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The Effect of Customer Involvement on Green Innovation and the Intermediary Role of Boundary Spanning Capability

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Abstract: With the rapid development of industrialization and the economy, the side effects of ecological problems have become more and more serious, and the importance of the sustainable development paradigm has begun to be valued. This study conducts an empirical analysis of green enterprises and explores the influence of customer involvement and boundary spanning capability on green innovation. The results of the analysis show that there is a positive correlation between customer involvement and boundary spanning capability (including three subordinate factors). Secondly, the results of analyzing the influence relationship between customer involvement and green innovation show that customer involvement has a positive impact on green innovation. In addition, the analysis of the relationship between boundary expansion force and environmental protection innovation shows that there is a positive correlation between the two variables, and the analysis of the mediation effect of boundary spanning capability shows that there is a partial mediation effect between customer involvement and green innovation. However, this study has various limitations in the context of environmental protection, as it is an exploratory study in which the boundary expansion capabilities of firms are manipulated in the context of environmental protection and empirically analyzed through a questionnaire method. For clearer research results, it is necessary to re-validate this research model with objective data in the future.

Keywords: green innovation; enterprise performance; customer involvement; boundary spanning capability; open innovation

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1. Introduction

In the 21st century, the world's industrialization and urbanization are accelerating; in particular, China's manufacturing industry has contributed to the development of the global economy and the accumulation of economic wealth. However, urbanization and industrialization are causing natural resource depletion and environmental pollution problems. Since the reform and opening, China has also achieved a rapid industrialization and economic development while facing various ecological problems. In recent years, the side effects of these problems have become more serious. In addition, environmental problems cause social problems, which have a great impact on the stability of individual countries and societies. This context prompts a recognition of the problems in the paradigm of economic development achieved at the expense of the environment. Considering the seriousness of the environmental problem, the government's environmental protection policy and the enterprise's restrictive policy should be discussed. At the same time, it is necessary to conduct research on environmental protection enterprises that promote sustainable development of corporate earnings and environmental protection.

Several years ago, the OECD put forward the factors for achieving economic growth without increasing the environmental load in an environment-related report [1]. According to this, the green innovation of enterprises can only be successful if public policies to promote this innovation are parallelized. In other words, climate change and environmental problems cannot be solved with existing methods, and new product innovation and process innovation must be carried out in parallel. The general innovation of enterprises can play a substantial role in improving the environment, but the effect is not significant, so there are limitations such as being offset by pollution caused by increased consumption and performance. Based on the DEA model, existing research studies the relationship between eco-efficiency and economic benefits. Selecting 4-year data of 23 domestic enterprises, analyzing the technical efficiency, pure technical efficiency, and scale efficiency of enterprises in each year, and making comparisons, the countermeasures to improve the eco-efficiency of low-efficiency enterprises are put forward. Studies have shown that there is a causal relationship between eco-efficiency and economic benefits [2]. In addition, some scholars analyzed the effect of environmental investment on corporate performance. For example, according to their analysis, there was a significant positive correlation between the increase in the amount of long-term environmental investment and the increase in production and sales, which are corporate performance. Namely, if environmental investment is continued in the long term, production and sales will increase. On the other hand, their study suggested that short-term environmental costs had no effect on management efficiency improvement [3]. The author verified the effect of reducing greenhouse gas emissions by unit and the current and accumulated environmental investment on financial performance (return on total assets, net income on sales, and total asset turnover). According to the results of the author's analysis, the total return on assets (ROA) and return on sales (ROS) increased in companies with large environmental investments, but the total asset turnover (AT) decreased, which showed that the asset efficiency decreased, although environmental investment had an effect on the increase in the net return on assets or net income on sales [4]. The author empirically tested the relationship between proactive green technology innovation and corporate financial performance using a dynamic panel dataset of 126 Chinese listed semiconductor concept stocks from 2010 to 2020 and a difference-GMM approach. It was found that proactive green process innovation has a significant positive effect on both short-term and long-term corporate financial performance [5]. The author conducted an empirical analysis of the impact of environmental investment on corporate value targeting companies that had undertaken continuous environmental investment for five years. The study results showed that long-term environmental investment had a negative effect on corporate value, suggesting that environmental investment could conflict with corporate value [6].

In Chinese society, public interest in the environment and climate is increasing, and related government regulations and support policies are increasing day by day. Therefore, although there is a need for a study on the relationship between eco-friendly investment, green innovation, and business performance targeting Chinese companies, there are few prior studies specifically dealing with such research.

The rest of the paper is structured as follows. Section 2 examines the theoretical background and previous research related to this research and proposes research hypotheses. Section 3 introduces a research model based on the research design, sample selection, and data collection based on the above content and covers the research method. In addition, data collection and analysis methods are presented in detail to describe the research methodology of this study. Section 4, based on the research model established in the third chapter, provides a detailed explanation of the empirical analysis results and shows the results of this research. Section 5 summarizes the results of this study and discusses the implications and limitations of this study and future research methods.

2. Theoretical Basis and Research Hypothesis

2.1. Customer Involvement and Green Innovation

Recently, many companies have been using methods to engage customers in their innovation activities or to induce them to do it independently [7]. Participation in customer innovation activities allows companies to share more details with customers because they can gain more meaningful innovation-related ideas or knowledge from customers [8].

Previous studies classify customer engagement into three forms based on the degree to which customers participate in innovation activities [9–12]. The first form of customer participation is to use innovation-related information provided by customers. In this form, the customer's opinions and requirements are reflected in the development of the product without being deeply involved in the innovation process.

As a form of customer participation that most companies implement while carrying out new product innovation, Aekyung Industrial developed and launched an eco-friendly detergent based on the eco-friendly needs of customers [13].

The second type of customer participation is when a company engages customers in its innovation activities and conducts joint R&D. A business example of this form of customer engagement is that Microsoft and SAP invite customer (company) representatives, appoint them as members of their new product launch teams, and conduct new product development activities with them [12]. The third form of customer participation is to induce customers' independent innovation and use it to create innovative outcomes.

In the case of a specific customer, realistically, there are problems of time and cost or limitations in the customer's technical ability [14,15], so it is a minor weighted form of customer participation. This can be found in GE Plastic's case [16], which encourages the participation of the customer community to generate innovation ideas themselves, and in the case where P&G decides to achieve its product innovation through customers [17].

Previous studies have mentioned that customer participation in innovation activities can play an important role in achieving corporate innovation goals even in an eco-friendly context [18,19]. This study refers to the above research cases and defines customer participation in the context of green innovation using [14] as follows, "an activity in which customers participate in green innovation activities to continuously provide new or improved eco-friendly knowledge or information". Customer involvement enables customer-oriented product development, so new product innovation can be achieved in a true sense [14,20,21]. Specifically, customers' demands for products are so complex that a deep understanding of their needs and wants is needed to deliver customer value [22]. Participation in innovation activities can play a positive role in the innovation and creation of businesses, as frequent and in-depth interaction between companies and customers allows for an intimate understanding of their needs. Additionally, by being able to provide the market trends, technical feedback, and customer information needed for corporate innovation [14,23], companies will be able to achieve successful innovation based on this information and equation.

Prior research suggests that companies can secure relevant information or knowledge necessary for cooperation in eco-friendly management activities with customers [18]. Because such knowledge from customers can address high interdependence and uncertainty among stakeholders in the process of eco-friendly product innovation [19], it can have a positive impact on the company's outstanding green innovation. In addition, continuous information exchange and mutual learning activities with customers through customer involvement can facilitate green innovation activities of enterprises [24,25]. Grekova et al. [18] also demonstrated in a study on the Dutch food and beverage manufacturing industry that environmentally friendly cooperation with customers could enhance business-friendly performance. Therefore, this study develops the following hypotheses:

Hypothesis 1 (H1). *Customer involvement will have a positive impact on the company's green product innovation performance.*

Hypothesis 2 (H2). *Customer involvement will have a positive impact on the company's eco-friendly process innovation performance.*

2.2. The Impact of Customer Involvement on Corporate Boundary Spanning Capability

The problem of customer involvement encourages companies to develop border expansion capabilities. First, when customers engage in corporate innovation, information and knowledge management issues arise, including information overload [26–30]. Specifically, because the information and knowledge that a company can gain from a customer's involvement in innovation activities are complex and unclear in nature, the company's ability to integrate and convert it into meaningful knowledge belongs to the company's innovation [31]. It requires the ability of companies to efficiently manage unnecessary information and knowledge (excessive information) that may arise from customer involvement [32]. Customer involvement is a language that is different from the enterprise, goal, and faith. It means collaborative innovation activities with outside partners with a culture [33,34]. Various disputes can occur during innovation activities. Customer engagement involvement thus requires companies' cooperative relationship management capabilities to resolve these potential disputes [10,35].

Even in the context of green innovation, customer involvement requires the knowledge management and relationship management capabilities of enterprises. This is because customer involvement should not only highlight the need to manage a wide range of information and knowledge, such as potential eco-friendly requirements, market knowledge, and new product ideas but also establish and manage a cooperative relationship with customers, which is the basis for the creation of high green innovation results [36].

To summarize the claims of such prior research, customer involvement can improve the organization's capabilities by inducing corporate knowledge management activities necessary for green innovation and relationship management activities for interaction with customers. Therefore, this study develops the following hypotheses:

Hypotheses 3 (H3). *Customer involvement will have a positive impact on a company's knowledge expansion capacity.*

Hypotheses 4 (H4). *Customer involvement will have a positive impact on a company's capacity to expand relationships.*

2.3. The Mediating Effect of Border Spanning Capability

This study found that the company's boundary spanning capability enables companies to achieve outstanding innovative performance by solving problems corresponding to knowledge and relationship management caused by the participation of external partners in innovation. First, the involvement of customers and suppliers causes knowledge overload, which can be a hindrance to a company's innovation performance, so successful innovation will be possible when the problem of knowledge surplus can be solved, which may arise from the participation of external stakeholders The Corporate Knowledge Expanding Capacity [37] selects and interprets the information and knowledge necessary for innovation based on the understanding of the goal and strategy of the company, thereby ensuring the outstanding innovation performance of the company [38].

Secondly, the involvement of customers and suppliers can hinder innovation and creation by causing various disputes among participants that are obstacles to mutual cooperative activities. This means that a company can carry out successful innovation activities when it can build and maintain cooperative relationships with external participants [39]. It can resolve potential conflicts with participants in advance by forming and managing cooperative relationships with major external stakeholders [38,40–43]. In summary, companies will be able to overcome various obstacles that can be caused by customer and supplier involvement and achieve outstanding innovation results through the company's boundary expansion capabilities. Therefore, this study develops the following hypotheses:

Hypotheses 5 (H5). *A company's ability to expand knowledge will mediate the relationship between customer involvement and eco-friendly product innovation.*

Hypotheses 6 (H6). *A company's ability to expand knowledge will mediate the relationship between customer involvement and eco-friendly process innovation.*

Hypotheses 7 (H7). *A company's capacity to expand relationships will mediate the relationship between customer involvement and eco-friendly product innovation.*

Hypotheses 8 (H8). *A company's capacity to expand relationships will mediate the relationship between customer involvement and eco-friendly process innovation.*

The analysis framework of the research is shown in Figure 1 below.

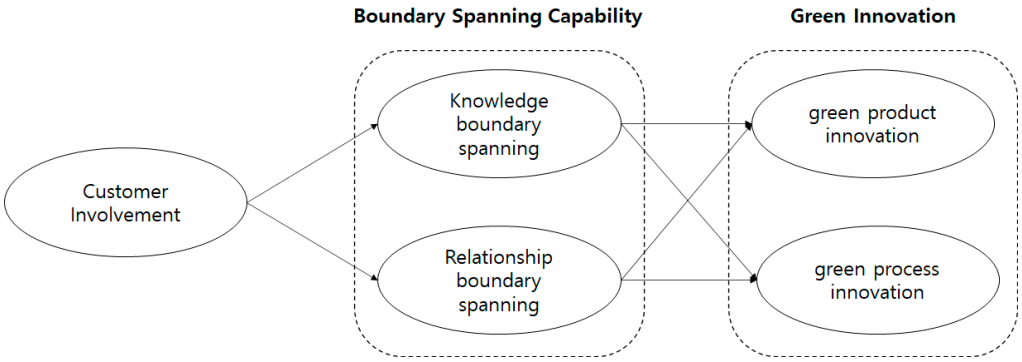

Figure 1. Analysis framework.

3. Research Design

3.1. Selection of Research Targets and Data Collection

This study aimed to identify the impact of customer participation on the company's eco-friendly innovation performance. Therefore, the manufacturing industry, which has a huge influence on the environment and is actively engaged in corporate eco-friendly management activities, was selected as a suitable industrial group for this study.

Previously, a survey was conducted on companies collected for panel data analysis. Since all companies did not agree to participate in the survey, the survey was requested through E-mail, and only the data of the companies that responded to them were selected for the final analysis. The response was asked to be conducted by the strategic business department in the company. This is because the department understands the overall strategy within the company, and it is more reliable to analyze it at the strategic business unit than at the corporate level.

The survey was conducted from 10 April 2022 to 20 April 2022. The survey distributed a total of 600 copies, surveyed 30 companies, and sent 20 questionnaires to each company, of which 543 were recovered. Of the collected data, 511 copies were finally selected for analysis, excluding 32 copies of data that were unfaithful or omitted. Because face-to-face surveys were difficult due to COVID19, online survey platforms were used, and questionnaires were distributed using the commonly used Mike CRM in China.

Additionally, in this study, multiple regression analysis was conducted by the SPSS 27 statistical package to verify the causal relationship between customer participation and green innovation, customer and supplier participation, and corporate boundary expansion capabilities. The mediating effect verification was verified through hierarchical regression analysis based on the procedures presented by Baron and Kenny (1986), and additional butting effect verification [44] was conducted using SPSS 27's Process plug-in.

3.2. Development of Measurement Questions

Most of the measurement variables for each configuration concept used in this study were modified to match the context of the relevant prior studies. Specifically, survey

questions on customer engagement [14,17,45] and green innovations [46–49] were adapted to the context of this study based on previous empirical studies. The boundary extension capability was revised and supplemented to meet the purpose and target of this research by referring to the study of Kim (2018), who developed a questionnaire referring to the five-step scale development model of Churchill (1979). As mentioned earlier, the measurement of this study, organized through the contents of the preceding study, is shown in Table 1.

Table 1. Questionnaires and Sources of Each Variable.

Factor	Survey Questions	Reference
Customer Involvement	1. We actively share information about the eco-friendly market. 2. We actively share eco-friendly technology. 3. We actively share our ideas about eco-friendly products. 4. We actively share our ideas about the eco-production process. 5. Actively participate in the evaluation of eco-friendly products (environmental impact assessment, performance, and quality evaluation). 6. Actively participate in research and development (R&D) of eco-friendly products. 7. Actively participate in the process of developing an eco-friendly production process. (Our department has the following capabilities needed for eco-friendly management activities.)	[14,17,45]
Capacity to Expand Relationships (Building relationships)	1. It is possible to communicate smoothly with major external stakeholders. 2. Cooperative relations can be established with major external stakeholders. 3. Continuous exchanges with major external stakeholders may be carried out. 4. Official/unofficial interactions can be carried out with major external stakeholders.	[40,41,50–52]
Capacity to Expand Relationships (Relationship persuasion)	1. The best compromise can be proposed in the event of a dispute with a major external interested party. 2. Major external stakeholders may be persuaded to recognize the importance of our eco-friendly management activities. 3. Major external stakeholders may be persuaded to participate in our eco-friendly management activities. 4. Major external stakeholders may be persuaded to support our decision on environmentally friendly management activities. 5. Major external stakeholders can be persuaded to understand that our green management activities are genuinely carried out.	[42,43,53–57]
Knowledge Expansion Capacity	1. Among environmentally friendly information provided by major external stakeholders, it may be provided to the relevant departments, except for inaccurate or overlapping information. 2. Only information suitable for our eco-friendly management strategy from among the information provided by major external stakeholders may be selected and provided to the relevant departments. 3. Among environmentally friendly information provided by major external stakeholders, information necessary for the development of environmentally friendly technology/product may be selected and provided to the relevant departments. 4. Environmentally friendly information provided by major external stakeholders may be reinterpreted to suit the reality of Korean enterprises and provided to the relevant departments. 5. Information related to environmentally friendly management activities provided by major external stakeholders may be interpreted so that in-house members can understand them and deliver them to the relevant departments.	[53,58–61]

Table 1. *Cont.*

Factor	Survey Questions	Reference
Innovation of Eco-friendly Products	1. Excellent eco-friendly product innovation. 2. Launch various eco-friendly products. 3. Launch various eco-friendly products. 4. The quality of eco-friendly products is excellent. 5. The development speed of eco-friendly products is fast. 6. The return on investment (ROI) in the development of eco-friendly products is high. 7. The market share of eco-friendly products is high. 8. Customer satisfaction with eco-friendly products is high.	[46,48]
Eco-friendly Process Innovation	1. Use fewer resources (water, energy). 2. Use fewer raw materials/materials. 3. The degree of recycling/reusing raw materials and materials is high. 4. The discharge of waste is low. 5. Less use of harmful substances. 6. The overall eco-friendliness of the production process is high.	[47,49]

4. Empirical Analysis

4.1. Reliability and Validity of Measured Variables

For reliability and validity analysis of measurement variables, reliability was measured by calculating Cronbach's alpha coefficient, and validity was confirmed by performing exploratory factor analysis. The validity of the measured variables through factor analysis is as follows.

4.1.1. Factor Analysis of Customer Involvement

In the factor analysis of customer participation shown in Table 2, variants with factor loading less than 0.4 were removed, but in the results of this study, values less than 0.4 were not found. In addition, as shown in Table 2, the Eigenvalue explained in the customer participation factor analysis was a factor with a value greater than 1, and a total of 1 factor were extracted. The eigenvalue of one factor extracted was 4.563. The cumulative variance of the factor in rotation squared was 65.184, which means that the total cumulative explanatory power was 65.184%. Additionally, in the component matrix shown in the result of factor analysis, the factor loading of each item tied to one factor was 0.749~0.862. Through this, all the items tied to one factor were composed of a common concept.

Table 2. Factor Analysis Results of Customer Involvement.

Variables	Measurement Items	Loading	Commonality
Customer Involvement	1. We actively share information about the eco-friendly market.	0.797	0.635
	2. We actively share eco-friendly technology.	0.862	0.742
	3. We actively share our ideas about eco-friendly products.	0.856	0.733
	4. We actively share our ideas about the eco-production process.	0.824	0.678
	5. Actively participate in the evaluation of eco-friendly products (environmental impact assessment, performance, and quality evaluation).	0.785	0.617
	6. Actively participate in research and development (R&D) of eco-friendly products.	0.749	0.560
	7. Actively participate in the process of developing eco-friendly production process.	0.773	0.597
	Eigenvalue	4.563	
	Cumulative value	65.184	

4.1.2. Factor Analysis of Boundary Spanning Capability

In the capacity to expand relationships (building relationships), capacity to expand relationships (relationship persuasion), and knowledge expansion capacity factor analysis, which is a sub-factor of boundary spanning capability shown in Table 3, factors with a factor loading of 0.4 or less were removed, but in the result of this study, a value of 0.4 or less was not found.

Table 3. Factor analysis result of boundary spanning capability.

Measurement Items	Factor Loading			Commonality
	1	2	3	
It is possible to communicate smoothly with major external stakeholders.	0.153	0.090	0.830	0.720
Cooperative relations can be established with major external stakeholders.	0.118	0.108	0.874	0.789
Continuous exchanges with major external stakeholders may be carried out.	0.062	0.055	0.804	0.654
Official/unofficial interactions can be carried out with major external stakeholders.	0.046	0.093	0.810	0.667
The best compromise can be proposed in the event of a dispute with a major external interested party.	0.145	0.867	0.078	0.778
Major external stakeholders may be persuaded to recognize the importance of our eco-friendly management activities.	0.091	0.777	0.106	0.623
Major external stakeholders may be persuaded to participate in our eco-friendly management activities.	0.115	0.800	0.126	0.670
Major external stakeholders may be persuaded to support our decision on environmentally friendly management activities.	0.114	0.736	0.025	0.555
Major external stakeholders can be persuaded to understand that our green management activities are genuinely carried out.	0.152	0.801	0.064	0.668
Among environmentally friendly information provided by major external stakeholders, it may be provided to the relevant departments, except for inaccurate or overlapping information.	0.830	0.132	0.077	0.713
Only information suitable for our eco-friendly management strategy from among the information provided by major external stakeholders may be selected and provided to the relevant departments.	0.879	0.113	0.117	0.800
Among environmentally friendly information provided by major external stakeholders, information necessary for the development of environmentally friendly technology/product may be selected and provided to the relevant departments.	0.866	0.136	0.094	0.777
Environmentally friendly information provided by major external stakeholders may be reinterpreted to suit the reality of Korean enterprises and provided to the relevant departments.	0.806	0.156	0.026	0.675
Information related to environmentally friendly management activities provided by major external stakeholders may be interpreted so that in-house members can understand them and provide them to the relevant departments.	0.836	0.115	0.140	0.732
Eigenvalue	3.683	3.295	2.843	
Cumulative value	26.310	49.848	70.157	

As shown in Table 3, a total of three factors were extracted as factors whose eigenvalue, explained in the factor analysis of boundary spanning capability, was greater than 1. The eigenvalues of the extracted three factors were 3.683, 3.295, and 2.843, respectively. If

we look at the cumulative variance of factors with rotation squared, factor 1 accounted for 26.310%, factor 2 accounted for 23.539%, factor 3 accounted for 20.308, and the total cumulative explanatory power was 70.157%. In the component matrix shown in the result of factor analysis, factor 1 was 0.804 to 0.874, factor 2 was 0.736 to 0.867, and factor 3 was 0.806 to 0.879 in the factor loadings of each item tied to the three factors.

Through this, the items tied to the three factors were all composed of a common concept.

4.1.3. Factor Analysis of Green Innovation

In the factor analysis of innovation of green products and green process innovation, which are sub-factors of green innovation shown in Table 4, variables with factor loading less than 0.4 were removed, but in this study, values less than 0.4 were not found. As shown in Table 4, a total of two factors were extracted as factors whose eigenvalue was greater than 1 in the factor analysis of green innovation. The eigenvalues of the two extracted factors were 5.215 and 4.147, respectively. If we look at the cumulative variance of factors that were rotated and squared, factor 1 was 37.252% and factor 2 was 29.621%, and the total cumulative explanatory power was 66.872%.

Table 4. Factor analysis result of eco-friendly innovation.

Variables	Factor Loading		Commonality
	1	2	
Excellent eco-friendly product innovation.	0.783	0.125	0.628
Launch various eco-friendly products.	0.848	0.176	0.750
Launch various eco-friendly products.	0.764	0.225	0.635
The quality of eco-friendly products is excellent.	0.750	0.172	0.592
The development speed of eco-friendly products is fast.	0.767	0.207	0.630
The return on investment (ROI) in the development of eco-friendly products is high.	0.855	0.229	0.783
The market share of eco-friendly products is high.	0.794	0.158	0.656
Customer satisfaction with eco-friendly products is high.	0.753	0.219	0.614
Use fewer resources (water, energy).	0.228	0.752	0.617
Use fewer raw materials/materials.	0.178	0.823	0.709
The degree of recycling/reusing raw materials and materials is high.	0.171	0.826	0.712
The discharge of waste is low.	0.211	0.856	0.778
Less use of harmful substances.	0.147	0.792	0.648
The overall eco-friendliness of the production process is high.	0.204	0.754	0.610
Eigenvalue	5.215	4.147	
Cumulative value	37.252	66.872	

In the component matrix shown in the result of factor analysis, factor 1 showed 0.753 to 0.855 and factor 2 showed 0.752 to 0.856 in the factor loadings of each item tied to the two factors. Through this, the items tied to the two factors were all composed of a common concept.

4.1.4. Reliability Analysis of Measurement Variables

For the reliability coefficient of each scale used in this study, the reliability coefficient Cronbach's alpha coefficient, which examines the degree of internal agreement between items, was used. When evaluating the reliability coefficients of major variables, the statements in Table 5 were used.

Table 5. Reliability analysis of measurement variables.

Variables	Factor		Number of Items	Cronbach's Alpha	
Independent variable	Customer Involvement		7	0.907	
mediator variable (0.858)	Capacity to expand relationships	building relationships	4	0.860	0.821
		relationship persuasion	5	0.865	
	Knowledge expansion capacity		5	0.909	
dependent variable (0.919)	Innovation of eco-friendly products		8	0.926	
	Eco-friendly process innovation		6	0.903	

The reliability coefficient of customer participation was 0.907. Among parameters, the reliability coefficient of the capacity to expand relationships (building relationships) was 0.860, the reliability coefficient of the capacity to expand relationships (relationship persuasion) was 0.865, and the overall reliability coefficient of both variables was 0.821. Additionally, the reliability coefficient of knowledge expansion capacity was 0.909, and the reliability coefficient of all parameters was 0.858. As for the dependent variable, the reliability coefficient of Innovation of eco-friendly products was 0.926, the reliability coefficient of eco-friendly process innovation was 0.903, and the reliability coefficient of the entire dependent variable was 0.919. All three variables were above 0.80, indicating very good reliability.

4.2. Response Tendency of Measurement Variables

The purpose of descriptive statistics in this study was to show the status of variables used in research and to understand the suitability of data used in research analysis. The following Table 6 show the minimum, maximum, standard deviation, mean, skewness, and kurtosis of customer involvement, capacity to expand relationships (building relationships), capacity to expand relationships (relationship persuasion), knowledge expansion capacity, innovation of eco-friendly products, and eco-friendly process innovation used in this study. As a result of analyzing the skewness and kurtosis of the major variables extracted from the factor analysis in this study, the skewness was distributed between −0.157 and −0.389, and the kurtosis was distributed between −0.636 and −1.238 for each variable. It was confirmed that the results had the normal distribution necessary for hypothesis testing.

Table 6. Descriptive statistics for major variables.

Variable		Min	Max	Mean	sd	Skewness	Kurtosis
Independent	Customer Involvement	1.57	7.00	4.96	1.38	−0.324	−0.957
Mediator	Capacity to expand relationships (building relationships)	1.00	7.00	4.56	1.73	−0.271	−1.238
	Capacity to expand relationships (relationship persuasion)	1.20	7.00	4.67	1.49	−0.211	−1.043
	Capacity to expand relationships (all)	1.44	7.00	4.62	1.25	−0.157	−0.636
	Knowledge expansion capacity	1.20	7.00	4.87	1.66	−0.389	−1.129
Dependent	Innovation of eco-friendly products	1.38	7.00	4.69	1.52	−0.309	−1.102
	Eco-friendly process innovation	1.67	7.00	5.05	1.30	−0.246	−0.952

4.3. Correlation Analysis

Table 7 show the correlation between customer involvement, capacity to expand relationships (building relationships), capacity to expand relationships (relationship persuasion), knowledge expansion capacity, innovation of eco-friendly products, and eco-friendly

process innovation, as the main variables of this study. As a result of the analysis, all correlations between each variable showed significant correlations.

Table 7. Robustness test 1.

	1	2	3	4	5	6	7
1. Customer involvement	1						
2. Capacity to expand relationships (building relationships)	0.468 **	1					
3. Capacity to expand relationships (relationship persuasion)	0.409 **	0.220 **	1				
4. Capacity to expand relationships(all)	0.560 **	0.762 **	0.800 **	1			
5. Knowledge expansion capacity	0.444 **	0.233 **	0.308 **	0.348 **	1		
6. Innovation of eco-friendly products	0.458 **	0.417 **	0.376 **	0.507 **	0.393 **	1	
7. Eco-friendly process innovation	0.503 **	0.421 **	0.452 **	0.559 **	0.489 **	0.451 **	1

Note: ** $p < 0.01$.

4.4. Results Analysis and Discussions

4.4.1. Influence of Customer Involvement and Capacity to Expand Relationships

The results of regression analysis of the effect of customer involvement on the capacity to expand relationships are shown in Table 8.

Table 8. Relationship between Customer Involvement and Capacity to expand relationships.

Dependent Variables	Independent Variables	Non-Standardized Coefficient		Standardization Factor	t	*p*	Collinearity Statistics	
		B	S.E.	β			Tolerance	VIF
CER (BR)	(Constant)	1.642	0.254		6.462	0.000		
	CI	0.589	0.049	0.468	11.927	0.000	1.000	1.000
	$R^2 = 0.219$, adj.$R^2 = 0.218$ F = 142.265 ($p = 0.000$), Durbin Watson = 1.965							
CER (RP)	(Constant)	2.470	0.227		10.902	0.000		
	CI	0.444	0.044	0.409	10.093	0.000	1.000	1.000
	$R^2 = 0.167$, adj.$R^2 = 0.166$ F = 101.860 ($p = 0.000$), Durbin Watson = 2.023							
CER (all)	(Constant)	2.102	0.172		12.215	0.000		
	CI	0.508	0.033	0.560	15.210	0.000	1.000	1.000
	$R^2 = 0.313$, adj.$R^2 = 0.312$ F = 231.354 ($p = 0.000$), Durbin Watson = 1.952							

First, as a result of examining the relationship between 'building relationships' among the capacity to expand relationships, customer involvement explained 'building relationships' as 21.8% (=0.281). Durbin Watson was 1.965, which is close to 2, so the regression model was suitable. The F value was 142.265 ($p = 0.000$) and was statistically significant, indicating that the regression line was suitable for the model. Additionally, looking at the collinearity statistics, there was no problem in multicollinearity because the VIF value was less than 10, and the tolerance limits were all greater than 0.1. As a result of examining the effect of the customer involvement factor on 'building relationships', it was found that it had a significant effect (t = 11.927, $p < 0.001$). Customer involvement was found to have a positive (+) effect on 'building relationship'. The result suggests that higher customer involvement increases a firm's ability to build its relationships. Our finding was consistent with results from Anning-Dorson, T. (2018) [62]. Therefore, firms should focus on customer involvement to enhance the ability to build relationships.

Next, as a result of examining the influence relationship between 'relationship persuasion' among the capacity to expand relationships, customer involvement explained 'relationship persuasion' as 16.6% (=0.166). Durbin Watson was 2.023, which was close to 2, so the regression model was suitable. The F value showed a value of 101.860 (p = 0.000) and was statistically significant, indicating that the regression line was suitable for the model. In addition, when analyzing collinearity statistics, there was no problem in multicollinearity because the VIF value was less than 10, and the tolerance limits were all greater than 0.1. As a result of examining the effect of the Customer Involvement factor on 'relationship persuasion', it was found to have a significant effect (t = 10.093, $p < 0.001$), and customer involvement had a positive (+) effect on 'relationship persuasion'. The result also suggests that higher customer involvement brings a firm better relationship persuasion. Our finding was consistent with the results from Nicolajsen and Scupola (2011) [63]. Therefore, we believe that major external stakeholders (e.g., customers) may be persuaded to support our decision on environmentally friendly management activities.

Finally, as a result of examining the influence relationship with all factors of capacity to expand relationships, customer involvement explained the capacity to expand relationships as 31.2% (=0.312). Durbin Watson was 1.952, which was close to 2, so the regression model was suitable. The F value was 231.354 (p = 0.000), which was statistically significant, indicating that the regression line was suitable for the model. Additionally, when evaluating collinearity statistics, the VIF value was found to be less than 10, and all tolerance limits were greater than 0.1, so it was confirmed that there was no multicollinearity problem. The influence of the customer involvement factor on the capacity to expand relationships was examined. A significant influence relationship was formed between these two (t = 15.210, $p < 0.001$), and customer involvement was found to have a positive (+) effect on the capacity to expand relationships. This result was consistent with the results from Vivek et al. (2012) [64]. Therefore, our finding indicates that firms can enhance the capacity to expand relationships by improving customer involvement.

4.4.2. Influence of Customer Involvement and Eco-Friendly Innovation

The results of the regression analysis of the impact of customer involvement on eco-friendly innovation are shown in Table 9 below. As a result of examining the relationship between the 'Innovation of eco-friendly products and customer participation among eco-friendly innovations', customer involvement explained the 'Innovation of eco-friendly products' as 20.8% (=0.208). Durbin Watson's value was 2.041, which was close to 2, so the regression model was suitable. The F value was 134.392 (p = 0.000) and was statistically significant, indicating that the regression line was suitable for the model. Additionally, when evaluating the collinearity statistics, there was no problem in multicollinearity because the VIF value was less than 10, and the tolerance limits were all greater than 0.1. The effect of the customer involvement factors on the 'Innovation of Eco-Friendly products' was found to have a significant effect (t = 11.593, $p < 0.001$), and customer involvement was found to have a positive (+) effect on 'Innovation of Eco-Friendly Products'. This result was consistent with the results from Wang et al. (2020) [65]. Specifically, the innovation of eco-friendly products benefits a relationship more if customer involvement and relational embeddedness are high.

Table 9. Relationship between Customer Involvement and Eco-Friendly Innovation.

Dependent Variables	Independent Variables	Non-Standardized Coefficient		Standardization Factor	t	*p*	Collinearity Statistics	
		B	S.E.	β			Tolerance	VIF
IEF	(constant)	2.182	0.224		9.724 ***	0.000		
	CI	0.505	0.044	0.458	11.593 ***	0.000	1.000	1.000
R^2 = 0.210, adj.R^2 = 0.208 F = 134.392 (p = 0.000), Durbin Watson = 2.041								
EPI	(constant)	2.689	0.187		14.371 ***	0.000		
	CI	0.477	0.036	0.503	13.118 ***	0.000	1.000	1.000
R^2 = 0.253, adj.R^2 = 0.252 F = 172.082 (p = 0.000), Durbin Watson = 1.844								

*** $p < 0.001$.

Next, as a result of examining the influence relationship between 'Eco-friendly process innovation' among eco-friendly innovations, customer involvement explained 'Eco-friendly process innovation' as 25.2% (=0.252). Since Durbin Watson's value was 1.844, which is close to 2, the regression model was suitable. The F value was 172.082 (p = 0.000) and was statistically significant, indicating that the regression line was suitable for the model. Additionally, when evaluating the collinearity statistics, there was no problem in multicollinearity because the VIF value was less than 10, and the tolerance limits were all greater than 0.1. As a result of examining the effect of the customer involvement factor on 'Eco-friendly process innovation', it was found to have a significant effect (t = 13.118, $p < 0.001$), and customer involvement, which was positive for 'Eco-friendly process innovation' (+), was also found to have an effect. This result was consistent with the results from Burki et al. (2019) [66]. The finding suggests that customer involvement increases the adoption of eco-friendly process innovation to mitigate the negative impact on the environment.

4.4.3. Capacity to Expand Relationships and the Impact of Eco-Friendly Innovation

The results of the regression analysis of the impact of customer involvement on eco-friendly innovation are shown in Table 10 below.

Table 10. Impact relationship between Capacity to expand relationships and green innovation.

Dependent Variables	Independent Variables	Non-Standardized Coefficient		Standardization Factor	t	*p*	Collinearity Statistics	
		B	S.E.	β			Tolerance	VIF
IEF	(constant)	1.862	0.223		8.335	0.000		
	CER (BR)	0.309	0.034	0.352	8.966 ***	0.000	0.951	1.051
	CER (RP)	0.304	0.040	0.299	7.615 ***	0.000	0.951	1.051
R^2 = 0.259, adj.R^2 = 0.256 F = 88.514 (p = 0.000), Durbin Watson = 1.967								
EPI	(constant)	2.355	0.185		12.763	0.000		
	CER (BR)	0.254	0.028	0.338	8.944 ***	0.000	0.951	1.051
	CER (RP)	0.329	0.033	0.377	9.983 ***	0.000	0.951	1.051
R^2 = 0.313, adj.R^2 = 0.310 F = 115.070 (p = 0.000), Durbin Watson = 1.813								

*** $p < 0.001$.

As a result of examining the impact relationship between the 'Innovation of eco-friendly products and Capacity to expand relationships', the Capacity to expand relationships explains the 'Innovation of eco-friendly products' as 25.6% (=0.256). Durbin Watson's value was 1.967, which was close to 2, indicating that the regression model was suitable. The F value showed a value of 88.514 (p = 0.000) and was statistically significant, indicating that the regression line was suitable for the model. Additionally, when evaluating the collinearity statistics, there was no problem in multicollinearity because the VIF value was less than 10, and the tolerance limits were all greater than 0.1. The capacity to expand relationships by building relationships (t = 8.966, $p < 0.001$), capacity to expand relationships via relationship persuasion (t = 7.615, $p < 0.001$), and sub-factors of capacity to expand relationships were found to have a significant effect on the 'Innovation of eco-friendly products'. As a result, it was confirmed that all sub-factors of the capacity to expand relationships had a positive (+) effect on the 'Innovation of eco-friendly products'. This result was consistent with the results from Leal-Millán et al. (2016) [67]. It indicates that the better a firm can expand relationships, the more beneficial it is to its eco-friendly product innovation. A firm's internal capabilities (e.g., capacity to expand relationships) play an important role in its participation in eco-friendly product innovation. Our finding suggests that in order to have customer involvement continuously lead to eco-friendly product innovation, firms should build close relationships with external players.

Next, examining the impact relationship between 'Eco-friendly process innovation' among eco-friendly innovations, the capacity to expand the relationship explained 'Eco-friendly process innovation' as 31.0% (=0.310). The Durbin Watson value was 1.813, close to 2, indicating that the regression model was suitable. The F value was 115.070 (p = 0.000) and was statistically significant, indicating that the regression line was suitable for the model. Additionally, when evaluating the collinearity statistics, there was no problem in multicollinearity because the VIF value was less than 10, and the tolerance limits were all greater than 0.1. The capacity to expand relationships by building relationships (t = 8.944, $p < 0.001$), the capacity to expand relationships via relationship persuasion (t = 9.983, $p < 0.001$), and sub-factors of capacity to expand relationships were found to have a significant effect on 'Eco-friendly process innovation'. As a result, it was found that all sub-factors of capacity to expand relationships had a positive (+) effect on 'Eco-friendly process innovation'. This result was consistent with the results from Nguyen et al. (2016) [68]. It also shows that the better a firm has the capacity to expand relationships, the more it is able to achieve eco-friendly process innovation. Therefore, we believe that firms should focus on improving their capacities to expand relationships, then gaining the opportunity to be the first in the industry to implement eco-friendly process innovation and mitigate the negative impact on the environment.

4.4.4. Mediating Effect of Capacity to Expand Relationships

(1) Mediating effect of innovation of eco-friendly products

Hierarchical regression analysis was performed to analyze the mediating effect of capacity to expand relationships in the relationship between customer involvement and innovation of eco-friendly products.

For the mediating effect to be analyzed, the relationship between the independent variable and the mediating variable, the relationship between the independent variable and the dependent variable, the independent variable, and the relationship between the mediating variable and the dependent variable should be analyzed in turn. In other words, hierarchical multiple regression analysis was performed according to the steps suggested by Baron and Kenny to understand the mediating effect of the parameters in the dependent and independent variables.

A total of three conditions must be satisfied. First, the independent variable must affect the mediating variable, and second, the independent variable must affect the dependent variable. Third, when verifying whether the independent variable and the parameter have a significant effect on the dependent variable at the same time, the relationship between the

independent variable and the dependent variable should not weaken (partial mediating), and significance should not disappear (complete mediating).

The results of analyzing the mediating effect of cognitive flexibility through this analysis process are shown in Table 11 below.

Table 11. Mediating effect of capacity to expand relationships.

Step	Independent Variables	Dependent Variables	Non-Standardized Coefficient		Standardization Factor	t	*p*
			B	S.E.	β		
1	Customer Involvement	Capacity to expand relationships	0.508	0.033	0.560	15.210	0.000
2	Customer Involvement	Green Innovation (IER)	0.505	0.044	0.458	11.593	0.000
3	Customer Involvement	Green Innovation (IER)	0.280	0.050	0.253	5.652	0.000
	Capacity to expand relationships		0.443	0.055	0.365	8.135	0.000
1st step: R^2 = 0.313, F = 231.354 (p = 0.000) 2nd step: R^2 = 0.208, F = 134.392 (p = 0.000) 3rd step: R^2 = 0.298, F = 108.921 (p = 0.000)							

According to the result of examining the effect of the independent variable on the mediating variable in step 1, it was found that the customer participation of the independent variable had a significant effect on the mediating variable, the capacity to expand relationships (=0.560, $p < 0.001$). It satisfied the first condition. According to the result of examining the effect of the independent variable on the dependent variable in step 2, it was found that customer participation, the independent variable, had a significant effect on the dependent variable, the innovation of eco-friendly products (=0.458, $p < 0.001$); therefore, the second condition was satisfied.

According to the results of analyzing the effect on the dependent variable by adding the independent variable and the mediating variable at the same time in step 3, it was found that both customer participation and capacity to expand relationships had a significant effect on eco-friendly innovation. Additionally, the influence of customer participation on the capacity to expand relationships decreased compared to the second stage (stage 2: =0.458, stage 3: =0.253). The capacity to expand relationships, a mediating variable, had a partial mediating effect between customer participation and the innovation of eco-friendly products.

Finally, according to the results of the Sobel test to verify the significance of the indirect effect on eco-friendly innovation through the capacity to expand relationships, which was a mediator of customer participation, the indirect effect of the mediating variable was found to be significant (Sobel's Test: Z = 7.137, $p < 0.001$). If the Z value was less than −1.96 or greater than 1.96, there was a partial mediating effect, so the mediating variable could be seen as partially mediating the effect of the independent variable on the dependent variable.

(2) Mediating effect of eco-friendly process innovation

Hierarchical regression analysis was performed to analyze the mediating effect of capacity to expand the relationships between customer participation and innovation of eco-friendly products. For the mediating effect to be analyzed, it is necessary to analyze the relationship between the independent variable and the mediating variable, the relationship between the independent variable and the dependent variable, the independent variable, and the relationship between the mediating variable and the dependent variable should be analyzed sequentially.

In other words, hierarchical multiple regression analysis was performed according to the steps suggested by Baron and Kenny to understand the mediating effect of the

parameters in the dependent and independent variables. A total of three conditions must be satisfied. First, the independent variable must affect the mediating variable, and second, the independent variable must affect the dependent variable. Third, when verifying whether the independent variable and the parameter have a significant effect on the dependent variable at the same time, the relationship between the independent variable and the dependent variable should not weaken (partial mediating), and significance should not disappear (complete mediating). The results of analyzing the mediating effect of cognitive flexibility through this analysis process are shown in Table 12 below.

Table 12. Mediating effect of capacity to expand relationships 2.

Step	Independent Variables	Dependent Variables	Unstandardized Coefficients		Standardized Coefficient	t	*p*
			B	SD	β		
1	Customer Involvement	Capacity to expand relationships	0.508	0.033	0.560	15.210	0.000
2	Customer Involvement	Green Innovation (EPI)	0.477	0.036	0.503	13.118	0.000
3	Customer Involvement	Green Innovation (EPI)	0.263	0.040	0.277	6.489	0.000
	Capacity to expand relationships		0.421	0.045	0.404	9.449	0.000
1st Step: R^2 = 0.313, F = 231.354 (p = 0.000) 2nd Step: R^2 = 0.253, F = 172.082 (p = 0.000) 3rd Step: R^2 = 0.363, F = 145.669 (p = 0.000)							

As a result of examining the effect of the independent variable on the mediating variable in step 1, it was found that the customer participation of the independent variable had a significant effect on the mediating variable, the capacity to expand relationships (=0.560, $p < 0.001$). This satisfies the first condition.

As a result of verifying the effect of the independent variable on the dependent variable in step 2, it was found that the independent variable, customer participation, had a significant effect on the dependent variable, eco-friendly process innovation (=0.503, $p < 0.001$). This satisfies the second condition.

In step 3, the independent and mediator variables were simultaneously input, and the effect on the dependent variable was analyzed. As a result, both customer participation and capacity to expand relationships significantly affected eco-friendly process innovation. Additionally, the influence of customer participation on the capacity to expand relationships decreased compared to the second stage (stage 2: =0.503, stage 3: =0.277). The capacity to expand relationships, a mediating variable, had a partial mediating effect between customer participation and eco-friendly process innovation.

Finally, the Sobel test was conducted to verify the significance of the indirect effect on eco-friendly innovation through the capacity to expand relationships of customer participation as a mediator. As a result, the indirect effect of the mediator was significant (Sobel's Test: Z = 7.995, $p < 0.001$).

If the Z value is less than −1.96 or greater than 1.96, there is a partial mediating effect, so the mediating variable can be seen as partially mediating the effect of the independent variable on the dependent variable.

5. Conclusions

This study was conducted on green companies, and the relationship between customer participation and boundary spanning capabilities were studied as factors affecting eco-friendly innovation. Through this, a plan for the eco-friendly innovation of green companies was identified in detail. As a result of testing the hypothesis proposed in this study, it was confirmed that customer participation affects eco-friendly innovation. It was demonstrated

that relationship boundary spanning capability mediates the relationship between customer engagement and green innovation. Specifically, it was found that relationship expansion capacity could partially mediate the relationship between customer participation and eco-friendly innovation. These results show that for customer participation to continuously lead to eco-friendly innovation, a close relationship should be established with external participants, suggesting that the company's internal capacity (relationship expansion capacity) to persuade these companies to participate in eco-friendly activities plays an important role.

The findings of this paper have the following management implications: on the one hand, enterprises should pay attention to internal control in business management, actively play the effective function of internal control on green innovation, and improve internal control not only from the source design of the internal control system, but monitor whether the internal control process is effectively implemented so as to mitigate the agency problem of enterprises, reduce the risk of environmental protection investment, optimize the innovation environment, and enhance enterprises' green innovation capability of enterprises. On the other hand, green innovation is not developed in isolation, and it cannot be developed without the support of environmental protection investment; enterprises should reshape the cognitive concept of environmental protection investment and not only be aware of the economic benefits of environmental protection investment, but also be aware of the environmental and social benefits it can bring. Enterprises should also actively fulfill their environmental responsibility based on the strategic goal of sustainable development, and further enhance the level of green innovation.

This study, in an eco-friendly context, has several limitations as it is an exploratory study in which the boundary spanning capability of a company is manipulated in an eco-friendly context and empirically analyzed through a questionnaire method. First, this study has a limitation in that it did not fully reflect the concept of boundary spanning with multidimensionality. Because this study focused on the participation of external partners in innovation, especially customer participation, persuasion activities for internal stakeholders or corporate participation pointed out as significant activities for boundary expansion were not reflected in the study. Therefore, additional empirical studies are needed to fully reflect the multidimensionality of this boundary extension. Second, since this study surveyed only Chinese companies, it is challenging to apply these results to companies in other countries. Thus, it is necessary to study companies in various countries in future research, and it is also essential to study the differences between countries. Third, this study measured the perception level of respondents in measuring a company's eco-friendly innovation. Although the degree of perception of respondents may show results such as objective measurement results [69], it will be necessary to re-verify this research model using objective data in the future to derive clearer research results.

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