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Open for Green Innovation: From the Perspective of Green Process and Green Consumer Innovation

Ji Yeon Yang [1] and Taewoo Roh [2,*]

[1] Department of Global Business, The University of Suwon, Business School 810, 17 Wauan-gil, Bongdam-eup, Hwaseong-si, Gyeonggi-do 18323, Korea; jiyyang@suwon.ac.kr
[2] Department of International Trade and Commerce, Soonchunhyang University, Unitopia 901, Soonchunhyang-ro 22, Sinchang-myeon, Asan-si, Chungchungnam-do 31538, Korea
* Correspondence: troh@sch.ac.kr

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Abstract: This study is about open innovation, which suggests that companies should aim to cooperate with other companies or organizations for green innovation. While previous research has focused on the mechanism through which the company achieves green innovation, mainly from the supplier perspective, we have taken a more demand-driven approach to product innovation by introducing the green process and consumer perspectives. Also, this study not only considers collaboration with other companies whose interests are complicated in terms of open innovation but also cooperation with other organizations whose interests are unsophisticated. We examined the relationship between open innovation and green innovation by using the structural equation method and 2496 manufacturing companies in South Korea, and further confirmed the robustness by using OLS (ordinary least square) regression. As a result of the empirical analysis, all four hypotheses were supported, and the effect of collaboration with organizations was stronger than with firms. Based on these results, this study suggests that if managers prioritize green performance, they should consider co-prosperity with other companies and organizations. In addition, this study found that green innovation, which can contribute to the environment while consumers use products with green innovation, is also becoming central. Compared with previous studies, we expect that our alternative approaches to open and green innovation will contribute to corporate sustainability in the future.

Keywords: green consumer innovation; green process innovation; open innovation; environmental performance

1. Introduction

The Paris Agreement on Climate Change, held in December 2015, adopted an agreement to establish a new climate change regime after the Kyoto Protocol, which is scheduled to end in 2020. It is the launch of a new climate change system after 2020, and countries that are participating in the climate change regime are facing urgent and essential challenges in solving environmental problems [1]. While various efforts have been made to reduce greenhouse gas emissions, the most effective policy has been the average automobile greenhouse gas regulation which limits the average greenhouse gas of all automobiles sold by each car manufacturer [2]. The discussion shows that a variety of methodologies will be studied to encourage corporate participation in order to solve national and global environmental problems. In other words, organizations cannot merely ignore the development of green products or green technologies due to the institutional changes that they are facing. These challenges are often viewed as crises, but they also serve as opportunities depending on how organizations perceive them. For example, it has been found that when organizations adopt environmental mitigation technologies on a preemptive basis, it has been easier to advance into the European markets [3].

Organizations that actively participate in environmental management and green innovation can improve productivity and enhance corporate reputation by minimizing wastes in the production process. Therefore, strengthening their environmental competitiveness is very important under the high level of consumer awareness of environmental protection and strict international regulations on environmental protection. While studies on green innovation have been primarily divided into green product innovation and green process innovation, various studies have been conducted on the drivers and outcomes of green innovation and have focused mainly on innovative technologies [4]. It is costly, time consuming, and even risk-taking if a company independently undertakes a series of technology investments that develop technologies, apply them to processes, and produce products [5,6]. Nonetheless, research is still in its infancy and efforts to comprehensively study both organizations and consumers have rarely looked at performance through green innovation [7,8].

This study aims to contribute to research on green innovation on the two research streams. First, an entity needs to discuss innovations that can reduce emissions of environmental pollutants. Organizations have so far made various efforts for green innovation, but given the complexity and cost of environmental issues, this is difficult to overcome by the efforts of a single company alone. Therefore, for a more effective and sustainable method, the creation of environmental core competencies through collaboration with other organizations beyond a single organization's environmental innovation or collaboration with other agencies and organizations is required [7]. In recent studies, research has been conducted on the importance of market knowledge that can be gained from stakeholders such as suppliers, competitors, customers, and universities, rather than acquiring green knowledge alone [9]. In this study, we propose open innovation as a theoretical basis for the development of these conventional green technologies and productivity gains [10,11]. While previous research has primarily considered innovation within or between enterprises, this study attempts to break open innovation into open innovation between enterprises and between enterprises and institutions in order to examine the impact of innovation not only between competitive partners but also between non-competitive partners on green innovation. Second, discussions will be needed on which direction the effect of green technology developed by an enterprise's efforts can represent performance [12]. While previous studies have considered the financial performance aspects of an entity or further technological improvements of an entity as a result of green innovation, this study seeks to derive more realistic implications by looking at green innovation as a disaggregation into corporate performance and customer environment participation. In addition, this study emphasizes that companies can benefit directly from sales of green innovation products and that consumers purchasing products with green technologies can make an environmental contribution by using them.

Additionally, this study contributes to the literature by establishing an interface to the different academic concepts of open innovation and green innovation that will widen the scope of the two research areas. Also, by segregating and approaching the concepts of open innovation and green innovation, this will lead to deeper and richer implications for existing studies. Last, by presenting open innovation as a way to achieve green innovation, the study will provide implications for organizations to realize green innovation more efficiently.

2. Literature Review and Hypothesis Development

The environmental agenda has become the most crucial topic in the global manufacturing industry. Consequently, the development of technologies that reduce or prevent pollution in the production processes is becoming a necessary condition for survival. Green innovation has emerged as one of the solutions to this growing economic and environmental pressure [7,12,13]. Many manufacturers' concerns have recently changed from "How do we produce products efficiently?" to "How do we develop more eco-friendly materials or reduce the generation of pollutants in the production process?" [14]. Manufacturing companies have begun to perceive themselves as an entity that faithfully performs the needs of society, and the societal expectations have increased as manufacturing companies are perceived to contribute in improving the environment or quality of life within society [15,16]. There

are various assessments of green innovation among manufacturing companies, but the action required to harmonize with significant economic, environmental, and social targets has become a prominent concern. It began in 1992 with the discussion of reducing environmental pollution in the manufacturing process of manufacturing companies initiated at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro and is in line with sustainable manufacturing [17]. This study seeks to discuss how these green innovations can be better represented in the product production process and the relationship with open innovation that enables innovation together.

In the knowledge-based view, an entity seeks to grow through the creation, diffusion, and utilization of knowledge and to innovate through continued investment to obtain new competitive knowledge to respond to the changing environment [18,19]. However, due to the accelerated pace of the expansion of knowledge, rapid obsolescence in the value of existing knowledge, frequent turnover among knowledge workers, and firms having difficulties in creating innovative ideas have become unfortunate consequences [20]. These changes in the knowledge environment make a variety of ways in which organizations can acquire new ideas when they attempt to innovate. In the past, a single entity had to invest vast amounts in order to develop innovation into new opportunities [21], but now it has become a situation where it has to consider the access to and organization of these knowledge sources beyond the efforts of a single company alone because the knowledge sources of the enterprise have become more diversified.

With this notion, existing studies on innovation emphasized that an organization's strategy to disclose its innovation process to the outside world can strengthen the competitiveness of the organization. Chesbrough [22] suggested that many organizations that have succeeded in innovating, such as IBM, Intel, and AT&T, continue to innovate and achieve high results through open innovation that opens their internal innovation processes to the outside world and actively absorbs and utilizes the knowledge that exists outside. Indeed, P&G has overcome the limitations of growth faced by market saturation and depletion of ideas through the Connect and Development Program, which utilizes external ideas. Through this program, P&G expanded its share of new products from 15 to 50% and increased R&D productivity by 60% [22]. South Korea's Hyundai Motor recently established next generation vehicle (NGV), an industry-academic cooperation company, to develop future eco-friendly vehicles, and successfully developed a new concept hybrid system by pursuing research on electronics, machinery, chemicals, materials and convergence technologies [3]. Therefore, the importance of external knowledge activities of an enterprise is being emphasized and increasing the knowledge exploration activities of enterprises that explore ideas and opportunities for innovation through a variety of external knowledge and sources of information are being prioritized [23].

Recently, we believe that exploring innovative ideas with the potential to become commercialized as one of the most critical knowledge exploration processes to achieve innovation plays an important role [24,25]. Organizations spend significant amounts of time and money, discovering opportunities for innovation, which increases their ability to create innovation through a combination of existing and new knowledge held by the firm [26,27]. Many previous studies have empirically analyzed that such repeated internal knowledge exploration and cumulative innovation capabilities play an essential role in the achievement of innovation [28,29]. However, empirical verification was somewhat sluggish for open innovation, which recognized the economic value of external knowledge and emphasized the importance of commercially applicable external innovation activities by understanding this knowledge. If the focus of the empirical studies in which the existing studies have validated the open innovation is primarily focused on how to improve the performance of innovation, this study will look at the relationship between the two types of open innovation and the types of green innovation that result from it. Companies will innovate to address a variety of pollution caused by the inefficient use of resources, and most of them will have to make efforts to reduce such environmental costs through green innovation [12]. Porter and van der Linde [30] argued that pioneers who created green innovation early might have a first mover advantage that would give consumers a premium price over competitors who produce the same product. Behind the consumer's willingness to pay a little high price is the

premise that environmentally immoral companies may be subjected to harsh trials. Furthermore, for companies that continue to promote green innovation, the potential for attracting investment from home and abroad increases, which can then result in competitive advantage [12,31].

2.1. Open Innovation and Green Process Innovation

Green innovation can be defined as new or modified processes, technologies, systems, and products to reduce or avoid environmental problems. Green innovation is divided into two types: green process innovation and green product innovation [7,32–34]. Green process innovation (GPI) refers to green process technologies such as clean production, pollution control, pollution prevention, environmental efficiency, and recirculation, with new or improved activities contributing from an environmental perspective to the production of goods or services. Green product innovation means that the nature or purpose of an enterprise's goods or services is new or noticeably improved in terms of the environment. In this study, we will focus on the green process innovation as a result of green innovation. Green process innovation has recently gained much attention in that manufacturing companies are making great efforts to minimize waste and pollution generated in the production process and optimize resource utilization. Such efforts are required by businesses because in many cases, including the domestic market, strict environmental standards are applied when entering foreign markets, and consumers purchasing them are also becoming more focused on reducing pollutants rather than the characteristics of the finished products.

Existing studies on green process innovation first addressed the fundamental question of why companies should respond to environmental regulations [12]. More specifically, the question of "do we need corporate social responsibility or corporate social response to environmental issues?" In fact, a number of companies recognized it as an unnecessary investment in environmental management, but, in contrast, products completed through green process innovation were able to offer higher prices to customers [35], with the effect of improving their corporate image [10]. Furthermore, by pioneering new markets, it was a means to gain competitive advantage for the enterprise [28]. Moreover, the government's environmental policies in corporate management and environmental regulations in the international community are increasingly influential not only in local management but also in the management paradigm in the overseas markets [12]. In response, companies are forced to carry out environmental protection activities to respond to international regulations and pressures [36,37].

In terms of the institutional aspect, green process innovation functions as institutional pressure that companies cannot easily avoid. Even 20 years ago, environmental regulation was not a change that could cause punitive damages for not acting, because it was considered as an alternative for companies. However, due to the emergence of environmental issues such as climate change, the global issue has been ignited by the fact that the most CO_2 emissions-driven entity is not a matter of choice but a need for justification for survival. This series of processes can also be understood as changes in the homomorphism that are emphasized in the theory of institutionalization.

However, if green innovation is a necessity, we must think about one important issue, the methodology of how to achieve green process innovation. In the past, many companies doubted the effectiveness of green innovation and dismissed it as an unnecessary investment because of the costs required for green innovation and the question of whether knowledge and technology can be obtained through green innovation and connected to actual business performance [38]. Therefore, if all companies that are required to perform green innovation are burdened with the cost and cost–benefit effects of achieving green innovation, they should "work together" more to ensure sustainable development is possible [5,39]. Kim, Kim and Foss [39] suggested that companies that have decided to actively introduce environmental management for green innovation should consider ways to integrate within a company or utilize inter-company environmental management and technology to achieve the goal of achieving environmental regulations. Also, Ma, et al. [14] stated that compared to other types of innovation, green innovation was highly likely to cooperate because it was better to be together than to be alone. Cooperation on environmental issues provides companies with opportunities to reduce

costs and allows businesses and societies to move together in a better direction [40]. Above all, green innovation must be sustainable in that it contributes to environmental issues globally and, therefore, has significant external effects than other types of innovation.

Open innovation between companies or between companies and organizations will make green innovation efficient and sustainable. Corporate innovation is an integral part of competitive advantage and sustainable survival [41]. Moreover, comprehensive innovation that can contribute to the environment while jumping over existing technologies is a momentous challenge for companies. Therefore, it is vital to discover and realize the source of this innovation. The recent rapid changes in the market environment and the increasing complexity of technology have led to increased activities to gain new knowledge not only within the enterprise but also from the outside [28]. International firms should work with business partners to promote the relevance of business participation to improving and enriching the delivery of products and services, and to work with trusted partners to engage partners in the process of creating ideas and enabling rapid response to safe data sharing, business strategies and development and market intelligence and trends [42]. Activities to obtain new knowledge from the outside can be accomplished through open innovation [22]. Open innovation occurs on the premise of continuous interaction and openness with other organizations, which include clients, suppliers, competitors, or related research institutes and government agencies. Previous research on R&D cooperation and knowledge diffusion focused mainly on a variety of external R&D sources, but little effort was made to investigate the impact of competitive and non-competitive R&D cooperation on innovation at the same time. Lazzarotti and Manzini [43] argue that the difference between organizational and management expertise and firm strategy and competence can lead to other forms of open innovation, even if firms operate in the same industry. In response, Huang and Yu [44] demonstrated that both non-competitive R&D cooperation and competitive R&D cooperation bring a positive adjustment effect to the relationship between R&D and innovation within the enterprise, but non-competitive R&D cooperation is more favorable than competitive R&D cooperation. As a result, the knowledge gained from these non-competitive partners can be interpreted as being helpful because research institutes and universities are not direct competitors and are not willing to compete with companies that cooperate in the same market in the foreseeable future, which further strengthens and complements the company's in-house efforts for innovation [45].

Various studies have shown that collaboration with external networks facilitates innovation activities and reduces the costs and risks of innovation, particularly for innovation with high technological opportunities but high complexity, such as green innovation, preferring open innovations with access to a wide range of external ideas, knowledge, and resources [44,46]. Thereby, the following hypotheses were derived:

Hypothesis 1: *Open innovation with firms will be positively related to green process innovation.*

Hypothesis 2: *Open innovation with organizations will be positively related to green process innovation.*

2.2. Open Innovation and Green Consumer Innovation

Green innovation can be seen as an introduction or implementation of new or radically improved products (services), processes, organizational methods, and marketing methods to increase environmental contributions. Among these, this study defines green consumer innovation (GCI) as a firm's contribution to the environment that the ecological loss of its products and services used by consumers has been reduced. Enhancing the understanding of eco-friendly consumer behavior is vital in both environmental and business aspects [15]. In order for the international community to achieve its stated goals, it is not only essential to reduce the negative impact on consumers, but also to lay the groundwork for a good consumption [47]. In the past, there was a level of mimetic isomorphism that saw other companies develop green technologies. However, as coercive isomorphism has progressed,

or if images that harm nature are delivered to consumers, the company may find it challenging to survive [16].

As the environmental consciousness of customers who feel this global warming issue is evolving, green process innovation is not only pressure in terms of corporate management, but also terms of customers [31]. For example, the perception of so-called "good consumption" appears to be growing, with customers opting for eco-friendly products and willing to pay relatively high prices for eco-friendly products [48]. From a green consumer innovation perspective, companies are forced to carry out environmental protection activities to counter consumer awareness of environmental issues and the regulatory pressure of the international society [36].

If an understanding of eco-friendly consumer behavior is imperative, there is a need to look at the motives behind creating eco-friendly consumer behavior. Among studies that have been conducted on eco-friendly consumer behavior, the study of Stern [49] is representative. He suggested four factors that lead to eco-friendly consumer behavior: contextual pressures, attitude factors, habits or routines, and personal capacity, and cited these as the most important psychological and strategic factors. Eco-friendly consumers have a higher level of awareness of the environment in advance and, in fact, consumers' green options have been shown to reduce the use of cars even for personal consumption [50], reduce energy consumption in the eco-friendly production process [51] or prefer products with processes favorable to the preservation of natural resources [52]. Thus, from a business and strategic point of view, the development of environmentally friendly products can hardly be expected to cause an effect unless eco-friendly technologies are linked to consumers and their lifestyle. Indeed, it has been argued that the eco-friendly production process in the product production phase has the potential to reduce and even eliminate environmental damage in the later stages of the consumption cycle [53]. Reducing the environmental impact of companies, such as energy conservation and recycling, has drawn much more attention than consumers buying eco-friendly products [15]. As a result, companies need higher capabilities to meet the needs of eco-friendly consumers, need external capabilities to supplement limited time and resources, as well as inter-organizational connectivity to develop existing knowledge into new types of knowledge or to develop new products, processes, and services [7]. In particular, external R&D cooperation has been recognized as a focal source of technological learning when an entity has limited resources. As a result, the knowledge gained from competitive or non-competitive partners is expected to have a positive impact on meeting the requirements of eco-friendly consumers. Subsequently, Hypothesis 3 and 4 are posited below:

Hypothesis 3: *Open innovation with firms will be positively related to green consumer innovation.*

Hypothesis 4: *Open innovation with organizations will be positively related to green consumer innovation.*

Based on the above review, the theoretical model set up by this study is shown in Figure 1.

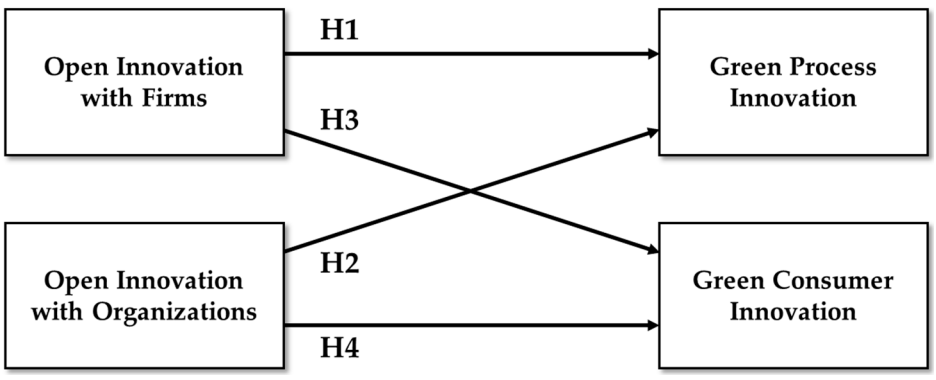

Figure 1. Research model.

3. Methodology

3.1. Samples

The sample used in this study is based on the questionnaire obtained from the Science and Technology Policy Research Institute (STEPI) by conducting an innovation survey of Korean manufacturing companies in 2016. STEPI is a pivotal technology research institute under the Prime Minister's Office and is also a representative organization for science and technology policy. STEPI collects innovation data on Korean companies and compares them with the innovation index of various countries such as Europe and the United States. The Korean Innovation Survey (KIS) conducts annual surveys of over 10,000 private companies engaged in the manufacturing and service industries through Gallup Korea. The survey was held for three years from 2013 to 2015 and inquired extensively about innovations in addition to necessary corporate and financial information. KIS, in particular, explores the innovation performance of companies belonging to the manufacturing industry in various perspectives and identifies the technological workforce, the elements required for innovation, the activities and types of innovation, the inhibition of innovation activities, and the type and amount of intellectual property rights [3].

In the necessary information, it reveals whether the form of the company is an independent company, an affiliate of a domestic conglomerate, or a subsidiary of an overseas group. The company listing status is also identified—whether it is listed on the Korea Exchange (KRX) or the Korea Securities Dealers Association KOSDAQ, or whether it is unlisted. Among the innovations covered in KIS, typical examples include the development of innovative products for the first time in the overseas market, the development of innovative products for the first time in the domestic market, and the launch of new products compared with existing ones. Also, to identify open innovation, KIS details the relevant entities involved in various innovation activities, including affiliates in each company, competitors in the region, and universities and other higher education institutions. The focus of this study is to understand the relationship between open innovation and green innovation, and the results of our analysis are related to environmental contribution. The size of the population is 41,485, and the size of the company is divided into the number of employees as follows: 81.2% of companies with 10–49 employees, 10.6% with 50–99 employees, 6.4% with 100–299 employees, 0.8% with 300–499 employees, and 0.9% with more than 500 employees. We selected the final sample companies as a random sampling method using the Neyman sample allocation method by industry and employee size criteria, except for the tobacco manufacturing industry [54]. Sampling errors that can occur in the sampling process of this survey are within ±3.34% at 95% confidence level. As a result of examining all of the above, while the total sample was 3925, the number of valid samples excluding the missing values was finally determined to be 2496 for the structural equation method. It is found that there is no problem in this study to test the hypothesis because it exceeds the minimum requirement of 300 in confirming the structural equation method.

3.2. Variables

The dependent variable used in this study is the green process innovation that contributes to the environment in the production process and the green consumer innovation that helps the environmental contribution of the final consumer. Chen, Lai and Wen [12] defined a green process innovation that means energy savings, pollution prevention, waste recycling, or less toxicity in the production process. The green process innovation consists of three items such as an answer to the reduction of material consumption per unit of output, energy usage per unit of production, and carbon dioxide generation in the process of producing a product [55,56]. The definition of green consumer innovation is similar to the green product innovation proposed in previous studies. However, we changed the original meaning to the purpose of the research to fit this study because the company destined to raise sustainability can accomplish the final goal as consumers contribute to the environment by using the company's products. Green consumer innovation consists of the following six items. Each question is about what

the end consumer can contribute to the environment while using the outcomes of each company, such as replacing pollutants or hazardous materials, recycling waste, reducing energy use, and improving recyclability after product use [12]. When dealing with green innovation in previous studies, most of the dependent variables are defined as innovation in the form of environmental performance that can be achieved by the firm. We believe that sustainability can be achieved through developing the eco-friendly product by a firm's green innovation and reducing the waste of products by consumers. [57].

In this study, independent variables affecting green innovation are related to open innovation, and we divided open innovation into open innovation with firms and open innovation with organizations and identified the significance of each effect on the dependent variables. The previous study on open innovation mainly revealed the source of information for new knowledge among innovation activities conducted by the company for several years and examined the influence of the breadth and depth of open innovation on business performance [22,58]. However, the interest structure of open innovation is not so simple to understand, and, thus, the results may be different from what firms initially expected, depending on the organizational characteristics involved in such collaboration or the speed of environmental change [59,60]. When a certain degree of conflict with competitors occurs after open innovation is initiated, there are some cases where a company continues to support the cooperation for sustainability while others take opportunistic behavior such as the extortion of knowledge about green technology from rivals. Therefore, the discrepancy may arise from an opportunistic asymmetry between a firm's goal and its expected outcome by open innovation [44].

In order to contribute to the extant literature on open innovation, this study examined the original research on open innovation and found 12 sources of knowledge that were confirmed from the inside of a firm's head office to the government-sponsored research institute and public research institutes [10,11]. Among 11 sources of knowledge except for firms' headquarters, four sources were composed of group affiliates, suppliers, demand companies, and competitors in the same industry. The other seven sources are an open innovation between a firm and organizations that do not conflict with a firm's interests, such as associations, consulting firms, universities, conferences, fairs, exhibitions and private researchers [25,60].

As control variables, we included a firm's age and size as a representative variable that could affect green process innovation and green consumer innovation. The firm age was defined as the value subtracted from the time the company was established, and the firm size was calculated by taking the natural logarithm as the total sales of the company. Also, R&D intensity used in some studies to estimate an ordinary innovation as well as a green innovation is controlled to reduce the unobserved error that may lead an overestimation for the green innovation [13], and we measured it as R&D expenditure of a firm divided by total sales. To verify the open innovation effect in the structural equation model, we included all control variables when endogenous variables were estimated. The explanation for details is described the result section [13,61].

4. Results

4.1. Descriptive Statistics

KIS is the approval statistics of the Korea National Statistical Office and aims to support the establishment of government policies to promote technological innovation and enhance the international competitiveness of private companies by grasping the actual state of technological innovation activities of Korean companies. Therefore, under the direction of the technical officer who can comprehend the overall strategy of technological development, the informant should prepare all the relevant items regardless of whether or not the technology innovation performance exists. The results of descriptive statistics on 2496 companies used to test the hypotheses are described in Table 1. As for a firm's age, 968 samples (38.78%) were the most frequent with over 20 years. The frequency of medium-sized (44.35%) and small-sized (39.10%) firms were higher than that of large firms (16.55%). In the case of subsidiaries, 2087 (83.61%) were independent firms, and 893 (35.78%) venture companies were found. There were 447 (17.91%) listed companies in the KRX and KODAQ. The most common way of R&D management is a research institution (56.13%) and a task force team (TFT) (20.99). The most prominent

samples belonging to the chemical manufacturing industry were 1562 (62.58%), followed by 563 firms in the consumer manufacturing industry (22.56%).

Table 1. Descriptive statistics.

Variables	Frequency (N)	Percent (%)
Firm age		
Less than 11 years	774	31.01
11–20 years	754	30.21
Over 20 years	968	38.78
Firm size		
Large-sized company	413	16.55
Medium-sized company	1107	44.35
Small-sized company	976	39.10
Subsidiary		
Independent firm	2087	83.61
Domestic firm's subsidiary	301	12.06
Foreign firm's subsidiary	108	4.33
Venture firm		
Yes	893	35.78
No	1603	64.22
Listed on the KRX or KOSDAQ		
Yes	447	17.91
No	2049	82.09
R&D activity		
Institution	1401	56.13
Department	490	19.63
Task force team	524	20.99
None	81	3.25
Industry		
Consumer manufacturing	563	22.56
Chemical manufacturing	1562	62.58
Electronic manufacturing	371	14.86
Total	2496	100

4.2. Reliability and Factor Analysis

Reliability refers to how consistently the measured phenomena or objects are measured. In other words, it is a measure of how much the result is consistent with the original measurement, assuming that the researcher repeats the survey on the questionnaire conducted on a particular research question. Reliability is generally measured by test–retest, split-half, and internal consistency. This study used Cronbach's alpha as a measure of internal consistency. In general, the reliability is obtained when the Cronbach's alpha coefficient for a latent variable is 0.7 or more and all latents in our model satisfy the criterion.

Exploratory factor analysis (EFA) is a scaling-down method that reduces variables and derives essential concepts by grouping variables where the correlation between each is high. Principle component analysis (PCA) is often used as EFA, and it has the advantage of minimizing the loss of information when reducing the number of factors in the process. The factor to be extracted from the EFA of this study is specified as eigenvalue 1 or more.

A large eigenvalue indicates a high correlation between variables, which can be interpreted as an essential factor. Also, since the factor loading is limited in confirming the vertical relationship between variables, varimax rotation is used as one of the most-used orthogonal rotations. According to the results of EFA, the factor loading of all latent variables was 0.4 or more, Kaiser–Meyer–Olkin (KMO) index indicated 0.000, and Bartlett's sphericity test showed less than 0.05. Therefore, the factors that we extract are certified, ensuring the validity of the overall measurement tool. In this study, confirmatory factor analysis (CFA) was performed to verify the validity. Generally, after EFA is performed and revalidated through CFA, more accurate results can be obtained. The fitness index of factor analysis can be divided into the absolute index, incremental fit index, and parsimonious index. Among the above indexes, comparative fit index (CFI), Tucker–Lewis index (TLI), standardized root mean squared residual (SRMR), root mean squared error of approximation (RMSEA) provided by 'estat gof' of STATA package were adopted to verify the fitness of our model [62]. By comparing EFA and CFA in Table 2, we removed two items (one from open innovation with firms and one from green consumer innovation) from the factor. In Table 3, composite reliability (CR) and average variance extracted (AVE) are measures used to evaluate convergent validity. Although the acceptable level of reliability of a CR is 0.70 or higher, it is acceptable if the research has an exploratory nature even if it is less than 0.70. AVE should be at least 0.5 to be considered reliable.

Table 2. Fit index between exploratory factor analysis and confirmatory factor analysis.

Fit Index	Measurement Model			Accept
	EFA	CFA	Difference	
Comparative fit index (CFI)	0.918	0.936	0.018	Good
Tucker–Lewis index (TLI)	0.906	0.924	0.018	Good
Standardized root mean squared residual (SRMR)	0.043	0.032	−0.011	Good
Root mean squared error of approximation (RMSEA)	0.067	0.067	0.000	Acceptable

Table 3. Reliability and convergent validity.

Latent Variables	Item	Factor Loading	z	*p*	AVE	CR
Open Innovation with Firms	OIF1	0.66	47.45	0.00	0.54	0.78
	OIF2	0.75	62.77	0.00		
	OIF3	0.79	70.34	0.00		
Open Innovation with Organizations	OIO1	0.72	66.63	0.00	0.53	0.89
	OIO2	0.69	57.49	0.00		
	OIO3	0.71	63.85	0.00		
	OIO4	0.75	71.81	0.00		
	OIO5	0.73	68.55	0.00		
	OIO6	0.75	71.88	0.00		
	OIO7	0.75	72.22	0.00		
Green Process Innovation	GPI1	0.79	84.74	0.00	0.66	0.85
	GPI2	0.87	112.1	0.00		
	GPI3	0.77	76.28	0.00		
Green Consumer Innovation	GCI1	0.72	65.06	0.00	0.53	0.85
	GCI2	0.82	93.68	0.00		
	GCI3	0.71	60.91	0.00		
	GCI4	0.76	73.20	0.00		
	GCI5	0.64	46.86	0.00		

According to the CFA results, the CR of all the extracted factors was more than 0.7 and the AVE of was 0.5 or more and such factors were significant ($p < 0.001$), indicating that convergent validity is confirmed. For discriminant validity, intra-class correlation (ICC), AVE, and the square root of AVE were compared in Table 4. All ICCs were significant at a significance level of 0.01, and the correlation

coefficients between latent variables were lower than the AVE square root of each latent variable, indicating that discriminant validity is verified.

Table 4. Intra-class correlations and discriminant validity.

Variables	1	2	3	4
1 Open Innovation	0.736			
2 Open Innovation	0.660 *	0.728		
3 Green Process Innovation	0.267 *	0.313 *	0.810	
4 Green Consumer Innovation	0.275 *	0.312 *	0.740 *	0.731

Notes: (1) * $p < 0.01$; (2) Diagonal represents the square root of average variance extracted (AVE) values.

4.3. Structural Equation Model

This study analyzed the effects of open innovation with firms and open innovation organizations on green process innovation and green consumer innovation, respectively, by the structural equation method. The validity of our model was verified for the estimation since CFI, TLI, and RMSEA are higher than 0.8 while SRMR is less than 0.1. In the interpretation of the results, this study controlled a firm's age, firm size, and R&D intensity as variables that may have a distortion effect on the dependent variables and cause bias. The results show that each control variable has a significant impact on green process innovation and green consumer innovation ($p < 0.05$).

The results show that the effect of open innovation with firms on green process innovation (H1) was significant ($\beta = 0.07$, $p < 0.05$). The impact of open innovation with firms on green consumer innovation (H3) was significant ($\beta = 0.09$, $p < 0.01$). While the impact of open innovation with firms on green process innovation and green consumer innovation was significant, the effect was slightly weak (0.07, 0.09, respectively). Of course, the impact of open innovation with firms on green consumer innovation was found to be a little larger than that of green process innovation.

H2 and H4 are about the impact of open innovation with organizations on green innovation, and the interpretation of each result is as follows. The hypothesis on the effect of open innovation with organizations on green process innovation (H2) was positive ($\beta = 0.24$, $p < 0.001$), and the influence of open innovation with organizations on green consumer innovation were also positive (H4) ($\beta = 0.22$, $p < 0.001$). The influence of open innovation with organizations on green process innovation and green consumer innovation was found to be larger than that of open innovation with firms, and the degree of significance was also stronger. The result of structural equations for all hypotheses in this study are graphically summarized in Figure 2.

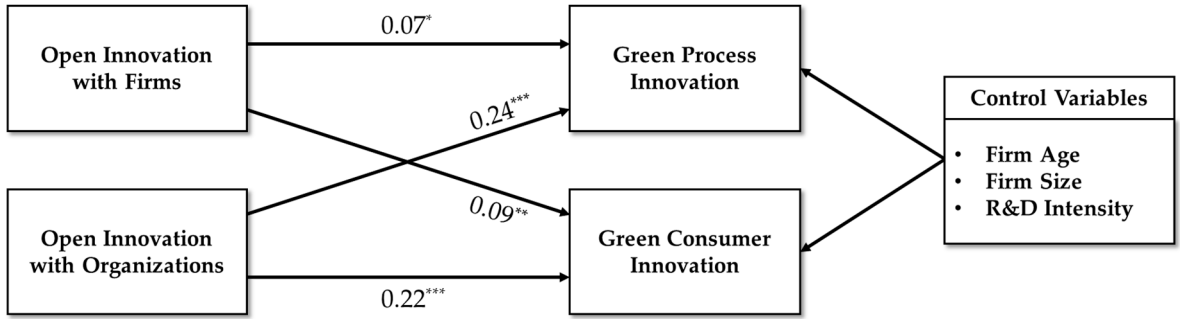

Figure 2. Results of the structural equation method. Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Comparing the explanatory power (R^2) of the endogenous variables, the green process innovation was 12.2%, and the green consumer innovation was 12.6%. Green consumer innovation has more explanatory power (overall $R^2 = 0.964$). The finding shows that the effect on the green process and consumer innovation is stronger when cooperating with other organizations that have less interest

in profits and less hostility to common outcomes than firms coping with the competition when participating in open innovation.

4.4. OLS Regression

Although all hypotheses tested by the structural equation method were verified as significant, we analyzed them again by regression to confirm the robustness. The correlation test and multi-collinearity test were performed for each dependent variable with other explanatory variables before the regression analysis was examined in Table 5. Although open innovation with firms and open innovation with organizations are theoretically highly correlated variables, the coefficient was found as 0.63, which is regarded as a proper degree. Furthermore, there is no problem regarding multicollinearity because variance inflation factor (VIF) ranges from the lowest 1.02 to the highest 2.05 (average 1.57) [63]. Most of the correlations were significant at 0.05.

Table 5. Correlations of explanatory variables.

Variables	GPI	Firm Age	Firm Size	R&D intensity	OIF	OIO
GPI	1.00					
Firm age	0.15 *	1.00				
Firm size	0.24 *	0.39 *	1.00			
R&D intensity	0.01	−0.03	−0.11 *	1.00		
OIF	0.21 *	0.10 *	0.14 *	−0.02	1.00	
OIO	0.28	0.18 *	0.22 *	−0.04 *	0.63 *	1.00
Variables	**GCI**	**Firm Age**	**Firm Size**	**R&D intensity**	**OIF**	**OIO**
GCI	1.00					
Firm age	0.14 *	1.00				
Firm size	0.23 *	0.39 *	1.00			
R&D intensity	0.02	−0.03	−0.11 *	1.00		
OIF	0.21 *	0.10 *	0.14 *	−0.02	1.00	
OIO	0.26 *	0.18 *	0.22 *	−0.04 *	0.63 *	1.00

Notes: (1) GPI, green process innovation; OIF, open innovation with firms; OIO, open innovation with organizations; (2) * $p < 0.05$.

As shown in Table 6, firm age, firm size, and R&D intensity were used as control variables for all models. H1 and H2 were verified in Model 1, and H3 and H4 were confirmed in Model 2. In each hypothesis, the level of significance was slightly different, but all of them were significant at 0.05. Similar to the results of the structural equation method, the effect of open innovation with organizations on each dependent variable is stronger than that of open innovation with firms. Therefore, the hypothesis test of this study through regression analysis is considered to have some degree of robustness.

Table 6. Results of the OLS regression.

Variables	Model 1 (GPI)		Model 2 (GCI)	
	Coefficient	t-Value	Coefficient	t-Value
Firm age	0.04 +	(1.71)	0.04 +	(1.71)
Firm size	0.18 ***	(8.50)	0.17 ***	(8.02)
R&D intensity	0.04 *	(2.31)	0.05 *	(2.36)
OIF	0.06 *	(2.47)	0.07 **	(2.95)
OIO	0.19 ***	(7.77)	0.18 ***	(7.10)
R^2	0.114		0.106	
Adjusted R^2	0.112		0.104	
Log-likelihood	−1038.1		−819.5	
df(m)	5		5	

Notes: (1) GPI, green process innovation; OIF, open innovation with firms; OIO, open innovation with organizations; (2) Standardized beta coefficients; (3) t statistics in parentheses; (4) + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

5. Conclusions

5.1. Theoretical Contribution

This study has three theoretical contributions to the field of open innovation and green innovation research. First, in examining green innovation, we are adding a theoretical depth of green innovation by dividing the target of collaboration into a competitive object and a non-competitive object. In previous research on green innovation, the subject of developing innovation was mainly the company alone, and the know-how gained from the process of obtaining innovation was also limited to the company alone. However, it can be done jointly with various companies and organizations and Wagner and Llerena [64] found that collaboration with a variety of external institutions is crucial in order for an enterprise to implement an environmentally conscious strategy at the micro level through nine case studies. Brunnermeier and Cohen [65] show that pollution costs by state regulation decisively increased the rationale for environmental innovations by US manufacturing firms. In order to reduce such cost increases, firms argue that the cost risk of the entire technology share should be lowered rather than trying to dominate the patents competitively in the industries in which they are involved. In other words, it is interpreted that the spill-over effect that occurs in the process of creating green innovation achievement by various economic entities, including corporations, can positively affect the business ecosystem [64–66]. It is essential to discuss how to develop green innovation together, not alone, because the way a company solely attempts to achieve green innovation increases the risk of cost and failure [5,6]. Therefore, this study considers that the creation of green innovation through collaboration with other organizations has a positive effect in terms of open innovation. Although open innovation defines anything that collaborates in any form as open innovation without reflecting the stake characteristics of each partner in the existing literature [25], this study highlighted that interests differ from one organization to another. Through open innovation, companies achieve positive results in collaboration with organizations, with fewer conflicts of interest and collaboration between different companies that may have greater conflicts of interest.

Second, this study examined the sustainable aspect that consumers can contribute to the environment beyond the focus on product process innovation in existing green innovation research. In order to analyze the actual performance of the company through green innovation, it is crucial to examine not only the product production process but also the process after the product has been consumed. However, little effort has been made to study both the enterprise and the consumer comprehensively [7,8]. Existing literature on green innovation focuses largely on product-based output, so it emphasizes the achievement of reducing pollutants in the process of product innovation. Ali, et al. [67] found that analyzing 73 small high-tech manufacturing companies and reducing the time it takes to develop new products is likely to bring about environmentally superior product innovation. Bartlett, Trifilova, Bartlett and Trifilova [4] found that green technology for green innovation in Russia's eco-product created pollution reduction through the new design process. Despite the existing literature, there is still a lack of empirical research on how green technology brings consumers benefits. For example, Kammerer [16] focuses more on the environmental contribution performance that consumers may experience when using environmentally improved products for kitchen appliances sold in Germany. Chen [7] argues that for a company to have green core competence, forming a green image so that consumers can have more green benefits will contribute to future reputation. To summarize, in order for a company to maintain its competitiveness and maintain sustainability, it is necessary to bring green benefits to consumers in some form, and the environment-contributing processes that occur in the process should occur naturally. Considering these two aspects, this study considers green innovation that the company can reduce in the process of the product as green innovation and the green benefit that the consumer can practically contribute to the environment. As discussed above, this study broadens the scope of the two research areas by establishing the contact points of different academic concepts such as open innovation and green innovation.

Finally, the research sample of this study is based on the results of the questionnaire obtained by conducting the innovation survey on all the Korean manufacturing companies authorized by government agencies. Many studies address the problem of the generalization of research results, which are pointed out as the limitations of the study.

5.2. Managerial Implications

Since South Korea still complies with the Tokyo Protocol Annex II, it is not necessary for companies to produce eco-innovation. Many advocates of the Tokyo Protocol Annex I have already introduced the green concept to their products and services for several years and Nordic countries in the EU have applied international standardization organization (ISO) to new numbers for export and import products. While green innovation may not be considered a new cost to the company right now, managers may face unforeseen risks if they respond to inertia in the routine without careful consideration of green environmental changes. In particular, South Korean companies subject to this study have been producing carbon dioxide for a long time because of insufficient government regulation, and if they cannot meet the environment standard through creating green innovation within a short period, there is uncertainty about the exports to developed countries belonging to Annex I in the future. The results of this study provide three practical implications for companies that need to develop green innovation, and especially for companies and policymakers in Annex II like South Korea.

First, managers considering environmental performance need to change the way they collaborate with other companies. Tajeddini [27] argues that manager awareness is vital to reduce the speed of technological innovation and reduce costs, which provides an initial roadmap for organizational strategy characteristics as well as innovation in small and medium-sized enterprises (SMEs) operating environment. Since managers are interested in how much their products are sold in the market, it is highly likely that they will dichotomously think that classifies other institutions involved in market share as competitors. However, as the results of this study show, companies can collaborate with competitors and other organizations. Companies have a variety of peripheral technologies that can be shared except core technologies and patents, which is also the case with competitors. Despite knowing each other's necessary information and skills, playing a zero-sum game due to the market game, logic can be a waste of time when green innovation is needed [68]. In particular, it is more important for Korean companies to produce new green technologies and processes through collaborations since domestic demand is small and products are to be exported overseas in the long term. Thus, managers will be able to increase the likelihood of green innovation as they learn indirectly from the experience of competitors and other organizations and out of the limited decision-making process they experience [56]. On the other hand, government policymakers will also be able to make a consortium by improving the systems for inter-company collaborations. In particular, it may provide a certain level of support to small- and medium-sized firms participating in the green innovation consortium and may exempt certain companies from the Ministry of Environment's goal management system [69]. A green innovation environment will be developed more quickly as a means of creating a sense of a goal for all participants in the collaboration.

Second, it is necessary for the manager to take into consideration the fact that the products produced by the company can make a real environmental contribution through its consumers. Most of the people living in developed countries have high environmental consciousness levels, so they consider environmental pollution of the constituent material of the product when purchasing products that cause pollution or the level of recycling [15]. These green user innovations are not entirely new concepts, but management often misses them because they focus on current product sales rather than future green environmental changes. From the management's perspective, it is difficult to set the appropriate standard because it is quite costly to administer fewer pollutants chemically in the production process or to create a purifier to reduce the discharge of pollutants [7,12]. However, as the results of this study show, it is no longer overlooked because consumers value the importance of simultaneously obtaining green environmental performance while using products. It is more important

for management to consider various consumer positions such as the degree to which products can be returned to other raw materials after purchasing our products, the possibility of recycling, the reduction of energy use, and the cost of disposal. Government planners are aware that these changes can contribute to sustainability, and it is important to reorganize existing environmental regulations and taxes. If new environmental regulations and taxes to be filed for fragrance are from a past green user innovation, it would be beneficial to give them some tax benefits. Alternatively, if there are cases in which voluntary codes are created to create environmental best practices in a specific industry, the government can recognize them and publicize them to sustainable change in the industry.

Finally, countries such as Korea, which are in Annex II, can establish government policies for green innovation based on the results of this study. Most Annex II countries are part of emerging economies, especially in the case of many Asian countries, where economic development is government-led and consists of a few large companies and the majority of small- and medium-sized enterprises. For example, in Korea and China, the ratio of large enterprises and SMEs is 0.1 to 99.9 [70]. Therefore, green innovation of SMEs should also be accompanied (and for that matter is also in urgent in most other countries). Although large companies with sufficient capacity can easily obtain open innovation targets, SMEs are difficult to simply obtain open innovation targets due to lack of resources and competence. Therefore, it is necessary for the government to consider policies for promoting open innovation of SMEs through various nonprofit organizations such as research institutes and universities. The government's efforts not only promote SMEs' green innovation, but they can also serve as a way to improve the sustainability of SMEs.

5.3. Limitation and Future Research

Although the study offers theoretical and practical contributions to green innovation, this study has several limitations. The performance of green innovation among firms or nonprofit organizations can be different because the importance of the company's green innovation, its capacity, and its relationship with external networks may be different. For example, a company with a high level of importance and competence for green innovation will show a high performance of green innovation among companies or non-profit organizations. The closer the relationship with the partner is, the higher the possibility of the transfer of knowledge and the higher the performance of green innovation. For future research, it is necessary to examine the effects of cooperation with external networks for green innovation on the performance of green innovation based on the understanding of the size of the company. For example, large corporations are required to have a higher level of green innovation than SMEs, and they are more likely to be criticized when they cause environmental problems [9]. It is possible that these pressures on green innovation will show different aspects depending on the size of the company. Also, the data in this study may be different from the long-term effects because it was cross-sectional. Therefore, it is also necessary to examine the long-term dynamics through long-term data.

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References

1. Hong, J.H.; Kim, J.; Son, W.; Shin, H.; Kim, N.; Lee, W.K.; Kim, J. Long-term energy strategy scenarios for South Korea: Transition to a sustainable energy system. *Energy Policy* **2019**, *127*, 425–437. [CrossRef]
2. Kown, S.I. The domestic regulations on recognition list of automobile eco-innovation technology. *Auto J.* **2018**, *40*, 18–24.

3. Science and Technology Policy Institute (STEPI). *Korea Innovation Survey: Manufacturing*; Science and Technology Policy Institute Report; STEPI: Sejong, Korea, 2014.
4. Bartlett, D.; Trifilova, A.; Bartlett, D.; Trifilova, A. Green technology and eco-innovation: Seven case-studies from a Russian manufacturing context. *J. Manuf. Technol. Manag.* **2010**, *21*, 910–929. [CrossRef]
5. Pavitt, K. Sectoral patterns of technical change: Towards a taxonomy and a theory. *Res. Policy* **1984**, *13*, 343–373. [CrossRef]
6. Revilla, A.J.; Fernández, Z. The relation between firm size and R&D productivity in different technological regimes. *Technovation* **2012**, *32*, 609–623.
7. Chen, Y.-S. The Driver of green innovation and green image—Green core competence. *J. Bus. Eth.* **2007**, *81*, 531–543. [CrossRef]
8. Cheng, C.C.J.J.; Yang, C.-L.; Sheu, C. The link between eco-innovation and business performance: A Taiwanese industry context. *J. Clean. Prod.* **2014**, *64*, 81–90. [CrossRef]
9. Guo, Y.; Wang, L.; Wang, M.; Zhang, X. The mediating role of environmental innovation on knowledge acquisition and corporate performance relationship—A study of SMEs in China. *Sustainability* **2019**, *11*, 2315. [CrossRef]
10. Chesbrough, H.; Crowther, A.K. Beyond high tech: Early adopters of open innovation in other industries. *R D Manag.* **2006**, *36*, 229–236. [CrossRef]
11. Chesbrough, H.; Vanhaverbeke, W.; West, J. *Open Innovation: Researching a New Paradigm*; OUP Oxford: Oxford, UK, 2006.
12. Chen, Y.-S.; Lai, S.-B.; Wen, C.-T. The Influence of green innovation performance on corporate advantage in Taiwan. *J. Bus. Eth.* **2006**, *67*, 331–339. [CrossRef]
13. Schiederig, T.; Tietze, F.; Herstatt, C. Green innovation in technology and innovation management—An exploratory literature review. *R D Manag.* **2012**, *42*, 180–192. [CrossRef]
14. Ma, Y.; Hou, G.; Yin, Q.; Xin, B.; Pan, Y. The sources of green management innovation: Does internal efficiency demand pull or external knowledge supply push? *J. Clean. Prod.* **2018**, *202*, 582–590. [CrossRef]
15. Jansson, J.; Marell, A.; Nordlund, A. Green consumer behavior: Determinants of curtailment and eco-innovation adoption. *J. Consum. Mark.* **2010**, *27*, 358–370. [CrossRef]
16. Kammerer, D. The effects of customer benefit and regulation on environmental product innovation. Empirical evidence from appliance manufacturers in Germany. *Ecol. Econ.* **2009**, *68*, 2285–2295. [CrossRef]
17. Eco Innovation Observatory (EIO). *Europe in Transition: Paving the Way to a Green Economy Through Eco-Innovation*; European Commission: Paris, France, 2012.
18. Grant, R.M. Toward a knowledge-based theory of the firm. *Strateg. Manag. J.* **1996**, *17*, 109–122. [CrossRef]
19. Kogut, B.; Zander, U. Knowledge of the firm, combinative capabilities, and the replication of technology. *Organ. Sci.* **1992**, *3*, 383–397. [CrossRef]
20. Stuart, T.E. Interorganizational alliances and the performance of firms: A study of growth and innovation rates in a high-technology industry. *Strateg. Manag. J.* **2000**, *21*, 791–811. [CrossRef]
21. Teece, D.J. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Res. Policy* **1986**, *15*, 285–305. [CrossRef]
22. Chesbrough, H. *Open Innovation: The New Imperative for Creating and Profiting from Technology*; Harvard Business Press: Harvard, MA, USA, 2003.
23. Klewitz, J.; Hansen, E.G. Sustainability-oriented innovation of SMEs: A systematic review. *J. Clean. Prod.* **2014**, *65*, 57–75. [CrossRef]
24. Cohen, W.M.; Levinthal, D.A. Absorptive capacity: A new perspective on learning and innovation. *Adm. Sci. Q.* **1990**, *35*, 128–152. [CrossRef]
25. Laursen, K.; Salter, A. Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms. *Strateg. Manag. J.* **2006**, *27*, 131–150. [CrossRef]
26. Van Den Bosch, F.A.; Volberda, H.W.; De Boer, M. Coevolution of firm absorptive capacity and knowledge environment: Organizational forms and combinative capabilities. *Organ. Sci.* **1999**, *10*, 551–568. [CrossRef]
27. Tajeddini, K. Financial orientation, product innovation and firm performance—An empirical study in the Japanese SMEs. *Int. J. Innov. Technol. Manag.* **2016**, *13*, 1640005. [CrossRef]
28. Ahuja, G. Collaboration networks, structural holes, and innovation: A longitudinal study. *Adm. Sci. Q.* **2000**, *45*, 425–455. [CrossRef]

29. Katila, R.; Ahuja, G. Something old, something new: A longitudinal study of search behavior and new product introduction. *Acad. Manag. J.* **2002**, *45*, 1183–1194.
30. Porter, M.; van der Linde, C. Toward a new conception of the environment-competitiveness relationship. *J. Econ. Perspec.* **1995**, *9*, 97–118. [CrossRef]
31. Hart, S.L. Beyond greening: Strategies for a sustainable world. *Harv. Bus. Rev.* **1997**, *75*, 66–77.
32. Arundel, A.; Kemp, R. *Measuring Eco-Innovation*; UNU-MERIT: Maastricht, The Netherlands, 2009.
33. Fussler, C.; James, P. *A Breakthrough Discipline for Innovation and Sustainability*; Pitman Publishing: London, UK, 1996.
34. Klemmer, P.; Lehr, U.; Löbbe, K. *Environmental Innovation: Incentives and Barriers*; Analytica: Berlin, Germany, 1999.
35. Yildiz Çankaya, S.; Sezen, B. Effects of green supply chain management practices on sustainability performance. *J. Manuf. Technol. Manag.* **2019**, *30*, 98–121. [CrossRef]
36. Berry, M.A.; Rondinelli, D.A. Proactive corporate environmental management: A new industrial revolution. *Acad. Manag. Perspect.* **1998**, *12*, 38–50. [CrossRef]
37. Kassinis, G.; Vafeas, N. Stakeholder pressures and environmental performance. *Acad. Manag. J.* **2006**, *49*, 145–159. [CrossRef]
38. Hojnik, J.; Ruzzier, M. What drives eco-innovation? A review of an emerging literature. *Environ. Innov. Soc. Trans.* **2016**, *19*, 31–41. [CrossRef]
39. Kim, B.; Kim, E.; Foss, N.J. Balancing absorptive capacity and inbound open innovation for sustained innovative performance: An attention-based view. *Eur. Manag. J.* **2016**, *34*, 80–90. [CrossRef]
40. Karakaya, E.; Hidalgo, A.; Nuur, C. Diffusion of eco-innovations: A review. *Renew. Sustain. Energy Rev.* **2014**, *33*, 392–399. [CrossRef]
41. Tushman, M.L.; Anderson, P. Technological discontinuities and organizational environments. *Adm. Sci. Q.* **1986**, *31*, 439–465. [CrossRef]
42. Tajeddini, K.; Ratten, V. The moderating effect of brand orientation on inter-firm market orientation and performance. *J. Strateg. Mark.* **2017**, 1–31. [CrossRef]
43. Lazzarotti, V.; Manzini, R. Different modes of open innovation: A theoretical framework and an empirical study. *Int. J. Innov. Manag.* **2009**, *13*, 615–636. [CrossRef]
44. Huang, K.-F.; Yu, C.-M.J. The effect of competitive and non-competitive R&D collaboration on firm innovation. *J. Technol. Transf.* **2011**, *36*, 383–403.
45. Wang, Q.; von Tunzelmann, N. Complexity and the functions of the firm: Breadth and depth. *Res. Policy* **2000**, *29*, 805–818. [CrossRef]
46. Lim, M.S.; Kim, J.H.; Byeon, H.S. A study on characteristics of eco-friendly behaviors using big data: Focusing on the customer sales data of green card. *J. Digit. Converg.* **2016**, *14*, 151–161. [CrossRef]
47. OECD. *Eurostat, Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, 3rd ed.; OECD: Paris, France, 2005.
48. Henriques, I.; Sadorsky, P. The determinants of an environmentally responsive firm: An empirical approach. *J. Environ. Econ. Manag.* **1996**, *30*, 381–395. [CrossRef]
49. Stern, P.C. New environmental theories: Toward a coherent theory of environmentally significant behavior. *J. Soc. Issues* **2000**, *56*, 407–424. [CrossRef]
50. Tanner, C. Constraints on environmental behaviour. *J. Environ. Psychol.* **1999**, *19*, 145–157. [CrossRef]
51. Jansson, J.; Marell, A.; Nordlund, A. Exploring consumer adoption of a high involvement eco-innovation using value-belief-norm theory. *J. Consum. Behav.* **2011**, *10*, 51–60. [CrossRef]
52. Guagnano, G.A.; Stern, P.C.; Dietz, T. Influences on attitude-behavior relationships: A natural experiment with curbside recycling. *Environ. Behav.* **1995**, *27*, 699–718. [CrossRef]
53. Thøgersen, J. Spillover processes in the development of a sustainable consumption pattern. *J. Econ. Psychol.* **1999**, *20*, 53–81. [CrossRef]
54. Neyman, J. On the two different aspects of the representative method: The method of stratified sampling and the method of purposive selection. *J. R. Stat. Soc.* **1934**, *97*, 558–625. [CrossRef]
55. Ekins, P. Eco-innovation for environmental sustainability: Concepts, progress and policies. *Int. Econ. Econ. Policy* **2010**, *7*, 267–290. [CrossRef]
56. Ma, Y.; Hou, G.; Xin, B. Green process innovation and innovation benefit: The mediating effect of firm image. *Sustainability* **2017**, *9*, 1778.

57. Dangelico, R.M.; Pujari, D. Mainstreaming green product innovation: Why and how companies integrate environmental sustainability. *J. Bus. Eth.* **2010**, *95*, 471–486. [CrossRef]
58. West, J.; Vanhaverbeke, W.; Chesbrough, H. Open innovation: A research agenda. In *Open Innovation: Researching a NEW Paradigm*; West, J., Chesbrough, H., Vanhaverbeke, W., Eds.; Oxford University Press: Oxford, UK, 2005; pp. 285–307.
59. Dahlander, L.; Gann, D.M. How open is innovation? *Res. Policy* **2010**, *39*, 699–709. [CrossRef]
60. Laursen, K.; Salter, A. Searching high and low: What types of firms use universities as a source of innovation? *Res. Policy* **2004**, *33*, 1201–1215. [CrossRef]
61. Hung, K.-P.; Chou, C. The impact of open innovation on firm performance: The moderating effects of internal R&D and environmental turbulence. *Technovation* **2013**, *33*, 368–380.
62. Hancock, G.R.; Mueller, R.O. *Structural Equation Modeling: A Second Course*; Information Age Publishing: Charlotte, NC, USA, 2006.
63. Hair, J.; Black, W.; Babin, B.; Anderson, R.; Tatham, R. *Multivariate Data Analysis*; Prentice Hall: Upper Saddle River, NJ, USA, 1998.
64. Wagner, M.; Llerena, P. Eco-innovation through integration, regulation and cooperation: Comparative insights from case studies in three manufacturing sectors. *Ind. Innov.* **2011**, *18*, 747–764. [CrossRef]
65. Brunnermeier, S.B.; Cohen, M.A. Determinants of environmental innovation in US manufacturing industries. *J. Environ. Econ. Manag.* **2003**, *45*, 278–293. [CrossRef]
66. Wagner, M. Empirical influence of environmental management on innovation: Evidence from Europe. *Ecol. Econ.* **2008**, *66*, 392–402. [CrossRef]
67. Ali, A.; Krapfel, R., Jr.; LaBahn, D. Product innovativeness and entry strategy: Impact on cycle time and break-even time. *J. Prod. Innov. Manag.* **1995**, *12*, 54–69. [CrossRef]
68. Epicoco, M.; Oltra, V.; Saint Jean, M. Knowledge dynamics and sources of eco-innovation: Mapping the green chemistry community. *Technol. Forecast. Soc. Change* **2014**, *81*, 388–402. [CrossRef]
69. Roh, T.; Koo, J.-C.; Cho, D.-S.; Youn, Y.-C. Contingent feasibility for forest carbon credit: Evidence from South Korean firms. *J. Environ. Manag.* **2014**, *144*, 297–303. [CrossRef] [PubMed]
70. UNCTAD. *World Investment Report*; United Nations: Geneva, Switzerland, 2018.