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RESEARCH ARTICLE

Research on the Relationship between Green Supply Chain Management and Corporate Sustainable Performance in Manufacturing Enterprises

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ARTICLE INFO	ABSTRACT
	In order to clarify the relationship between green supply chain management (GSCM) and sustainable performance of manufacturing enterprises, and to explore the intrinsic links between green innovation and environmental regulation, we analyze the impacts of green purchasing, green manufacturing, and green recycling in GSCM on the sustainable performance of enterprises, as well as the role mechanisms of green innovation and environmental regulation in GSCM, starting from the three main practices of green purchasing, green manufacturing, and green recycling in GSCM. Based on 405 valid questionnaires from manufacturing enterprises in the Pearl River Delta region of Guangdong Province, the hypotheses were empirically tested using SPSS and AMOS software, which indicated that green procurement, green manufacturing and green recycling included in green supply chain management have a significant positive effect on the sustainable performance of enterprises, while green innovation has a partially intermediary role, and environmental regulation has a positive moderating effect. Environmental regulation has a positive moderating effect. When implementing green supply chain management and promoting green innovation, enterprises should fully consider the impact of environmental regulations and actively seek cooperation with stakeholders to achieve higher levels of sustainable performance. It provides more effective coping strategies and practical guidance for enterprises in the changing market environment.
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INTRODUCTION

Against the backdrop of increasingly severe global climate change and environmental pollution problems, the Chinese government has proposed to unswervingly implement the concept of green and low-carbon development, and made clear China's goal of reducing carbon emissions to achieve carbon neutrality by 2060. By implementing green supply chain management, enterprises can not only reduce environmental pollution, but also enhance their market competitiveness and sustainable development ability(Khan et al., 2019a, 2019b).The manufacturing industry, as one of the major carbon emission industries, needs to strengthen the research and practice of carbon emission control and emission reduction technologies to make positive contributions to the realization of carbon neutrality and climate improvement（zhang，2021）. Green supply chain management, as a new type of management, reduces resource consumption, pollution emission and waste generation through the implementation of environmental protection measures in the whole process of raw material procurement, manufacturing, logistics and distribution, and realizes a "win-win" situation for the economy and the environment (Cheema et al., 2020).

Nowadays, manufacturing enterprises are involved in more complex supply chain networks and need to withstand pressure from different aspects, especially government environmental regulations,

which put forward higher requirements for enterprises, which undoubtedly creates challenges to the development of enterprises (Laari et al., 2018). Affected by government environmental regulations, enterprises have to make adjustments to the traditional supply chain, integrate green management concepts into practical work, carry out green innovation, continuously expand sustainable inputs, and launch more sustainable products or services. At present, scholars have explored the association between green supply chain management and enterprise performance from various perspectives and produced many useful research conclusions. The research mainly focuses on the relationship between green supply chain management and sustainability performance, and many researchers point out that green supply chain management can help to improve the sustainable performance of enterprises and enhance their competitive advantages. Generally speaking, green supply chain management, that is, effective collaboration with upstream and downstream enterprises in the supply chain, pays close attention to environmental protection matters in all links and processes, minimises resource consumption, achieves the goals of economic, environmental and social benefits, and promotes the long-term healthy operation and development of enterprises and the supply chain. Xiong et al. (2023) pointed out that enterprises can significantly improve their sustainable performance through green innovation and supply chain management under environmental regulations, both to meet legal requirements and to promote the long-term development of enterprises.Zhang et al. (2018) emphasised that under the dual pressure of market and policy, the implementation of green supply chain management strategies by enterprises not only contributes to environmental protection, but also enhances their market competitiveness, thus improving their sustainable performance.Panigrahi et al. (2019) emphasised that, with the tightening of global climate policies and the increase in environmental standards, manufacturing enterprises need to improve their sustainable performance through green supply chain practices to reduce carbon emissions and optimise resource efficiency to improve corporate environmental sustainability.

As environmental issues are more and more emphasised, more and more scholars in the academic world have begun to pay attention to enterprises' green supply chain management and corporate sustainable performance against the background of increasingly stringent environmental protection policies and fierce market competition. However, there are still not many empirical research results on the intrinsic relationship between external factors, green supply chain management and enterprise sustainable performance, which need to be explored at the theoretical level to guide the management practice of enterprises. This study takes Chinese manufacturing enterprises as the research object to explore whether the sustainable performance of enterprises is affected by green supply chain management and external factors of enterprises, such as environmental regulations and green innovation activities, and to clarify their mutual influence mechanisms.

LITERATURE REVIEW AND RESEARCH HYPOTHESIS

Green supply chain management and sustainable business performance

Green supply chain management refers to a management approach that focuses on reducing negative environmental impacts, improving resource efficiency, and promoting green innovation by integrating the concepts of environmental protection and sustainable development within the framework of supply chain management (Rakhmawati et al.,2019) .Tantan and Akdağ (2023) state that green supply chain management covers, for example, green procurement, green packaging, recycling, eco-design, internal environmental management, reverse logistics, green production, green marketing, and environmental co-operation with suppliers and customers, which are interrelated and together constitute the overall framework of green supply chain management. In this study, we refer to the research results of scholars and select the three main practices of green supply chain management: green procurement, green manufacturing and green recycling, taking into account the characteristics of the manufacturing industry. Enterprise sustainable performance refers to the performance of enterprises in pursuing economic benefits while taking into account environmental protection and social responsibility. The core concept is that enterprises should not only focus on short-term financial performance, but also optimise the use of resources, reduce environmental burdens, and promote social progress in order to achieve long-term sustainable development, which is defined by Carter and Rogers (2008) as the ability to achieve economic, environmental and social performance in the supply chain at the same time .

Geng et al. (2017) stated that the economic efficiency of enterprises can be improved by implementing green supply chain management. On the one hand, green supply chain management can reduce the cost of consumables as well as pollution control during production and operation, and prevent economic penalties for violating current legal regulations. On the other hand, green activities such as green design and purchasing can help enterprises to build a quality corporate image and cater to the preferences and needs of customers and the market for green protection in order to gain a larger market share and higher economic benefits.Samad et al. (2021) pointed out that green purchasing, co-operation with customers in the green field, and environmental performance have a positive association, and the above activities can promote the adoption of ecologically appropriate modes of co-existence between enterprises and customers, while avoiding the need for enterprises to adopt The above activities can promote the adoption of appropriate ecological mode of co-existence with customers, while avoiding irreparable damage to the environment, thus improving the environmental performance of enterprises. Huo et al. (2023) studied and analysed the impact of green supply chain management on the social performance of different types of enterprises. It was found that the implementation of green supply chain management can enhance corporate social responsibility, improve employee satisfaction, promote sustainable social development, and have a positive impact on social performance. As a result, the following hypotheses are made:

H1: Green supply chain management significantly and positively affects corporate sustainable performance.

Green supply chain management and green innovation

Green innovation refers to innovative activities achieved through optimizing production processes, reducing energy consumption and lowering waste emissions. Enterprise green innovation not only improves environmental performance, but also brings about the improvement of economic and social performance, which improves the overall enterprise sustainable performance level. Li and Tang (2014) argued that enterprises in the process of carrying out economic and environmental benefits appear to improve the quality of the environment and enhance the creative activities of the product, to a certain extent, is conducive to the promotion of sustainable development can be called green innovation. Zhao et al. (2024), in the context of the manufacturing industry, argued that in the process of manufacturing design, production and manufacturing, technology creation activities to eliminate the negative consequences of pollution and resource waste are called green innovation . The overall goal of green supply chain management is to reduce environmental impacts and improve resource utilization efficiency in the supply chain, including product design, production, marketing, and logistics. And green innovation refers to new technologies and services introduced to mitigate climate change and protect the environment, etc. Raza et al. (2023) considered green supply chain management as an effective and environmentally friendly business management practice. Based on institutional theory and dynamic capability theory, the research results found that the coercive pressure, normative pressure, and imitative pressure implemented by green supply chain management are sufficient conditions to promote green innovation.Hu et al. (2021) concluded that the impact of proactive green supply chain management on green innovation is higher than that of reactive green supply chain management, and that the impact of green supply chain management on green innovation varies depending on the learning situation and national green orientation has an enhancing effect on the relationship between green supply chain management and green innovation. Thus, the hypothesis is:

H2: Green supply chain management significantly and positively affects green innovation.

Green innovation and sustainable business performance

Through green innovation, firms can develop environmentally friendly products and services and reduce the consumption of resources and impact on the environment, thus realizing the goal of sustainable development.Tantayanubutr and Panjakajornsak (2017) study examined the impact of green innovation on the sustainable performance of the food industry in Thailand, and found that green innovation can enhance the overall corporate sustainable performance of firms by reducing the production cost, improving the resource utilization efficiency and enhancing firm competitiveness to improve the overall corporate sustainable performance of firms.Wang and Yang (2021), through a survey of manufacturing firms, found that green innovation not only helps to

reduce environmental pollution and resource wastage, but also enhances the economic performance of firms by improving production efficiency and product quality. In addition, green innovation enhances the social responsibility and public image of enterprises, which leads to higher social performance. Fernando et al. (2019) showed that green innovation not only involves the development of new products and processes, but also includes the optimization of management processes and the enhancement of employees' environmental awareness. There is a significant positive correlation between a company's investment in green innovation and its sustainable corporate performance. As a result, the following hypotheses are made:

H3: Green innovation significantly and positively affects corporate sustainable performance.

The mediating role of green innovation

From the previous literature, it can be seen that in green supply chain management activities, the Porter's Hypothesis suggests that good environmental regulation can stimulate firms to engage in green innovation practices, which will affect sustainable performance in the long run. Therefore, green innovation can be viewed as a mediator between green supply chain management and sustainable firm performance. Novitasari and Agustia (2021) investigated the relationship between green innovation and sustainable firm performance in SMEs in an emerging economic environment from the perspectives of green innovation and green supply chain management. The data were analyzed using partial least squares structural equation modeling. The results showed that green innovation mediates between green supply chain management and sustainable firm performance. Seman et al. (2019) found a significant positive relationship between green supply chain management and green innovation as well as sustainable firm performance. Green supply chain management further enhances the enterprise's corporate sustainable performance by promoting green innovation. Green supply chain management can effectively promote green innovation activities of enterprises, thus significantly improving their economic, environmental and social performance. As a result, the following hypotheses are made:

H4: Green innovation has a mediating effect between green supply chain management and corporate sustainable performance.

The regulatory role of environmental regulation

Institutional theory suggests that firms' behaviors and decisions are influenced by the external institutional environment, including laws, regulations, policies, and social norms. In green supply chain management, environmental regulation, as an important institutional factor, can significantly influence firms' green supply chain management practices and sustainable firm performance. Clemens and Douglas (2006) indicated that environmental regulation has a moderating effect on firms' resource and environmental management practices. This suggests that institutional factors such as government regulations, industry standards, and societal expectations can influence firms' decisions and behaviors in resource and environmental management. Institutional pressures can motivate firms to adopt more stringent environmental management practices to meet regulatory requirements and societal expectations, thereby enhancing their resource utilization efficiency and environmental performance. Wei and Wang (2022) studied the textile, automotive, and tobacco industries and found that environmental regulations significantly moderated the relationship between green supply chain management and sustainable economic performance, suggesting that the strength of environmental regulations can influence the implementation of green supply chain practices. Overall, several studies have shown that environmental regulations play an important role in moderating the relationship between green supply chain management and sustainable business performance, which is supported by studies from different regions and industries. As a result, the following hypotheses are made:

H5: Environmental regulation has a moderating effect between green supply chain management and corporate sustainable performance.

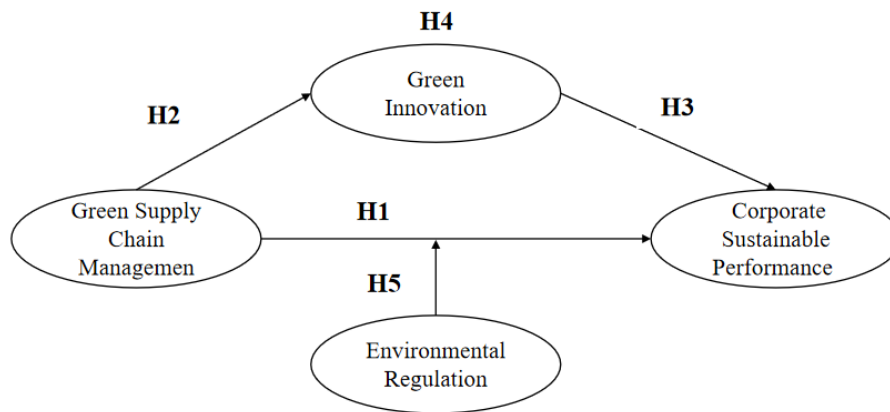The theoretical framework of the study is shown in Figure 1.

Figure 1: Theoretical framework diagram

METHODOLOGY

Data collection and sample selection

The Pearl River Delta region of Guangdong Province is one of the most economically developed regions in China, concentrating a large number of manufacturing enterprises. These enterprises have more practical experience and cases in green supply chain management and green innovation, which can provide rich data support. In this study, enterprises in the manufacturing industry in the Pearl River Delta region were used as the research object, and the respondents were selected as middle-level managers (workshop supervisors, department managers, etc.) and top-level managers (factory managers, general managers, presidents, etc.) of the enterprises, and the questionnaires were recovered in phases. Zhu and Geng (2009) argued that middle and senior managers have a comprehensive understanding of the overall operation, strategic planning, and management decisions of an enterprise. Questionnaire anti-bias measures were carried out to reduce bias by means of pre-survey instructions, anonymous and honest completion by respondents, and commitment to confidentiality of questionnaire results. The questionnaire was designed with reference to mature scales at home and abroad, while some questions were modified or expanded in accordance with the specific needs of this study. After the completion of the first draft of the questionnaire, academic experts and senior managers of enterprises in the fields of green supply chain management, equipment manufacturing, innovation management and enterprise management were invited to evaluate the questionnaire. The questionnaire was modified and adjusted according to the review comments and then the official questionnaire was distributed. A total of 500 questionnaires were issued and 450 questionnaires were retrieved. Deleting the questionnaires with short answer time and incomplete information, 405 valid questionnaires were retrieved, with an effective recovery rate of 81.00%. Characteristics of managers: middle managers accounted for 67.65%, top managers accounted for 32.35%; the number of people with 3-5 years and more than 5 years of work accounted for 36.79% and 42.47% respectively, while the number of people with less than 3 years of work accounted for 20.74%; the proportion of undergraduate university degree is the highest, accounting for 44.2%, followed by university college degree, accounting for 33.09%. The proportion of those with master's degree and above is lower, only 14.32%. And the proportion of college degree or below is the lowest, accounting for 8.4%; business nature: state-owned enterprises accounted for 31.85%, private enterprises accounted for 31.11%, foreign-funded enterprises accounted for 24.2%, and Sino-foreign equity joint ventures accounted for 12.84%; enterprise size (number of employees): the size of the enterprises participating in the survey is mainly concentrated in the range of 300-1000 people, accounting for 52.35%. The second is enterprises with more than 1,000 employees, accounting for 19.26%, and the smallest enterprise size is below 300 employees, accounting for 28.4%. Among the industries belonging to, the food processing manufacturing industry accounts for the highest proportion of 19.26%, followed by general equipment manufacturing industry, accounting for 13.58%. Textile and Garment Manufacturing, Transportation Equipment Manufacturing, Biochemical Medical Manufacturing, and Petrochemical Manufacturing accounted for 13.33%, 12.1%, 10.62%, and 10.37% respectively. The proportion of other industries is relatively low, all below 10%.

Measurement scale

The questionnaire was designed using a 5-point Likert scale, with "1" very dissatisfied, "2" dissatisfied, "3" fair, "4" satisfied, and "5" very satisfied. "satisfied and "5" very satisfied. The related variables and specific measurement entries are described as follows: (1) Green supply chain management scale, with reference to the research results of scholars such as Wang and Luo (2010), includes three dimensions of green procurement, green manufacturing and green recycling, with a total of 12 question items. (2) Corporate Sustainable Performance Scale, with reference to Zhu (2009), Tantan and Akdağ (2023) research, with 9 items. (3) Green Innovation Scale, with reference to Ma et al. (2016), Yi and Xue (2016) study, with 4 items. (4) Environmental regulation scale, with reference to the studies of Hu and Yang (2018) and Cong and Hu (2019), with 4 items.

DATA ANALYSIS AND RESULTS

Reliability and correlation analysis

As can be seen from Table 1, the KMO of green procurement, green manufacturing, green recycling, green innovation, environmental regulation, and corporate sustainable performance is maximum 0.952 and minimum 0.820. The Cronbach alpha reliability coefficients are all greater than 0.8 and minimum 0.852. the factor loadings are minimum 0.714, and the overall reliability value of the questionnaire is 0.935, thus indicating that the data quality of the study's reliability is qualified, and the level of reliability meets the standard, which comprehensively indicates that the data reliability quality is high. This shows that the internal consistency of the scale is good and can be used for further analysis.

Table 1: Cronbach's reliability analysis

Variable	Markings	KMO	Cronbach α	Minimum factor loading
Green Procurement	GP	0.825	0.852	0.752
Green Manufacturing	GM	0.826	0.854	0.751
Green Recycling	GR	0.826	0.856	0.748
Green Innovation	GI	0.820	0.927	0.760
Environmental Regulation	ER	0.828	0.861	0.763
Corporate Sustainable Performance	CSP	0.952	0.860	0.714

From the analysis of variable correlation coefficients in Table 2, GP, GM, GR, GI, ER and CSP are all positively correlated, and the variables are all significant at the 1% level. The correlation coefficient analysis of the variables shows that the green supply chain management practices of enterprises are positively correlated with green innovation and sustainable performance of enterprises, and the average variance extraction AVE values of the six factors are all greater than 0.5, and the combined reliability CR values are all higher than 0.7, and the square root of AVE is higher than that of the correlation coefficient matrix, which implies that the data of the present analysis has a good aggregation (convergence) and discriminant validity, and the data of this analysis are suitable for for subsequent research analysis and theory construction.

Table 2: Analysis of variable correlation coefficients

	GP	GM	GR	GI	ER	CSP
GP	0.768					
GM	0.426**	0.770				
GR	0.370**	0.387**	0.774			
GI	0.426**	0.372**	0.456**	0.765		
ER	0.405**	0.424**	0.363**	0.427**	0.779	
CSP	0.403**	0.429**	0.439**	0.463**	0.392**	0.778
AVE	0.590	0.593	0.599	0.607	0.605	0.585
CR	0.852	0.854	0.857	0.861	0.860	0.927
* $p<0.05$、 ** $p<0.01$，Square root of AVE on diagonal line						

Hypothesis testing

Structural equation modeling is a method for building, estimating and testing causal models. It can replace multiple, through-trail analysis, factor analysis, analysis of covariance and other methods to clearly analyze the role of single indicators on the whole and the interrelationship between single indicators. In this paper, structural equations are used for testing, and the unstandardized path coefficient model is shown in Figure 2.
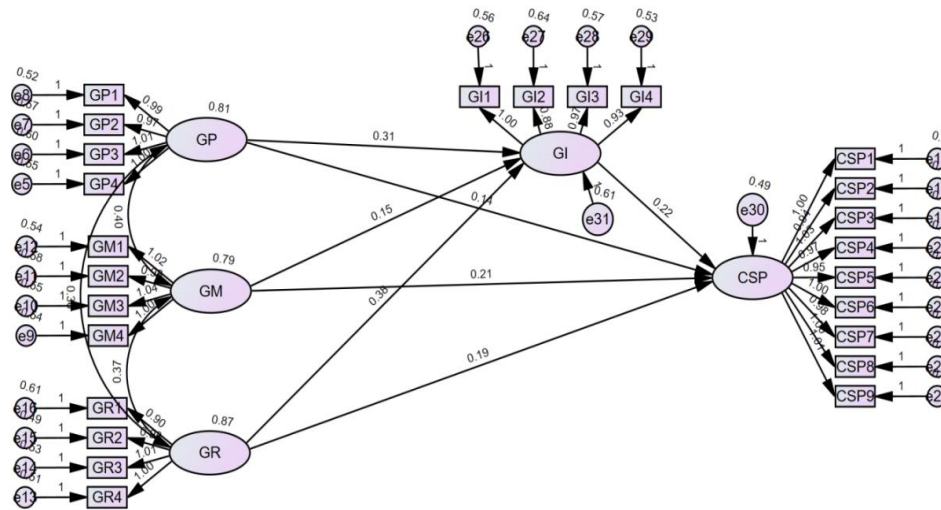

Figure 2: Unstandardized path coefficient model

The model fit is shown in Table 3, and the overall model test results from CFA factor analysis show that the CMIN/DF value is 1.232, which is less than the fitness criterion of 3-5, and the RMSEA value is 0.024, which is less than the critical value of 0.08, whereas the values of the statistical test quantities GFI, AGFI, NFI, TLI, IFI, and CFI have reached the fitness criterion of 0.9 or more, which indicates that this model has a better fitness.

Table 3: Indicators of model fit

Adaptation index	CMIN/DF	RMSEA	GFI	AGFI	NFI	IFI	TLI	CFI
Adaptation Standards	$<$3-5	$<$0.08	$>$0.85	$>$0.9	$>$0.9	$>$0.9	$>$0.9	$>$0.9
Test results	1.232	0.024	0.936	0.922	0.943	0.989	0.987	0.989
Adaptation Decision	match	Match	match	match	match	match	match	match

Direct effect test

According to the path coefficients of structural equation modeling, green purchasing has a significant positive impact on corporate sustainable performance (non-standard path coefficient of 0.140, $P = 0.021 < 0.05$). Green manufacturing has a significant positive effect on corporate sustainable performance (non-standard path coefficient is 0.215, $P < 0.001$). Green recycling has a significant positive effect on corporate sustainable performance (non-standard path coefficient of 0.195, $P < 0.001$). Therefore, the research hypothesis H1: green supply chain management significantly and positively affects corporate sustainable performance, the hypothesis is established. Green procurement has a significant positive effect on green innovation (non-standard path coefficient is 0.305, $P < 0.001$). Green manufacturing has a significant positive effect on green innovation (non-standard path coefficient of 0.155, $P = 0.028 < 0.05$). Green recycling has a significant positive effect on green innovation (non-standard path coefficient is 0.379, $P < 0.001$). Therefore, the research hypothesis H2: Green supply chain management significantly and positively affects green innovation is hypothesized. Green innovation has a significant positive effect on corporate sustainable performance (non-standard path coefficient is 0.223, $P < 0.001$), and research hypothesis H3: green

innovation significantly positively affects corporate sustainable performance, the hypothesis is established.

Table 4: Structural equation modeling path coefficients

Path			Non-standard path factor	S.E.	C.R.	*P*	Standardized path factor
CSP	<---	GP	.140	.060	2.312	.021	.140
CSP	<---	GM	.215	.061	3.546	***	.212
CSP	<---	GR	.195	.059	3.312	***	.202
GI	<---	GP	.305	.070	4.384	***	.276
GI	<---	GM	.155	.070	2.199	.028	.138
GI	<---	GR	.379	.066	5.757	***	.354
CSP	<---	GI	.223	.057	3.935	***	.248

Intermediation effect test

As shown in Table 5, Amos's Bootstrap method was used to mediate the paths "Green Purchasing => Green Innovation => Corporate Sustainable Performance" and "Green Manufacturing => Green Innovation => Corporate Sustainable Performance" for this model, "Green Recycling=>Green Innovation=>Enterprise Sustainable Performance" are analyzed.

Table 5: Intermediation effects

	c	A	b	a*b	c*	Effectiveness ratio formula	Effect Percentage of	Test Conclusion
Green Purchasing => Green Innovation => Corporate Sustainable Performance	0.21	0.28	0.25	0.07	0.14	a * b / c	50.00%	intermediary
Green Manufacturing => Green Innovation => Corporate Sustainable Performance	0.25	0.14	0.25	0.04	0.21	a * b / c	16.67%	intermediary
Green Recycling=>Green Innovation=>Enterprise Sustainable Performance	0.29	0.35	0.25	0.09	0.20	a * b / c	43.75%	intermediary

Summarizing the above data, c* ≠ 0, the mediating paths "Green Purchasing => Green Innovation => Corporate Sustainable Performance", "Green Manufacturing => Green Innovation => Corporate Sustainable Performance", "Green Recycling => Green Innovation = >enterprise sustainable performance" are partially mediated, the research hypothesis H4: green innovation has a mediating effect between green supply chain management and enterprise sustainable performance, the hypothesis is valid.

Moderating effect test

In this study, for the test of moderating effect, the statistical test was conducted by using the second-order interaction regression method, which requires that the interaction term between the independent variable and the moderating variable has a significant regression effect on the dependent variable. Therefore, the moderating effect is divided into three models to carry out the study, and Model 1 includes the independent variable. Model 2 includes the moderating variable on the basis of model 1, and model 3 includes the interaction term (the product term of the independent variable and the moderating variable) on the basis of model 2. To ensure data and model stability, the independent variable (green supply chain management) and the moderating variable (environmental regulation) are centered in this study, and the dependent variable (corporate sustainable performance) is not treated. Model 1 includes the independent variable (green supply chain management). Model 2 includes the moderator variable (environmental regulation) based on Model 1, and Model 3 includes the interaction term (the product term of the independent variable and the moderator variable) based on Model 2.

Table 6: Moderating role of environmental regulation in green supply chain management and firms' sustainable performance

	Model 1	Model 2	Model 3
Math.	3.309** (78.863)	3.309** (81.882)	3.245** (74.836)
GSCM	0.382** (8.852)	0.277** (6.094)	0.252** (5.567)
ER		0.253** (5.696)	0.224** (5.041)
GSCM*ER			0.163** (3.700)
sample size	405	405	405
R 2	0.163	0.225	0.251
Align R 2	0.161	0.221	0.245
F	F (1,403)=78.367 p=0.000	F (2,402)=58.463 p=0.000	F (3,401)=44.770 p=0.000
△R 2	0.163	0.063	0.026
△F	F (1,403)=78.367 p=0.000	F (1,402)=32.445 p=0.000	F (1,401)=13.691 p=0.000

Note: Dependent Variable = Corporate Sustainable Performance * $p<0.05$ ** $p<0.01$ Inside the parentheses is the t-value

The moderating effect can be viewed in two ways, the first is to view the significance of the change in the F-value from Model 2 to Model 3; the second is to view the significance of the interaction term in Model 3, and this time, we analyze the moderating effect in the second way. As can be seen from Table 6, the interaction term between green procurement and environmental regulation shows significance (t=3.700, p=0.000<0.05). It means that the magnitude of the effect of the moderating variable (environmental regulation) is significantly different at different levels when the green supply chain management has an impact on the sustainable performance of the company, which can be viewed through the next simple slope diagram. The simple slope diagram shows the difference in the magnitude of the impact of green purchasing on firms' sustainable performance at different levels of the moderating variable environmental regulation. First of all, environmental regulation at different levels means that the environmental regulation takes the mean, mean + standard deviation, and mean - standard deviation; i.e., Z takes the average, high level, and low level in three cases.
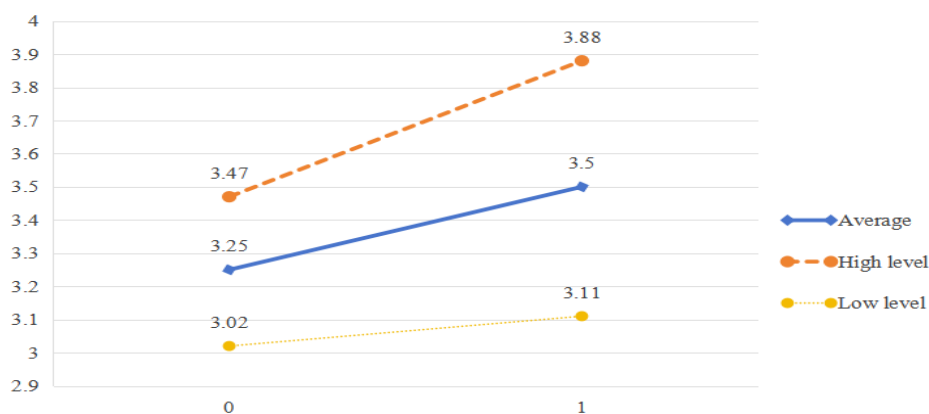

Figure 3: Moderating effects test

The impact on the sustainable performance of the firm is compared for the size of the slope of the straight line. For example, in Figure 3, the slope is significantly larger at high levels and significantly smaller at low levels. That is to say, at a high level of environmental regulation, the impact of green purchasing on the sustainable performance of enterprises is significantly larger; at a low level of environmental regulation, the impact of green purchasing on the sustainable performance of enterprises is relatively small. In summary, H5: Environmental regulation has a moderating effect between green supply chain management and corporate sustainable performance, and the hypothesis is valid.

DISCUSSION

Conclusions

This study provides new ways for manufacturing enterprises to develop green supply chain management for sustainable enterprise performance, and the main conclusions obtained are as follows:

(1)Enterprises must incorporate green supply chain management into their strategic decisions in order to achieve long-term sustainable development. Only through the systematic implementation of green procurement, green manufacturing and green recycling can enterprises realize economic benefits while enhancing their social and environmental responsibility, thus gaining a lasting competitive advantage in the market.

(2) The significant positive impact of green innovation on the sustainable performance of enterprises is not only reflected in the enhancement of economic benefits, but also in its contribution to environmental protection and fulfillment of social responsibility. Enterprises should pay more attention to green innovation in their strategy and actively explore the development path of green products and services.

(3) Green procurement, green manufacturing and green recycling play an important role in promoting green innovation, and the positive relationship among the three shows that enterprises can effectively promote green technology and product innovation when implementing green supply chain management.

(4) Green innovation has a partial mediating effect between green supply chain management and enterprise sustainable performance. Green procurement, green manufacturing and green recycling all enhance the sustainable performance of enterprises by promoting green innovation.

(5) Environmental regulation plays a significant moderating role in the relationship between green supply chain management and corporate sustainable performance. Strong environmental policies and regulations not only push firms to actively implement green procurement, green manufacturing and green recycling, but also encourage them to inject more innovation and resources into these practices.

Implications

This study provides an in-depth analysis of the relationship between green supply chain management, green innovation, environmental regulation and corporate sustainable performance, and draws a number of important managerial insights that can provide guidance for manufacturing companies in implementing sustainable development strategies.

(1) Enterprises should actively promote green supply chain management practices such as green procurement, green manufacturing and green recycling. These practices can not only directly improve the sustainable performance of enterprises, but also further enhance the performance by promoting green innovation.

(2) Green innovation is a key driver for realizing sustainable development. Companies should invest in R&D and innovation, encourage employees to come up with green innovation ideas, and establish an open innovation culture. Managers should develop incentives to encourage cross-departmental collaboration to improve the efficiency of green technology and product development.

(3) Enterprises should actively adapt to environmental regulations, viewing them as an opportunity to enhance competitiveness rather than a mere compliance burden. When formulating business strategies, companies can incorporate environmental regulations into their decision-making process and look for innovative solutions that are in line with regulations. In addition, firms can create a favorable brand image and enhance their competitiveness in the market by going beyond the minimum regulatory requirements.

This study has the following limitations:

> (1) Limitations of the study scope. This study focuses on manufacturing companies in specific regions and may not fully reflect the situation in other industries or regions. Different

industries, cultures, and economic backgrounds may lead to differences in green supply chain management practices and their impact on sustainable performance. Therefore, future studies should consider expanding the scope of the sample to obtain more generalized conclusions.

(2) Limitations of data collection method. This study used convenience sampling method to collect data, which may lead to sample selection bias, thus affecting the representativeness of the findings. Nevertheless, convenience sampling is still common in exploratory research. Future studies may consider using random or stratified sampling methods to improve the representativeness and reliability of data.

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