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Environmental Capabilities of Suppliers for Green Supply Chain Management in Construction Projects: A Case Study in Korea

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Abstract: Green supply chain management (GSCM) enhances a firm's competitiveness for sustainable growth. GSCM is especially important in the construction industry, a project-based business that often results in heavy environmental pollution. For the successful implementation of GSCM in the construction industry to occur, contractors should make the best use of suppliers' environmental capabilities based on shared understanding of the capabilities. This paper examines the shared understanding of suppliers' environmental management capabilities between the contractor and suppliers by assessing the consistency between the contractor's and suppliers' evaluations of the capabilities. This explorative case study investigates a supply chain comprised of a major construction firm and 106 suppliers in Korea. The results of the case analysis show that the suppliers' self-evaluation scores of environmental capability are higher than the contractor's evaluation scores. Furthermore, from both evaluators, suppliers received the lowest scores in the evaluation item rating the relationship with second-tier suppliers and the highest in the evaluation item rating the relationship with the contractor. The consistency between the suppliers' and contractor's evaluation is related to several characteristics of suppliers, such as industry type, firm size and partnership duration with the contractor. This study contributes to the literature of GSCM and strategic alignment amongst supply chain partners for the construction industry.

Keywords: GSCM; construction industry; project-based business; environmental management capability; resource-based view; capability evaluation; supplier capability

1. Introduction

The conflict between economic growth and environmental pollution has been a serious issue, not only in academia, but also for the whole society, since the Industrial Revolution, now more than ever before [1]. Firms have consistently placed their efforts in achieving competitive advantages through the concept of specialization and cooperation where the Industrial Revolution was based, while suffering the environmental consequences induced by the process of economic growth [1–3]. However, firms do not see the conflict between the two as a necessary evil any more. Since the introduction of green supply chain management (GSCM), this has garnered much attention from industries and academia as a way to grow firm's competitiveness based on specialization and cooperation, while simultaneously enabling environmentally-sustainable growth.

Among many different definitions of GSCM, Sarkis *et al.* [1] simply defines it as an integrated concept of supply chain management (SCM) practices and environmental concerns. Hervani *et al.* [4] introduced an equation, which defines the coverage of the concept, where GSCM consists of green purchasing, green manufacturing/materials management, green distribution/marketing and reverse

logistics. Increased interest in environmental issues and sustainable development has prompted adopting GSCM to respond to the environmental challenges all industries face [5]. In line with the efforts of industries, GSCM has been a popular subject for researchers. Min and Kim [6] give much attention to GSCM from academia through the extensive review on extant literature that addresses various subjects, including policy, synthesis, purchasing, manufacturing, logistics and reverse logistics.

Considering that the term GSCM consists of two parts "green" and "supply chain management" in its definition, GSCM has specialties in the construction industry in two aspects; one is the part of "green" related to environmental concern and the other is "supply chain management", which is different from the traditional way of SCM in the manufacturing industry. First, the construction industry is inherently not eco-friendly considering its nature and tends to be the primary cause of environmental pollution in many countries [5]. As such, GSCM of construction companies has a great impact on the environment. Second, GSCM in the construction industry should be based on the distinctive characteristics of the industry as one of the representative project-based businesses [7]. According to Park *et al.* [8], a successful SCM in the construction industry results from strategies based on the differences between SCM of the construction industry and that of other manufacturing industries where the concept SCM was developed. As GSCM is a concept derived from SCM, for successful implementation of GSCM to occur, those intrinsic characteristics of construction project SCM, such as the unstandardized production process and the unique supply chain formation process, must be considered [8].

SCM in project-based industries, such as the construction sector and the shipbuilding industry, requires the alignment of contractor's knowledge about supplier's capabilities with supplier's capabilities actually contributing to the project [2]. According to Ruuska *et al.* [2], as suppliers are external sources of knowledge and innovation and their capabilities create values for the entire supply chain that carries out the project, as well as the contractor, the contractor should exactly understand the suppliers' capabilities and then make the best use of them. Therefore, the contractor's accurate evaluation of the suppliers' capabilities in various areas, such as operational capabilities, technical capabilities and relational capabilities, is the first step for the supply chain to gain a competitive advantage [2]. This is also true in GSCM. To gain a competitive advantage through GSCM in the construction industry, first of all, the contractor's selection of its suppliers should be based on an accurate assessment of the suppliers' capabilities, especially related to environmental capabilities. According to a recent study of Woo *et al.* [9], a contractor's exact assessment of the suppliers' environmental capabilities contributes to the corporate competitiveness of the suppliers in the construction sector.

The aim of this paper is to examine the consistency between the contractor's assessment of the suppliers' capabilities related to environmental management and the suppliers' self-assessment in GSCM of the construction industry through an explorative case study. While prior studies focused on questions, such as the influence of certain capabilities of firms on the GSCM performances and how the level of the capabilities contribute to the GSCM performances, this paper focuses on how accurate evaluation of the suppliers' capabilities contributes to performances. This research investigates a supply chain consisting of a representative construction firm in Korea and its 106 suppliers. By looking deeply into the case, the reasons of inconsistency in suppliers' capability assessments are clarified, and potential solutions are proposed accordingly.

The remaining parts of this paper are structured as follows. The next section presents literature reviews on the suppliers' environmental capabilities and the evaluation of the capabilities for GSCM in the construction industry, followed by research methods dealing with the procedure of data collection and data analysis. Finally, the results are described, and the findings from the results are discussed with limitations and the direction of future study.

2. Literature Review and Theoretical Background

Ruuska *et al.* [2] looked into a large shipbuilding project to see how important supplier capabilities are and how accurately the contractor evaluates them in a collaborative and discontinuous project-based industry. The results show the differences between the contractor's perspective and those of its 20 suppliers that exist and imply that these differences lead to misunderstanding and harm the relationship between them. Motivated and inspired by Ruuska *et al.* [2], this paper investigates the case of the construction industry in the perspective of GSCM.

The literature review consists of three subsections. First of all, the importance of GSCM in the construction industry is dealt with from the perspective of environmental impact and the necessity of collaboration for the successful performance of a construction project. Second, the environmental capabilities required of the construction project suppliers are reviewed. Lastly, based on prior studies and especially from the resource-based view (RBV), this paper reasons why an objective evaluation of the suppliers' environmental capabilities is critical to not only a contractor firm or individual suppliers, but also to the entire supply chain for GSCM in the construction industry.

2.1. GSCM in the Construction Industry

Environmental concerns and environmental regulations have led to the demand of activities to increase environmental performance over all industries, including the construction sector. Among many industries, GSCM is particularly important in the construction industry, considering that it is one of the main sources of environmental problems and that it is a project-based business, where SCM practices are quite different from traditional SCM in the manufacturing industries, such as the electronics industry or the automotive industry [5,7,10].

Construction activities are not eco-friendly and contribute significantly to environmental degradation in many countries [5,10]. According to Widen and Hansson [11], as the construction industry turnover accounts for 5%–12% of GDP in a country, the environmental impact of emissions, energy usage and poisonous by-products from the production process and the end product is immense [12]. In the United States, the construction industry is one of the primary sources of greenhouse gas emissions [13], while in China, environmental pollution related to the industry has been a serious problem since the radical urbanization began in the early 1980s [14]. In Hong Kong, about a quarter of total solid waste sent to landfills in 2013 was from construction activities [15]. As a result, managers in the construction industry have implemented environmental management to obtain benefits, such as the reduction of environmental complaints and cost saving due to the reduction of environmental fines [5].

To understand the importance of GSCM in the construction industry, the characteristics of SCM in this industry also should be taken into account. The construction sector is a project-based business where a group of firms collaborate together to achieve the goals of the project, usually requiring special capabilities for various construction activities, such as design, manufacturing, procurement, engineering and logistics [2,7,16,17]. Firms form a temporary supply chain, which organizes its structures, strategies and capabilities according to the customer's needs, while the contractor firm receiving an order from a customer performs a key role as a leading firm of the project [7,8]. The contractor chooses firms that can best contribute to the project outcomes before actually beginning the construction, coordinating and controlling problems while working on the project [2,8]. It is noteworthy that the requirements of construction projects vary depending on different clients due to the non-continuity of the projects [18]. Because of this, the structure and participants of a supply chain also change for each project, and the processes of production are not standardized [8]. Therefore, not only the competitiveness of individual firms, but also the collaboration between these firms are critical for enabling GSCM in the construction industry. GSCM strategy planning and implementation without consideration of these factors cannot be successful.

There have been several studies focusing on GSCM in the construction industry. Thipparat [18] reveals that green purchasing and internal environmental management are the most important

constructs of GSCM in the construction sector by using a fuzzy analytic hierarchy process (FAHP). Balasubramanian [19] identifies and classifies 32 barriers to the adoption of GSCM in the United Arab Emirates' (UAE) construction sector. While these studies mainly focus on the priority of the implementation or adoption of GSCM in the construction sector, there are studies investigating the impact of GSCM on the performances in various aspects. The research of Ketikidis *et al.* [20] analyzes the data from Kosovo's construction industry and suggests that GSCM practices and GSCM pressures, such as market, regulation and supply chain pressures, have significant positive effects on GSCM performances, including environmental performance, operational performance and positive/negative economic performance. Vachon and Klassen [21] reports the result of a survey conducted with North American manufacturers in the package printing industry, which shows that collaborative green practices of the supply chain, such as joint environmental goal/plan setting and joint efforts for reducing pollution, have positive impacts on manufacturing performance. Woo *et al.* [9] show that collaborations between supply chain members for GSCM have a positive relationship with the members' environmental performances, as well as the financial performances in the construction sector. Meanwhile, other researchers have studied the indicators of GSCM in the construction industry. Table 1 shows the tangible and intangible indicators of GSCM in the construction industry with the related literature.

Table 1. Tangible and intangible indicators of GSCM in the construction industry.

Tangible Indicators	Literature	Intangible Indicators	Literature
1. Resource consumption - Energy consumption - Timber consumption - Paper consumptio - Water consumption - Non-renewable resource consumption 2. Pollution - Air pollution - Noise pollution - Liquid waste - Solid waste - Water Polluton 3. Green cost - Cost of material purchasing - Fee for waste treatment - Fine for environmental accidents	Tam *et al.* [22]; Wagner and Schaltegger [23]; Zhu *et al.* [24]	1. Internal environmental management - Commitment of GSCM from senior managers - Support for GSCM from mid-level managers - Cross-functional cooperation for environmental improvements - Total quality environmental management - Existence of environmental management systems 2. Green purchasing - Eco labeling of products - Cooperation with suppliers for environmental objectives - Second-tier supplier environmentally-friendly practice evaluation 3. Cooperation with customers - Cooperation with customers for eco-design, cleaner production and green packaging	Zhu *et al.* [25]; Thipparat [18];

2.2. Supplier Environmental Capabilities for GSCM

Capability is defined as "a firm's capacity to deploy resources, usually in combination, using organizational processes, to effect a desired end" [26]. As firm-specific resources and capabilities are the core to accounting for a firm's performance, managers exert themselves to identify, develop and deploy them to gain a sustainable competitive advantage [26]. In project-based firms, including construction firms, individual firms concentrate on developing and utilizing their core capabilities and outsource other works requiring capabilities that they are not confident in [2,27]. This is why firms should form a supply chain consisting of competitive and reliable suppliers [27]. As the environmental impact directly linked to the economic burden of disposal cost is a critical dimension of GSCM performance in the construction industry, suppliers' capabilities pertaining to environmental management are key elements for successful implementation of GSCM in this industry [9].

According to Shang *et al.* [28], GSCM capability includes finance/logistics/information flow, integration, relationship and, in particular, environmental management, as crucial sources of competitive advantage. Firms can improve environmental management through efforts, such as investment in environmental technology and pollution prevention, instead of pollution control, but firms should consider the manufacturing operations of their partner firms along the supply chain [29]. Environmental management capabilities in terms of SCM are characterized by joint collaborative activities among supply chain members and evaluative activities to screen the environmental management of suppliers [29]. Zhu *et al.* [30] categorizes GSCM practices into four aspects: internal environmental management, external GSCM, investment recovery and eco-design. Wong *et al.* [31] measures environmental management capabilities based on the research of Zhu *et al.* [30]. The measurement scales are concerned with the ISO 14000 certificate, second-tier suppliers' environmental activities' evaluation, ecological proof of products, environmental management guidelines and cooperation for reducing environmental impact [31]. Yang *et al.* [32] argues that green practices are potential strategic capabilities and used measurements related to green policy, green shipping practices and green marketing to evaluate internal green practices of container shipping firms in Taiwan.

2.3. Resource-Based View and Supplier Capability Evaluation

The resource-based view (RBV) provides this paper with a core theoretical foundation. RBV contends that firm's sustained competitive advantage comes from various resources, including capabilities, information and knowledge, that have value, rareness, inimitability and unsubstitutability [33]. In particular, capabilities referring to the capacity to deploy resources are a crucial source of value creation [26]. In the perspective of SCM in the construction industry, suppliers' capabilities are important sources of the value creation of the supply chain, and the contractor needs to deploy these capabilities to achieve the competitive advantage of the supply chain [2]. Hence, the contractor's accurate evaluation of suppliers' capabilities is essential for the successful result of the construction project. According to Purdy [34], supplier evaluation and certification is a way of increasing the ability of the contractor to deal with undesirable variability caused by suppliers with respect to delivery, quality and adjustment. Supplier capability evaluation is based on answering questions, such as what capabilities the suppliers have, when and how the contractor can utilize them and how the capabilities create values [2]. Therefore, it is impossible for the contractor to form a competitive supply chain or to make the best use of the capabilities through collaboration without exactly understanding suppliers' capabilities [35].

This also applies for GSCM. For better environmental performance in the construction industry, the contractor should form an environmentally-competitive supply chain consisting of suppliers selected by the contractor according to accurate evaluation of the environmental capabilities and collaborate with them while communicating based on the understanding of their environmental capabilities. Hart [36] proposed a natural-resource-based view (NRBV), suggesting that a firm's relation to the natural environment should be considered critical in the resource-based view. Hart [36] reckoned the unavoidable constraints of the natural environment on business activities in the near future and contended that the competitive advantage of a firm stems from capabilities enabling environmentally-sustainable growth. According to Wong *et al.* [31], firms can prosper by obtaining the capabilities to exploit and preserve natural resources, and partner firms' engagement in coordinated activities helps the firm access the resources of the partner firms. Furthermore, capability based on the complexity of inter-firm collaboration and coordination is an inimitable resource, which gives the firm a competitive advantage [31]. Therefore, suppliers' environmental management capabilities, as well as contractors' evaluations of the capabilities are crucial in GSCM of the construction industry.

3. Research Methods

An embedded single-case design is used in this paper in order to investigate how a contractor evaluates the suppliers' environmental capabilities in the construction industry, especially focusing on

the consistency of contractor's and suppliers' point of view on suppliers' environmental capabilities. A case study is an appropriate method to deal with the questions of how and why and the problems of contemporary phenomenon in depth without the control of behaviors within the real-world context [37]. In particular, an embedded single-case design is useful to analyze the single case with its subunits while enabling extensive analysis and enhancing the insights [37]. In that sense, the research method (embedded single-case design) can be properly matched with the research question focused on the single supply chain and the relationship of its subunits, including the contractor and its partner firms.

The selected case of analysis is a supply chain of a Korean major construction company who takes the role of contractor and its 106 first-tier suppliers, which have collaborated for at least one project. In Korea, diverse policies related to green growth, carbon dioxide reduction and green construction supports have been implemented. Relative technologies have been developed to achieve environmentally-sustainable growth with the view toward reducing the large environmental impact of the construction industry [38,39]. For instance, the Korean national certification system, GBCS (Green Building Certification System) developed in 2002, changing its name to G-SEED (Green Standard for Energy and Environmental Design) with amendments in its contents and active promotion in 2013, and technologies related to new and renewable energy have been developed and applied in the industry [38,39]. In that sense, the Korean construction industry is appropriate for the research question of this study. Especially, the contractor has a number of suppliers satisfying the international standard for environmental management systems, and it can be a representative case for GSCM study of the Korean construction industry.

3.1. Data Collection Process

The empirical data were gathered from a pilot test with interviews and mainly a matched survey on which the comparison analysis between the contractor's and suppliers' evaluations of supplier environmental capabilities is based. First, pilot tests and interviews were conducted with the questionnaires developed based on literature reviews. Four persons who represent each of the suppliers filled out the questionnaires and had a face-to-face semi-structured interview with the researchers. One more from the supplier firm participated in the pilot test, but did not have an interview, while one from the contractor gave helpful comments on the questionnaires and the result of the interviews throughout the whole process of this research. The interviews with the informants from the contractor and the suppliers were mainly concerned with the appropriateness of the developed questionnaire considering the characteristics of the construction industry. Further, the interviewees gave their opinions on the most reliable department to evaluate suppliers' environmental capabilities, the overall status of SCM utilization in each firm, as well as the Korean construction industry in general and more. As the informants did not feel comfortable with recording the interviews, the researchers took notes. Interviews including pilot tests took approximately 40–60 min in general.

Based on the interviews and pilot tests, questions were customized to the current construction industry, and the final questionnaire for the main survey was developed. Table 2 shows measurement items used to evaluate the suppliers' environmental capabilities in this study and related literature. The measurements consist of items related to internal environmental management capability and external environmental management capability. Supplier firms within the contractor's supply chain network and departments of the contractor, which are responsible for managing those suppliers, were required to take part in the matched survey. More in detail, an appropriate individual from a certain supplier self-rated the environmental management capabilities of her/his firm according to the questionnaire, and another single informant from the contractor who is regarded as capable and reliable in evaluating that supplier's capabilities was selected and required to answer the same questionnaire. Then, those two completed questionnaires about the evaluation of the same supplier's capabilities were matched and regarded as one sample. The survey used a 7-point Likert scale ranging from "strongly disagree" to "strongly agree", an online survey website, Qualtrics, and took about 6 months from March–August in 2014.

Table 2. Measurement items of supplier environmental management capability.

	Internal capability (A)	*Literature*
1.	My company has a clear environmental policy and systems.	Adopted from Yang *et al.* [32]
2.	Managers in my company do their best efforts to support GSCM.	
3.	Cross-functional cooperation works well for innovations and operations for the provision of green products and services in my company.	
4.	My company provides green education and training to enhance the employees' awareness of the needs of green activities.	
	External capability (B)	
1.	We conduct effective evaluations of our suppliers in terms of environmental management (second-tier suppliers' environmental activities).	Adopted and customized from Wong *et al.* [31] and Zhu *et al.* [30]
2.	We provide eco-friendly products and services.	
3.	We are provided with specific environmental management guidelines by our customer (the contractor).	
4.	We contribute to the reduction of environmental impact and risk in the processes of providing goods and services for the project.	
5.	We immediately respond to the requirement for environment management from our customer and report the results to the customer (the contractor).	

Table 3 shows the descriptive statistics of respondents. While respondents from the contractor consist of mangers (31.1%), assistant managers (42%) and staff (22%), those from the suppliers are mostly directors (62.3%) and general managers (17.9%). As representatives of the contractor should be capable and reliable in evaluating suppliers' environmental capability, people who actually work with the suppliers in the positions of manager, assistant manager and staff are appropriate to be informants. On the other hand, as representatives of the suppliers should be able to evaluate the entire firm's environmental capability, people in the higher positions, such as general managers and directors, are suitable informants. Meanwhile, respondents of the contractor are mainly working in the production/construction department (61.3%) and purchasing/quality department (25.5%), and those of the suppliers are from the production/construction department (54.7%) and the sales department (20.8%). Considering the roles of workers in the departments of the respondents, the survey informants are reliable. Lastly, 76.4% of the contractor respondents and 85.9% of supplier respondents have worked and built up relevant experiences for more than 3 years. This also shows the appropriateness of the respondent composition.

Table 3. Profile of respondents.

	Contractor		**Supplier**	
Gender	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Male	104	98.1	102	96.2
Female	2	1.9	4	3.8
Position	**Frequency**	**Percentage**	**Frequency**	**Percentage**
CEO	0	0	1	0.9
Director	0	0	66	62.3
General Manager	9	8.5	19	17.9
Manager	33	31.1	9	8.5
Assistant Manager	42	39.6	8	7.5
Staff	22	20.8	3	2.8

Table 3. *Cont.*

Age	Frequency	Percentage	Frequency	Percentage
20s	4	3.8	1	0.9
30s	46	43.4	20	18.9
40s	55	51.9	56	52.8
50s or over	1	0.9	29	27.4
Seniority	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Less than 1 year	2	1.9	5	4.7
1–3 years	23	21.7	10	9.4
3–5 years	20	18.9	13	12.3
5–10 years	24	22.6	28	26.4
10 years or more	37	34.9	50	47.2
Department	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Production/Construction	68	64.2	58	54.7
Purchasing/Quality	27	25.5	1	0.9
Sales	0	0	22	20.8
Strategy/Planning	0	0	16	15.1
Others	11	10.4	9	8.5

Note: $N = 106$.

Table 4 shows the profiles of 106 supplier firms that participated in this survey. The majority of the suppliers are small and medium-sized enterprises (SMEs) that have less than 500 employees (90.5%). The suppliers mostly have more than 10 years of industry experiences (74.5%) and have established long-term relationships with the contractor for more than ten years (51.9%). In particular, 57.5% of the suppliers are ISO 14001 certified.

Table 4. Profile of supplier firms.

Industry	**Steel**	**Construction**	**Chemical**	**Design**	**IT**	**Others**
	2 1.9%	68 64.2%	4 3.8%	5 4.7%	18 17.0%	9 8.5%
Employees	**Less than 50**	**50–100**	**100–500**	**500–1000**	**1000–3000**	**3000 and more**
	26 24.5%	40 37.7%	30 28.3%	4 3.8%	2 1.9%	4 3.7%
Sales (billion KRW)	**Less than 5**	**5–10**	**10–30**	**30–50**	**50–100**	**100 and more**
	21 19.8%	22 20.8%	29 27.4%	6 5.7%	11 10.4%	17 16.0%
Years engaged in industry	**Less than 1**	**1–2**	**2–3**	**3–5**	**5–10**	**10 and more**
	2 1.8%	0 0%	2 1.9%	7 6.6%	16 15.1%	79 74.5%
Years of partnership with contractor	**Less than 1**	**1–2**	**2–3**	**3–5**	**5–10**	**10 and more**
	3 2.8%	3 2.8%	4 3.8%	12 11.3%	29 27.4%	55 51.9%
Number of projects per year	**1**	**2**	**3**	**4**	**5**	**6 and more**
	14 13.2%	14 13.2%	17 16.0%	9 8.5%	11 10.4%	41 38.7%
ISO 14001 *		**Certified**			**Not certified**	
		61 57.5%			45 42.5%	

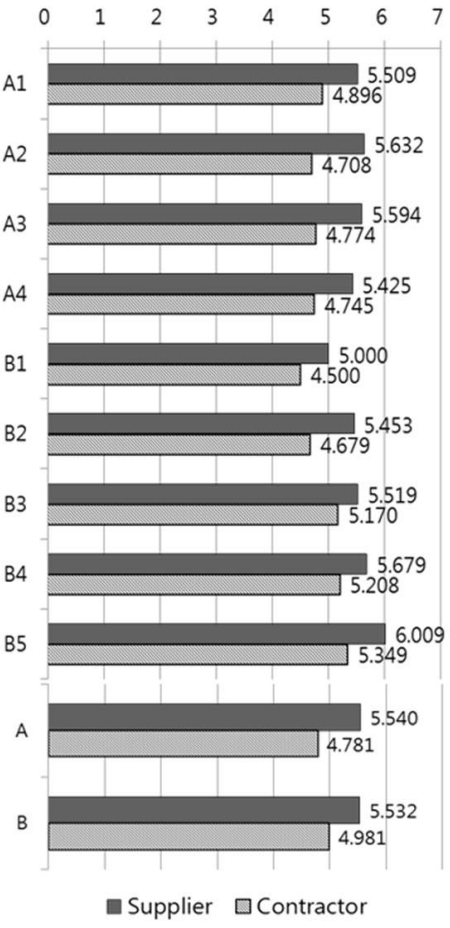
Note: $N = 106$; * ISO 14001 is an international standard for environmental management systems (EMS) involving an environmental policy, commitment to an EMS, a plan to implement the EMS, its implementation and operation, monitoring and correction, top manager's review and continuous improvement [40,41].

3.2. Data Analysis

Firstly, means and standard deviations of the measurement items in each category of the suppliers' environmental management capabilities were calculated for each firm (contractor's evaluation and suppliers' self-evaluation, respectively). Thereby, each firm is given four means and standard deviations of evaluation scores, including the internal/external environmental management capability score assessed by the supplier and its customer (contractor). The gaps between contractor's evaluation and supplier's self-evaluation of each firm are calculated and provide the basis of comparison of those perspectives. In addition, to find the clues explaining what influences these gaps, an independent sample *t*-test is conducted by using the suppliers' characteristics listed in Table 4 as group variables.

4. Results and Discussion

The analysis focused on comparing the differences between the contractor's evaluation and suppliers' self-evaluations for suppliers' environmental capabilities. Figure 1 shows the result of the analysis. First, the bar graph on the left side shows the means of the scores given to each question by the informants of the contractor and those of the suppliers, respectively. On the right side, the differences between the contractor's averages and the suppliers' averages in each question and the corresponding standard deviations are followed. Finally, means and standard deviations of absolute values of the differences between contractor's rating and supplier's rating in each supplier are provided.



	Mean of S − C	Standard Deviation		Absolute Value $\|S - C\|$	
		S	C	Mean	S.D.
A1	0.613	1.311	1.373	1.387	1.092
A2	0.925	1.245	1.294	1.434	1.147
A3	0.821	1.271	1.221	1.425	1.077
A4	0.679	1.359	1.273	1.528	1.156
B1	0.500	1.685	1.520	1.726	1.444
B2	0.774	1.513	1.458	1.736	1.326
B3	0.349	1.494	1.431	1.443	1.332
B4	0.472	1.418	1.343	1.377	1.246
B5	0.660	1.334	1.428	1.453	1.353
A	0.759	1.196	1.171	1.443	0.854
B	0.551	1.324	1.217	1.547	1.106

Figure 1. Means and standard deviations of each item. A1 means the first measurement item for the evaluation of the suppliers' internal environmental management capability. B5 means the fifth measurement item for the evaluation of the suppliers' external environmental management capability. A is the average of A1, A2, A3 and A4, and B is that of B1, B2, B3, B4 and B5. S means a supplier's self-evaluation score, and C means a contractor's evaluation score.

The numbers on the first column show a tendency for suppliers to overestimate themselves in terms of GSCM compared to the estimation of their customer, the contractor. This result is consistent with the previous research by Ruuska *et al.* [2], which shows the same tendency in the evaluation of supplier capabilities (technical/operational, developmental, relational and business capabilities) for large shipbuilding projects. The findings of Park *et al.* [42], who adopted the research framework of Ruuska *et al.* [2] to supplier relationship management in Korean construction industry, are also consistent with the results of this study. It can be also said that contractors underestimate the suppliers'

environmental management capabilities. Either way, the gap between those perspectives can lead to a huge loss of potential opportunities for the entire supply chain. For example, suppliers who overestimate themselves can fail to meet the maximum target for environmental pollutants, leading to tremendous economic costs. On the other side, a contractor who underestimates the suppliers can miss opportunities to provide the final customer with more eco-friendly products or services, when the contractor assumes that there are no suppliers having capabilities needed to satisfy the final customer's needs within its supply chain network.

On average, suppliers gave the highest score to B5 (6.009 in the bar graph of Figure 1) that measures the immediacy of the response to the requirement for environment management from the contractor, and representatives of the contractor also gave the highest score to the same question (5.349 in the bar graph of Figure 1). It is interesting to note that this question had been added to the questionnaire through the interviews and pilot tests with the experienced workers of the industry. Based on the hands-on experiences, one of the participants of the pilot tests might suggest the item related to important collaborative capability. Considering the characteristics of the construction industry as a project-based business, suppliers' collaboration with the contractor is crucial for the successful performance and timely communication, and information sharing could be a key element of the collaboration [43]. In this sense, suppliers have tried to develop the corresponding capability, and the contractor has tried to accurately assess the essential capability.

Similarly, item B1 received the lowest score from both the contractor side (4.500 in the bar graph of Figure 1) and the supplier side (5.000 in the bar graph of Figure 1). B1 is related to suppliers' evaluation of second-tier supplier environmental activities. Considering the sizes of the suppliers (refer to the Table 4), the majority of suppliers are small and medium-sized enterprises (SMEs), and usually, their suppliers (second-tier suppliers of the contractor) could be smaller firms [44,45]. According to Baylis *et al.* [44], large firms undertake more environmental activities than SMEs due to higher awareness of environmental obligations and greater environmental pressures received. On the other hand, SMEs have poor environmental performances due to little motivation to improve and the lack of conviction for sustainable growth [45]. Therefore, small and medium-sized suppliers are reluctant to invest and develop environmental management systems to manage their suppliers. Furthermore, fierce competition and low profit margins drive SMEs to concentrate more on cost and speed as their key differentiation strategies [45].

It is noteworthy that the item B5 related to the supplier's relationship with its customer received the highest scores, and the item B1 related to the supplier's relationship with the second-tier suppliers received the lowest scores from the suppliers and the contractor. This implies that the suppliers pay more attention to the customer rather than their suppliers. However, without collaboration with suppliers, firms cannot satisfy the customers eventually. Firms should integrate suppliers to harvest the full benefits from the environmental management [46]. As suggested by Walton *et al.* [46], despite the challenges, such as supplier resistance and continuously varying regulations, firms can accomplish competitive advantage by committing resources to environmental activities. Passive efforts only to meet the short-term requirements of customers and government are not enough to achieve long-term customer satisfaction, eventually leading to sustainable growth [46]. More interestingly, Vachon and Klassen [47] contends that logistical integration with primary suppliers contributes to the supply chain environmental activities, while logistical integration with customers does not. Thsi can be the reason why suppliers should not ignore the roles and contributions of second-tier suppliers to the entire supply chain in order to concentrate only on the customer.

The numbers on the column named means of the absolute values $|S - C|$ in Figure 1 only focus on the gap in the perspectives of the contractor and the suppliers, regardless of the gap's sign (whether the contractor underestimates the suppliers' environmental capabilities or overestimates them) and the level of the suppliers' capability (how good the capabilities of the suppliers are). Though suppliers' self-evaluations are higher than contractor's evaluations in general, as in some cases contractor's evaluation score is higher than the supplier's self-evaluation score, it is needed to see the absolute

values of $|S - C|$ to focus on the difference specifically. In item B2 related to the provision of eco-friendly products or services, the difference is the biggest (1.736, second column from the right side in the Figure 1). Item B4 is about the suppliers' contributions to the reduction of environmental impact and risk in projects and received the smallest value (1.377, second column from the right side in the Figure 1). One of the convincing reasons for the differences between suppliers' and contractor's knowledge about the suppliers' capabilities is ambiguity [48]. In other words, the absence of objective standards hinders supply chain partners from sharing understandings of the suppliers' capabilities. Furthermore, complex and numerous interactions between suppliers and contractor in a supply chain can be one of the challenges to aligning contractor's and suppliers' knowledge about supplier's environmental capabilities [9,21].

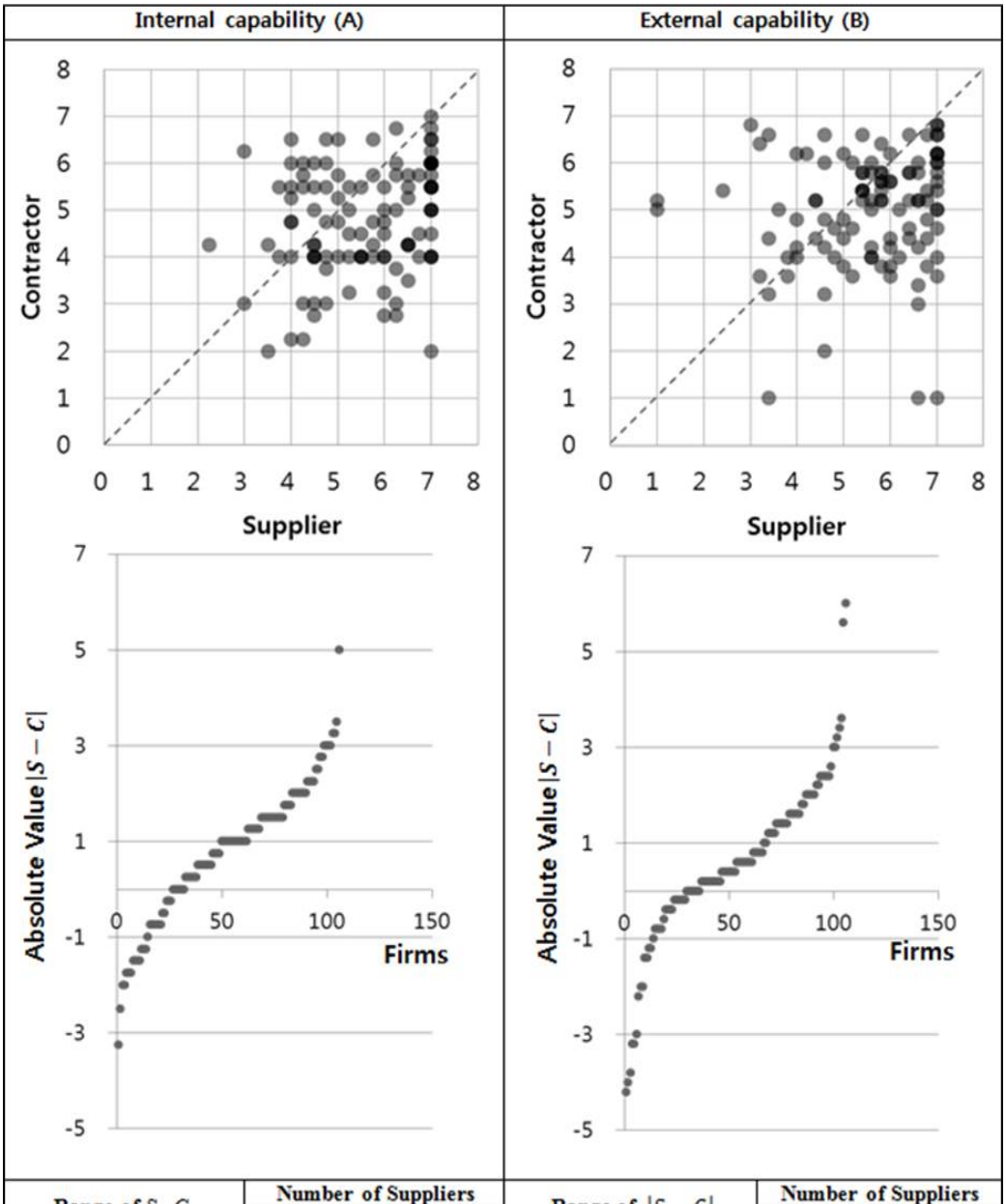
Figure 2 shows the differences in contractor and supplier evaluation of internal and external environmental management capabilities. For all graphs, each dot represents one specific supplier. On the upper side square graph, the darker the dot is, the more suppliers are located on the same spot, and the suppliers closer to the diagonals achieved better consistency between the self-assessment on their environmental management capabilities and the contractor's assessment on them. The suppliers located under the diagonal are overestimating themselves, while those over the diagonal are underestimating compared to the estimations of the contractor. The dots on the right graph are more dispersed (the SD of the gaps in B is 1.106 in Figure 1) compared to those on the left graph (the SD of the gaps in A is 0.854 in Figure 1).

The lower graphs of Figure 2 show the overall distributions of the gaps in the contractor's and suppliers' perspective on suppliers' internal (A) and external environmental management capabilities (B). The average gap of each firm in each capability is numbered from 1–106 in ascending order and placed on the graphs. The distribution of gaps in external capability is more dispersed. The bottom table in Figure 2 shows the distributions. Considering the distribution of $|S - C|$, more suppliers achieved consistent evaluation with the contractor in external environmental management capabilities than internal. Forty eight suppliers in A and 55 suppliers in B evaluated themselves within ± 1 difference. On the other hand, only five firms made evaluation gaps over three in A, while 10 firms in B.

Lastly, to see the factors explaining the gaps ($|S - C|$), this paper investigated the relationships between the gaps and each of the suppliers' defining characteristics, such as industry type, number of employees, firm's sales amount, years engaged in the construction industry, years of partnership with the contractor, number of projects per year and ISO 14001 certification. In addition, by checking the relations between the evaluator and the gaps in the evaluation scores, the authors identified if the suppliers' evaluation score is statistically and significantly higher than the contractor's evaluation score of each item. Table 5 shows the results of the independent sample *t*-test.

As shown in the results, the environmental management capability evaluations of bigger sized suppliers in terms of employees and sales are more consistent with their contractor's evaluations. Suppliers with less than 100 employees made significantly bigger gaps in the evaluation of manager's commitment to support GSCM (A2) and cross-functional cooperation for green products and services (A3) than suppliers having 100 or more employees (A2: 1.62 and 1.13, A3: 1.59 and 1.15, respectively in the fourth column of Table 5). In particular, the gap for item B1 that achieved the lowest scores from the contractor and suppliers on average (in the bar graph of Figure 1) is explained by the suppliers' size in terms of employees and sales. Suppliers with less than 100 employees or less than 10 billion in sales made significantly bigger gaps in the evaluation of managing second-tier supplier environmental activities (B1) than the rest of the suppliers (1.98 and 1.30 in the difference of employee size, 2.16 and 1.43 in the difference of sales amount in the fourth column of Table 5). This could be because of SME suppliers' overinflated optimism on their environmental management capability and low awareness of environmental concerns [44]. However, SMEs in the construction industry have poor environmental performances differently from their expectation [45]. Besides, the characteristics, such as the formality of knowledge management practices in SMEs, are different depending on the firm's

size [49]. It also could be one of the reasons why a big contractor firm fails to achieve consistency with smaller suppliers in terms of the suppliers' environmental management capabilities.



Range of $S-C$	Number of Suppliers	
	A	B
$5 < S-C \leq 7$	-	2
$3 < S-C \leq 5$	4	3
$1 < S-C \leq 3$	40	33
$-1 \leq S-C \leq 1$	48	55
$-3 \leq S-C < -1$	13	8
$-5 \leq S-C < -3$	1	5

Range of $\lvert S-C \rvert$	Number of Suppliers	
	A	B
$5 < \lvert S-C \rvert \leq 7$	-	2
$3 < \lvert S-C \rvert \leq 5$	5	8
$1 < \lvert S-C \rvert \leq 3$	53	41
$0 \leq \lvert S-C \rvert \leq 1$	48	55

Figure 2. Plot chart of differences in contractor and supplier evaluation. S means a supplier's self-evaluation score, and C means a contractor's evaluation score.

Table 5. Independent sample *t*-test results.

Group Variable		Test Variable	Mean	Standard Deviation	T	*p*
Industry	Construction (N = 68) Others (N = 38)	$\|S - C\|$ in A2	1.63 1.08	1.196 0.969	2.587 *	0.011
Employees	Less than 100 (N = 66) 100 and more (N = 40)	$\|S - C\|$ in A2	1.62 1.13	1.237 0.911	2.367 *	0.020
Employees	Less than 100 (N = 66) 100 and more (N = 40)	$\|S - C\|$ in A3	1.59 1.15	1.095 1.001	2.074 *	0.041
Employees	Less than 100 (N = 66) 100 and more (N = 40)	$\|S - C\|$ in B1	1.98 1.30	1.452 1.344	2.420 *	0.017
Sales (billion KRW)	Less than 10 (N = 43) 10 and more (N = 63)	$\|S - C\|$ in B1	2.16 1.43	1.495 1.341	2.642 *	0.010
Years of partnership	10 and more (N = 55) Less than 10 (N = 51)	$\|S - C\|$ in B1	1.44 2.04	1.371 1.469	−2.185 *	0.031
Contractor Department	Construction (N = 68) Others (N = 38)	$\|S - C\|$ in A1	1.21 1.71	1.030 1.137	−2.330 *	0.022
Evaluator	Supplier (N = 106) Contractor (N = 106)	A1	5.51 4.90	1.311 1.373	3.326 **	0.001
	Supplier (N = 106) Contractor (N = 106)	A2	5.63 4.71	1.245 1.294	5.301 **	0.000
	Supplier (N = 106) Contractor (N = 106)	A3	5.59 4.77	1.271 1.221	4.795 **	0.000
	Supplier (N = 106) Contractor (N = 106)	A4	5.42 4.75	1.359 1.273	3.756 **	0.000
	Supplier (N = 106) Contractor (N = 106)	B1	5.00 4.50	1.685 1.520	2.269 *	0.024
	Supplier (N = 106) Contractor (N = 106)	B2	5.45 4.68	1.513 1.458	3.791 **	0.000
	Supplier (N = 106) Contractor (N = 106)	B3	5.52 5.17	1.494 1.431	1.737	0.084
	Supplier (N = 106) Contractor (N = 106)	B4	5.68 5.21	1.418 1.343	2.487 *	0.014
	Supplier (N = 106) Contractor (N = 106)	B5	6.01 5.35	1.334 1.428	3.479 **	0.001
	Supplier (N = 106) Contractor (N = 106)	A	5.54 4.78	1.196 1.171	4.671 **	0.000
	Supplier (N = 106) Contractor (N = 106)	B	5.53 4.98	1.324 1.217	3.154 **	0.002

* $p < 0.05$ ** $p < 0.01$. A1 means the first measurement item for the evaluation of suppliers' internal environmental management capability. B5 means the fifth measurement item for the evaluation of suppliers' external environmental management capability. A is the average of A1, A2, A3 and A4, and B is that of B1, B2, B3, B4 and B5. S means a supplier's self-evaluation score, and C means a contractor's evaluation score. Note that the variables of the test in the group difference by the evaluators are the actual scores the item received from each informant of the suppliers and contractor, while the test variables of the other tests are $|S - C|$ in each item.

As the partnership lasts longer, the consistency between suppliers' and contractor's perspectives on those capabilities increases. Suppliers with a length of partnership shorter than 10 years made significantly bigger differences in the evaluation of managing second-tier supplier environmental activities (B1) than the other suppliers (2.04 and 1.44, respectively, in the fourth column of Table 5). This is consistent with the results of prior research by Dyer and Singh [50], which argues that competitive advantages come from the relationship between firms. They insist that firms' collaboration experiences accumulate specialized information and know-how, leading to efficient and effective communication and a reduction of communication errors, contributing to inter-organizational competitive advantages [50–52]. Though knowledge about suppliers' environmental management capabilities in the construction industry is tacit and difficult to share, a strong relationship between firms enhances the extent of the tacit knowledge transfer [53,54].

In addition, when the construction departments of the contractor assess the suppliers' environmental management capability related to the establishment of the environmental policy and system (A1), the evaluations are more consistent with the self-evaluations of suppliers compared to those from the other departments (1.21 and 1.71 in the fourth column of Table 5). The reason behind

this difference could be related to the nature of construction industry. In the construction industry, the head offices of a contractor and suppliers are not located in the same place as the construction sites. In some cases, the information of the head offices is different from the information of the construction site [42]. Therefore, accurate assessment of suppliers' environmental capabilities should be based on the voices of the construction sites.

Lastly, the general tendency of suppliers' overestimation of their environmental management capabilities is observed in comparing suppliers' self-assessment with contractor's assessment in each item, except the item related to the provision of environmental management guidelines from the contractor (B3) in Table 5. However, even in B3, the difference was significant at the significance level of $p < 0.1$ (5.52 from suppliers and 5.17 from the contractor in Table 5).

5. Implications and Conclusions

The aim of this study is to investigate the consistency between contractor's perspective and the suppliers' perspective on the suppliers' environmental management capabilities in GSCM of the construction industry through an explorative case study of Korean construction companies. A supply chain consisting of a major construction company in Korea and 106 suppliers is selected. The results of this case analysis indicate the following. First, in supplier environmental capability evaluations, suppliers' self-evaluation scores are higher than contractor's evaluation scores. Second, participant suppliers received the highest scores in the item related to the relationship with the customer from both evaluators and the lowest scores in the item related to relationship with the second-tier supplier. Lastly, there are several factors explaining the consistency of the suppliers' and contractor's evaluation, such as the industry of the suppliers, the suppliers' size, the length of the partnership with the contractor and the departments of the contractor that conduct supplier capability evaluation.

Based on the findings of this paper, managerial implications are drawn as follows. First, suppliers and contractors should put their efforts to reach consistent perspectives on suppliers' environmental capabilities, which are their crucial shared resources. It is not the responsibility of either just the contractor or suppliers; rather, both of them should continuously communicate to understand and develop each other. Second, suppliers should extend their focus to second-tier suppliers to satisfy their customers. Second-tier suppliers are usually very small firms that lack resources for environmental management. However, their ignorance of environmental concerns can harm the entire supply chain. Lastly, contractors and suppliers should be well aware of the factors hindering their shared knowledge on the resources of the supply chain.

This paper contributes to the literature on GSCM in the construction industry. This paper focused on assessing the consistency between different stakeholders' evaluation of the environmental capabilities of suppliers, rather than the level of capabilities themselves. Even though all of the suppliers have excellent capabilities, if the capabilities are not well integrated to meet the final customer's needs, the entire supply chain cannot achieve successful performances. However, suppliers having clear weakness in some areas can complement one another if the members of the supply chain share exact knowledge about the capabilities of each other. In this sense, this paper contributes to the literature on strategic alignment amongst supply chain members.

This study has several limitations as follows. First, an explorative case study has the limitations of generalization. The authors selected only one contractor to exclude the confounding effect from different characteristics of the contractors and, thereby, to focus on the suppliers' perspective. Furthermore, collecting enough contractors and their supply chain members requires tremendous costs in terms of time and finances. Comparisons between supply chains of contractors with different characteristics can be an appropriate approach as a next step to deepen the insight on the issue that this paper handles. Secondly, this study conducted an independent sample *t*-test to find out the factors explaining the differences in the perspectives of the contractor and suppliers. Though it provides clues for finding the ideal direction of future studies, it is still not enough to answer the inquiry on the fundamental cause behind such differences. Studies with theoretically rigorous approaches are needed

to find the reasons for the differences, based on the result of the *t*-test conducted in this study. Thirdly, this study does not deal with the question about whose evaluation reflects actual environmental management capabilities of suppliers more closely. Various research questions can be derived from this, such as "whose evaluation is more significantly and closely related to the sustainable performances of a supply chain?" and "how can suppliers or contractors evaluate suppliers' environmental management capabilities more accurately?" It is not a matter of supplier or contractor only. Studies on the most appropriate departments for the evaluation of suppliers' capabilities in GSCM aspects are needed, as well. Lastly, this study only deals with the gaps between supplier's and contractor's perceptions on the supplier environmental capabilities and does not examine the relationship between the gap and supply chain performances. Empirical studies on these issues should investigate the impacts of supplier's overestimation and underestimation on the supply chain performances.

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