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The Impact of Green Supply Chain Practices on Supply Chain Performance

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By

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The Impact of Green Supply Chain Practices

on Supply Chain Performance

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Supply Chain Management (SCM) has become a critical factor to sustain organization's competitive advantages. In this regard, many firms and researchers have attempted to find out factors that affect either positively or negatively on SCM. Recently, Green Supply Chain Management (GSCM) has been receiving the spotlight in many studies. Social and political concerns about the environment in Korea emerged in the early 1990s when Korean government established new environmental regulations in order to implement environmental management throughout the entire supply chain. The Korean government established national GSCM strategies. However, there has been minimal research on measuring GSCM performance among Korean enterprises. It is critical to conduct the research on the relationship between GSCM practices and supply chain performance among Korean firms. In this research, the relationship among Korean enterprises will be empirically tested. The supply chain performance measurement system includes three dimensions: resource, output, and flexibility.

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CHAPTER 1 INTRODUCTION

1.1 The Problem

Supply Chain Management (SCM) has become a critical factor for the organization's success. In this regard, many firms and researchers have attempted to find out variables that affect either positively or negatively on SCM. Recently, Green Supply Chain Management (GSCM) has been receiving the spotlight in many studies. According to Green et al. (1997), in the context of the deteriorating environment, GSCM stands for innovations in supply chain management and industrial purchasing. Zhu and Sarkis (2004) suggest that GSCM practices consist of four major dimensions: internal environmental management, external environmental management, investment recovery, and eco design.

Although organizations consider environmental management their own strategies, measuring GSCM performance based on practices implemented has attracted little attention. The existing research has focused on GSCM performance measurement methods reflecting not just indigenous features but economic or competitive advantage of SCM. The existing SCM performance measurement methods are insufficient to reflect critical SCM characteristics such as the organization's strategic goals and interactions with partners (Beamon, 1999).

Social and political concerns about the environment in Korea emerged in the early 1990s when Korean government established new environmental regulations in order to implement environmental management throughout the entire supply chain (Lee, 2008). The Korean government set up national GSCM strategies in 2003. However, there has been minimal research on measuring GSCM performance among Korean enterprises.

1.2 Purpose of the Study

It is important to carry out the research on the relationship between GSCM practices and supply chain performance among Korean firms. In this research, this relationship among Korean enterprises will be empirically investigated.

1.3 Research Question

The main research questions addressed in this research are:

(1) What is the relationship between GSCM internal practices and supply chain output?

(2) What is the relationship between GSCM external practices and supply chain output?

(3) What is the relationship between GSCM eco design practices and supply chain output?

(4) What is the relationship between GSCM internal practices and supply chain resource?

(5) What is the relationship between GSCM external practices and supply chain resource?

(6) What is the relationship between GSCM eco design practices and supply chain resource?

(7) What is the relationship between GSCM internal practices and supply chain flexibility?

(8) What is the relationship between GSCM external practices and supply chain flexibility?

(9) What is the relationship between GSCM eco design practices and supply chain flexibility?

1.4 Methodology

This study has two measurement models that include GSCM practices, supply chain performance measure, and a structural model. In addition, nine hypotheses are developed for the research. A survey is conducted to collect the measuring data for the research. This study uses principle component analysis (PCA) and multiple linear regression to test and measure posited hypotheses using survey data using SPSS (16.0).

1.5 Organization of the Thesis

This study is organized as follows. The first chapter has outlined the problem, purpose of the study, research questions, methodology, and organization of the thesis. In the second chapter, the relevant literature related to GSCM, GSCM practices, supply chain performance measurement, and GSCM performance measurement is reviewed. The third chapter outlines the research framework, measurement models, and hypotheses. This chapter also describes how the data is collected and presents the characteristics of the sample. In the fourth chapter, hypotheses are tested empirically and the result is presented. In the fifth chapter, the findings with implications, limitations, and suggestions for the future research are discussed.

CHAPTER 2 LITERATURE REVIEW

2.1 Green Supply Chain Management

Scott and Westbrook (1991) and New and Payne (1995) pointed out that SCM stands for the chain connecting each element of the manufacturing and supply process from raw materials through to the end users, and handling integration of all participating firms contributions in the supply chain. Over the past decade, SCM has played an important role for organizations' success and subsequently the green supply chain (GSC) has emerged as an important component of the environmental and supply chain strategies of a large number of companies. Although the term "environment" or "greening" has an ambiguous meaning in various fields, the term indicates not only harmonizing corporate environmental performance with stockholders' expectations but also developing a critical new source of competitive advantage in terms of management perspective (Gupta, 1994). According to Gupta (1995), environmental management relieves environmental destruction and improves environmental performance by institutionalizing various greening practices and initiating new measures and developing technologies, processes and products.

In recent years, numerous studies have attempted to find and explore GSCM. Green supply refers to the way in which innovations in supply chain management and industrial purchasing may be considered in the context of the environment. Narasimhan and Carter (1998) define GSCM as the purchasing function including reduction, recycling, reuse, and the substitution of materials. The GSC covers wide areas of GSCM practices and SCM's participants and practices from green purchasing to integrated supply chains flowing from suppliers, to manufacturers, to customers, and to the reverse supply chain (Zhu and Sarkis, 2006; Raoand Holt, 2005).

Brown et al. (2001) suggests two main types of green supply management process: greening the supply process and product-based green supply. Greening the supply process stands for accommodations made to the firm's supplier management activities for considering environmental perspectives. In addition, product-based green supply focuses on changes to the product supplied and attempts to manage the by-products of supplied inputs. According to Pagell et al. (2004), leaders of the logistics and supply chain department should balance low cost and innovation process while maintaining good environmental performance. Through supply chain analysis, organizations are able to check whether environmental issues can be incorporated into industrial transformation processes (Green et al., 1996).

Green supply commitment through the corporate environmental approach and management commitment to environmental issues improve the possibility of green supply implementation (Drumwright 1994; Cramer 1996; Green, Morton, and New 1996). However, Brown et al. (2001) states that the motivation for implementing GSCM process may come entirely outside the firm's normal supply management process if the fimrs capabilities are insufficient to launch green supply chain on its own. The strategy literature stresses that environmental management can play a critical role as both a social responsibility and an important corporate duty (Arlow and Gannon, 1982). The social and political interest in green issues has promoted implementing GSCM (Van Hoek, 1999). In addition, the response to environmental issues in socially responsible manner still remains as a social and business matter (Murphy and Poist, 2003).

2.1.1 GSCM Practices

To implement GSCM, organizations should follow GSCM practices which consist of environmental supply chain management guidelines. Numerous studies have tried to identify GSCM practices in organization which are referred to such internal systems as environmental and quality management systems. Internal environmental management is critical to improving the organization’s environmental performance (Zhu et al., 2008). Zhu and Sarkis (2004) indicate that quality management lubricates implementation of GSCM. They suggest that under rigorous quality control, organizations can improve their environmental practice by learning from experiences of their quality management programs. By receiving the certificate for the ISO 14001 environmental management system (EMS) standard, organizations are able to create structured mechanisms for continuous improvement in environmental performance (Kitazawa and Srakis, 2000). Beamon (1999) suggested that GSCM and logistics efforts have encouraged firms to adapt the closed-loop supply chain. Closed-loop supply chain management stands for “the design, control and operation of a system to maximize value creation over the entire life-cycle of a product with the dynamic recovery of value from different types and volumes of returns over time” (Guide and Van Wassenhove 2006).

Some studies focused on external environmental factors such as customers and suppliers. To improve their own environmental supply chain performance, organizations need the interactions with the government, suppliers, customers, and even competitors (Carter and Ellram, 1998). Cooperation with suppliers and customers has become extremely critical for the organizations' to close the supply chain loop (Zhu et al., 2008).

Importance of the design process in environmental management is well demonstrated by the existing literature. Reuse stands for both the use of a product without re-manufacturing and is a form of source reduction. Recycling is the process which makes disposal material reusable by collecting, processing, and remanufacturing into new products (Kopicki et al., 1993). As an environmental practice, resource reduction enables firms to minimize waste which results in more efficient forward and reverse distribution processes (Carter and Ellram, 1998). Eco-design, design for environmental management, enables organizations to improve their environmental performance and close the supply chain loop by handling product functionality while minimizing life-cycle environmental impacts (Zhu et al., 2008).

As shown in Table 2.1, GSCM practices are divided into four major dimensions: internal environmental management, external environmental management, investment recovery, and eco design (Zhu and Sarkis, 2004).

Internal environmental management	Commitment of GSCM by senior managers Support for GSCM by mid-level managers Cross-functional cooperation for environmental improvements Total quality environmental management Environmental compliance and auditing programs ISO 14001 certification Environmental management systems
External GSCM practices	Providing design specification to suppliers that include environmental requirements for purchased item Cooperation with suppliers for environmental objectives Environmental audit for suppliers' internal management Suppliers' ISO14000 certification Second-tier supplier environmentally friendly practice evaluation Cooperation with customer for eco-design Cooperation with customers for cleaner production Cooperation with customers for green packaging
Investment recovery	Investment recovery (sale) of excess inventories/materials Sale of scrap and used materials Sale of excess capital equipment
Eco-design	Design of products for reduced consumption of material/energy Design of products for reuse, recycle, recovery of material, component parts Design of products to avoid or reduce use of hazardous products and/or their manufacturing process

<Table 2.1> Categories of green supply chain management from literature (Zhu and Sarkis, 2004)

2.2 Supply Chain Performance Measure

SCM focuses on how organizations control their suppliers' processes, technology, and capability to improve competitive advantage (Farley 1997). Lee and Billington (1992) suggest that SCM is based on interactions of manufacturing, logistics, materials, distribution, and transportation functions within an organization. In this regard, for measuring supply chain performance, many characteristics of SCM should be reflected in the supply chain performance measurement system.

Supply chain performance measurement models are divided into four categories: 1) cost and 2) a combination of cost and customer responsiveness, 3) activity time, and 4) flexibility (Cohen and Lee, 1988; Arntzen et al., 1995; Cook and Rogowski, 1996; Lee and Billington 1993; Voudouris, 1996). Cooper et al. (1997) suggested that supply chain performance measurement system needs to be enhanced by developing metrics and an assessment of implementation barriers to overcome in implementing the existing measurement system.

The existing supply chain performance measurement systems are problematic because they commonly use cost as the primary measure and they do not reflect the strategic goals of the organization nor consider the effect of supply chain disruption due to uncertainty (Beamon, 1996). Vickery et al. (1999) defined five supply chain flexibilities based on previous operations literature in order to look at supply chain uncertainty problems. Table 2.2 shows five types of flexibility.

Flexibility Type	Description
Product flexibility	The ability to customize product to meet specific customer demand
Volume flexibility	The ability to adjust capacity to meet changes in customer quantities
New product flexibility	The ability to launch new or revised products
Distribution flexibility	The ability to provide widespread access to products
Responsiveness flexibility	The ability to respond to target market needs

<Table 2.2> Supply Chain Flexibilities (Vickery et al., 1999)

Bechtel and Jayaram (1997) indicate that supply chain measurement should involve integrated measures applied to the whole process in order to prevent optimization at one point without reflecting potential consequences at other points in the supply chain. Scapens (1998) suggests that supply chain performance measurement system is needed to deal with innovative strategies like teamwork and non-financial metrics such as lead times. Characteristics of employees in an organization should be considered as an important variable for the overall supply chain performance (Gunasekaran et al., 2001).

A number of studies have attempted to propose updated measurement systems to reinforce the existing supply chain measurement system to overcome its limitations. Beamon (1998) suggested that supply chain performance measure can be categorized by the characteristics of performance measure type. Qualitative performance measures for supply chain include Customer Satisfaction, Flexibility, Information and Material Flow Integration, Effective Risk Management, and Supplier Performance. Quantitative supply chain performance measures handle (1) objectives that are based directly on cost or profit and (2) objectives that are based on some measures of customer responsiveness (Beamon, 1998). Gunasekaran et al. (2004) stated that a framework for supply chain performance measures should consider the four major supply chain activities/processes.

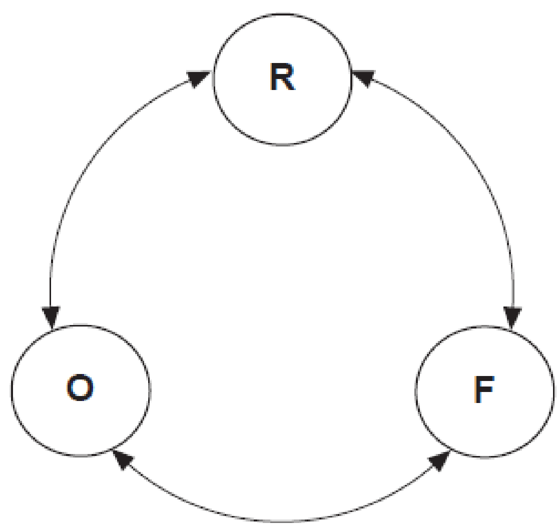
1) Plan: Order entry methods, Human resource productivity
2) Source: Efficiency of purchase order cycle time, Supplier pricing against market
3) Make/Assemble: Percentage of defects, Cost per operation hour, Human resource productivity index
4) Deliver: Flexibility of service system to meet customer needs, Effectiveness of enterprise distribution planning schedule

Beamon (1999) developed a clearer and refined supply chain measurement system including resource measures, output measures, and flexibility measures in order to reflect inherent complexity of the typical supply chain. As shown in Table 2.3, resources are associated with supply chain efficiency including total cost, distribution cost, manufacturing cost, inventory cost, and return on investment. Output stands for the level of customer service including sales, profit, on-time deliveries, backorder/stockout, customer response time, manufacturing lead time, shipping errors, and customer complaints. Flexibility is defined as the ability to respond to uncertainty which is related to volume, distribution, responsiveness, product and/or new product flexibility.

Performance measure type	Goal	Purpose
Resources	High level of efficiency	Efficient resource management is critical to profitability
Output	High level of customer service	Without acceptable outputs, customers will turn to other supply chains
Flexibility	Ability to respond to a changing environment	In an uncertain environment, supply chains must be able to respond to change

<Table 2.3> Goals of performance measure types (Beamon, 1999)

Beamon (1999) indicated that these three measurements are critical to assess supply chain performance and each of three types affects the others. The interrelationship among the three types of measures, Resource (R), Output (O), and Flexibility (F), is shown in Figure 2.1.



<Figure 2.1> The supply chain measurement system (Beamon, 1999)

2.2.1 GSCM Performance

Over the past decade, GSCM has emerged as an important component of the environmental and supply chain strategies for a number of companies. In recent years, some studies have attempted to explore economic and environmental performance of GSCM. Walley (1994) stated that many managers consider environmental management as compliance with regulations while evaluating tradeoffs between environmental and economic performance. Zhu et al. (2007) indicates that enterprises implementing GSCM in China have only slightly improved environmental and operational performance, and GSCM practices have not resulted in a significant economic performance improvement. However, some anecdotal evidence showed that substantial environmental management performance leads to lower manufacturing costs by eliminating waste (Allen, 1992). Rao and Holt (2005) pointed out that organizations adopting GSCM in the South East Asian region ultimately enhanced both competitiveness and economic performance. A study indicated that environmental performance positively affected financial performance of the firms through both increasing the market share and decreasing cost (Klassen and Mclaughlin, 1996). The reasons why the results of these studies differ from each other may be due to the heterogeneity of environmental management practices adopted by organizations and industries (Elsayed and Paton, 2005).

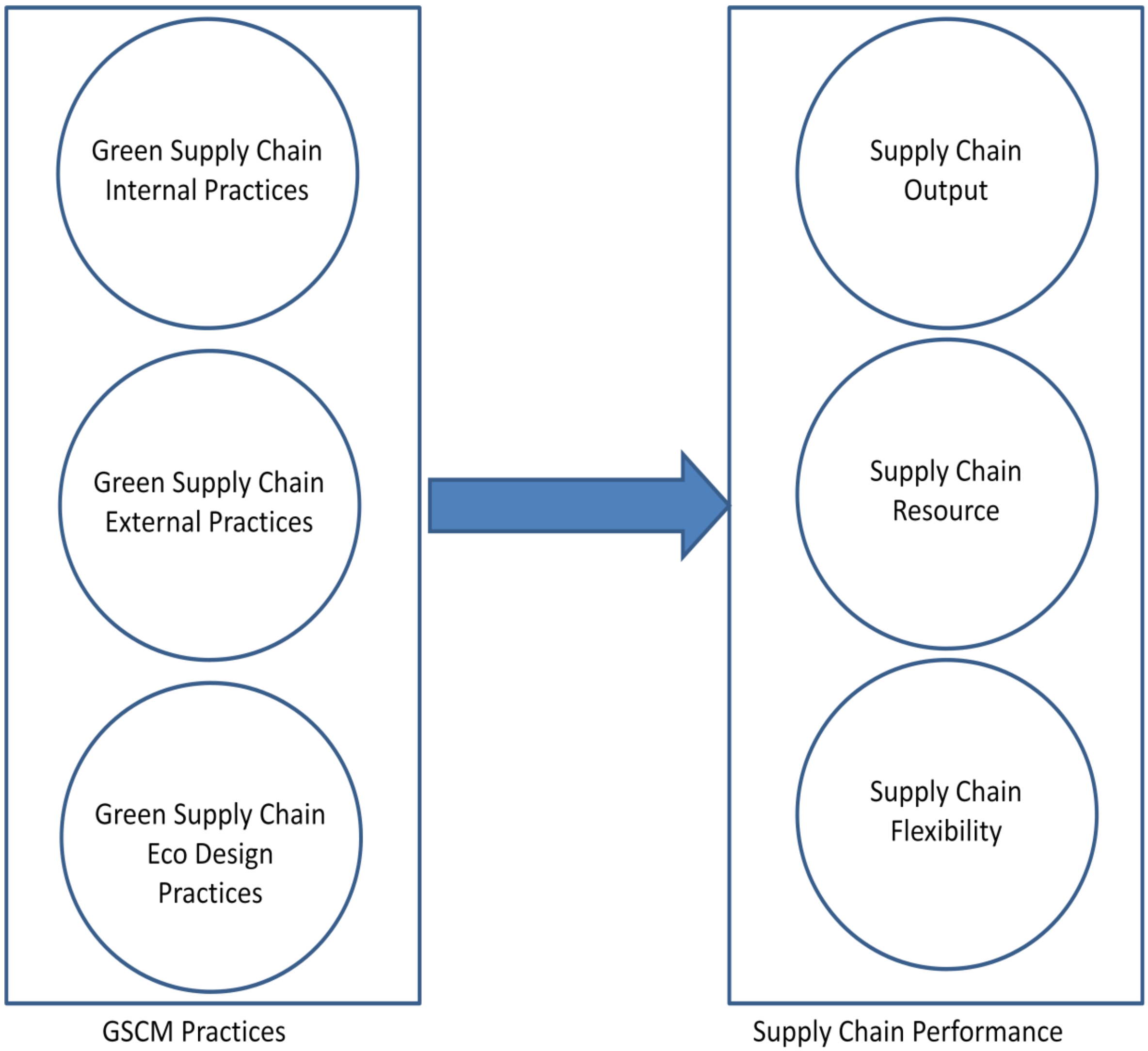
Numerous studies have tried to find the relationship between strategies and environmental performance. Klassen and Mclaughlin (1996) state that environmental management performance is derived from longer term decisions. They also indicated that environmental management is associated with corporate and functional strategies. The performances of environmental management system and the green supply chain were positively related to corporate competitive advantage (Yu-Shan Chen et al., 2006).

CHAPTER 3 RESEARCH MODEL AND METHODOLOGY

3.1 Research Model

Curiously, despite the rise of concerns about environmental management, few studies have attempted to address a systematic measurement of GSCM performance. Some studies simply tried to find the relationship between GSCM and economic or environmental performance. In this research, the effect of GSCM practices on firm's supply chain performance is empirically examined. GSCM practices investigated in this study include internal environmental management, external environmental management, investment recovery, and eco-design dimensions (Zhu and Sarkis, 2004). Beamon (1999) suggested, as discussed earlier, that the SCM performance measuring system must consider three dimensions including resources, output, and flexibility. He indicated that three measure types of SCM performance interact with each other.

Figure 3.1 shows the conceptual framework of this study. GSCM practices affect each supply chain performance measure type.



<Figure 3.1> Conceptual Framework

3.2 Hypotheses development

From reviewing the relevant literature, many studies found that environmental management is generally beneficial for environmental performance and some aspects of economic performance of the firm.

Supply chain output involves sales, profit, on-time deliveries, backorder/stockout customer response time, manufacturing lead time, shipping errors, and customer complaints (Beamon, 1999). Numerous studies have proved the relationship between GSCM practices and economic and environmental output (Walley, 1994; Zhu et al., 2007; Allen, 1992; Rao and Holt, 2005; Klassen and Mclaughlin, 1996). Therefore, hypothesis 1,2, and 3 are proposed.

Hypothesis 1: GSCM internal practice is positively related to supply chain output.

Hypothesis 2: GSCM external practice is positively related to supply chain output.

Hypothesis 3: GSCM eco design practice is positively related to supply chain output.

Rao and Holt (2005) pointed out that organizations implementing GSCM improved competitiveness. They suggested that competiveness consists of improved efficiency, quality improvement, productivity improvement, and cost savings. As a performance measure type, supply chain resource is associated with efficiency and cost (Beamon, 1999). Therefore, hypothesis 4, 5, and 6 are posited.

Hypothesis 4: GSCM internal practice is positively related to supply chain resource.

Hypothesis 5: GSCM external practice is positively related to supply chain resource.

Hypothesis 6: GSCM eco design practice is positively related to supply chain resource.

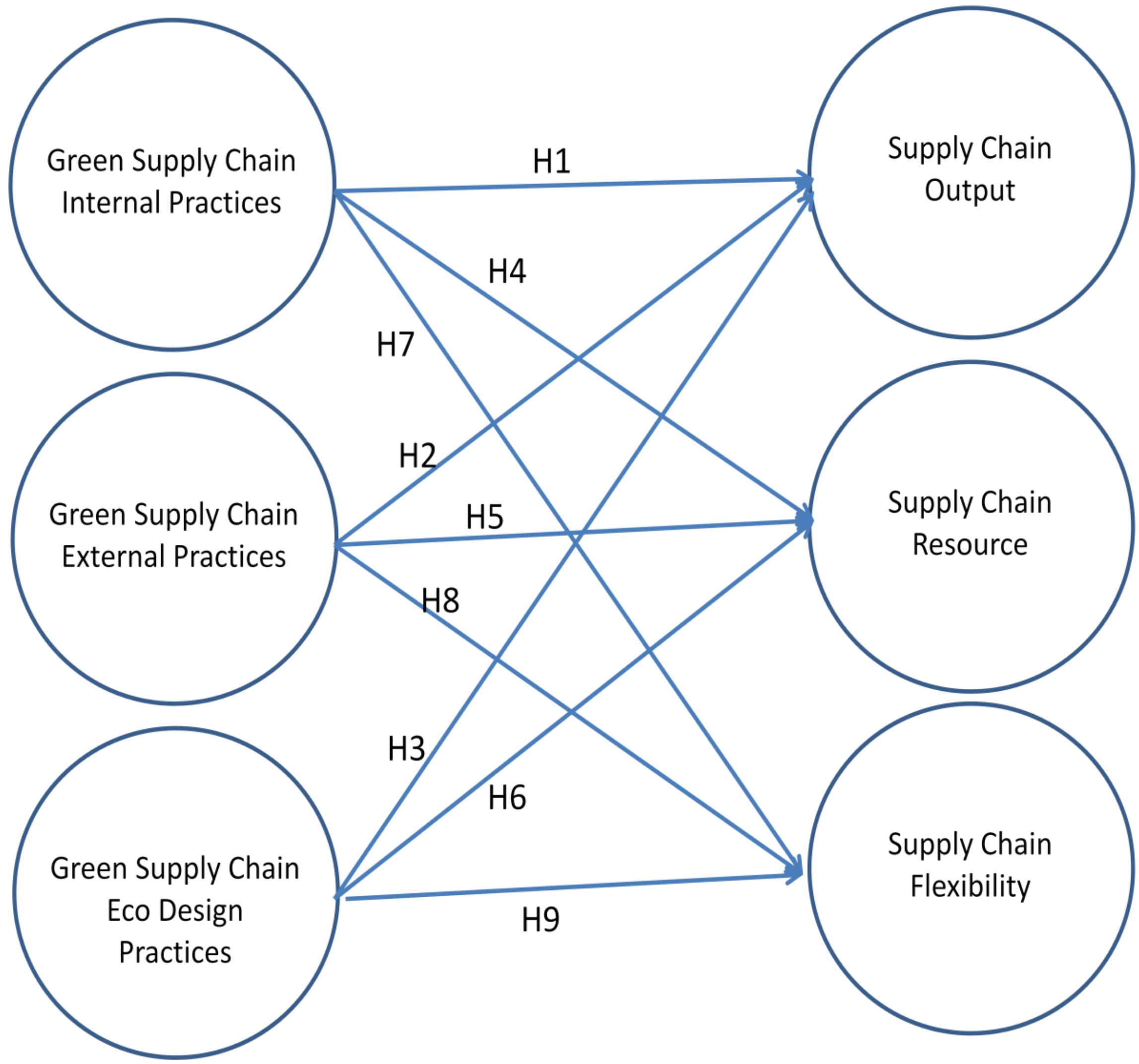
To implement GSCM practices, enterprises require their supply chain partners to enhance environmental management capabilities by providing training programs and sharing their green system. Knowledge sharing in green supply chains leads supply chain participants to develop new capabilities for effective actions (Cheng et al., 2008). Supply chain flexibilities enable organizations to handle uncertainty in the changing environment (Vickery et al, 1999). Thus, hypothesis 7, 8, and 9 are proposed.

Hypothesis 7: GSCM internal practice is positively related to supply chain flexibility.

Hypothesis 8: GSCM external practice is positively related to supply chain flexibility.

Hypothesis 9: GSCM eco design practice is positively related to supply chain flexibility.

Figure 3.2 represents the research model and hypotheses of this study.



<Figure 3.2> Research Model and Hypotheses

3.3 Methods

This study uses principle component analysis (PCA) and linear regression to test and measure posited hypotheses using survey data. All analyses are conducted using SPSS (16.0).

3.4 Factor Analysis

3.4.1 GSCM Practices

In this research, 10 items on a seven-point scale (1 = very bad, 7 = very good) was used for measuring GSCM practices including internal environmental management, external environmental management, and eco design.

	Item no.	Item
Internal	IN1	Commitment for GSCM from senior managers
	IN2	Support for GSCM from mid-level managers
	IN3	Cross-functional cooperation for environmental improvements
	IN4	Environmental compliance and auditing programs ISO 14001 certification
External	EX1	Providing design specification to suppliers that include environmental requirements for purchased item
	EX2	Environmental audit for suppliers' internal management
	EX3	Suppliers' ISO14000 certification
Eco Design	ED1	Design of products for reduced consumption of material/energy
	ED2	Design of products for reuse, recycle, recovery of material, component parts
	ED3	Design of products to avoid or reduce use of hazardous products and/or their manufacturing process

<Table 3.1> Items for GSCM practices

The scale items are based on existing literature on GSCM (Zhu and Cote, 2002; Zhu and Sarkis, 2004; Zsidisin and Hendrick, 1998). To measure overall GSCM practices, PCA was used. The items for factor analysis are shown in Table 3.1.

A factor analysis was conducted to further confirm grouping of GSCM practice and supply chain performance from the survey data. Factors were extracted using the maximum likelihood method, followed by a varimax rotation.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.112	51.116	51.116	5.112	51.116	51.116	2.866	28.658	28.658
2	1.513	15.133	66.249	1.513	15.133	66.249	2.498	24.985	53.643
3	1.009	10.092	76.341	1.009	10.092	76.341	2.270	22.698	76.341

<Table 3.2> Total variance of factor analysis

As shown in Table 3.2, the Kaiser criterion (eigenvalues>1) was employed in conjunction with an evaluation of scree plots. According to Table 3.3, initial eigenvalue test suggested the presence of three meaningful factors for GSCM practice. This factor analysis divided GSCM practices into three factors: GSCM internal practices (GSIN), GSCM external practices (GSEX), and GSCM eco design practices (GSED).

	Factors		
Survey Item	1	2	3
IN1	.861	.143	.201
IN2	.830	.246	.255
IN3	.826	.398	.051
IN4	.617	.387	.196
EX1	.316	.814	.054
EX2	.232	.899	.112
EX3	.331	.661	.338
ED1	.198	.406	.697
ED2	.082	.178	.879
ED3	.254	-.063	.857

<Table 3.3> Results of rotated component matrix

Further analysis confirms the reliability of these three factors with Cronbach's alpha, of 0.882, 0.841, and 0.869.

3.4.2 Supply Chain Performance

Eleven items about GSCM performance were developed by the author based on Beamon's supply chain performance measurement system reflecting supply chain resource, flexibility, and output (Beamon, 1999). Questions about supply chain performance results from implementing GSCM practices were answers using a seven-point scale (1 = strong disagreement, 7 = strong agreement). Items for the supply chain performance model are listed in Table 3.2.

Construct	Item no.	Item
Resource	R1	Total cost
	R2	Distribution cost
	R3	Manufacturing cost
Output	O1	Sales
	O2	Profit
	O3	On-time deliveries
	O4	Customer response time
Flexibility	F1	The ability to change the output level of products produced
	F2	The ability to change planned delivery dates
	F3	The ability to change the variety of products produced
	F4	The ability to introduce and produce new products

<Table 3.4> Items for supply chain performance

A factor analysis was used to verify grouping of supply chain performance from the survey data. Like the method to conduct factor analysis for GSCM practices, the maximum likelihood method was used with a varimax rotation.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.670	42.453	42.453	4.670	42.453	42.453	2.882	26.203	26.203
2	2.127	19.334	61.787	2.127	19.334	61.787	2.682	24.378	50.581
3	1.197	10.884	72.671	1.197	10.884	72.671	2.430	22.090	72.671

<Table 3.5>Total variance of factor analysis

Total variance of factor analysis table (Table 3.5) suggested the presence three meaningful factors for supply chain performance in terms of the Kaiser criterion (eigenvalues>1). This factor analysis empirically categorized supply chain performance types into three factors: resource (R), output (O), and flexibility (F).

	Factors		
Survey Item	1	2	3
R1	.142	.033	.894
R2	.264	-.039	.887
R3	.069	.179	.837
O1	.777	.379	.156
O2	.736	.340	.088
O3	.822	.300	.126
O4	.762	-.079	.276
F1	.322	.719	-.017
F2	.470	.615	.062
F3	.249	.808	.053
F4	-.013	.862	.110

<Table 3.6> Results of rotated component matrix

Further analysis confirms the reliability of these three factors with Cronbach's alpha, of 0.818, 0.869, and 0.854.

3.5 Data Collection

The data used in this survey consist of survey responses from managers in Korean enterprises. Due to the difficulties in collecting data, the author did not contact supply chain managers in Korea individually and alternatively contacted the Korean Logistics and Distribution Association because the respondents targeted by this study are supply chain manager and logistics manager. An executive of the association distributed the survey for this study and a total of 157 enterprise responses were received. The author solicited only one response from each firm. Survey was conducted on Qualtrics, the web based survey system.

3.6 Sample Description

The author received 157 responses on Qualtrics but 36 of them were incomplete and deleted (n=121). The sample statistics are given in Table 3.3. Supply chain manager (39%) and logistics manager (25%) mainly consist of job title of respondents since the most of respondents are member of the Korean Logistics and Distribution Association. In sum, the majority of respondents were supply chain manager from manufacturing firms with more than 900 employees.

Job Title	Frequency	Percent
Supply Chain Manager	47	39
Logistics Manager	30	25
Sales Manager	10	8
Product Manager	8	8
Manufacture Manager	6	5
Others	18	15
Industry Type	Frequency	Percent
Manufacturing	74	61
Service	19	16
Electronics	17	14
Construction	10	8
Others	1	1
Number of Employees	Frequency	Percent
1~299	26	21
300~499	17	14
500~699	15	12
700~899	16	13
900~	47	39

<Table 3.7> Characteristics of the sample

CHAPTER 4 RESULTS

4.1 Correlations between GSCM Practices and Supply Chain Performance

The bivariate correlation results, using Pearson correlation coefficients, are shown in Table 3.8. Results show a significant relationship among internal management, external management, and eco design with each of three supply chain performance types including output, resource, and flexibility. The correlations between GSCM practices and supply chain performance types are in the expected direction.

Scale	1	2	3	4	5	6
GSCM Practices						
(1)GSIN	1.0					
(2)GSEX	0.645**	1.0				
(3)GSED	0.451**	0.428**	1.0			
Performance						
(4)PEOP	0.506**	0.468**	0.280**	1.0		
(5)PERE	0.378**	0.348**	0.383**	0.292**	1.0	
(6)PEFL	0.561**	0.536**	0.428**	0.524**	0.180*	1.0

*p ≤ .05, ** p ≤ .01

<Table 4.1> Correlations between GSCM practices and supply chain performance

4.2 Results of Regression of Supply Chain Output on GSCM Practices

To test hypothesis 1, hypothesis 2, and hypothesis 3, the author regressed supply chain output performance parameter on GSCM practices including internal management, external management, and eco design.

As shown in Table 4.2, R Square value is 0.270. This means that the research model explains 27 per cent of the variance in supply chain output performance. Through the ANOVA table, the model reaches statistical significance (Sig.=.000, and $p \leq .01$).

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.537[a]	.289	.270	2.325
a. Predictors: (Constant), GSED, GSEX, GSIN				

<Table 4.2> Model summary of regression of supply chain output

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	254.679	3	84.893	15.707	.000[a]
	Residual	626.968	116	5.405		
	Total	881.648	119			
a. Predictors: (Constant), GSED, GSEX, GSIN						
b. Dependent Variable: O						

<Table 4.3> ANOVA table of regression of supply chain output

The test of hypothesis 1 assessed whether GSIN practices were positively related to supply chain output performance. This hypothesis was tested by regressing supply chain output on the GSIN. Results suggest that the higher the level of GSIN practices leads the higher the supply chain output (β = 0.348, t = 3.281, $p \leq .01$), thus hypothesis 1 was supported. Also, Table 4.4 shows results of significance test for the relationship between GSEX practices and supply chain output performance. The relationship is positive and significant (β = 0.234, t = 2.244, $p \leq .05$). Therefore, hypothesis 2 is strongly supported. Hypothesis 3 proposed that GSED practices are positively associated with supply chain output. The results shows that the relationship between GSED and supply chain output is insignificant (β = 0.015, t = 1.172, $p \geq .05$).

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.281	1.260		.223	.824	-2.215	2.777
	GSIN	.886	.270	.348	3.281	.001	.351	1.422
	GSEX	.581	.259	.234	2.244	.027	.068	1.094
	GSED	.041	.239	.015	.172	.864	-.432	.514

a. Dependent Variable: O

<Table 4.4> Coefficients of regression of supply chain output

4.3 Results of Regression of Supply Chain Resource on GSCM Practices

Supply chain resource performance was regressed on the GSCM practices to test empirically hypothesis 4, hypothesis 5, and hypothesis 6. According to Table 4.5, R Square value accounts for 0.176., and the model explains 18 per cent of the variance in supply chain resource performance. As shown in Table 4.6, the regression model has statistical significance (Sig.=.000, and $p \leq .01$).

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.444[a]	.197	.176	1.020
a. Predictors: (Constant), GSED, GSEX, GSIN				

<Table 4.5> Model summary of regression of supply chain resource

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	29.582	3	9.861	9.485	.000[a]
	Residual	120.595	116	1.040		
	Total	150.177	119			
a. Predictors: (Constant), GSED, GSEX, GSIN						
b. Dependent Variable: R						

<Table 4.6> ANOVA table of regression of supply chain resource

Table 4.7 shows that the main effects of GSIN (β = 0.203, t = 1.803, p ≥.05) and GSEX (β = 0.116, t = 1.048, p ≥.05) were insignificant. Therefore, hypothesis 4 and hypothesis 5 were rejected. However, the main effect of GSED is significant (β = 0.222, t = 2.337, p ≤.05), thus, hypothesis 6 was supported.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.993	.553		1.797	.075	-.101	2.088
	GSIN	.214	.119	.203	1.803	.074	-.021	.448
	GSEX	.119	.114	.116	1.048	.297	-.106	.344
	GSED	.245	.105	.222	2.337	.021	.037	.452
a. Dependent Variable: R								

<Table 4.7> Coefficients of regression of supply chain resource

4.4 Results of Regression of Supply Chain Flexibility on GSCM Practices

Regression of supply chain flexibility on GSCM practices was conducted to prove Hypothesis 7, Hypothesis 8, and Hypothesis 9.

As shown in Table 4.8, R Square value is 0.402. This value indicated that the research model explains 40 per cent of the variance in supply chain output performance. ANOVA table shows that the regression is statistically significant (Sig.=.000, and $p \leq .01$).

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.634[a]	.402	.386	.775
a. Predictors: (Constant), GSED, GSEX, GSIN				

<Table 4.8> Model summary of regression of supply chain flexibility

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	46.762	3	15.587	25.975	.000[a]
	Residual	69.611	116	.600		
	Total	116.373	119			
a. Predictors: (Constant), GSED, GSEX, GSIN						
b. Dependent Variable: F						

<Table 4.9> ANOVA table of regression of supply chain flexibility

Hypothesis 7 proposed that GSIN practices are positively related to supply chain flexibility. Table 4.10 indicated that the relationship is significant ($\beta = 0.298$, $t = 3.056$, $p \geq .01$). In addition, GSEX practices are significantly associated with supply chain flexibility ($\beta = 0.267$, $t = 2.787$, $p \geq .01$).Therefore, hypothesis 8 was supported. The test of hypothesis 9 assessed whether GSED practices were positively related to supply chain output flexibility. Hypothesis 9 was supported by the regression results ($\beta = 0.200$, $t = 2.443$, $p \leq .05$).

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1.033	.420		2.459	.015	.201	1.864
	GSIN	.276	.090	.298	3.066	.003	.098	.454
	GSEX	.240	.086	.267	2.787	.006	.070	.411
	GSED	.195	.080	.200	2.443	.016	.037	.352
a. Dependent Variable: F								

<Table 4.10> Coefficients of regression of supply chain flexibility

A summary of all the results of hypotheses are shown in Table 4.11.

Hypothesis	Results
Hypothesis 1: GSCM internal practice is positively related to supply chain output.	Supported
Hypothesis 2: GSCM external practice is positively related to supply chain output.	Supported
Hypothesis 3: GSCM eco design practice is positively related to supply chain output.	Rejected
Hypothesis 4: GSCM internal practice is positively related to supply chain resource.	Rejected
Hypothesis 5: GSCM external practice is positively related to supply chain resource.	Rejected
Hypothesis 6: GSCM eco design practice is positively related to supply chain resource.	Supported
Hypothesis 7: GSCM internal practice is positively related to supply chain flexibility.	Supported
Hypothesis 8: GSCM external practice is positively related to supply chain flexibility.	Supported
Hypothesis 9: GSCM eco design practice is positively related to supply chain flexibility.	Supported

<Table 4.11> Summary of all the results of hypotheses

CHAPTER 5 CONCLUSIONS AND LIMITATIONS

This chapter presents the conclusion of this study. It contains conclusions, implications, limitations, and suggestions. The purpose of this study was to measure performance of GSCM practices including external, internal, eco design factors with supply chain performance measurement system reflecting resource, output, and flexibility. To test hypotheses, PCA and multiple regression method were conducted. Existing body of literature indicates that GSCM practices are positively or negatively associated with economic and environmental performance. In this paper, GSCM practices revealed a significantly positive relationship with the three supply chain performance parameters.

This research makes three major managerial contributions to the existing literature. First, except for eco design, GSCM practices improve supply chain output performance. Although some studies investigated the relationship between GSCM practices and economic or environmental performance, measuring green supply chain performance with supply chain performance measurement systems has received minimal attention. Through the multiple regression analysis, this study found that implementing GSCM practices enable organizations to strengthen sales, profit, on-time delivery, and the customer service level. Second, because of the cost problem, internal management and external management for GSC do not improve supply chain resource performance. Beamon (1999) stated that resource is related to cost. Since organizations usually need more budget to implement GSCM practices, supply chain resource performance was not enhanced in the research. Lastly, all GSCM practices positively affects supply chain flexibility. Supply chain flexibility stands for ability to respond to uncertainty (Vickery et al., 1999). In this regard, implementing GSCM practices improves organizations' capacity to handle the supply chain disruption.

There are limitations to this study that should be considered when interpreting the study results. These limitations are left for future research. First, this study did not include all GSCM practices. The study included only three dimensions of GSCM practices: internal, external, and eco design factors. The existing studies suggest several other types of GSCM practices such as investment recovery and the closed-loop system. Future research should contain divers GSCM dimensions. Second, the sample size was insufficient to test additional hypotheses and the industrial type of the respondents was restricted to primarily manufacturing. Because of the difficulties involved in collecting data from Korean enterprises, this research solicited help from the Korean Logistics and Distribution Association where members are mostly from the manufacturing sector. Future research should collect data from a more diverse sample. Lastly, the research did not control the organization size. Because large firms typically have more available resources and well developed GSCM practices, organization size should be controlled (Zhu and Sarkis, 2004). Dean and Snell (1991) indicate that full-time employees can represent firm size. In this regard, future research should control organization size with the number of full-time employees.

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Appendix A

The Survey Questionnaire

Question No.1 ~ No.19

The questions are about the green supply chain practices. Please weigh up the questions, and choose your organization's status of each green supply chain practice.

1. Commitment of GSCM from senior managers

Very Bad	Bad	Poor	Neither Good nor Bad	Fair	Good	Very Good

2. Support for GSCM from mid-level managers

Very Bad	Bad	Poor	Neither Good nor Bad	Fair	Good	Very Good

3. Cross-functional cooperation for environmental improvements

Very Bad	Bad	Poor	Neither Good nor Bad	Fair	Good	Very Good

4. Total quality environmental management

Very Bad	Bad	Poor	Neither Good nor Bad	Fair	Good	Very Good

5. Environmental compliance and auditing programs ISO 14001 certification

Very Bad	Bad	Poor	Neither Good nor Bad	Fair	Good	Very Good

6. Providing design specification to suppliers that include environmental requirements for purchased item

Very Bad	Bad	Poor	Neither Good nor Bad	Fair	Good	Very Good

7. Cooperation with suppliers for environmental objectives

Very Bad	Bad	Poor	Neither Good nor Bad	Fair	Good	Very Good

8. Environmental audit for suppliers' internal management

Very Bad	Bad	Poor	Neither Good nor Bad	Fair	Good	Very Good

9. Consideration of Suppliers' ISO14000 certification

Very Bad	Bad	Poor	Neither Good nor Bad	Fair	Good	Very Good

10. Second-tier supplier environmentally friendly practice evaluation

Very Bad	Bad	Poor	Neither Good nor Bad	Fair	Good	Very Good

11. Cooperation with customer for eco-design

(Eco-design: design of a product with special consideration for the environmental impacts of the product during its whole lifecycle.)

Very Bad	Bad	Poor	Neither Good nor Bad	Fair	Good	Very Good

12. Cooperation with customers for cleaner production

Very Bad	Bad	Poor	Neither Good nor Bad	Fair	Good	Very Good

13. Cooperation with customers for green packaging

Very Bad	Bad	Poor	Neither Good nor Bad	Fair	Good	Very Good

14. Investment recovery (sale) of excess inventories/materials

(Investment recovery: disposing off obsolete, scrap, surplus, or waste goods or material in a manner that maximizes the return while minimizing the costs and liabilities)

Very Bad	Bad	Poor	Neither Good nor Bad	Fair	Good	Very Good

15. Sale of scrap and used materials

Very Bad	Bad	Poor	Neither Good nor Bad	Fair	Good	Very Good

16. Sale of excess capital equipment

(Capital equipment: Equipment that you use to manufacture a product, provide a service or use to sell, store and deliver merchandise.

Very Bad	**Bad**	**Poor**	**Neither Good nor Bad**	**Fair**	**Good**	**Very Good**

17. Design of products for reduced consumption of material/energy

Very Bad	**Bad**	**Poor**	**Neither Good nor Bad**	**Fair**	**Good**	**Very Good**

18. Design of products for reuse, recycle, recovery of material, component parts

Very Bad	**Bad**	**Poor**	**Neither Good nor Bad**	**Fair**	**Good**	**Very Good**

19. Design of products to avoid or reduce use of hazardous products and/or their manufacturing process

Very Bad	**Bad**	**Poor**	**Neither Good nor Bad**	**Fair**	**Good**	**Very Good**

Question No.20 ~ No.41

Please weigh up the questions, and choose your best answer.

20. After establishment of GSCM, Total Cost has increased.

Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree

21. After establishment of GSCM, Distribution Cost has increased.

Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree

22. After establishment of GSCM, Manufacturing Cost has increased.

Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree

23. After establishment of GSCM, Inventory Cost has increased.

Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree

24. After establishment of GSCM, Return on Investment (ROI) has increased.

Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree

25. After establishment of GSCM, Sales (Total Revenue) has increased.

Strongly Disagree	**Disagree**	**Somewhat Disagree**	**Neither Agree nor Disagree**	**Somewhat Agree**	**Agree**	**Strongly Agree**

26. After establishment of GSCM, Profit (Total revenue less expenses) has increased.

Strongly Disagree	**Disagree**	**Somewhat Disagree**	**Neither Agree nor Disagree**	**Somewhat Agree**	**Agree**	**Strongly Agree**

27. After establishment of GSCM, On-time Deliveries has increased.

Strongly Disagree	**Disagree**	**Somewhat Disagree**	**Neither Agree nor Disagree**	**Somewhat Agree**	**Agree**	**Strongly Agree**

28. After establishment of GSCM, Backorder/Stockout has increased.

Strongly Disagree	**Disagree**	**Somewhat Disagree**	**Neither Agree nor Disagree**	**Somewhat Agree**	**Agree**	**Strongly Agree**

29. After establishment of GSCM, Customer Response Time has increased.

Strongly Disagree	**Disagree**	**Somewhat Disagree**	**Neither Agree nor Disagree**	**Somewhat Agree**	**Agree**	**Strongly Agree**

30. After establishment of GSCM, Manufacturing Lead Time has increased.

Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree

31. After establishment of GSCM, Shipping Error has increased.

Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree

32. After establishment of GSCM, Customer Complaints has increased.

Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree

33. After establishment of GSCM, the ability to change the output level of products produced has increased.

Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree

34. After establishment of GSCM, the ability to change planned delivery dates has increased.

Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree

35. After establishment of GSCM, the ability to change the variety of products produced has increased.

Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree

36. After establishment of GSCM, the ability to introduce and produce new products (this includes the modification of existing products) has increased.

Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree

37. What is your job title?

Product Manager	Supply Chain Manager	Logistics Manager	Sales Manager	Manufacture Manager	Etc.

38. What is your organization industry classification?

Construction	Manufacturing	Electronics	Service	Etc.

39. What is the primary business goal?

Produce Own Brand	Outsourcing	Suppliers to major corporation	Etc.

40. What is the number of permanent employees in your organization?

1~299	300~499	500~699	700~899	900~

41. How long has your organization established GSCM?

Considering it currently	It has been 1 year.	It has been 2 years.	It has been 3 years.	It has been more than 4 years.