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Implementing Environmental Practices for Accomplishing Sustainable Green Supply Chain Management

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Abstract: With the emergence of environmental protection as a global issue, implementing environmental practices for sustaining green supply chain management (GSCM) has received a lot of attention. This study investigates the impact of integration with suppliers and supply disruption risk on environmental practices. It also examines the role of supplier integration and supply disruption risk on performance. Finally, it investigates the relationship between environmental practices and performance in order to sustain green supply chains. Based on 272 survey responses from supply and purchase managers, our research results support the positive impact of integration with suppliers and the negative impact of supply disruption risk on the adoption of environmental practices. Furthermore, they provide empirical evidence that environmental practices and integration with suppliers are positively associated with performance, while supply disruption risk is negatively associated with performance. This study identifies antecedents and establishes a research framework of GSCM. More importantly, it provides meaningful insights to managers regarding the implementation of environmental practices related to other supply chain practices for sustaining green supply chains.

Keywords: environmental practices; integration with suppliers; supply disruption risk; performance; green supply chain management (GSCM)

1. Introduction

In recent times, sustaining green supply chain management (GSCM), defined as a maintenance system for helping the supply chain to manage a flow of materials in protecting environments, has emerged as a very significant issue in manufacturing industries. Moreover, over the past few decades, environmental issues have created social, economic, and political pressure on organizations to implement green practices in manufacturing activities. The average temperature of the earth has been rising and greenhouse effects have led to an increase in the occurrence of natural disasters. Consequently, the importance of green practices has received a lot of attention from both academic researchers and operations management personnel. Further, stakeholders have influenced firms to adopt environmental practices that control their impact on the natural environment [1]. While firms in the supply chain have made collective efforts in response to pressures from stakeholders regarding environmental issues, they must deal with intense market competition, changes in the business environment, and supply disruptions (as a worst case scenario). Thus, supply chain managers must find solutions that address both environment protection and performance improvement; this can be achieved by implementing GSCM (that is defined as the integration of environmental concerns with supply chain management (SCM) practices [2]). Thus, this study investigates the impact of adopting

environmental practices, along with supplier integration, on supply disruption risk in order to improve performance in the supply chain.

From the SCM perspective, organizations are affected by internal and external factors in adopting environmental practices, defined as management practices (for applying the eco-design of firms, reducing material usages, and maintaining environmental systems). The adoption of environmental practices is closely linked to organizations in the supply chain and their business environments. Although numerous studies have emphasized the importance of dealing with the external supply chain environment [3], the internal context of organizations must not be neglected in SCM. This study assigns supply disruption risk as an external environment, integration with suppliers as an internal context of organizations, and firm performance as an output of environmental practices. This study also investigates the impact of environmental practices on performance.

The main objective of this study is to establish a research framework for green practices, based on internal and external factors of green supply chain management. First, this study investigates the impact of supply disruption risk and supplier integration on environmental practices. It attempts to address a gap in the supply chain management literature by providing evidence regarding the impact of supply disruption risk and supplier integration on the adoption of environmental practices. Second, this study examines how green practices affect performance. Finally, this study also provides meaningful insight to managers regarding decisions on the adoption of environmental practices for improving performance.

2. Literature Review

For the literature review, we began to use keywords to search important papers, such as environmental practices, supply chain integration, and supply disruption risk. Then, we attempt to establish linkages among these terms, like environmental practices and green supply chain management, and supply chain integration and integration with suppliers. Searching in ABI Proquest, we also found associations among environmental practices, integration with suppliers, supply disruption risk, and performance. After we found as a key paper, we expanded our literature review from integration with suppliers, supply disruption risk, and performance by identifying key antecedents from prior studies. Thus, we could investigate associations among those constructs.

2.1. Supply Disruprion Risk

Supply disruption is defined as unknown events that hinder the flow of materials in the supply chain [4], thereby leading to various negative effects on the supply chain. This study incorporates supply disruption into supply and purchase managers' perceived loss due to disruption [5]. However, this study follows the research of [6] as regards the definition of supply disruption risk that directly incorporates the probability and magnitude of loss. Thus, this study establishes two dimensions of supply disruption risk: the probability or perceived likelihood of a supply disruption, and the magnitude or perceived severity of losses from a supply disruption [6].

The supply disruption risk is amplified by various factors such as supplier attributes, supply chain strategy and structure, and business environment [7]. The impact of supply disruption has been empirically validated in the previous literature. The public announcement of supply disruption in the stock market leads to negative abnormal stock price returns [8]. Supply disruption risk plays a significant role in increasing the price-sensitivity of demand and market scale, in terms of single or dual sourcing decisions [9]. Prior studies presented various strategies to reduce supply disruption risk, and [10] proposed both the reduction of the frequency and severity of risks, and increasing capacities in the supply chain, as strategies for mitigating supply disruption risk. Tomlin also indicated the importance of volume flexibility and capacity on reducing supply disruption risk [11]. Risk sharing contracts and information sharing within the supply chain are also considered effective strategies for minimizing supply disruption risk [12]. Activities such as supply risk identification, supply risk assessment, and continuous improvement processes also help to mitigate supply disruption risk [13].

While previous studies present various strategies in mitigating supply disruption risk, this study investigates the impact of managers' perceived supply disruption risk on environmental practices, as well as performance, in order to sustain green supply chains.

2.2. Integration with Suppliers

Integration with suppliers has been defined as a mechanism for supporting collaborative intra-business processes with suppliers for managing the strategic, tactical, and operational levels of business [14]. The previous literature emphasized the importance and benefits of integration with suppliers to SCM performance. Although integration with suppliers deal with barriers such as organizational culture, information systems compatibility, lack of a will of top management and information sharing and organizational structure, it generates various benefits in the supply chain. According to [15], integration with suppliers improves the agility of the firm's supply chain. Childerhouse and Towill also provided empirical evidence that as the arc of integration with suppliers becomes wider, performance improves [16]. Supplier integration also has a moderating effect on the relationship between customer integration and efficiency [17]. The study of [18] showed that supplier integration positively affects delivery performance and mediates the relationship between process modularity and delivery performance. The research of [19] suggests that while integration with suppliers does not have a direct influence on operational and business performance, interactions between suppliers and customer integration do impact operational performance. Integration with suppliers also has a positive impact on establishing linkages in the supply chain, leading to improvement in performance [20]. Kim also investigated the indirect impact of integration with suppliers through SCM practices and competitive capability on firms' performance [21]. Supplier integration is positively related to on-time delivery, quality, production costs, and production flexibility [22].

Integration with suppliers has been examined in various contexts. If the supply chain complexity increases, the positive impact of integration with suppliers on performance becomes greater [23]. Implementation of information technology affects integration with suppliers and mediates the relationship between IT implementation and supply chain performance [24]. Supplier integration was also examined in the context of lean production [25]. As discussed above, the previous literature attempted to investigate the impact of integration with suppliers on performance and other areas. This study examines the role of integration with suppliers in improving financial, operational, and supply chain performance and, more importantly, in sustaining GSCM by investigating the relationship with environmental practices.

3. Research Model and Hypothesis

Environmental practices fall into different categories, depending upon the proactive approach used to persuade employees and management of the need for and significance of environmental practices. Managers who face environmental demands are engaged more in proactive environmental practices [26]. GSCM has three dimensions: the importance of GSCM, green design, and green operations [27]. Moe importantly, GSCM is defined as the management of internal environments, external environmental practices, eco-design, and investment recovery [28]. Based on the definitions by [29], environmental practices are defined as management practices for applying the eco-design of firms, reducing material usages and maintaining environmental systems [29] and the dimensions of environmental practices, including designs for the environment, material reduction practices, and process management from the managerial perspective. Therefore, by matching the three dimensions of GSCM to environmental practices, this study uses three dimensions of proactive environmental practices, including designs for the environment (green design), material reduction practices (green operations), and process management, from the managerial perspective (the importance of GSCM). GSCM contains environmental practices, since it covers the whole supply chain; environmental practices, however, focus on the internal practices of a

manufacturing company. The main purpose of eco-designs is to manufacture products, as well as create processes that minimize their impact on the environment. Eco-designs encourage various activities relating to assembling, disassembling joints, and component design, thereby generating significant advantages [29]. More importantly, eco-designs lead to many positive outputs. First, designs for the environment contribute to product innovation, since designers and engineers are always conscious about environmental protection and environmental issues [30]. Second, such designs can create new markets that demand eco-friendly products and are conscious about environment protection [31].

Material reduction practices are associated with improving the quality of the products in order to protect the environment in a way that the operational process does not emit waste [29]. Like total quality management (TQM), source reduction activities include mistake-proofing, substitution identification, and simple housekeeping [28]. Since material reduction practices attempt to reduce waste by improving quality, they can contribute to operational cost reductions. Through material reduction practices, managers can reduce production inputs, energy consumption, the amount of waste and defective products, the number of components, logistics costs, disposal costs, legal expenses, and the mitigation of risks by adhering to regulations [32]. Process management, from the managerial perspective, involves the implementation of an environmental management system (EMS), defined as a formal system that not only integrates recycling procedures and prevention programs, but also monitors, summarizes, and reports environmental performance [29]. Environmental management systems also involve obtaining the ISO 14000 certification and encourage the adoption of other environmental practices, such as waste reduction in manufacturing operations, analysis of the product life cycle, and the establishment of environmental performance measurements [33]. Therefore, this study investigates the role of environmental practices in GSCM by examining these three dimensions: eco-design, source reduction, and EMS.

Environmental practices have been receiving a lot of attention in the operations management literature, since they can create sustainability, as well as significantly impact the supply chain and the firm itself. Through various efforts, and by keeping regulations in protecting environments, companies attempt to establish green supply chains with lower costs and better customer service. Thus, the role of supply and purchase managers is emphasized, since they need to integrate suppliers with environmental practices [34]. In order to establish sustainable GSCM, suppliers must also contribute to and participate in implementing environmental practices. The research of [35] indicates the importance of information, relationships, and linkages in the supply chain for establishing GSCM. Holt and Ghobadian also indicate the importance of suppliers' involvement in GSCM [36]. Strategic relationships with suppliers also entail the development and diffusion of environmental practices [37]. Cooperation and collaboration with suppliers minimizes the negative impact on the environment and results in eco-friendly designs and investments in recycling. More importantly, an internal and external environmental orientation promotes environmental practices in adopting GSCM [26]. Suppliers with a high level of cross-functional communications in the supply chain are more willing to participate in green supply chain initiatives [38]. Integrating with suppliers will encourage information sharing, collaboration, cooperation, and communication within the supply chain [22]. As logistical and technological integration pertaining to environmental issues becomes more extensive, collaborative environmental practices will be facilitated in GSCM [39]. Therefore, integration with suppliers plays a key role in implementing environmental practices aimed at establishing GSCM. More importantly, integration with suppliers helps buyers to be involved in participating environmental practices based on collaboration, leading to positive outcomes in the context of GSCM.

In contrast, supply disruption risk has been identified as a negative influence on the supply chain. Thus, the previous literature presented various risk-mitigating strategies in the supply chain. In this study, we considered managers' perceived supply disruption risk as a barrier to implementing environmental practices in the supply chain with an external environmental perspective. Perceived supply disruption risk has been summarized as significant antecedents that negatively impact SCM decisions regarding business, supply strategies, and purchases. Technological uncertainty can also

boost the magnitude and probability of supply disruption risk [6]. Supply disruption risk results in an inability to respond to customer demands, and creates threats to the safety and lives of customers [40]. More importantly, perceived supply disruption risk forces managers to consider item, market, and supplier characteristics, thereby increasing the complexity of SCM decisions [41]. Therefore, perceived supply disruption risk minimizes managers' willingness to implement environmental practices and establish GSCM. The existence of risk usually makes managers think one more time in the decision making process. All these factors influence managers to prevent them from forming positive attitudes, as well as decisions, toward environmental practices. Thus, we propose two contrasting hypotheses:

Hypothesis 1 (H1): *Perceived supply disruption risk has a negative relationship with implementing eco-design, source reduction, and EMS of environmental practices in the supply chain*.

Hypothesis 2 (H2): *Integration with suppliers has a positive relationship with implementing eco-design, source reduction, and EMS of environmental practices in the supply chain*.

The previous literature investigated the relationship between environmental practices and firm performance in order to determine whether environmental practices can improve the firm's performance [42,43]. Based on the previous studies, this study also examines the positive and direct associations between environmental practices and green supply chain performance. However, this study attempts to fill a gap in the literature by not only establishing environmental practices that address the three aspects of eco-design for the product, material reduction, and EMS, but also attempts to measure the performance on three dimensions (financial, operational, and supply chain performance). According to the study of [32], announcements on corporate environmental initiatives, and environmental awards and certifications, elicit positive reactions from the stock market, thereby increasing the market value of the firm. The research of [44] empirically confirmed that implementing EMSs improved both corporate (as well as environmental) performance. The study of [30] demonstrated that environmental practices including recycling, proactive waste reduction, remanufacturing, environmental design, specific design targets, and market surveillance (regarding environmental issues) positively influence firms' performances. The research of [26] found that an internal and external environmental orientation has a direct and positive impact on green purchases and customer cooperation, thereby positively affecting corporate performance.

As per [45], GSCM practices are categorized into five dimensions: internal environmental management, green purchasing, cooperation with customers in terms of environmental requirements, eco-design, and investment recovery.) Green inbound is positively associated with green outbound, as well as the economic performance of the supply chain [46]. They also found that green production has a positive impact on green outbound that indirectly but positively affects economic performance through improved competitiveness. GSCM practices, including internal environmental management and external GSCM practices, are positively associated with a firm's economic performance [28]. GSCM practices in the Chinese manufacturing industries, including internal environmental management, green purchasing, eco-design, cooperation with customers, and investment recovery, positively affect the organization's environmental performance, as well as leading to both positive and negative economic performance in the GSCM [47]. This study also investigates the direct relationship between environmental practices and the green supply chain performance. Unlike prior studies, this study examined the positive relationship between three dimensions of environmental practices and the comprehensive aspects of firm performance. Therefore, we propose that:

Hypothesis 3 (H3): *Implementing eco-design, source reduction, and EMS of environmental practices in the supply chain positively affects firms' financial, operational, and supply chain performances*.

The direct relationship between supply disruption risk and performance has not been investigated in the supply chain and operations management literatures. Empirically determining the relationship between supply and purchase mangers' perceived supply disruption risk and financial, operational, and supply chain performance continues to be an area that warrants further research. Hendricks and Singhal [48,49] found that glitches and delays in the introduction of new products in the supply chain lead to loss of stock market value after bad news announcements. However, there are very few empirical studies that examine the direct relationship between supply disruption risk and performance.

After Hendricks and Singhal [48,49] provided evidence that supply disruptions can lead to the loss of firms' market values, many studies demonstrated that successful risk mitigation strategies can overcome supply disruption risk by reducing insurance costs, as in Ericson's case [50]. Ritchie and Brindley established a conceptual framework regarding the causal relationship between supply disruption risk sources and performance [51]. They proposed a linkage between these two factors using case study approaches. More importantly, poor logistics, poor supplier market performance and quality, and defaults by suppliers will negatively impact supply chain performance [52]. Based on the above discussions, this study empirically investigates whether supply disruption risk is negatively associated with the firm performance. Even perceived supply disruption risk by managers affects the negative total dimensions of firm performance. Thus, we propose that:

Hypothesis 4 (H4): *Perceived supply disruption risk negatively affects firms' financial, operational, and supply chain performance*.

Integration with suppliers is often studied in the supply chain and operations management literature as one of the dimensions of supply chain integration. Integration with suppliers holds a very significant purpose of establishing strategic cooperation and collaboration between manufacturers and suppliers in the supply chain, in order to perform various production activities [53,54]. With collaboration, as well as information sharing, integration with suppliers positively impacts performance. The research of [55] highlights the following benefits of integration with suppliers: increased coordination, cost reduction, better communication with suppliers, and reduction in uncertainty. Previous research provides evidence that a positive relationship exists between supply chain integration and performance [56], between supply chain integration and supply chain performance [24], and between the drivers of supply chain integration and firm performance [57]. The study of [18] empirically found that supplier integration positively affects delivery and performance in the supply chain. More importantly, supplier integration positively affects delivery performance, production cost, production quality, and production flexibility [22]. Although prior studies confirmed a positive association between integration with suppliers and firm performance, it examines the impact of supplier integration on comprehensive aspects of firm performance. Therefore, this study proposes that:

Hypothesis 5 (H5): *Integration with suppliers in the supply chain positively affects firms' financial, operational, and supply chain performance*.

Figure 1 describes our research model.

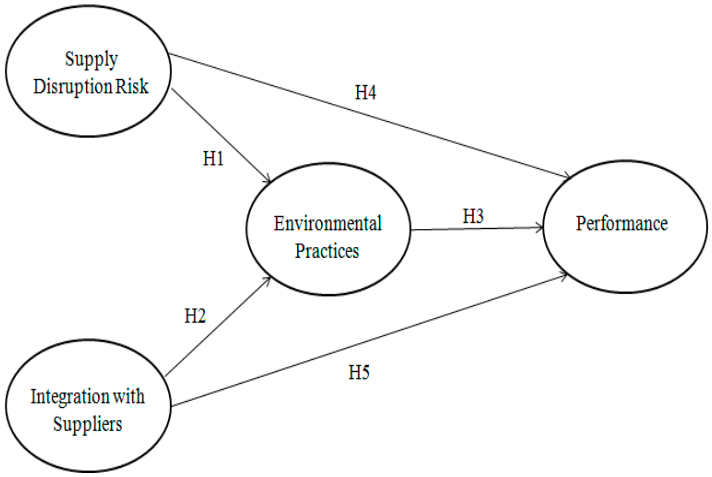

Figure 1. Research Model.

4. Methods

4.1. Instrument Development

To examine our research model, we developed survey questionnaires. All measurement items are developed from the previous literature and modified in the SCM context. Supply disruption risk measures the probability and magnitude of managers' perceived disruption risk in the supply chain. Integration with suppliers measures collaboration with suppliers, such as communication frequency and information sharing. Environmental practice measures manufacturing practices aimed at preserving the natural environment, such as material reduction, eco-design, and environmental management systems. Performance measures financial, operational, and supply chain performance compared with competitors in the same industry. Table 1 describes all the measurement items used in this study. After developing the survey items, we conducted interviews with supply and purchase managers from manufacturing firms to elicit feedback regarding these items. To ensure the content validity of this study, we conducted a pilot study using a modified survey covering 30 supply and purchase managers in the manufacturing industry. Although no measurement items were dropped for lack of reliability, we finalized the survey after taking into consideration all comments and feedback from the respondents. The questions were asked to indicate a scale from strongly disagree to strongly agree. A seven-point Likert scale was utilized and confirmatory factor analysis was performed using the partial least squares (PLS) technique. Table 2 presents all the factor loadings in the measurement items.

Table 1. Measurement items with reliability.

Factor	Measurement Items	Cronbach's Alpha	Average Variance Extracted (AVE)	Composite Reliability (CR)
Supply Disruption Risk [6]	It is highly likely that we will experience an interruption in the delivery of supplies from our suppliers.	0.844	0.719	0.876
	There is a high probability that our suppliers will fail to provide supplies.			
	We worry that suppliers may not provide supplies as per the specifications in the purchase agreement.			
	An interruption in supplies from our suppliers would have severe negative financial consequences for our business.			

Table 1. *Cont.*

Factor	Measurement Items	Cronbach's Alpha	Average Variance Extracted (AVE)	Composite Reliability (CR)
	Suppliers' inability to provide supplies would jeopardize our business performance and information system sophistication.			
	We would incur significant costs and/or losses in revenue if our suppliers failed to provide supplies and legal liabilities.			
Integration with Suppliers [15]	Our inventory levels are shared with our suppliers.	0.855	0.834	0.888
	Our key suppliers deliver to our plant on a JIT basis.			
	We have a high level of corporate communication regarding important issues with key suppliers.			
	Information sharing via the Internet is important for our supply chain.			
	We work with our suppliers to seamlessly integrate our inter-firm processes.			
	Our supply chain employs rapid response initiatives.			
	We jointly develop new products/services with our suppliers.			
Environmental Practice [29]	Reduction in the variety of materials employed in manufacturing the company's products.	0.902	0.891	0.925
	Reduction in raw materials (the use of recycled material) to manufacture products.			
	Avoidance of materials that are considered harmful, but not illegal.			
	Use of LCA for product design.			
	Use of easy-to-break joins between components to facilitate disassembly.			
	Clear identification of materials (colors, codes, etc.) to facilitate disassembly.			
	Use of standardized components to facilitate their reuse.			
	Recycling of solid wastes.			
	Environmental management procedures for internal use.			
	Use of advanced prevention and safety systems at work.			
Performance [58–60]	Average return on assets.	0.878	0.796	0.864
	Average profit.			
	Percent defects during production.			
	Delivery reliability.			
	Ability to respond to and accommodate periods of poor supplier performance.			
	Total cost of distribution, including transportation and handling costs.			

Table 2. All factor loadings with factor analysis.

Factors	SDR	IS	EP	PER
SDRa	0.779	0.147	0.215	0.191
SDRb	0.769	0.214	0.046	0.156
SDRc	0.804	0.325	0.135	0.144
SDRd	0.870	0.286	0.152	0.110
SDRe	0.864	0.225	0.157	0.206
SDRf	0.745	0.118	0.001	0.299
ISa	0.250	0.852	0.217	0.198
ISb	0.213	0.897	0.331	0.142
ISc	0.339	0.893	0.234	0.183
ISd	0.321	0.883	0.459	0.083
ISe	0.370	0.876	0.204	0.104
ISf	0.309	0.907	0.293	0.180
ISg	0.280	0.808	0.357	0.234
EPa	0.234	0.259	0.829	0.306
EPb	0.381	0.334	0.877	0.335
EPc	0.412	0.386	0.847	0.295
EPd	0.411	0.343	0.928	0.325
EPe	0.295	0.250	0.886	0.264
EPf	0.277	0.264	0.861	0.393
EPg	0.270	0.249	0.857	0.252
EPh	0.204	0.339	0.779	0.250
EPi	0.301	0.102	0.910	0.112
Epj	0.178	0.057	0.845	0.211
PERa	0.356	0.326	0.198	0.862
PERb	0.274	0.335	0.223	0.802
PERc	0.045	0.006	0.106	0.921
PERd	0.089	0.053	0.221	0.812
PERe	0.163	0.422	0.043	0.854
PERf	0.365	0.259	0.172	0.773

4.2. Study Sample

The respondents to the survey included supply and purchase managers in manufacturing firms located in Korea. The main products for those firms are manufactured from various sections of the manufacturing industry. Firm sizes were classified by number of employees. Major firms have between 1000 and 5000 employees; surveys were randomly distributed and 272 responses were collected, implying a response rate of 24.73%. Given that we surveyed a single respondent for a single company, a common method bias test had to be conducted using Harman's single factor test. Based on two studies [61,62], we examined all the eigenvalues using an un-rotated factor analysis. The results provided evidence that a single factor and the first factor did not represent greater than 20% of the variance in the data, leading to the conclusion that the common method bias does not exist in this data.

5. Results

5.1. Measurement Model

This research used the partial least squares technique of the structural equation method. It has two advantages of establishing measurement and structural models together and having no strict assumption on the population's distribution, as well as sample size [63–65]. Using PLS, we conducted a confirmatory factor analysis to make sure that all measurement items were grouped into the same construct, and presented the results in Table 2. We also established our measurement model with PLS. For assessing the reliability of our constructs, we examined Cronbach's α and factor loadings. All factor loadings for all constructs are greater than 0.7, as shown in Table 2 [66]. Cronbach's α for all measurement items is also greater than 0.7, as shown in Table 1. Therefore, all measurements in

this study presented strong reliability. To investigate convergent validity, we checked the composite reliability (CR) and average variance extracted (AVE). In order to confirm internal consistency, the CR numbers must greater than 0.7 [67] and AVEs must be greater than 0.5 [68]. All values for CR and AVE indicate strong convergent validity, as presented in Table 1. Finally, based on [66], in order to confirm the discriminant validity of our measurement model (representing no correlations exist among constructs), we calculated the square root of AVEs and then compared those values with the correlations of each variable. Table 3 shows that the values of the diagonal elements and the square root of AVEs are greater than those of the non-diagonal elements and the correlation values of all variables [66,67].

Table 3. Correlation Matrix: Discriminant Validity.

Variables	SDR	IS	EP	PER
SDR	**0.848**			
IS	0.214	**0.913**		
EP	0.397	0.416	**0.944**	
PER	0.242	0.404	0.401	**0.892**

SDR: Supply disruption risk; IS: Integration with suppliers; EP: Environmental practices; PER: Firm's performance.
* The numbers in bold are the square root of AVE.

5.2. Structural Model

We used the PLS technique to establish the structural model using a bootstrapping procedure. Our research results support Hypothesis 1: supply disruption risk has a negative relationship with environmental practice. The result provided empirical evidence of a statistically significant relationship between supply disruption risk and environmental practices, with a path coefficient of −0.323 and a t-score of 4.37 at 0.01 level of significance. Supply disruption risk negatively affects environmental practices. Perceived supply disruption risk prevents managers from implementing environmental practices. Our results also supported Hypothesis 2: integration with suppliers has a positive relationship with environmental practices. We found a statistically significant positive relationship between integration with suppliers and environmental practices, with a path coefficient of 0.348 and a t-score of 4.00 at a 0.01 level of significance. Integration with suppliers is positively associated with the implementation of environmental practices. Collaboration with suppliers helps to facilitate buyers' environmental practices.

Our empirical results confirmed Hypothesis 3: environmental practices positively affect performance, with a path coefficient of 0.401 and a t-score of 4.76 at a 0.01 level of significance. There is a statistically significant positive relationship between environmental practices and performance. Environmental practices improve firms' financial, operational, and supply chain performance. Our data analysis supports Hypothesis 4: supply disruption risk negatively affects performance, with a path coefficient of −0.130 and a t-score of 2.99 at a 0.01 level of significance. As supply managers' perceived risk increases, firm performance declines. As managers perceived more supply disruption risk, they that that firm performance would go down. Our results support Hypothesis 5: integration with suppliers positively affects performance, with a path coefficient of 0.157 and a t-score of 2.71 at a 0.01 level of significance. As per our empirical results, integration with suppliers can improve the firm's performance. Consistent with previous studies, supplier integration improves firms' financial, operational, and supply chain performance. Figure 2 describes our research results.

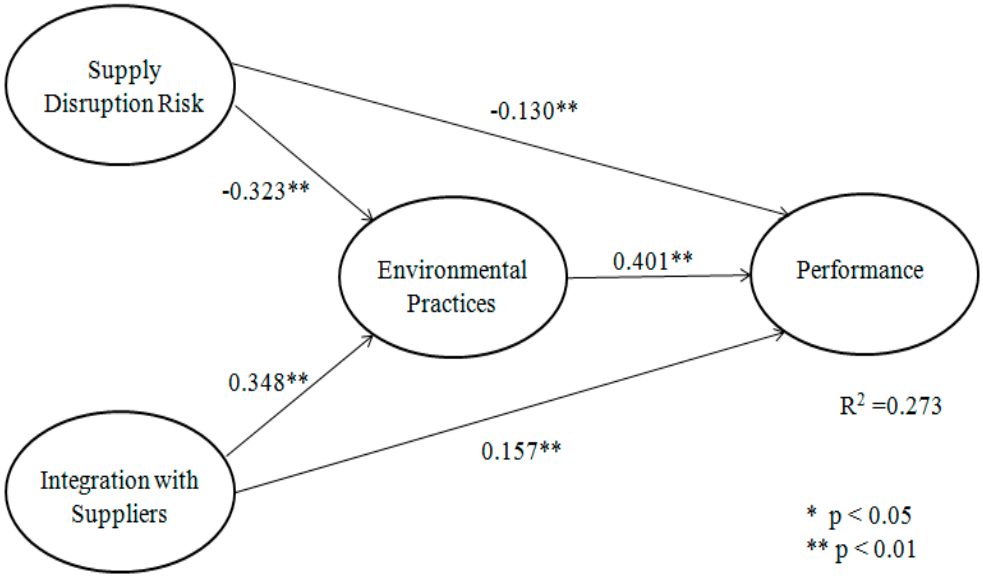

Figure 2. Research Results.

6. Discussion and Conclusions

This study investigates the impact of implementing environmental practices in managing green supply chains. It examines the role of supply disruption risk in terms of the external environment, integration with suppliers (as organizational and supply chain characteristics), and environmental practices as technology. This study establishes a research framework to understand the importance of environmental practices for GSCM and performance.

Our research provides meaningful insight for both academic researchers and management personnel. We attempted to include internal and external factors in the context of GSCM. By reflecting internal and external factors together, this study presents useful approaches to adopting environmental practices in the supply chain and operations management literature. More importantly, this study establishes a linkage between environmental practices and supplier integration as organizational and supply chain characteristics, and between environmental practices and supply disruption risk as the external environment. With our research framework, this study provides empirical evidence supporting the positive relationship between environmental practices and financial, operational, and supply chain performance. More importantly, this research framework added integration with suppliers (as a positive impact supply disruption risk) as a negative impact, affecting environmental practices in the supply chain.

This study contributes to addressing a gap in the supply chain and operations management literatures by representing the impact of integration with suppliers on environmental practices with the three dimensions of eco-design, material reduction, and EMSs. Integration with suppliers is considered a popular supply chain practice, due to the benefits in the supply chain such as cost savings and delivery reduction [55]. Our research results provide empirical evidence that integration with suppliers also promotes coordination and collaboration for ecological product design, source reduction, and implementation of EMSs. Thus, this study confirms that integration with suppliers plays an important and positive role that facilitates comprehensive aspects of environmental practices in managing green supply chains when managers decide to adopt environmental practices in their firms. Although prior studies point out various benefits of integration with suppliers in supply chain management [19,22], this study found out that integration with suppliers, resulting in more collaborations with suppliers, facilitates manufacturers' environmental practices, including eco-design, source reduction, and EMS. Collaboration and frequent communications with suppliers helped manufacturers to establish eco-design of the process, and to reduce source materials and EMS together

in supply chain. In addition, this research emphasized the importance of working with suppliers on vitalizing the manufacturers' environmental practices. In other words, it provides empirical support regarding integration with suppliers, generating various benefits, including helping to facilitate buyers' environmental practices.

While implementing environmental practices, manufacturers share their information, as well as know-how, with their suppliers. The study of [39] pointed out the positive link between integration and supply chain environment practices. Unlike their study, this research added more contributions that integration with suppliers helped manufacturers to boost their eco-product design, material reduction, and EMS implementation by identifying the integration with suppliers as an antecedent of manufacturers' decision making on implementing eco-product design, source reduction, and EMS implementation. Thus, this study provided empirical evidence of the benefits of supplier integration on manufacturers' various environmental practices, leading to better firm performance. It provides managers with another reason for encouraging integration with suppliers with regard to implementing environmental practices in the supply chain. When managers establish green supply chain strategies, this research will give useful insights to managers by considering integration with suppliers as a driving force of facilitating eco-design, source reduction, and EMS. By categorizing environmental practices into three dimensions, eco-product design, material reduction, and EMS implementation, supplier integration helps to design the product with environmentally friendly, material reduction in the whole supply chain process, using EMS implementation (which needs to collaborate with suppliers as one of success factors in environmental practices).

This study also found a negative association between perceived supply disruption risk and eco-design, source reduction, and the EMS of environmental practices. While the relationship between perceived supply disruption risk and environmental practices has not been investigated so far, our research examines the effect of supply disruption risk on establishing green supply chains. The research results confirmed the negative relationship between perceived supply disruption risk and environmental practices, showing that supply disruption risk is an obstacle to implementing environmental practices. Previous studies identified the negative impact of perceived supply disruption risk in the context of performance [40,41]. This study newly identifies that perceived supply disruption risk is considered as a negative antecedent of encouraging manufacturers' environmental practices in the supply chain. Supply disruption risk negatively affects maintaining a smooth flow in the supply chain when establishing eco-design of the process and EMS, and attempting to reduce source materials. More importantly, perceived supply disruption risk might be considered as a barrier to implement or facilitate manufacturers' environmental practices. Therefore, when managers decide to implement environmental practices, such as eco-design, source reduction, and EMS in their supply chains, they also need to consider risk-mitigating strategies in order to prevent and minimize supply disruption risk. Perceived supply disruption risk affects negative firm performance, as well as facilitation of environmental practices (which plays a barrier role).

In order to emphasize the prominence of implementing environmental practices in manufacturing firms, they should take care of issues of supply disruption risk to maximize the effects of environmental practices. Kleindorfer and Saad introduced ten principles for risk mitigating strategies in the supply chain: mitigating each supply chain members' risk, sourcing diversification, collaboration, a prevention-first strategy, avoiding extreme leanness and efficiency, contingency plans, information sharing, risk assessment, supply chain agility and flexibility, and quality management [10]. In other words, when faced with both perceived supply disruption risk and environmental practices, managers should consider strategies in mitigating supply disruption risk, in order to facilitate the successful implementation of environmental practices in the supply chain. Since supply disruption risk is considered as a perceived barrier for managers implementing environmental practices, managers need to think of risk-mitigating strategies in the supply chain, in order to adopt environmental practices successfully. They also need to establish a mitigating plan toward supply disruption risk in implementing environmental practices. In addition, managers need to consider the type of product

when establishing a mitigating strategy, since it can establish single sourcing in the supply chain structure, due to the fact that it is very difficult to find a supplier with a special product.

Supply chain integration has been heavily discussed in the SCM literature, in order to determine its relationship with firm performance. In line with the results of the previous literature, we found a positive relationship between integration with suppliers and performance [22]. However, this study contributed to the literature that integration with suppliers improves financial aspects of performance such as revenue and incomes, as well as supply chain performance (like supply chain response time) and operational performance (such as lead time Prior literatures, which focus on the positive impact of integration with suppliers on firm's financial performance [19,22]). The study of [43] used the performance in the context of market-based, operational-based, and accounting-based systems in their meta-analysis research. Managers need to recognize that supplier integration can be beneficial to all aspects of firm performance. More importantly, this study attempts to eliminate conflicting issues regarding performance measurement by having three dimensions of measurement; financial, operational, and financial performance [69]. By measuring all aspects of the firm performance, this research answered which performance was positively influenced by integration with suppliers. Therefore, we empirically support that supplier integration has a positive impact on all areas of performance in the supply chain. In addition, this study affirmed the literature that states that integration with suppliers positively influences firms' financial, operational, and supply chain performance via environmental practices. Integration suppliers makes a positive impact on performance, directly and indirectly. This research changes the view of the benefits of supplier integration. Prior literatures focuses on the positive impact of supplier integration on firms' financial performance. However, this research applies this perspective to operational and supply chain performance. It provides empirical evidence that supplier integration also makes a positive impact on other firms' performance.

As supply chain networks become more complicated, the supply disruption risk increases. Thus, any disruptions in the supply chain will lead to poor consequences and losses in performance [51]. Given our findings regarding the negative relationship between perceived supply disruption risk and performance, establishing risk mitigating strategies in the supply chain for improving performance emerges as a priority for supply and purchasing managers. Hendricks and Singhal found negative abnormal returns of firm's stock market reactions with supply disruption announcements [48,49]. Wagner and Bode found negative associations between disruptions in supply and supply chain performance [52]. By differentiating prior studies, this research provided empirical evidence of a direct and negative relationship between supply disruption risk and firm performance. More importantly, this study confirmed that perceived supply disruption risk negatively and directly affects all aspects of performance, including financial, operational, and supply chain performance, thereby implying that managers perceive that supply disruption risk broadly damages all areas of the firm performance: financial, operational, and supply chain performance. More importantly, this study accomplished research suggested by [51] that proposed the negative relationship between supply disruption risk and performance by presenting empirical evidences.

Previous studies investigated the relationship between environmental practices and performance [26,30,32,44]. Our research results proved consistent with previous studies that found a positive relationship between environmental practices and performance. However, this study extended the literature by measuring comprehensive environmental practices using three dimensions: eco-design, material reduction, and EMSs, finding that all of these practices in the organizations and supply chains have a positive influence on performance. The results indicated that comprehensive environmental practices improve performance; this is an important finding for managers who are considering the implementation of environmental practices or looking for ways to improve performance. In implementing environmental practices, managers need to adopt a comprehensive approach by considering eco-design, material reduction, and EMS at the same time. By measuring performance along the financial, operational, and supply chain dimensions to differentiate from prior

studies that focus on firm's financial performance [42,43], we find that all aspects of environmental practices have a positive impact on all aspects of the firm performance.

In other words, this research would provide managerial implications for managers seeking to implement environmental practices, since they could improve firms' financial, operational, and even supply chain performance. More importantly, environmental practices have been receiving a lot of attention among Korean manufacturing companies. However, managers in Korean manufacturing firms hesitate to implement eco-design, source reduction, and EMS based on the belief that it would generate extra cost to their companies, leading to a decrease in profit. This study gives powerful confidence to managers that implementing environmental practices will increase the firm performance. Thus, managers do not have to worry about losing their own department's or team's profits due to the decision to implement environmental practices with evidences of improved performance. In addition, customers of Korean manufacturing firms become friendlier toward the products manufactured by firms which care about protecting the environment. Thus, firms' efforts to implement environmental practices would appear to result in better performance in the market.

This study deals with some limitations, because of characteristics of empirical studies. This research only applies applies to the buyer's perspective in the Korean manufacturing industry. To overcome this issue, we can expand our future research by applying the supplier's perspective. We also can apply and validate this research framework in other countries' manufacturing industry or service industry while considering the input of service industry characteristics. Another point is that since we applied the survey methodology, firm performance has been measured by subjective comparison. Future research can collect financial data and validate the causal relationship between environmental practices and firms' financial performance. In that way, we can apply a more objective approach. In addition, instead of using information sharing, we can further expand to knowledge sharing in the supply chain. Future research can apply knowledge as a strategic resource in the supply chain. In our research framework, we can develop knowledge sharing as a strategic way to strengthen the impact of environmental practices in the supply chain [70].

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