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THE IMPACT OF GREEN SUPPLY CHAIN MANAGEMENT PRACTICES ON ENVIRONMENTAL PERFORMANCE

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ABSTRACT

This study examines the effect of GSCM Practices on Environmental Performance in Bangladesh. The research method used for the study is quantitative, and the data collection technique for the primary data is a structured questionnaire. The survey was carried out with 400 respondents from various manufacturing organizations. The questionnaire was split into two sections: demographic questions and statements about green supply chain management practices, environmental sustainability outcomes and organizational performance. Partial least squares is used to analyze structural equation modeling. The results of the study revealed that Green Supply Chain Continuous Improvement (GSCCI) was the most influential construct in the model, with a very significant positive effect on the Manufacturing Firms' Performance (MFP) ($\beta = 0.628$, $t = 27.308$, $p < 0.001$). Green Supply Chain Execution (GSCE) had an extremely strong positive relationship with Manufacturing Firms' Performance in the model and was one of the other constructs that influenced the model. Green Supply Chain Execution (GSCE) was one of the other constructs that influenced the model, with an extremely strong positive relationship with Manufacturing Firms' Performance. Therefore, organizations need to consider green supply chain management (GSCM) as their strategic measure for implementing the sustainable business development.

Keywords: Green Supply Chain Continuous Improvement; Green Supply Chain Management, Environmental Performance.

1.0 INTRODUCTION

In recent years, the world has seen a radical shift in business, as the need to protect the environment, conserve resources and meet the demands of various stakeholders for corporate sustainability has intensified. The traditional supply chain management paradigm, focused on cost efficiency and operational performance, has shifted to include environmental considerations and sustainability goals. The development of this has led to the emergence of a new concept: Green Supply Chain Management (GSCM), which involves embedding environmental considerations into the operations of supply chain management such as product design, material procurement, production, transportation, distribution and end-of-life management of products (Sarkis, 2003).

In recent years, the concept of GSCM has attracted significant interest from practitioners and academics, owing to the strategic role of environmental sustainability in sustaining the long-term viability and competitive advantage of organizations. Climate change, environmental degradation and resource depletion have become a major challenge for businesses that have to

tackle both the environmental issues and their economic goals and the expectations of the stakeholders. The pressure from the regulators, consumers' demand for environmentally friendly products, and the possible cost reduction in supply chain resource use have further hastened the implementation of green practices (Zhu & Sarkis, 2006).

The application of GSCM practices involves a variety of activities such as green procurement, eco-design, cleaner production, reverse logistics and carbon footprint management. These practices are designed to minimize the impact of the activity on the environment, while ensuring the efficient and profitable operation of the business. The benefit of a successful GSCM practice is that there is a potential for both environmental and economic benefits, which can be seen as a 'win-win' scenario (Porter & van der Linde, 1995).

2.0 LITERATURE REVIEW

The idea of Green Supply Chain Management (GSCM) is not a random creation; it's the result of a development process that has added an environmental dimension to the traditional focus of Supply Chain Management (SCM) on efficiency. Traditional SCM (Supply Chain Management) is described as the systematic and strategic integration of the traditional business functions and the tactics between these business functions within the same company and between businesses within the SC to enhance the long-term performance of the individual company and the SC as a whole (Mentzer et al., 2001). In the past, the main objective of SCM was to lower costs, increase efficiency, and improve operational performance, such as through just-in-time (JIT) inventory, lean manufacturing, and logistics optimisation.

In parallel with the emergence of SCM, the second half of the 20th century saw the emergence of environmental management as a business function, which was stimulated by the command-and-control regulatory approach. This "end-of-pipe" approach saw environmental compliance as a cost centre where attention was paid to remediation and pollution control once the pollution was 'made' (Hart, 1995). The concept of the "Natural-Resource Based View" (NRBV) of the firm, which brought about a significant change toward a more proactive and integrated approach, started with the conceptualisation of the concept. In chapter five, Hart (1995) suggested that companies might be able to obtain sustainable competitive advantages by strategically managing their relations with the natural environment. This vision made environmental responsibility not a constraint, but a possible source of value creation and directly associated with the firm's strategy and capabilities.

Thus, the integration of two areas of study, namely Supply Chain Management (SCM) and strategic environmental management (SEM), introduced GSCM. Sarkis (2003, p. 267) gave a simple definition of GSCM, which is "the inclusion of environmental thinking in the management of the supply chain from product design to the final delivery of the product to the consumer, as well as the end-of-life management of the product after its useful life. The importance of this definition lies in the fact that it highlights the cradle-to-grave (or cradle-to-cradle) responsibility, which brings environmental aspects beyond the premises of the factory to include the whole product life cycle and all the upstream and downstream players. This integration makes the supply chain more circular than the linear value chain, aiming to reduce the environmental footprint at all stages and generate economic value (Seuring & Goldmann, 2001).

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Internal GSCM Practices are activities under the direct control of the organization. Eco-Design or Design for Environment (DfE) is one of the fundamental practices. This includes incorporating environmental aspects into the design process, such as using less or non-toxic materials, designing for disassembly, improving energy efficiency, and reducing waste generation (Boks, 2006). Another practice that is important at the in-house level is the Green Manufacturing, or cleaner production, which seeks to minimise the environmental footprint of production processes by modifying technology, processes and practices to prevent pollution at its source (de Oliveira et al., 2018). This includes initiatives like reducing energy and water consumption, minimising emissions, and managing hazardous substances. Reverse logistics is another practice that is both internal and external and involves the management of product returns, recycling, reuse and the proper disposal of end-of-life products. It is one of the pillars of the circular economy and is about converting waste flows into value flows (Rogers & Tibben-Lembke, 2001).

External GSCM practices extend beyond the firm's walls and into its partners' supply chains. Green purchasing, or sustainable procurement, is a basic external practice in which the organization considers environmental aspects in purchasing and chooses suppliers based on their environmental performance and commitment to sustainability (Carter & Carter, 1998). This can include working with suppliers to encourage them to take steps to improve their own environmental performance. Green Logistics and distribution emphasises minimising the environmental footprint of the transportation and warehousing activities, such as optimising routes, using alternative fuels, and efficient packaging (Sbihi & Eglese, 2010). Last but not least, Cooperation with customers on environmental matters, which can include providing information on correct product use and disposal or offering take-back schemes, is part of the external dimension (Zhu et al., 2008). These practices are adopted step by step or in stages. Based on their study of 80 companies, Zhu et al. (2008) came up with a model that suggests that firms will generally start with internal, reactive practices (e.g., adjusting to regulations) and will gradually evolve to more external, proactive and strategic practices (e.g., engaging with customers in green solutions) as their capability and commitment grow.

Although the literature is vast, several gaps remain that this thesis seeks to address. First, although it is generally agreed that GSCM has a positive effect on performance, the mechanisms by which this effect is realised need better understanding. More granular investigation is needed into the “black box” of how specific GSCM practices translate into specific performance outcomes. Second, these relationships are context-dependent, which has not been explored much. The effects of GSCM can be highly industry-specific, size-specific, and nation-specific, but a generalised approach is needed (Walker et al., 2008). Third, the social dimension of GSCM outcomes is not as well researched as the economic and environmental dimensions, and this is a gap in the understanding of GSCM outcomes in the context of sustainability. Finally, while theories such as RBV and Institutional Theory offer good explanations, more comprehensive models are needed to explain the multifaceted interaction of internal resources and external pressures in influencing the process of GSCM adoption and performance.

To conclude this chapter, the author has examined the underlying principles of GSCM, its main practices and documented results of the application of this concept to the performance of organisations. It has brought the main theoretical approaches to the study of this phenomenon

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to the fore. The gaps identified in the literature highlight the need for additional research, and the direction of this research will be explained in the following chapters of this thesis as the methodological approach and specific investigations.

2.1 Hypothesis Development

Hypothesis (H1): Green procurement (GP) has a significant positive impact on manufacturing firms' environmental performance (MFP)

Hypothesis (H2): Green supply chain continuous improvement (GSCCI)has a significant positive impact on manufacturing firms' environmental performance (MFP)

Hypothesis (H3): Green supply chain execution (GSCE)has a significant positive impact on manufacturing firms' environmental performance (MFP)

Hypothesis (H4): Implementation of comprehensive Green Supply Chain Practices (GSCP) has a significant positive impact on manufacturing firms' environmental performance (MFP)

Hypothesis (H5): Institutional pressures (IP) have a significant positive impact on manufacturing firms' environmental performance (MFP)

3.0 METHODOLOGY

The study mainly adopts the quantitative research method, with the data obtained by structured questionnaires and analysed using statistical analysis. This questionnaire included statements related to green supply chain management practices, environmental sustainability outcomes, organisational performance, and demographic questions. Respondents rated their opinions on a five-point Likert scale, from strongly disagree to agree strongly. This research design enables the researcher to systematically examine the data and identify patterns/hypotheses and relationships among variables.

3.1 Data Collection Method

Data collection is a crucial process in any research study. To ensure the reliability and validity of the study, the primary data was used in this research. The primary data were gathered from the respondents using a structured questionnaire. The questionnaire was created to collect data on the implementation of green supply chain management practices and the results of their implementation on organisational performance and sustainability outcomes.

The questionnaire had two parts. The first part included details on gender, age, education, role in the workplace, and work experience. The second section contained statements related to green supply chain management practices and organisational performance. The level of agreement was indicated on a five-point Likert scale.

This was followed by the collection of secondary data from different sources, including academic journals, books, research articles and online publications related to green supply chain management and sustainability. These sources provided theoretical support and background information for the study.

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3.2 Population and sample

The population for the study is the employees of the supply chain department of manufacturing companies in Chattogram. Their first-hand knowledge of the supply chain activities (procurement, production, distribution, logistics, etc) makes them the most suitable candidates for bringing in their insight and feedback on the purpose of the study. A structured questionnaire will be used to gather primary data, which will include relevant data regarding the performance of supply chains, including 400 employees, using convenience sampling to ensure a representative cross-section of the employees in the supply chain. The goal of this study is to obtain in-depth information about the challenges and performance metrics of the supply chain operations through the responses obtained from this sample. Ethical data collection and in-depth analysis of the selected participants will be ensured, as they will be contacted to take part in the survey voluntarily.

The respondents were selected through the convenience sampling method because of time constraints and resources. The researcher was able to gather data from the easily accessible and willing respondents by using this method. The respondents selected are in various positions in an organization ranging from top management to middle management to the officer level. The diversity allows for acquiring wider knowledge of green supply chain practices in companies.

Once the data has been gathered, it needs to be analysed to make sense of it and get meaningful results. This study used simple statistical tools to analyse the collected data. The data were analysed to present frequency and percentage distributions of responses in tables. Smart PLS is used for predictive modeling and structural analysis.

3.3 Variables

The elements or characteristics that are measured or observed in a research study are variables. In this study, variables could be divided into two groups: independent variables and dependent variables, which are used to analyze the relationship between green supply chain management practices and organisational performance and sustainability outcomes.

3.4 Independent Variables

Independent variables are the factors that influence or affect the dependent variables. In this research, the independent variables include:

- Green Procurement (GP)
- Green Supply Chain Continuous Improvement (GSCCI)
- Green Supply Chain Execution (GSCE)
- Green Supply Chain Planning (GSCP)
- Institutional Pressures (IP)

These variables represent the practices organisations adopt to promote environmental sustainability and improve operational efficiency. The study examines how these green practices influence organisational performance.

3.5 Dependent Variables

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Dependent variables are the outcomes that are affected by the independent variables. In this study, the dependent variable is Organisational Performance.

These variables help measure the impact of green supply chain management practices on organisational success and sustainability. The research aims to determine whether organisations that implement green practices experience improvements in performance and environmental outcomes.

3.6 Measurement instruments'

In the study in Table 1, a questionnaire using Likert scale questions (1 – strongly disagree, 5 – strongly agree) was used to assess the attitudes of the respondents. This approach enabled the quantitative data to be gathered and subsequently analysed using statistical methods to look for patterns and trends. The questionnaire was developed based on the Nazir et al. (2025) procedures.

Table 1: Variable description

Variable	Items Description
Green Procurement (GP)	In your opinion, how seriously does the industrial sector take the need to integrate sustainability into supply chain management?
Green Procurement (GP)	From your vantage point, how do you think manufacturing companies may see the beneficial effects of green procurement?
Green Procurement (GP)	What, in your view, is the significance of green buying procedures for manufacturing firms?
Green Supply Chain Continuous Improvement (GSCCI)	How much do manufacturing companies recognise the significance of constantly improving green supply chain practices?
Green Supply Chain Continuous Improvement (GSCCI)	In light of the possible benefits to manufacturing companies, how may people see the ongoing development of environmentally friendly supply chain practices?
Green Supply Chain Continuous Improvement (GSCCI)	What do you think the significance of green supply chain continuous improvement strategies for manufacturing firms?
Green Supply Chain Continuous Improvement (GSCCI)	In what ways may manufacturing companies save money via the implementation of more environmentally friendly supply chain practices?
Green Supply Chain Continuous Improvement (GSCCI)	Could you tell me how your organization feels about the need of continuously improving our supply chain's environmental performance?
Green Supply Chain Execution (GSCE)	What kind of beneficial effects do you think manufacturing companies might have on the environment if they implemented green supply chain execution?
Green Supply Chain Execution (GSCE)	If manufacturing companies used green supply chain methods, how do you think their environmental performance would improve overall?

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Green Supply Chain Execution (GSCE)	If manufacturing companies were to implement a green supply chain, how would you think their reputation would be affected?
Green Supply Chain Planning (GSCP)	What is your opinion on the potential effect of green supply chain planning on manufacturing enterprises' environmental impact?
Green Supply Chain Planning (GSCP)	How might green supply chain planning help manufacturing companies become more environmentally sustainable in general, in your view?
Green Supply Chain Planning (GSCP)	What role, in your opinion, should green supply chain planning play in helping manufacturing companies save money?
Green Supply Chain Planning (GSCP)	When it comes to manufacturing enterprises and environmental standards, how do you think green supply chain planning impacts compliance?
Green Supply Chain Planning (GSCP)	When it comes to environmental performance in particular, how do you think manufacturing companies will do in the long run if they implement green supply chain planning?
Institutional Pressures (IP)	The local government's environmental legislation will have an effect on our company's green environmental management.
Institutional Pressures (IP)	Our organization has adopted green practices in response to the growing environmental concern of our customers.
Institutional Pressures (IP)	When developing its green supply chain procedures, does the manufacturing business take into account the varying expectations of stakeholders such as regulatory agencies, consumers, and industry associations?
Institutional Pressures (IP)	Strict government requirements about recycling, environmental protection, and consumer rights protection force our business to embrace green methods.
Institutional Pressures (IP)	When developing its green supply chain management strategies and procedures, does the manufacturing business take into account external expectations and industry norms?
Manufacturing Firms' Performance (MFP)	How much do you think manufacturing companies' green supply chain management methods improve environmental performance, especially when it comes to resource efficiency?
Manufacturing Firms' Performance (MFP)	In what ways may manufacturing companies benefit from green supply chain management techniques that aim to decrease resource usage and waste?
Manufacturing Firms' Performance (MFP)	How much do you think environmentally conscious supply chain management methods help make manufacturing processes more efficient and cost-effective?
Manufacturing Firms' Performance (MFP)	How would you put into words the general consensus on the role that industrial companies may play in polluting the environment?
Manufacturing Firms' Performance (MFP)	To what extent do you think manufacturing companies can secure their long-term viability by adopting green supply chain management practices?

4.0 RESULTS

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4.1 Demographic Information

The demographic profile of the respondents gives a clear picture of the participants of this study on the effect of Green Supply Chain Management (GSCM) Practices on organisational performance. A total of 400 valid responses were received from the professionals in the supply chain departments of manufacturing companies in Chattogram. The respondents are a diverse group with different backgrounds, experiences and educational backgrounds, and the data collected are representative of a wide spectrum of views important to the research objectives.

Table 2: Gender of the Respondent

Gender	Frequency	Percentage
Male	282	70.5%
Female	118	29.5%
Total	400	100%

As seen in Table 2, 70.5% of the respondents were males and 29.5% were females. This distribution shows that more men are employed in the manufacturing sector studied than women at this time. But the appearance of female respondents suggests that women are still active in supply chain activities and sustainable positions in the industrial sector of Bangladesh.

Table 3: Age Group of Respondents

Age Group	Frequency	Percentage
20–30 Years	112	28%
31–40 Years	160	40%
41–50 Years	80	20%
Above 50 Years	48	12%
Total	400	100%

As far as age is concerned, the highest percentage, 40%, was for people aged 40. This indicates that a large number of the participants are working in the middle of their careers and have experience with supply chain activities. Twenty-eight per cent of respondents were between 20 and 30 years of age. Forty-eight (12%) respondents were older than 50 years of age. This age distribution indicates that the labour force is mainly active and directly engaged in operational and management aspects concerning green supply chain practices.

4.2 Data Quality Check Procedure

Obvious point: sample size is important for PLS-SEM and should be above 200. Our study's sample size is 400, confirming that this criterion might hinder the utilisation of PLS-SEM. In addition, we benefit from the large sample size and statistical power. A loading factor ≥ 0.55 is considered significant. This enhances the strength of our analysis and interpretation, thus making our research findings more credible. We conducted tests to examine the presence of multicollinearity by assessing Variance Inflation Factor (VIF) values shown in Table 4. The

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results showed no multicollinearity among the variables in this study, as all VIF values were below 5.

The Variance Inflation Factor (VIF) statistics for individual items measuring the different constructs in this Green Supply Chain Management (GSCM) are presented in this table. It includes data for separate variables such as Green Purchasing (GP), Internal and External GSCM Practices (GSCCI, GSCE), general Green Supply Chain Practices (GSCP), Innovation Performance (IP), and Market and Financial Performance (MFP). The VIF scores range from 1.957 to 4.933.

Table 4: Collinearity statistics (VIF)

Collinearity statistics (VIF)	VIF
GP1	4.604
GP2	4.412
GP3	3.153
GSCCI1	4.108
GSCCI2	3.504
GSCCI3	3.747
GSCCI4	3.870
GSCCI5	4.805
GSCE1	4.385
GSCE2	3.837
GSCE3	4.700
GSCP1	4.787
GSCP2	2.057
GSCP3	2.937
GSCP4	4.457
GSCP5	2.233
IP1	4.714
IP2	3.071
IP3	4.492
IP4	3.177
IP5	3.529
MFP1	4.933
MFP2	4.845
MFP3	1.957
MFP4	4.197
MFP5	3.322

From a statistical perspective, these values show that multicollinearity does not exist between these variables. A commonly accepted standard for the VIF in regression analysis is < 5.0. This

implies that the items in each group are lowly correlated because they measure the same underlying phenomenon. For instance, the VIF scores for item GSCCI5 are essentially the same as for GSCCI4, so there is a vast inflation effect.

4.3 Reliability and validity

In quantitative research, the metrics of validity and reliability play a crucial role in guaranteeing the accuracy and reliability of the data. Cronbach's alpha is used to assess the reliability for each variable. Convergent validity (AVE) is the degree of common variance shared among the items within a construct, which shows the consistency of the items' measurements of the construct. Cronbach's alpha and AVE are both very important measures for the assessment of the quality of measurement instruments and constructs in research studies. Another measure, composite reliability, looks at the consistency of the items to determine the extent to which each observed variable corresponds to the underlying construct.

Table 5: Reliability and validity measures.

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
GP	0.932	0.935	0.956	0.879
GSCCI	0.974	0.975	0.980	0.908
GSCE	0.966	0.966	0.978	0.936
GSCP	0.969	0.970	0.976	0.891
IP	0.964	0.965	0.972	0.873
MFP	0.976	0.976	0.981	0.911

Reliability and validity of the measurement model were assessed by Cronbach's Alpha (α), Composite Reliability (CR) and Average Variance Extracted (AVE). These provide measures of the internal consistency, convergent validity and overall reliability of each construct. The Cronbach's Alpha and Composite Reliability values of more than 0.70 suggest good reliability, and AVE values exceeding 0.50 indicate that the construct accounts for more than 50% of the variance in its indicators, as recommended by Cronbach (1970) and Kaiser (1956).

As shown in Table 5, all constructs meet or exceed the acceptable criteria, indicating high reliability and validity for the overall model.

The Cronbach's Alpha (0.932), Composite Reliability ($\rho_a = 0.935$; $\rho c = 0.956$) and AVE (0.879) values are excellent and show high internal consistency and convergent validity of Green Procurement (GP). The results show that the GP items consistently measure sustainable sourcing and procurement practices.

Green Supply Chain Continuous Improvement (GSCCI) also exhibits excellent reliability, as Cronbach's Alpha is found to be 0.974, the Composite Reliability is 0.975 for α and 0.980 for c, and the AVE is 0.908. The value is due to the high internal consistency and has been validated as a valid measure of continuous initiatives for environmental improvement in the supply chain operations.

The measurement properties of the construct Green Supply Chain Execution (GSCE) are very good: Cronbach's Alpha = 0.966, Composite Reliability (ρ_a = 0.966, ρc = 0.978) and AVE (AVE = 0.936). These figures show that the indicators reliably measure the implementation of environmentally sustainable practices in the supply chain.

The reliability and validity of Green Supply Chain Planning (GSCP) are also high, as shown by Cronbach's alpha (0.969), Composite Reliability (ρ_a = 0.970; ρc = 0.976), and AVE (0.891). The results indicate that the construct is consistently related to strategic environmental planning and green operational decision-making.

All Cronbach's Alpha scores (0.964), Composite Reliability (ρ_a = 0.965; ρc = 0.972) scores, and AVE scores (0.873) exceed the recommended thresholds, indicating that the construct is reliable and conceptually sound for measuring regulatory, competitive, and societal pressures that affect organisational environmental practices.

Finally, the Cronbach's alpha (0.976), Composite Reliability (ρ_a = 0.976; ρc = 0.981), and AVE (0.911) values of Manufacturing Firms' Performance (MFP) are excellent. High values show that the construct has a very high level of consistency in relation to organisational, operational and environmental outcomes.

The overall result shows that the measurement model has high internal consistency and convergent validity. All constructs show acceptable reliability and validity, providing a solid basis for further testing of the structural model and hypotheses.

4.4 Outer loadings

The outer loadings were examined for each observed indicator to assess the degree of correlation between each indicator and its corresponding latent construct. Outer loadings represent the correlation between each measurement item and the construct that it represents. For a sample size of 100, loading factor values above 0.55 are considered statistically significant. For n=400, loading factor values greater than 0.55 are considered to be high.

Table 6: Outer loadings of the construct

	GP	GSCCI	GSCE	GSCP	IP	MFP
GP1	0.945					
GP2	0.940					
GP3	0.928					
GSCCI1		0.932				
GSCCI2		0.946				
GSCCI3		0.961				
GSCCI4		0.964				
GSCCI5		0.960				
GSCE1			0.971			
GSCE2			0.973			

GSCE3			0.959			
GSCP1				0.937		
GSCP2				0.955		
GSCP3				0.949		
GSCP4				0.916		
GSCP5				0.960		
IP1					0.914	
IP2					0.953	
IP3					0.920	
IP4					0.945	
IP5					0.939	
MFP1						0.954
MFP2						0.964
MFP3						0.952
MFP4						0.957
MFP5						0.946

As revealed from the results presented in Table 6, all the items in the tool have high reliability and have been proven to have high convergent validity, indicating that the items are well measured.

Green Procurement (GP): All three items (GP1 = 0.945, GP2 = 0.940, GP3 = 0.928) have very high loadings, validating their compatibility with the construct and sustainable sourcing practices.

Green Supply Chain Continuous Improvement (GSCCI): All five of the indicators are over 0.90, meaning that there is a good level of measurement reliability: GSCCI1 (0.932), GSCCI2 (0.946), GSCCI3 (0.961), GSCCI4 (0.964) and GSCCI5 (0.960).

Green Supply Chain Execution (GSCE): Items for this construct also show high reliability and consistent, very high loadings for GSCE1 (0.971), GSCE2 (0.973), and GSCE3 (0.959).

The outer loadings for all five items of Green Supply Chain Planning (GSCP) are very high (0.937, 0.955, 0.949, 0.916 and 0.960), indicating that this construct is well represented by its indicators.

The IP construct also shows high reliability, with loadings between 0.914 and 0.953. IP2 (0.953) and IP4 (0.945) are the highest indicators, indicating that the items capture very well the essential parts of external regulatory and societal expectations.

Manufacturing Firms' Performance (MFP): For this construct, all five indicators—MFP1 (0.954), MFP2 (0.964), MFP3 (0.952), MFP4 (0.957), and MFP5 (0.946)—far exceed the 0.70 threshold. This creates a high level of reliability and indicates that the respondents consistently relate green practices to increased environmental and operational performance.

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Overall, the outer loading results validate that the outer loadings of all constructs in the model have good measurement reliability. All the items measure the constructs they are designed to measure, with a foundation for further reliability and validity testing.

4.5 Discriminant Validity

The discriminant validity was tested with the Fornell-Larcker criterion to make sure that each latent variable in the model is independent of the other latent variables. The approach is to assign the highest variance to the construct to which the indicators belong and the lowest variance to the other constructs in the structural model. In terms of Fornell and Larcker, the square root of the Average Variance Extracted (AVE) of each construct is greater than the highest correlation between constructs, which indicates that the constructs have discriminant validity.

Table 7: Fornell-Larcker criterion

	GP	GSCCI	GSCE	GSCP	IP	MFP
GP	0.938					
GSCCI	0.901	0.953				
GSCE	0.918	0.954	0.968			
GSCP	0.927	0.861	0.882	0.944		
IP	0.897	0.849	0.867	0.935	0.934	
MFP	0.903	0.960	0.943	0.881	0.865	0.955

The results of the analysis are as follows:

GP (Green Procurement): The square root of the AVE is 0.938, which is higher than its correlations with GSCCI (0.901), GSCE (0.918), GSCP (0.927), IP (0.897), and MFP (0.903).

GSCCI (Green Supply Chain Continuous Improvement) has a higher square root of the AVE than its correlations with other constructs, such as GSCE (0.954), GSCP (0.861), and IP (0.849).

The square root of the AVE is 0.968, a value larger than that of its correlation with GSCP (0.882), IP (0.867) and MFP (0.943).

GSCP (Green Supply Chain Planning): The square root of the AVE value is 0.944, which is higher than the one GSCP achieves with IP (0.935) and MFP (0.881).

The square root of the AVE is 0.934, and this is higher than the correlation of the AVE with the MFP of 0.865; this is for IP (Institutional Pressures).

The square root of the AVE is 0.955, or the MFP (Manufacturing Firms' Performance).

To summarise, the square roots of the AVE (bolded numbers) are greater than the correlations between the constructs (numbers in the off-diagonal positions). The results indicate that all constructs (GP, GSCCI, GSCE, GSCP, IP, and MFP) have high discriminant validity, meaning

they represent distinct concepts and constructs within the research model. This provides a strong foundation for further structural analysis and hypothesis testing.

4.6 Structural Model and R-Square Analysis

The structural model was created to examine the relationships between independent variables (Green Procurement (GP), Green Supply Chain Continuous Improvement (GSCCI), Green Supply Chain Execution (GSCE) and Green Supply Chain Planning (GSCP)) and Manufacturing Firms' Performance (MFP) as the dependent variable. Path coefficients reflect the magnitude and direction of the relationships, and R-square values reflect the per cent of variance in the dependent variable accounted for by the independent constructs.

Table 8: R-square Overview

	R-square	R-square adjusted
MFP	0.936	0.936

The statistically accepted value of 0.75 is considered a high level of predictive ability, 0.50 is considered moderate, and 0.25 is considered low. Based on the results of the PLS-SEM model, the combined effect of the dimensions of green supply chains significantly explains organisational performance outcomes.

The value for Manufacturing Firms' Performance (MFP) is 0.936, and the adjusted value is 0.936. Therefore, the independent variables used in the model can explain 93.6% of the variation in the performance of the firms. This is a very high value, indicating high predictive accuracy and a good model fit.

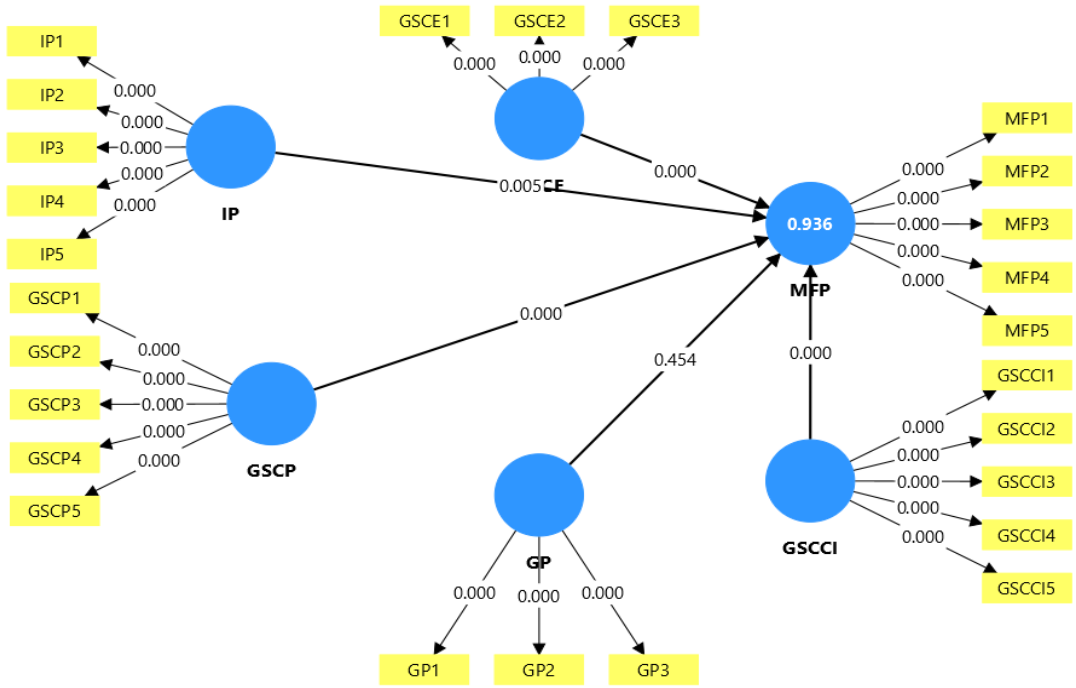

Fig 1: Coefficient of the construct

This observation indicates that green activities, especially activities in the field of continuous improvement, procurement and execution, have a significant impact on the overall performance of manufacturing companies. The explanatory power means that the implementation of planning and executing activities in an environmentally friendly manner creates a significant impact on improving the efficiency and optimisation of activities. These are consistent with the study results, which show that the application of the comprehensive green supply chain practices has a positive effect on the performance of the company and reduces the adverse effects on the environment. The results validate that the green supply chain management is a vital factor for attaining better organisational and environmental performance of manufacturing companies in Chattogram.

4.7 Hypothesis Testing

The findings of the hypothesis test using the Partial Least Squares Structural Equation Modeling (PLS-SEM) are presented in this section. The relationships among the dimensions of Green Supply Chain Management (GSCM) and the overall Manufacturing Firms' Performance (MFP) are analysed, which are Green Procurement (GP), Green Supply Chain Continuous Improvement (GSCCI), Green Supply Chain Execution (GSCE), and Green Supply Chain Planning (GSCP). The study also evaluates the influence of Institutional Pressures (IP) as a significant factor in performance. The significance and strength of each hypothesised relationship were determined using the path coefficient (β), t-statistics, and p-value. In the context of statistics, a path is said to be statistically significant if its Probability value (p) is less than 0.05. The results show that all hypothesised relationships are statistically significant, thus proving the relevance of the green supply chain management practices to improve the organisational performance.

Table 9: Total effects Mean, STDEV, T values, p values

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
GP -> MFP	0.215	0.216	0.021	4.749	0.034
GSCCI -> MFP	0.628	0.628	0.023	27.308	0.000
GSCE -> MFP	0.183	0.183	0.026	7.099	0.000
GSCP -> MFP	0.122	0.121	0.021	5.784	0.000
IP -> MFP	0.045	0.045	0.016	2.800	0.005

The construct that has the most influence on Manufacturing Firms' Performance (MFP) is Green Supply Chain Continuous Improvement (GSCCI) with a very strong positive effect ($\beta = 0.628$, $t = 27.308$, $p < 0.001$). The findings show that continuous work to improve environmental management and make the supply chain more sustainable is paramount to organisational success and better performance results.

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The positive influence of Green Procurement (GP) on Manufacturing Firms' Performance (MFP) is significantly positive ($\beta = 0.215$, $t = 4.749$, $p = 0.034$). This confirms that the manufacturing industry's efforts to include sustainability considerations in the procurement process and to choose suppliers that are environmentally responsible make a significant contribution to the overall performance of the organization.

There is also a strong and significant positive correlation between Green Supply Chain Execution (GSCE) and MFP ($\beta = 0.183$, $t = 7.099$, $p < 0.001$). The findings suggest that the green practice (incorporation and execution) within the manufacturing process has positive effects on the environment and organization efficiency.

The Green Supply Chain Planning (GSCP) has a positive and significant effect on the Manufacturing Firms Performance (MFP) ($p<0.001$, $\beta=0.122$, $t=5.784$). This suggests that strategic planning for green initiatives is an important element in attaining environmental sustainability and cost savings for manufacturing companies.

Lastly, the institutional pressures (IP) have a significant positive association with MFP ($\beta = 0.045$, $t = 2.800$, $p = 0.005$). Although the coefficient is lower than that of the other predictors, it indicates that adhering to regulatory, customer, and industry expectations influences green practices, which is a critical element of long-term sustainability and performance.

In general, the results of the hypothesis test showed that, in this model, the variables of Green Supply Chain Continuous Improvement and Green Procurement can be concluded as the main variables which determine the manufacturing performance. The results highlight the significance of an integrated GSCM approach, one where strategic planning, ethical purchasing and ongoing improvements in operating processes all contribute to overall organisational and environmental success.

5.0 FINDINGS

The study reveals that green supply chain planning is positively correlated with the performance of manufacturing companies. The study establishes a positive correlation between green procurement and the business performance of manufacturing companies. This implies that adopting environmentally friendly procurement processes has a beneficial impact on the overall organisational performance. The study concludes that green supply chain execution is positively related to the performance of manufacturing companies. This suggests that adoption of environmentally sustainable practices in the entire supply chain has a positive impact on the firm's performance and decreases the magnitude of negative effects on the environment. The study indicates that there is a positive correlation between the green supply chain management practices and manufacturing firm performance. This means that moving to greener supply chain practices positively impacts organisational performance. The research shows that the continuous improvement of green supply chain performance is positively related to the performance of manufacturing companies. This underscores the importance of continued efforts to improve the environmental sustainability of a firm, affecting overall firm performance. The results show that institutional pressure significantly influences the performance of manufacturing firms. This means external pressures such as regulatory and societal pressures affect the way that GSCM practices affect organisational performance.

5.1 Recommendations

To improve environmental performance, manufacturing companies should adopt a holistic strategy that includes investing in eco-friendly technologies, working with suppliers on sustainable sourcing, implementing environmental management systems such as ISO 14001 certification, conducting life cycle assessments to assess environmental impacts, and investing in green logistics and transportation. The use of renewable energy systems, energy-efficient machinery, and waste-reduction technologies are key strategies for reducing energy use, emissions, and resources used by companies, and help them comply with environmental regulations and lower their carbon footprints. Matching suppliers to environmental responsibility, auditing regularly, and implementing sustainable sourcing criteria address both normative pressures from environmentally conscious consumers and regulatory requirements. The use of EMS frameworks and execution of LCAs allow for tracking, measuring and enhancing environmental performance within the supply chain, which meets society's expectations of sustainability.

6.0 CONCLUSION

The concept of Green Supply Chain Management has emerged as a crucial approach for companies seeking to tackle economic and environmental sustainability. The results from this study suggest that many organisations are in the process of shifting to more environmentally responsible supply chain practices, including environmentally responsible supplier selection, waste reduction, utilisation of environmentally friendly materials and energy-efficient logistics practices. These practices not only help create a healthier environment but also make the organization more efficient, deliver short-term cost savings, and build a more positive corporate image. Furthermore, green efforts enhance customer satisfaction and trust, promoting long-term organisational success. Hence, efforts towards developing and implementing green supply chain management practices must be sustained within the organisations' sustainability drive. In the future, research can be carried out to see the effect of green supply chain management in various industries and regions and become more detailed about its benefits and challenges.

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