCM practices on firm performance. Using hierarchical regression, this study analyzes data from a survey of 230 South Korean manufacturers. The results show that the implementation of GSCM practices can improve both environmental and financial performance of the firm. Also, the findings indicate that firms can expect improved financial performance when they seek a synergistic effect by involving their partners in the GSCM implementation process.

Keywords Green supply chain management · Collaborative capability · Natural resource based view · Eco-design · Investment recovery · South Korea

1 Introduction

Green supply chain management (GSCM) can be generally defined as the practice of improving environmental performance along the supply chain, including product design, operations management, and customer relationships (Srivastava 2007). A significant number of GSCM studies have investigated whether the implementation of environmetal supply chain strategies leads to enhanced firm performance (Sarkis 2012). However, the results of these studies were mostly mixed, ranging from little or no improvement (Zhu et al. 2005). To explain these contrasting results, several researchers have explored factors that influence this relationship (Lopez-Gamero et al. 2009; Sarkis et al. 2010; Zhu and Sarkis 2007). Following this stream of thought, the present study intends to examine another possible moderating effect—collaborative capability, which can be defined as a firm's ability to leverage other actors' resources and knowledge (Kotabe et al. 2003; Koufteros et al. 2007; Patnayakuni et al. 2006). Collaboration relationships have helped firms to reduce transaction costs and create a sustainable competitive position in highly uncertain business environments (Cao and Zhang 2011).

Recently, a number of major firms have begun to capitalize on the potential of supply chain collaboration in the implementation of green strategies. For instance, Coca-Cola has launched a wide range of collaborative green practices such as the Community Water Partnership (Reuters 2011). Working jointly with bottling partners and environmental charities, it has developed PlantBottle, the first recyclable plastic beverage bottle made partially from plants. Coca-Cola has also formed a strategic partnership with H. J. Heinz Company, which uses PlantBottle for its ketchup.

Despite the popularity of collaborative green strategies, there has been little systematic research on the role of collaborative capability in the adoption of these strategies. The purpose of this study is to investigate the relationship between GSCM practices and firm performance by answering the following research questions: (1) Is GSCM implementation positively related to firm performance? (2) Does the firm's level

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of collaboration moderate the relationship between GSCM practices and firm performance? To answer these research questions, this study conducts a field survey of South Korean manufacturers. South Korea has been credited with adopting low carbon and green growth as a national goal (Lee et al. 2012). Most importantly, the Korean government has placed a greater emphasis on collaboration across the supply chain by encouraging large manufacturers to share their environmental management know-how with supply chain partners (Lee 2008; Lee and Klassen 2008). Thus, South Korea could provide a unique setting to examine the role of collaboration between GSCM practices and firm performance.

This study is organized as follows. The second section introduces GSCM practices and collaborative capability by focusing on the perspective of the natural resource based view (NRBV) and relational view. The third section presents the conceptual framework of this study and development of hypotheses. The fourth section provides the research methodology. The fifth section presents the results and the sixth section discusses the findings of the study. The final section concludes the study and also discusses the limitations of the study.

2 Theoretical backgrounds

2.1 The natural-resource based view (NRBV) and GSCM practices

The resource-based view (RBV) has been widely used to explain the impact of GSCM practices on firm performance (Sharma and Vredenburg 1998). The resource-based view (RBV) suggests that firms need to increase their strategic resources and leverage them to create sustainable competitive advantage (Barney 2001). These resources can include both tangible and intangible assets such as human, information technology, capital, equipment, and knowledge. RBV defines a strategic asset as a resource that is rare, valuable, imperfectly imitable and non-substitutable. Firms that establish distinctive competencies through unique combinations of strategic assets can achieve advantage over competitors and earn above-normal rates of return (Acedo et al. 2006).

Recently, Hart (1995) has attempted to expand the scope of RBV by including the constraints and opportunities given by the natural environment. Hart's typology, referred to as the natural resource-based view (NRBV), suggests that firms can gain competitive advantage from the implementation of green strategies such as pollution prevention, product stewardship, and sustainable development. Pollution prevention seeks to prevent waste and emissions at the source instead of at the end-of-the-pipe. Product stewardship ensures that all those involved in the life cycle of a product share responsibility for reducing its environmental impacts. Sustainable development, which goes beyond simply reducing environmental damage, encompasses economic and social concerns. A significant body of GSCM research has examined the competitiveness effects of these strategies, pollution prevention in particular (Hart and Dowell 2011). For example, Klassen and Whybark (1999) found that pollution prevention technologies, instead of pollution control technologies, were associated with improved firm performance. The NRBV has been further elaborated through the work of many researchers, showing the importance of environmental practices as a strategic asset that contributes directly to better firm performance (Shi et al. 2012).

2.2 The relation view and collaborative capability as a moderator

The RBV is considered to be essentially static in its nature. Adopting an inward-looking view, the RBV assumes that firms should own or fully control strategic resources in order to create sustainable competitive advantage. This assumption of ownership or control implies that firms should establish barriers to protect their core resources from being imitated by competitors.

However, a growing number of studies have begun to question this proprietary assumption, arguing that resources of supply chain partners have a considerable impact on firm performance (Lee et al. 2001). They criticized the RBV for remaining trapped in an internal perspective (Priem and Butler 2001). To address this theoretical challenge, some researchers have attempted to reformulate the RBV by arguing that a firm's competitiveness not only arises from internal resources but also depends on inter-firm collaborations (Dyer 1996; Dyer and Singh 1998). This line of thought, called the relational view, has been applied to the environmental sustainability context (Christmann 2000). Vachon and Klassen (2008) found that collaborative environmental activities with suppliers are related to process-based performance while collaborative green practices with customers are linked with product-based performance. Zhu et al. (2008) showed that knowledge created by collaboration plays a crucial role in eliminating environmentally harmful materials or processes. Sharfman et al. (2009) found that inter-firm trust is one of the main factors that affect the extent to which firms engage in cooperative GSCM. Albino et al. (2012) simultaneously considered the effects of environmental collaborations with different types of actors on environmental performance. They found that collaborations with a wide range of actors, including suppliers, customers, governments and non-governmental organizations, can be beneficial for a firm's environmental performance.

These previous studies made significant contributions to understanding the importance of collaborations in the context of GSCM. However, they did not differentiate between GSCM practices and a firm's collaborative capability. There is growing evidence that a firm's collaborative capability should be conceptualized as a distinct factor (Hofmann et al. 2012). For instance, many original equipment manufacturers (OEMs) have implemented asset recovery programs for their end-of-life (EOL) products (Toffel 2004). According to the NRBV, such GSCM practices can be considered a strategic resource that directly improves firm performance. However, when it comes to the question of whether these OEMs work with their supply chain partners to obtain the maximum benefits from asset recovery programs, it is another issue. In fact, after initiating asset recovery programs, quite a few OEMs are still unwilling to collaborate with other actors such as independent product recovery companies (Toffel 2004). Although these OEMs can reduce potential losses of both market share and brand image, this practice is self-defeating over the long run because it could be difficult for a single firm to possess all the resources required to implement GSCM programs successfully (Wiens 2014). After all, GSCM programs involve a wide range of activities, requiring expertise from almost all members of the entire supply chain (Nakano and Hirao 2011). Based on this rationale, this study draws a distinction between a firm's collaborative capability and GSCM programs, suggesting that firms with high levels of collaborative capability are likely to achieve better performance from the implementation of GSCM programs. In addition, this study focuses on a firm's collaborations and partnerships with actors such as suppliers, customers, governments, and non-governmental organizations because working with these actors does not have a different impact on firm performance (Albino et al. 2012).

3 Hypotheses development

Figure 1 shows our conceptual model. Building on the NRBV, we posit that GSCM practices are positively associated with firm performance. We also posit that a firm's collaborative capability moderates the relationship between GSCM practices and firm performance. Previously, GSCM practices largely operated under a firm-centered paradigm, focusing on environmental activities within the boundaries of a firm (Bansal and Roth 2000; Handfield et al. 2005). Although internally focused GSCM practices contribute to improving firm performance, achieving full value from GSCM programs requires a significant commitment to developing strong collaborations with various actors (Albino et al. 2012). Following this line of thought, we focus on two GSCM practices that are most likely to be influenced by a firm's collaborative capability: eco-design and investment recovery (Zhu and Sarkis 2004, 2007; Zhu et al. 2008). The purpose of eco-design is to reduce the negative environmental impacts of a product over its full life cycle (Aoe 2007). The objective of investment recovery is to recover the highest value from obsolete, EOL, and surplus items (Ayres et al. 1997).

We exclude internally oriented GSCM practices such as commitment of GSCM from senior managers, total quality environmental management, and ISO 14001 certification because they are likely to receive limited benefits from collaborations. In addition, as mentioned earlier, we intend to distinguish a firm's collaborative capability from GSCM practices. Thus, some external GSCM practices such as cooperation with external partners for environmental objectives are excluded for this study.

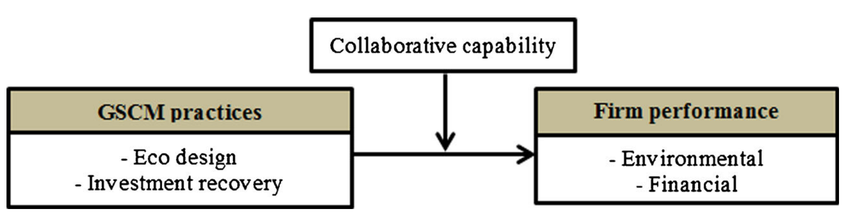
We use two important indicators of firm performance. The first is environmental performance, defined as the ecological results of a firm-wide commitment to preserve and improve the natural environment (Nawrocka and Parker 2009). With the growing number of firms that are committed to creating social and environmental value, the measurement and evaluation of environmental performance are becoming more important than ever before (Kainuma and Tawara 2006; Testa and Iraldo 2010). The second is financial performance, which is one of the most common drivers for the implementation of GSCM practices. A number of studies showed that firms that perform better environmentally are also the most successful financially (Berry and Rondinelli 1998; Tsoulfas and Pappis 2008).

3.1 GSCM practices and firm performance

The concept of eco-design has been described under various terms such as green design, design for environment, sustainable design, etc. (Luttropp and Lagerstedt 2006). As shown in Fig. 2, eco-design seeks to create a sustainable product by incorporating environmental considerations throughout its life cycle, from raw material acquisition to final disposal (Aoe 2007). Some eco-design strategies include:

– Using renewable and recyclable materials at the procurement stage
– Using less energy and water at the manufacturing stage

Fig. 1 Conceptual framework



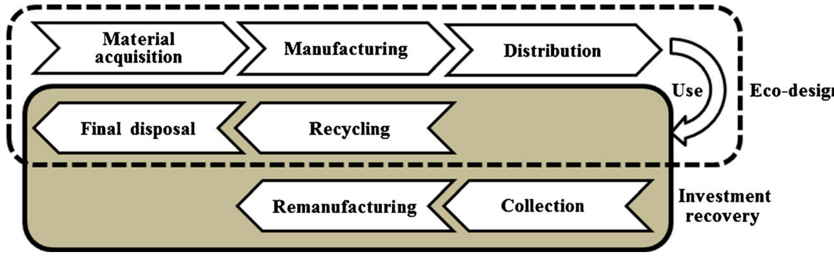


Fig. 2 Eco design and investment recovery in a closed loop supply chain

– Using less packaging at the distribution stage
– Reducing greenhouse gas emissions at the use stage

Eco-design seeks to systematically integrate environmental aspects into product design while maintaining all functional and safety requirements for consumers. It also emphasizes the importance of early product design decisions because approximately 80 % of all product-related environmental impacts can be identified during the design phrases of product development (Karlsson and Luttropp 2006). Researchers have proposed a number of eco-design tools to enhance the design of the product from an environmental perspective (Bovea and Pérez-Belis 2012). One of the most popular tools is life cycle assessment (LCA), which evaluates all relevant resources and emissions consumed at each stage of the product's life cycle (Arena et al. 2013).

Eco-design has been widely recognized as a useful tool for improving environmental performance, as evidenced by a number of empirical studies conducted in various fields such as electronics (Aoe 2007) and disposable diapers (Mirabella et al. 2013). However, despite explicit advantages from lower production costs, eco-design was often found to be related to poor financial performance (King and Lenox 2001). Recently, with growing consumer awareness about the environment, this conventional view has been challenged (Griskevicius et al. 2010). A number of environmentally conscious consumers are willing to pay more for eco-design products (Akehurst et al. 2012). Moreover, continuous eco-design innovations not only improve a firm's image as a green champion but also serve as the principal source of competition, leading to higher sales growth (Chen 2008). For example, Toyota Motor Corporation has introduced an LCA system called Eco-VAS (Eco-Vehicle Assessment System) to heighten the environmental performance of its vehicles (Nakano et al. 2007). The Toyota Prius has earned a reputation as the first hybrid car, achieving significant sales growth since its introduction in 1997. Therefore, it is reasonable to expect that eco-design contributes to financial performance as well as environmental performance.

H1a: Eco-design is positively related to environmental performance.
H1b: Eco-design is positively related to financial performance.

While eco-design is concerned with sustainable product/process development, investment recovery focuses on obsolete, EOL, and surplus asset recovery (Ayres et al. 1997). In addition, investment recovery differs from eco-design in that the former seeks to achieve a higher form of recycling/reuse by pursuing value-added recovery involving remanufacturing (Guide 2000). As shown in Fig. 2, investment recovery attempts to integrate obsolete, EOL, and surplus assets back into reverse logistics processes so that these assets can be properly recovered or disposed of (Chan et al. 2010). In this way, investment recovery can help firms to maximize cost savings and value recovery. Investment recovery has been successfully applied to a wide range of industries such as computers (White et al. 2003) and automobiles (Gerrard and Kandlikar 2007). Some investment recovery strategies include:

– Consolidating product returns from multiple locations at the collection stage
– Recovering valuable components from used materials at the recycling stage
– Making refurbished products for sales at the remanufacturing stage

Investment recovery has received increased attention in recent years as a growing number of environmental regulations impose greater responsibilities on OEMs for managing their EOL products (e.g., the European Union's Extended Producer Responsibility) (Spicer and Johnson 2004). Instead of simply banning EOL products from landfills or incinerators, these "product take-back" regulations offer financial incentives to encourage manufacturers to develop effective asset recovery strategies (Toffel 2004). Another significant driver towards investment recovery is the increasing volume of product returns (Petersen and Kumar 2009). According to a recent survey from the Reverse Logistics Association, the annual volume of products returned by consumers in the U.S. is estimated at between $150 and $200 billion at cost. This trend is expected to continue with more liberal return policies (Jayaraman and Luo 2007). Previously, product returns were considered troublesome; product returns were usually shipped in bulk to minimize costs, often resulting in significant delays in the recovery process (Guide et al. 2005). However, firms are now recognizing the potential value of product returns; product returns have recoverable value and can bring additional revenue into firm, if properly managed (Blackburn et al. 2004; Ilgin and Gupta 2010). For instances, Xerox has established an asset recovery program called the Xerox Green World Alliance, which aims to improve the environmental performance of its EOL products through a closed-loop supply chain (Xerox 2014). The program has helped Xerox to save millions of dollars in raw material costs over the past 20 years. Therefore, it is reasonable to argue that investment recovery contributes to financial performance as well as environment performance.

– H2a: Investment recovery is positively related to environmental performance.
– H2b: Investment recovery is positively related to financial performance.

3.2 Collaborative capability, GSCM practices and firm performance

As mentioned earlier, conventional eco-design approaches were internally oriented. As eco-design includes a broad range of environmental activities among supply chain members, it has become more difficult for a single firm to have all the information on a product and its production processes (Nakano and Hirao 2011). To truly maximize the value of eco-design, a firm should leverage potential synergistic effects of supply chain collaboration (Thabrew et al. 2009). This notion is clearly supported by the International Electrotechnical Commission (IEC), which suggests that eco-design requires collaborations and contributions of all supply chain participants (IEC 2010). A number of studies also indicate that firms can expect more substantial environmental and financial improvements when they take into account design factors outside of their immediate control, including suppliers, customers, recyclers, etc. (González-Benito and González-Benito 2005). Previously, it was difficult to collect all the data required to analyze eco-design activities from globally dispersed business partners (Nakano and Hirao 2011). With the recent rapid advances in information and communication technologies, it is now possible for firms to easily share their valuable experiences on eco-design. For instance, LCA software packages such as SimaPro can help firms to quantify their eco-design activities and goals, enabling them to accurately measure the potential environmental and financial consequences of their new product (Vallet et al. 2013).

Indeed, collaboration is not optional anymore, but a basic requirement for eco-design. For example, collaborative environmental assessment is one of the keys to L'Oréal's eco-design initiative (Fayolle et al. 2008). Specifically, L'Oréal works closely with its suppliers to evaluate the environmental impact of raw materials throughout their life-cycle. This is an important part of L'Oréal's long-term environmental plan, which aims to source 100 % renewable raw materials from sustainable sources by the year 2020. Collaborations are also crucial to Levi Strauss & Co.'s efforts to use less water in the life cycle of its new "Water < Less" jeans collection (Joule 2011). Because it was found that the majority of water use is for the cotton production process, Levi's joined the Better Cotton Initiative, a program that helps cotton suppliers to make cotton more sustainable. Since the launch of the collection in 2011, Levi's has saved over 770 million liters of water, selling over 13 million "Water < Less" pairs of jeans. These examples clearly show that collaborative improvement activities are essential to reap the full benefits of eco-design. Based on the above discussion, the following hypotheses are suggested.

– H3a: Collaborative capability moderates the relationship between eco-design and environmental performance.
– H3b: Collaborative capability moderates the relationship between eco-design and financial performance.

Previously, investment recovery tended to focus on how to handle surplus items within the boundaries of a firm (e.g., idle equipment within a firm) (Sinding 2000). Managers viewed reverse logistics as a series of fragmented non-value-added activities; this lack of supply chain visibility led them to address each reverse logistics activity in isolation from a silo perspective (Guide et al. 2005). Consequently, the focus of most investment recovery strategies was to achieve maximum local efficiencies and economies of scale.

However, as mentioned earlier, the responsibility to handle the EOL management increasingly shifts back to the manufacturers. As a result, the traditional supply chain has been expanded to include both forward and reverse logistics (Olorunniwo and Li 2010). Such a supply chain framework, the combination of forward and reverse logistics, is called a closed-loop supply chain (Savaskan et al. 2004). In this integrated environment, firms can benefit from collaborative investment recovery strategies; for example, a manufacturer facing time-sensitive product returns such as laptop computers can establish partnerships with its retailers to minimize the loss in product value due to time delays; retailers evaluate product condition as early as possible at the point of customer returns to identify product returns with high recoverable value (Blackburn et al. 2004).

Many firms have attempted to maximize the value of investment recovery through collaborative efforts of closed-loop supply chain members (Toffel 2004). For instance, Nissan Motor Corporation in Japan works with a number of supply chain partners to improve the recovery rate for its EOL vehicles (Nissan 2014). Nissan relies on its dealerships, which collect discarded bumpers. Nissan pulverizes these discarded bumpers so that bumper materials can be used to make new bumpers. In addition, Nissan has teamed with the Sumitomo

Corporation to evaluate the reuse of the Nissan LEAF battery for commercial purposes. Nissan recovered over 100 thousand tons of automobile shredder residue collected from vehicles in Japan, earning a profit of over 800 million Japanese yen (8 million US dollars). These examples clearly indicate that collaborative improvement efforts are important to maximize the value of investment recovery. Based on the above discussion, the following hypotheses are suggested.

H4a: Collaborative capability moderates the relationship between investment recovery and environmental performance.
H4b: Collaborative capability moderates the relationship between investment recovery and financial performance.

3.3 Control variables

Following the literature, this study included firm size as a control variable (Zhu and Sarkis 2004, 2007). Large firms are more likely to adopt GSCM practices because they have a greater amount of resources and typically face higher environmental pressure than small or medium sized firms. Industry type was also included as a control variable.

4 Research methodology

4.1 Sample

The data for this study were collected from South Korean manufacturers. Our empirical setting is particularly appropriate for several reasons: First, South Korea has taken many green initiatives as a national development strategy (Lee et al. 2012). For example, it has become the first Asian nation to pass legislation introducing the nation-wide greenhouse gas emission trading scheme, which is set to come into force in 2015 (Chae 2010). Recent studies have focused on South Korea to understand a variety of GSCM related issues (Kim and Rhee 2012; Kim et al. 2011). Second, the increasing global competition over the past decade has enabled South Korean firms to improve the ability to react to global standards for green business (Kwon et al. 2002; Lee and Kim 2011). The majority of South Korean firms rely on international trade for a large portion of their annual revenue. According to OECD statistics in 2010, 45 % of Korean GDP is from international trade. To create opportunities for new markets in the global market, South Korea's large firms such as Samsung, Hyundai, and LG have sought to develop green strategies that effectively address global environmental issues (Green Growth Korea 2010). Third, the Korean government's Green Partnership project is actively encouraging large manufacturers to contribute their green philosophy to small and medium-sized suppliers (Lee 2008; Lee and Klassen 2008). This has led manufacturers to shift the focus of their green strategies from single plant improvements to the entire supply chain. For instance, Samsung SDI has started the Global Green Partnership project, which aims to help its suppliers to enhance the ability to respond to environmental regulations (Samsung SDI 2012). Samsung SDI has recently created a green management collaboration system for its suppliers in China and plans to expand the systems to its suppliers in other countries such as Vietnam and Malaysia. For all of the reasons above, South Korea provides a quite suitable empirical setting for our research purposes.

4.2 Survey questionnaire and data collection

The survey questionnaire was developed to collect research data. The initial pool of items was selected from existing scales, with wording changed to reflect the context of manufacturing processes. The design process for the questionnaire consisted of two stages. In the first stage, an extensive literature review on environmental practices was conducted to ensure the questionnaire's content validity. Five academic colleagues were asked to review the initial questionnaire for ambiguity and appropriateness of the items. We modified the instrument based on their feedback. In the second stage, the survey questionnaire was pilot-tested in a sample of ten supply chain practitioners. They were also asked to evaluate whether the items reflect adequately the domain of interest. Their feedback resulted in minor changes. The double translation protocol was used for the questionnaire development because data were collected from South Korean firms (Brislin 1976). The authors of this study translated the final English version of the questionnaire into Korean and then translated the Korean version back into English. Two bilingual researchers who teach operation management in the US also examined the English versions and found no significant differences. As shown in Table 1, the questionnaire included seven items for GSCM practices (Zhu and Sarkis 2004, 2007; Zhu et al. 2008), eight items for firm performance (Zhu and Sarkis 2004, 2007), and eight items for collaborative capability (Kotabe et al. 2003; Koufteros et al. 2007; Patnayakuni et al. 2006). They were measured using a seven-point Likert scale with anchors ranging from strongly disagree (1) to strongly agree (7) in order to ensure high statistical variability among survey responses.

The Web-based questionnaire was sent out to supply chain managers of 910 South Korean manufacturing firms with ISO 14001, ISO 9001, or ROHS certification. The Web-based survey is a more convenient method with substantially fewer missing responses than mail-based surveys (Boyer et al. 2002). About 2 weeks later, we sent follow-up emails to remind managers who had not responded to take part in the survey. The non-response bias was assessed to compare early respondents who answered within the first 2 weeks, later respondents who answered after the third week, and non-

Table 1 List of questionnaire items

GSCM practice factors	
Eco-design	
	We design our products to avoid or reduce the use of hazardous products and their manufacturing process.
	We provide design specifications to our partners that include environmental requirements for purchased items.
	We design products considering life cycle assessment (LCA).
	We design our products for reuse, recycle, and recovery of material and component parts.
Investment recovery	
	We have implemented collecting policies.
	We have implemented recycle policies.
	We have implemented remanufacturing policies.
Collaborative capability factor	
	We rely on our partners' engineering capability.
	Our partners' tools and machinery are customized to our needs.
	Our partners spend a significant amount of time and effort to our relationship.
	Our partners' knowledge of our procedures, culture, and technological know-how are difficult to replace.
	The frequent contacts between our partners and our engineers are important.
	The direction of our communication is bilateral rather than unilateral.
	Our engineers and sales staff work closely with our partners' staff.
	We share our high level of engineering capability with our partners.
Firm performance factors	
Environmental performance	
	Our CO2 emission has been reduced after the introduction of green management.
	Our waste water has been reduced after the introduction of green management.
	Our solid waste has been reduced after the introduction of green management.
	Our energy consumption has been reduced after the introduction of green management.
Financial performance	
	Our profitability has increased after the introduction of green management.
	Our market share has increased after the introduction of green management.
	Our sale growth rate has increased after the introduction of green management.
	Our earnings per share rate has increased after the introduction of green management.

respondents (a sub-sample of 25 non-respondents were randomly selected from the sample of 910) (Armstrong and Overton 1977). A simple paired *t* test was conducted for three pairs (early-late; early-non respondent; late-non respondent). *T* test comparison showed no significant difference ($p<0.05$) between the firm size, industry sector, eco-design, investment recovery, two performance factors or levels of collaborative capability.

The survey yielded 230 useable responses (a response rate of 25.3 %), achieving an acceptable response rate for a supply chain management survey (Rosenzweig et al. 2003). The data shows the firms' annual sales ranged from 2.5 million to 325 million US dollars with a median of 184.1 million US dollars. Also, most respondents were from operations, purchasing, and supply chain management team. Relatively few respondents were (10 out of 230) from other departments such as marketing and R&D. Table 2 shows the sample characteristics in terms of industry type and the number of employees. Descriptive data, including means, standard deviations, and samples size are shown in Table 3.

4.3 Factor analysis

The influence of common methods variance might be problematic when data on the independent and dependent variables are collected from the same respondents in the same survey. A principal component factor analysis (with a direct oblimin rotation, delta=0) was conducted through SPSS 18.0 to further confirm grouping GSCM practices, collaborative capability and firm performance. The Kaiser criterion (eigenvalues> 1) was employed in conjunction with parallel analysis and Cattell's (1966) scree test. As expected, the results showed the presence of two, one, and two components for GSCM practices, collaborative capability and firm performance, respectively. It means that common methods bias is not a serious problem in the data. Tables 4 and 5 present the pattern matrix

Table 2 Sample charateristics

	Frequency	Percent
Industry type		
Miscellaneous manufacturing	56	24.3
Automobile hardware, metal, and manufacturing	42	18.3
Industrial, commercial machinery and computer equipment	39	17.0
Transportation services	29	12.6
Rubber and miscellaneous plastics products	26	11.3
Primary metal industries	25	10.9
Electronic/other electrical equipment and components, except computer	7	3.0
Equipment	6	2.6
Total	230	100.0
Number of employees		
Up to 100	34	14.8
101–300	23	10.0
301–500	19	8.3
501–700	30	13.0
701–900	39	17.0
Over 900	85	37.0
Total	230	100.0

Table 3 Descriptive statistics

Survey items	Mean	SD
Eco-design		
We design our products to avoid or reduce the use of hazardous products and their manufacturing process.	4.713	1.368
We provide design specifications to our partners that include environmental requirements for purchased items.	4.548	1.343
We design products considering life cycle assessment (LCA).	4.574	1.345
We design our products for reuse, recycle, and recovery of material and component parts.	4.696	1.309
Investment recovery		
We have implemented collecting policies.	4.683	1.193
We have implemented recycle policies.	4.735	1.191
We have implemented remanufacturing policies.	4.726	1.185
Collaborative capability		
We rely on our partners' engineering capability.	2.969	1.302
Our partners' tools and machinery are customized to our needs.	3.017	1.233
Our partners spend a significant amount of time and effort to our relationship.	3.057	1.223
Our partners' knowledge of our procedures, culture, and technological know-how are difficult to replace.	3.026	1.274
The frequent contacts between our partners and our engineers are important.	3.017	1.226
The direction of our communication is bilateral rather than unilateral.	3.044	1.125
Our engineers and sales staff work closely with our partners' staff.	2.913	1.160
We share our high level of engineering capability with our partners.	2.935	1.215
Environmental performance		
Our CO2 emission has been reduced after the introduction of green management.	4.752	1.176
Our waste water has been reduced after the introduction of green management.	4.835	1.163
Our solid waste has been reduced after the introduction of green management.	4.883	1.129
Our energy consumption has been reduced after the introduction of green management.	4.752	1.198
Financial performance		
Our profitability has increased after the introduction of green management.	4.817	1.208
Our market share has increased after the introduction of green management.	4.578	1.268
Our sale growth rate has increased after the introduction of green management.	4.630	1.225
Our earnings per share rate has increased after the introduction of green management.	4.574	1.275

for GSCM practices and firm performance, respectively. The two GSCM practice components explained 84.16 % of the total variance and two firm performance components accounted for 82.07 % of the total variance. As shown in Table 6, collaborative capability, extracted as one component with no cross-loadings, explained 69.55 % of total variance. Further analysis was conducted to test the reliability of all the scales. All Cronbach alpha values, including 0.916 for eco-design, 0.872 for investment recovery, 0.914 for environmental performance, 0.910 for financial performance, and 0.888 for collaborative capability, were well above the threshold value of 0.70 (Gefen et al. 2000).

Table 7 shows the means, standard deviations, and correlations of all the factors. Because investment recovery is

Table 4 Factor matrix-GSCM practices

Survey items	Component	
	1	2
We design products considering life cycle assessment (LCA).	<u>0.955</u>	−0.065
We provide design specifications to our partners that include environmental requirements for purchased items.	<u>0.888</u>	0.012
We design our products to avoid or reduce the use of hazardous products and their manufacturing process.	<u>0.858</u>	0.063
We design our products for reuse, recycle, and recovery of material and component parts.	<u>0.734</u>	0.160
We have implemented recycle policies.	0.244	<u>0.880</u>
We have implemented remanufacturing policies.	0.247	<u>0.858</u>
We have implemented collecting policies.	0.376	<u>0.791</u>

Extraction Method: Principal Component Analysis

Rotation Method: Oblimin with Kaiser Normalization

Rotation converged in 5 iterations

Table 5 Factor matrix-firm performance

Survey items	Component	
	1	2
Our waste water has been reduced after the introduction of green policies.	0.924	−0.007
Our solid waste has been reduced after the introduction of green policies.	0.921	−0.031
Our energy consumption has been reduced after the introduction of green policies.	0.909	0.006
CO2 emission has been reduced after the introduction of green policies.	0.844	0.042
Our earnings per share rate has increased after the introduction of green management.	−0.061	0.941
Our sale growth rate has increased after the introduction of green management.	0.013	0.916
Our market share has increased after the introduction of green management.	−0.032	0.914
Our profitability has increased after the introduction of green management.	0.099	0.775

Extraction Method: Principal Component Analysis
Rotation Method: Oblimin with Kaiser Normalization
Rotation converged in 6 iterations

correlated at 0.61 with eco-design and at 0.60 with environment performance, Fornell and Larcker's (1981) test was conducted for discriminant validity. This test requires that the average variance extracted (AVE) for each factor should be greater than the squared correlation between the factor and other factors in the model. Table 7 shows the square root of AVE on the diagonal axis. All diagonal elements are larger than their corresponding correlation coefficients, indicating appropriate discriminant validity.

5 Results

Hierarchical regression was used to test hypotheses. The analysis was conducted in four steps. First, the control variable, firm size was entered into the regression. Then one GSCM practice variable was entered into the regression. Third, the moderator variable, collaborative capability, and the interaction term of one GSCM practice variable and collaborative capability was entered. The data were mean-centered in order to mitigate the effects of multicollinearity in regression models with interaction terms (Cronbach 1987).

Hypotheses 1a and 1b posit a direct, positive relationship between eco-design and two performance factors. Table 8 indicates that both relationships were statistically significant, supporting both Hypotheses 1a and 1b. Hypotheses 2a and 2b posit a direct, positive relationship between investment recovery and two performance factors. Table 9 shows that investment recovery had a direct, positive association with two performance factors, supporting Hypotheses 2a and 2b.

Hypotheses 3a and 3b suggest that collaborative capability moderates the relationship between eco-design and two performance factors. Table 7 shows that the interaction terms between eco-design and collaborative capability had significant positive coefficients for financial performance, supporting Hypothesis 3b. Hypotheses 4a and 4b suggest that

Table 6 Factor matrix-collaborative capability

Survey items	Component 1
Our partners' tools and machinery are customized to our needs.	0.856
We rely on our partners' engineering capability.	0.855
Our partners spend a significant amount of time and effort to our relationship.	0.852
Our engineers and sales staff work closely with our partners' staff.	0.845
Our partners' knowledge of our procedures, culture, and technological know-how are difficult to replace.	0.823
The frequent contacts between our partners and our engineers are important.	0.816
We share our high level engineering capability with our partners.	0.815
The direction of our communication is bilateral rather than unilateral.	0.790

Extraction Method: Principal Component Analysis
1 component extracted

Table 7 Mean, standard deviations, correlations, and the square root of AVE

	Mean	SD	ED	IR	CC	EP	FP
Eco-design (ED)	4.63	1.19	0.838				
Investment recovery (IR)	4.71	1.06	0.610**	0.903			
Collaborative capability (CC)	2.99	1.01	−0.467**	−0.434**	0.883		
Environmental performance (EP)	4.80	1.05	0.545**	0.600**	−0.436**	0.889	
Financial performance (FP)	4.65	1.10	0.429**	0.426**	−0.504**	0.401**	0.922
Firm size	4.18	1.85	0.607**	0.550**	−0.448**	0.631**	0.312**

** $p<0.01$

collaborative capability moderates the relationship between investment recovery and two performance factors. The same pattern was observed as shown in Table 9. The interaction terms between investment recovery and collaborative capability had significant positive coefficients for financial performance only, supporting Hypothesis 4b.

Figure 3 and Table 10 summarize the results of the hypotheses testing. Overall, the implementation of GSCM practices was positively related to both firm performance factors. Collaborative capability positively moderated the relationship between GSCM practices and financial performance.

6 Discussion

6.1 The impacts of GSCM practices on firm performance

We found that GSCM practices can be beneficial for a firm's performance, thereby providing support to the NRBV. Thus, it can be argued that the implementation of GSCM practices helps a firm to develop unique environmental management capabilities that lead to higher performance. This finding is consistent with the results of recent studies drawing on the NRBV (Lee and Klassen 2008; Shi et al. 2012). Previously, most firms have relied on the "win-win" argument to justify investments in GSCM programs. This assumption has often been criticized on the ground that such investments will raise the cost burden and in turn influence financial performance negatively. For example, Green et al. (2012) have shown that both eco-design and investment recovery are positively linked to environmental performance but not financial performance.

However, we found that GSCM strategies can be integrated into business with improved environmental and financial performance. The discrepancy between these two studies could be due to differences in the samples. Green et al. (2012) used a diverse group of US manufacturers while this study employed a focused group of South Korean manufacturers. In fact, the results of this study are consistent with those of Zhu and Sarkis (2004), who used a homogeneous group of Chinese manufacturers.

Another explanation for improved financial performance is the Korean government's supply chain environmental management (SCEM) program, which includes special funds and tax-cut incentives for firms that actively implement environmental initiatives (Lee 2008). With such assistance programs, it is possible that South Korean manufacturers reduce costs related to the implementation of GSCM programs, leading to significant financial improvement.

Table 8 Hierarchical regression with eco-design and collaborative capability interaction

Variable entered	Dependent variable					
	Environmental performance			Financial performance		
	Step 1	Step 2	Step 3	Step 1	Step 2	Step 3
Firm size (control)	0.349** (0.030)	0.265** (0.036)	0.241** (0.037)	0.186** (0.038)	0.035 (0.045)	−0.043 (0.042)
Industry (control)	−0.023 (0.022)	−0.016 (0.021)	−0.015 (0.021)	−0.053 (0.028)	−0.042 (0.027)	−0.037 (0.024)
Eco-design		0.221** (0.055)	0.183** (0.057)		0.342** (0.069)	0.227** (0.064)
Collaborative capability			−0.116 (0.066)			−0.271 (0.075)
Collaborative capability × Eco-design			0.039 (0.041)			0.219** (0.046)
F	76.193**	59.574**	37.873**	14.190**	18.514**	26.931**
R^2	0.402	0.442	0.446	0.103	0.187	0.362
R^2 change	0.402**	0.039**	0.004	0.103**	0.083**	0.175**

** $p<0.01$

Table 9 Hierarchical regression with investment recovery and collaborative capability interaction

Variable entered	Dependent variable					
	Environmental performance			Financial performance		
	Step 1	Step 2	Step 3	Step 1	Step 2	Step 3
Firm size (control)	0.349** (0.030)	0.241** (0.033)	0.223** (0.034)	0.166** (0.039)	0.054 (0.043)	−0.010 (0.040)
Industry (control)	−0.023 (0.022)	−0.011 (0.020)	−0.009 (0.020)	−0.053 (0.028)	−0.040 (0.027)	−0.029 (0.024)
Investment recovery		0.356** (0.057)	0.316** (0.059)		0.370** (0.075)	0.204** (0.070)
Collaborative capability			−0.100 (0.060)			−0.339 (0.071)
Collaborative capability × Investment recovery			0.035 (0.039)			0.186** (0.046)
F	76.193**	72.684**	45.235**	14.190**	18.649**	25.358**
R^2	0.402	0.491	0.502	0.111	0.198	0.361
R^2 Change	0.402**	0.089	0.011*	0.111**	0.087**	0.163**

* $p<0.05$

** $p<0.01$

6.2 The moderating effects of collaborative capability on firm performance

We found that firms with high levels of collaborative capability tend to gain better financial performance from the implementation of GSCM programs. Figure 4a and b show that the stronger collaborative capability, the greater the positive relationship between GSCM practices and financial performance. In other words, firms that implement GSCM programs with close collaboration with their supply chain partners are more likely to experience high financial performance than those who do not have such strong relationships. Recent studies that focused on South Korean firms also reported similar results (Kim et al. 2011; Kim and Rhee 2012; Lee and Kim 2011).

However, the results of this study indicate that there is no significant moderating effect of collaboration for environmental performance. The results have an important implication for our understanding of how firms use their resources for supply chain collaboration. In South Korea, it is possible that some manufacturers implement environmental programs reactively because they are required to meet the government's environmental requirements. Those manufacturers that are less environmentally motivated are likely to put more resources into collaborative activities for financial improvement rather than environmental improvement. Presumably, after simply meeting the minimum requirements set by the government, less environmentally motivated manufacturers may focus on maintaining the status quo without further attempting to improve environmental performance.

Another explanation for this insignificant moderating effect may be simply that our sample firms did not collaborate on environmental activities. In this study, the scale of collaborative

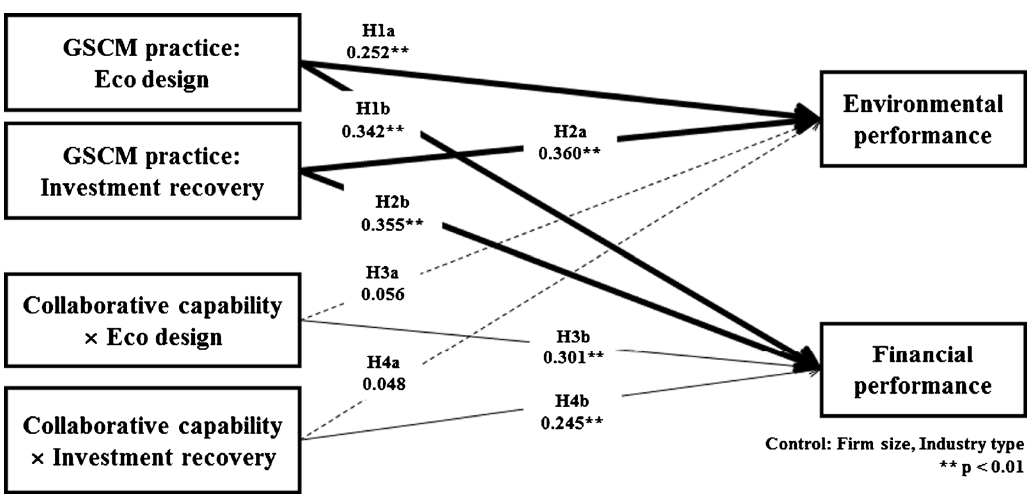


Fig. 3 Results of the hypotheses testing

Table 10 Hypotheses and results summary

Hypothesis		Statistics (beta)	Support
H1a	Eco-design is positively related to environmental performance.	0.252**	Supported
H1b	Eco-design is positively related to financial performance.	0.342**	Supported
H2a	Investment recovery is positively related to environmental performance.	0.360**	Supported
H2b	Investment recovery is positively related to financial performance.	0.355**	Supported
H3a	Collaborative capability moderates the relationship between eco-design and environmental performance.	0.056	Not supported
H3b	Collaborative capability moderates the relationship between eco-design and financial performance.	0.301**	Supported
H4a	Collaborative capability moderates the relationship between investment recovery and environmental performance.	0.048	Not supported
H4b	Collaborative capability moderates the relationship between investment recovery and financial performance.	0.245**	Supported

** $p<0.01$

capability did not differentiate the context of collaboration. Therefore, it could be possible that these firms collaborated more on traditional issues such as quality improvements and cost savings rather than on environmental issues.

6.3 Contributions of this study

Overall, this study contributes to the growing research on GSCM strategies by highlighting the role of another important complementary asset – collaborative capability. As discussed earlier, previous studies that examined the effects of GSCM practices underscored the necessity to identify possible moderators. Researchers should continue to explore potential moderators to better explain the effects of GSCM practices on firm performance.

Another contribution of this study is to add to a growing body of GSCM research conducted in a variety of countries. GSCM studies have traditionally tended to focus on developed countries such as Germany (Thun and Müller 2010), the UK (Holt and Ghobadian 2009), the US (Green et al. 2012), etc. As more and more firms are moving a significant portion of their manufacturing operations to Asia, recent GSCM research efforts have shifted toward countries such as China (Zhu et al. 2008), India (Mitra and Datta 2014), Malaysia (Eltayeb et al. 2011), Taiwan (Shang et al. 2010), Thailand (Setthasakko 2009), etc. These studies showed that those countries have developed unique green initiatives, suggesting that country-specific characteristics in this region deserve more research attention in the study of GSCM (Rao and Holt 2005). The results of this study also indicate that future GSCM studies should continue to place a greater emphasis on country-specific aspects.

7 Conclusion

As an important new strategy, GSCM allows firms to achieve financial and market share goals by lowering their environmental costs while ensuring environment friendly operations. Recently, the importance of GSCM has received considerable attention. Implementing GSCM can benefit the firm as it can be a revenue driver. However, most GSCM related studies have yet to investigate which capability of the firm is needed for successful GSCM. This study proposed collaborative capability as an important moderator for the relationship between GSCM implementation and firm performance. The results of this study show that the positive relationship between GSCM practices and financial performance is stronger when a firm actively collaborates with various partners. In an increasingly competitive and dynamic global business environment,

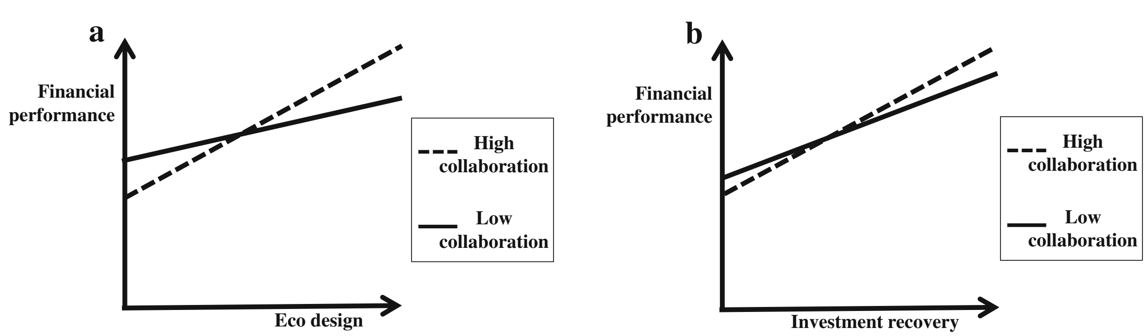


Fig. 4 Moderating effects of collaboration on financial performance

multinational manufacturers can seek benefits from investing in GSCM through collaboration with suppliers that implement operations that satisfy green standards. Firms that implement GSCM practices by building close relationships with their partners can obtain higher financial outcome. The literature on collaboration between inter-firm involvements also indicates that collaboration plays a critical role when the complexity increases in the business environment. Through communication, coordination, and conflict resolution processes with various partners, firms can obtain shared interpretation of the information, which enables swift and decisive actions to solve environmental problems.

There are some limitations to this study. Since our data were collected from a single source, the risk of common methods bias might be problematic. Also, financial performance is measured by perception of respondents, not by real financial data. This perception has potential to exaggerate the performance. The self-reported survey data used in this study might not fully reflect the actual situation. However, the self-reported survey data are commonly used to measure performance and we believe that our approach is sufficient to provide a snapshot of current practices of green practices among South Korean manufacturers. Last but not least, some supply chain partners might achieve some type of environmental certification, biasing our findings. These limitations should be addressed in the future research, including a longitudinal analysis of GSCM practices over time.

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