

The Relationship Between Green Supply Chain Integration and Sustainable Performance Among Manufacturing Firms in Malaysia

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Abstract

Green Supply Chain Management (GSCM) involves integrating environmental considerations into all stages of the supply chain process, including product design, material sourcing, production, and distribution to customers. In line with this, Green Supply Chain Integration (GSCI) has been introduced to align the environmental management practices of manufacturers, suppliers, and customers. Despite its importance, the adoption of GSCI practices remains limited, resulting in missed opportunities to optimize resource usage, reduce waste generation, and lower carbon emissions, all of which are critical for achieving sustainable performance objectives. This study aims to provide a deeper understanding of how green supply chain integration impacts sustainable performance. Specifically, the research focuses on examining the relationships between supplier integration, customer integration, internal integration, logistics integration, technology integration, and sustainable performance. The study targeted manufacturing companies in Johor Bahru that hold the Malaysian Standard (MS) ISO 14001 certification. A quantitative research approach is utilized, with data collected through a structured questionnaire distributed to management and operational staff in the manufacturing sector. Data analysis will be conducted using the Statistical Package for Social Sciences (SPSS). The anticipated findings of this research are expected to offer valuable insights for management, supporting them in achieving environmental objectives while maintaining high performance in response to demands from stakeholders, customers, and environmental regulations.

1. Introduction

Supply chain management (SCM) has garnered growing interest from industry professionals due to its role in strategic planning for the design, maintenance, and operation of supply chain processes. Although SCM has led to substantial advancements, some organizations have neglected environmental challenges such as global energy, global warming, reverse logistics, and ecological concerns in the context of global competition. Green supply chain management (GSCM) has arisen in response to growing environmental concerns in recent decades, aiming to adhere to standards for environmental protection (Alreahi *et al.*, 2023). Sustainability is an excellent method of conducting business, and one of the most important aspects of the transition process to sustainability is the development of a corporate culture that is both inventive and constructive through the introduction of integration

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(Mingaleva *et al.*, 2022). These strong organizational cultures can enhance performance and maximize the efficient use of existing resources, leading to positive economic, environmental, and societal outcomes (Shabbir & Kassim, 2018). Achieving economic, environmental, and social sustainability will ensure satisfaction among shareholders, suppliers, customers, employees, and the broader society. The GSCM is widely seen as a crucial management tool for enhancing sustainable performance, especially in manufacturing firms. The GSCM encompasses all aspects of supply chain management that must adhere to environmental protection regulations (Nazir *et al.*, 2024). Manufacturers must use Green Supply Chain Integration (GSCI) to include environmental management principles throughout their companies, as well as with their suppliers and customers (Ahmed Khamis al Naqbi *et al.*, 2018). This action will enhance inter-firm cooperation and encourage mutual GSCM as well as influence the firm's sustainable performance (Omar *et al.*, 2019).

Limited adoption of GSCI practices impedes the optimization of resource usage, minimization of waste generation, and reduction of carbon footprint, all of which are critical for achieving sustainable performance goals. Moreover, the lack of comprehensive GSCI adoption undermines Malaysia's progress towards achieving its sustainability targets outlined in initiatives such as the Sustainable Development Goals (SDGs) and the National Strategic Plan for Environmental Sustainability (NPS). Without effective integration of green practices into supply chain management, manufacturing firms in Malaysia risk falling short of these targets, thereby hindering the country's overall sustainable development agenda (Wong *et al.*, 2023). GSCI involves integrating environmental management practices within manufacturing firms and with their suppliers and customers to enhance inter-firm cooperation and encourage mutual GSCM, which can influence firms' sustainable performance (Afum *et al.*, 2020). However, studies have found that the implementation of GSCM and GSCI practices in Malaysia still requires further research. There is a need to explore the conceptualization of GSCI by enriching it with new variables like logistic integration and technology integration and examining their relationships with sustainable performance (Hassan, Akanmu, *et al.*, 2018). In response to this need, it has been determined that this study is required in order to bridge the gap on the GSCM, specifically with regard to the relationship between GSCI practices and the impact they have on sustainable performance. Consequently, the purpose of this study is to investigate the conceptualization of the GSCI by incorporating additional elements of technology integration and logistic integration, as well as the correlations between these variables and sustainable performance.

The study focused on Malaysian Standard (MS) ISO (International Organization for Standardization) 14001 certified manufacturing firms in Johor Bahru, Malaysia. The reason for choosing Johor Bahru because the strategic geographical location of Johor Bahru, its close proximity to Singapore, and its role as a prominent logistics and transportation center contribute to its attractiveness as a central location for research (Munir *et al.*, 2021). The target respondents are employees of managerial or executive level in manufacturing positions because they have knowledge of GSCI practices and have the authority to decisions making on manufacturing in Johor Bahru.

2. Literature Review

2.1 Manufacturing Firms and Environmental Issues

Manufacturing firms refer to as manufacturing companies or industrial enterprises, are organizations that are involved in the creation of commodities using procedures such as raw material processing, assembly, fabrication, or packaging. These firms generally operate in industries such as automotive, electronics, food and beverage, medicines, and consumer products, among others. Manufacturing firms are essential to the economy as they transform raw materials or components into finished products that are then sold to customers or other businesses.

Collaboration with stakeholders and the adoption of innovative capabilities have been highlighted as important drivers for manufacturing firms to respond effectively to sustainability pressures (Jakhar *et al.*, 2020). By engaging in sustainable operations management practices and leveraging environmental capabilities, firms can gain a competitive advantage while addressing environmental concerns (Swalehe *et al.*, 2020). Furthermore, the implementation of sustainable practices, such as energy-efficient scheduling and renewable energy usage, can contribute to reducing energy consumption and making manufacturing processes more environmentally sustainable (RANI, 2019; Utama *et al.*, 2020).

2.2 Green Supply Chain Integration (GSCI)

Green Supply Chain Integration (GSCI) is a strategic approach that involves the collaboration of internal and external stakeholders to address environmental concerns throughout the supply chain. GSCI encompasses both intra-organizational and inter-organizational processes, aiming to reduce negative environmental impacts and achieve sustainability goals. It involves integrating environmental objectives into a firm's strategic and operational management system, emphasizing coordination and cooperation among different departments to address environmental issues through information exchange and resource sharing (Holmberg, 2015).

GSCI contributes to environmental sustainability performance, with green supply chain management improving operational and financial performance through environmental performance (Hou, 2022). Fulfilling green contracts within supply chain networks can enhance profitability and sustainability. It is essential to measure green supply chain management performance to improve company performance through implemented improvements (Jamaluddin & Saibani, 2021). The application of green supply chain management strategies can result in green products, reducing environmental pollutants and waste while saving energy and resources (Aziziankohan, 2017).

2.2.1 Supplier Integration

According to Halili & Fernando (2019), supplier integration practices, such as supplier selection, development, and performance review, have a significant impact on economic, social, and environmental sustainability performance within the supply chain. Successful supplier integration is essential for successful production ramp-up and plays a crucial role in bridging the gap between production ramp-up and supplier integration in new product development (Wlazlak *et al.*, 2019). Supplier integration is a key component of green supply chain management and firm performance, contributing to sustainability and environmental objectives (Duoming & Chin, 2022). A strategic supply management reference model for supplier integration in the supply chain has been proposed to improve supply chain practices (Tarigan *et al.*, 2021).

2.2.2 Customer Integration

A customer refers to an individual or organization that obtains goods or services and has the freedom to choose from multiple suppliers and product options. Within the supply chain context, customers encompass merchandisers, retailers, wholesalers, online retailers and end consumers. In the context of GSCM, customer integration involves environmental collaboration between a focal company and its customers to address their environmental requirements. This concept emphasizes the downstream segment of the supply chain. It reflects the degree to which GSCM practices are adopted for environmental planning, management, and finding solutions to environmental challenges (Hassan, Abindin, *et al.*, 2018).

2.2.3 Internal Integration

Internal integration is crucial for streamlining operations, enhancing efficiency, and achieving environmental objectives within an organization (Bokrantz *et al.*, 2020). Many firms are moving towards environmental sustainability by implementing environmental management systems, conducting environmental audits, evaluating environmental reports internally, and obtaining ISO 14001 certification. Cooperation within the organization is essential to ensure sustainable performance, achieve environmental objectives, and improve economic and social outcomes (Basnet, 2013).

2.2.4 Logistics Integration

Logistics integration refers to the environmental management practices involved in the planning, execution and oversight of goods or services until they reach the consumer or customer (Oy & Kamthunzi, 2014). This integration is crucial for improving logistics efficiency, reducing costs, and achieving superior performance by integrating supply chain logistics resources and leveraging information technology to enhance logistics operations (Guo & Long, 2023). The integration of logistics and marketing practices has been investigated to determine the impact on market share outcomes, highlighting the importance of logistics-affordability, accessibility, acceptability, awareness, and full integration into business strategies (Dadzie *et al.*, 2023).

2.2.5 Technology Integration

Technology integration in green supply chain management involves the use of technology tools and resources by supplying and buying firms to enhance sustainability practices. This integration encompasses activities such as product development procedures, process re-engineering, and technical training to promote eco-friendly operations within the supply chain (Setyadi, 2019). Green supply chain integration allows enterprises to merge internal and external green technological resources, benefiting from advanced experiences from both sources. This integration underscores the significance of utilizing technology to boost sustainability practices and enhance environmental performance within supply chain operations (Xia *et al.*, 2020).

2.3 Sustainable Performance

The ability of a company or organization to continue growing and improving over time without endangering the ability of future generations to meet their own requirements is referred to as sustainable performance. The economic, environmental, and social pillars of sustainability are all included in this idea. It entails striking a balance between the organization's long-term objectives and stakeholders' immediate requirements, as well as

making sure that the organization's operations don't damage the environment or deplete natural resources and that they improve society well-being (Abdul-Rashid *et al.*, 2017).

To measure sustainable performance, organizations need to adopt a systematic and integrated approach that considers all aspects of sustainability, including economic, environmental, and social dimensions. Various models and frameworks have been developed to effectively measure sustainability performance, such as the Analytic Network Process and Balanced Scorecard. Additionally, the adoption of Key Performance Indicators (KPIs) that integrate sustainability into the business strategy is crucial for improving sustainability performance (Nowak *et al.*, 2024).

The role of green supply chain management in driving sustainability initiatives within organizations, underscoring the importance of environmentally conscious practices in supply chain operations (Hsu *et al.*, 2013). The adoption of sustainable practices in supply chains has become imperative for organizations aiming to achieve long-term sustainability goals. This study also highlighted the significance of policy development, health protocols, and automation in enhancing supply chain sustainability, especially in the context of the COVID-19 pandemic (Karmaker *et al.*, 2021).

2.4 Conceptual Framework

The research framework is portrayed in Fig. 1. There are five independent variables and one dependent variable involved in this study.

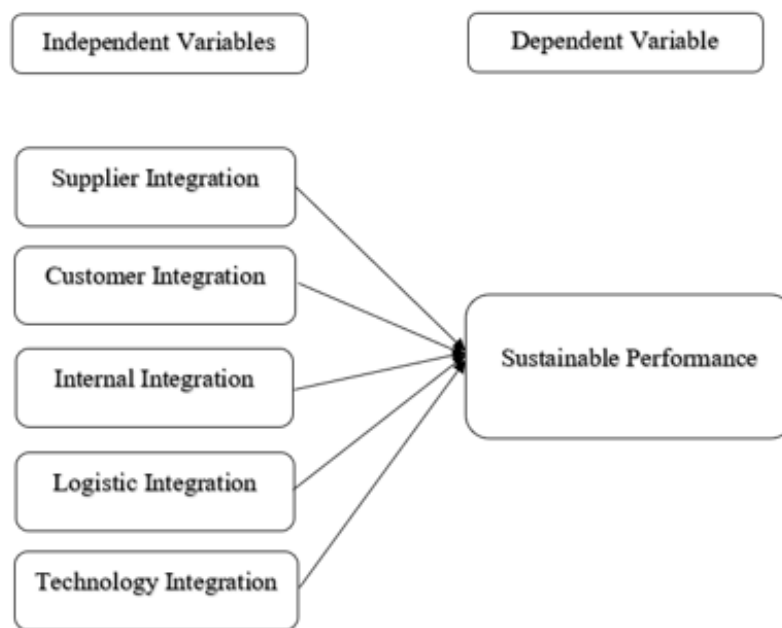


Fig. 1 Research framework of this study

3. Research Methodology

3.1 Research Design

Quantitative approach is defined as a systematic investigation of phenomena by gathering quantifiable data and performing statistical, mathematical or computational techniques (Ghanad, 2023). The survey was in the form of a Google Form, and the questions were given on a scale of 1-5 to rate the agreeableness of respondents to the questionnaires, and this survey was distributed by mail to the manufacturing firms' addresses. At the end of the research, the report has been able to answer the research questions with proof of data. Besides, the correlation of the research's dependent variable and independent variable has been carried out.

3.2 Research Population and Sample

Population can be defined as all people or items that one wishes to understand, while sampling is the process of selecting a segment of the population for investigation (Rahi, 2017). Based on the Federation of Malaysian Manufacturers (FMM) in Johor, there were 500 leading manufacturing companies in the state which offer a wide range of activities to facilitate manufacturing and business operations. Sample size represents the quantity of observations or individuals chosen from the population to be included in the study (Memon *et al.*, 2020). Based

on the table provided by (Krejcie, R. V., & Morgan, 1970), when the total population size is 500, the most appropriate sample size is 217. Therefore, a sample size of 217 respondents from ISO 14001 certified manufacturing firms in the country was required. Table 1 is a sample size selection table developed by Krejcie and Morgan (1970).

Table 1 *Determining sample size method Krejcie and Morgan (1970)*

<i>N</i>	<i>S</i>	<i>N</i>	<i>S</i>	<i>N</i>	<i>S</i>
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	100000	384

Note.—*N* is population size. *S* is sample size.

Source: Krejcie & Morgan, 1970

3.3 Data Collection

Data collection is the process of collecting and measuring information about variables, in establish a systematic way to enable people to answer established research questions, test hypotheses and evaluate results (Taherdoost, 2021). The primary data collection method will be used in this study which is the questionnaire survey technique. The questionnaire survey for this survey will be provided to respondents conducted by online survey using Email to make it easier and more convenient for both the researcher and the respondents to answer the survey.

3.4 Pilot Study

According to (Williams-Mcbean, 2019), a Pilot Study (PS) is a small-scale research project conducted before the full-scale study. It allows researchers to test the feasibility of the research process, helping them determine the most effective approach for conducting the final study. Through pilot testing, researchers can refine research questions, identify the most suitable methods, and estimate the time and resources required for the larger study. Additionally, pilot testing ensures the quality of the questionnaire, securing its validity and reliability while minimizing potential issues in the final data collection. For this study, the researcher distributed 30 sets of questionnaires to respondents from diverse backgrounds to gather feedback and comments on the questionnaire as part of the pilot testing process.

3.5 Research Instrument

The instrument of this research were questionnaires and scales. Questionnaires are the backbone of any survey and its success lies in the design of the questionnaire. Research instruments are crucial in gathering accurate and reliable information to address research questions and objectives. They play a vital role in ensuring the validity and reliability of the data collected, which are essential for drawing meaningful conclusions and making informed decisions based on research findings (Chen *et al.*, 2021). All of the questions will be created by the researcher in the form of a closed-ended inquiry. In other words, the researcher will give a set of possibilities for the respondent to choose from depending on their best skill. This collection of questionnaires may indicate that the researcher aims to keep things as simple as possible in terms of questionnaire design and phrasing in order to make it simpler for respondents to understand the questions and create the best answer. As a consequence, the researcher will be able to obtain more accurate responses from the participants.

3.6 Data Analysis

3.6.1 Descriptive Analysis

The researcher has emphasized using this method for data analysis, as it allows the collected data and information to be presented in tables and percentages, making it convenient for analysis. This approach helps in organizing general questions and presenting responses effectively in the research study. Furthermore, the data obtained from the questionnaire is crucial, as the numbers and percentages are used for further analysis to achieve the research objectives. Descriptive data analysis in this study enhances the understanding and interpretation of the collected findings.

3.6.2 Correlation Analysis

Correlation analysis evaluates how strongly and in what direction two continuous variables are related (Leech *et al.*, 2013). Pearson and Spearman correlations are two common types of correlation analyses utilised in research. Selecting between Pearson's and Spearman's correlation coefficients is roughly analogous to choosing between the median or IQR and the mean or standard deviation. This study will help verify whether the GSCI practices have a positive correlation with sustainable performance.

3.7 Research Flow Chart

Fig. 2 represents the process flow for conducting a study, beginning with the identification of the problem statement. This flowchart assists the researcher in conducting this study and gaining a deeper comprehension via the flowchart's summary.

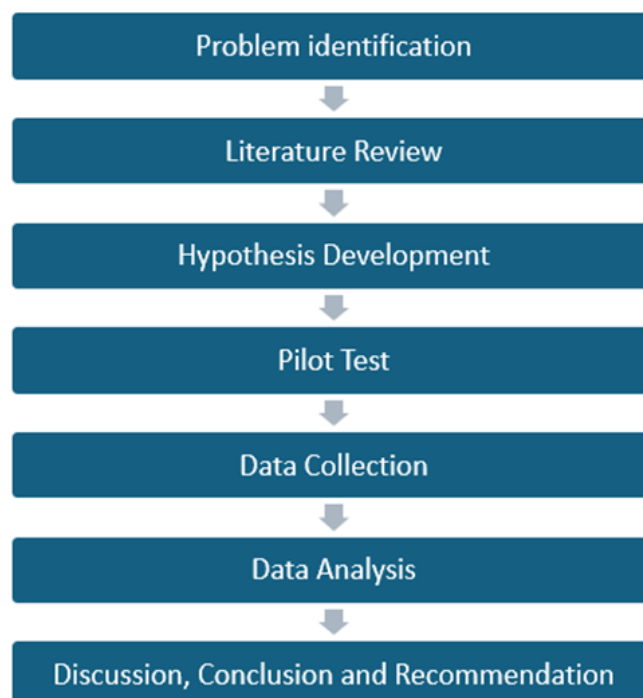


Fig. 2 Flow chart of this study

4. Results and Discussion

The population of manufacturing firms in Johor Bahru was 500 companies, while the sample size of this study was 217. As shown in Table 2, the questionnaires were emailed to 222 companies, and 222 valid questionnaires were returned. The questionnaire survey return rate attained there was 88.80%.

Table 2 Survey return rate

Population	Sample Size	Questionnaire Distribute	Questionnaire Returned	Percentage
500	217	250	222	88.80%

4.1 Reliability and Validity Analysis

The reliability test was conducted to evaluate the quality of the data, focusing on the stability and consistency of the items. Cronbach's alpha, an internal consistency measure, was utilized to assess the reliability of the scale. Researchers commonly use Cronbach's Coefficient Alpha, which ranges from 0 to 1, to determine the reliability of data. According to this method, a higher coefficient value indicates greater reliability (Hoekstra *et al.*, 2019). For example, in this study, a value of 0.60 or higher signifies reliability and internal consistency, whereas a value below 0.60 indicates the opposite. Table 3 displays the value of the dependability coefficient.

Table 3 Reliability coefficient value

Cronbach's Alpha (α)	Internal Consistency
$\alpha \geq 0.9$	Excellent
$0.9 \geq \alpha \geq 0.8$	Good
$0.8 \geq \alpha \geq 0.7$	Acceptable
$0.7 \geq \alpha \geq 0.6$	Be Disputed
$0.6 \geq \alpha \geq 0.5$	Bad
$0.5 \geq \alpha$	Unacceptable

4.1.1 Reliability and Validity Analysis of Pilot Study

A pilot test has been conducted in this study to examine that the questionnaire is reliable and valid before the actual study has been carried out. There were 30 targeted respondents involved and 30 questions are used in this pilot test is to determine the level of understanding of respondents toward the questionnaire provided. Table 4 showed that the value of Cronbach's Alpha (α) for the pilot study for 30 respondents. Based on the result, the values of Cronbach's Alpha (α) of supplier integration is 0.848, which is good, customer integration is 0.907, which is excellent, internal integration is 0.997, which is excellent, logistic integration is 0.861, which is good and technology integration is 0.874, which is good. Meanwhile, Cronbach's Alpha (α) for sustainable performance is 0.899, which is good. As shown in Table 4, since all the independent variables and the dependent variable have a value from 0.8 and above for their Cronbach's Alpha (α), the questionnaire can be used.

Table 4 Reliability test for pilot study

No	Variables	Number of items	Cronbach's Alpha (α)
1.	Supplier Integration	4	0.848
2.	Customer Integration	4	0.907
3.	Internal Integration	4	0.997
4.	Logistic Integration	4	0.861
5.	Technology Integration	4	0.874
6.	Sustainable Performance	5	0.899

4.1.2 Reliability and Validity Analysis of Actual Study

Table 5 detailed the reliability test for the actual investigation. The results showed that the values of Cronbach's Alpha (α) of supplier integration is 0.953, customer integration is 0.956, internal integration is 0.965, logistic integration is 0.955, and technology integration is 0.956. Meanwhile, Cronbach's Alpha (α) for sustainable performance is 0.966. Since all of the independent variables and the dependent variable have a value from 0.9 and

above for its Cronbach's Alpha (α), which the reliability is excellent. The reliability of every item that was chosen to be included in the questionnaire for this study was reliable.

Table 5 Reliability test for actual study

No	Variables	Number of items	Cronbach's Alpha (α)
1.	Supplier Integration	4	0.953
2.	Customer Integration	4	0.956
3.	Internal Integration	4	0.965
4.	Logistic Integration	4	0.955
5.	Technology Integration	4	0.956
6.	Sustainable Performance	5	0.966

4.2 Demographic Analysis

The questionnaires have been distributed to manufacturing sector in Johor Bahru with different backgrounds. The demographic information, which firms and respondents' profile were analysed and presented in Table 6. The firms and respondents profile included gender, age, education level, level of job position in the company, working experience and type of manufacturing job position in the company.

Table 6 Summary of demographic analysis

Demographic	Classification	Frequency (N)	Percentage (%)
Gender	Male	112	50.5
	Female	110	49.5
Age	Below 30 years old	36	16.2
	31-40 years old	61	27.5
	41-50 years old	64	28.8
	51 years old and above	61	27.5
Educational Level	SPM/STPM/Diploma	42	18.9
	Degree level	83	37.4
	Master level	59	26.6
	PhD level	38	17.1
	Executive or senior management	29	13.1
Level of Job Position in The Company	Middle Management	49	22.1
	First-level management	58	26.1
	Intermediate or experienced	52	23.4
	Entry-level	34	15.3
	Below 1 year	35	15.8
Working Experience	1-5 years	71	32.0
	5-10 years	85	38.3
	More than 10 years	31	14.0
	Chief Executives and Director Positions	20	9.0
	Management Positions	43	19.4
	Supervisory Positions	31	14.0
Type of Manufacturing Job Position in The Company	Manufacturing Engineer Positions	38	17.1
	Manufacturing Technician Positions	39	17.6
	Office Manufacturing Positions	31	14.0
	General Manufacturing Associate Positions	20	9.0

4.3 Descriptive Analysis for GSCI Practices

Table 7 shows the five items in this group with their mean and standard deviation, respectively. The highest mean is scored by the customer integration, with a mean value of 3.5124 and a standard deviation of 1.29898. Meanwhile, the technology integration had the lowest mean, which is 3.4955, with a standard deviation of 1.30695. The second highest mean is the supplier integration, with a mean value of 3.5056 and a standard deviation of 1.27663. The logistic integration scored a mean value of 3.5045 with a standard deviation of 1.29215. Lastly, the internal integration scored a mean value of 3.5034 with a standard deviation of 1.32810.

Table 7 Summary analysis of average mean

Item	Mean	Standard Deviation
Supplier Integration	3.5056	1.27663
Customer Integration	3.5124	1.29898
Internal Integration	3.5034	1.32810
Logistic Integration	3.5045	1.29215
Technology Integration	3.4955	1.30695

4.4 Descriptive Analysis for Sustainable Performance

Table 8 shows the descriptive analysis of sustainable performance. The highest mean score is by items 2, 3 and 5, reduction in wastewater caused by the firm's manufacturing activities, reduction in solid wastes caused by the firm's manufacturing activities and decrease in frequency of environmental accidents of the firm, with both the same mean value of 3.52 respectively. Meanwhile, reduction in air emission caused by firm's manufacturing activities and decrease in consumption for hazardous/ harmful/ toxic materials had the lowest mean with both same mean value of 3.49 respectively.

Table 8 Mean and standard deviation for sustainable performance

No	Item	Mean	Standard Deviation
	Operational Performance		
1	Reduction in air emission caused by firm's manufacturing activities.	3.49	1.344
2	Reduction in waste water caused by firm's manufacturing activities.	3.52	1.420
3	Reduction in solid wastes caused by firm's manufacturing activities.	3.52	1.344
4	Decrease in consumption for hazardous/ harmful/ toxic materials.	3.49	1.344
5	Decrease in frequency for environmental accidents of the firm.	3.52	1.420
	Average Mean	3.514	1.3744

4.5 Normality Test

Since the number of the respondent is more than fifty, this research has used Kolmogorov-Smirnov as the data to be referred in determine whether the variables are normal or not normal to ensure which analysis should be used for determining the result based on the research questions. Based on the Table 9, if the significant value is below 0.05 the variable considered as not normal and if the significant value is more than 0.05, the variables are considered as normal. Normality test is crucial to ensure the exact test should be used in the next process of data analysis. The result of the normality test for all item is not normal with are normally distributed with ($P < 0.05$).

Table 9 Normality Test for Independent Variables and Dependent Variable

Variables	Kolmogorov-Smirnov Test		
	Statistic	df	Sig.
Independent Variables			
Supplier Integration	.350	222	<.001
Customer Integration	.323	222	<.001
Internal Integration	.258	222	<.001
Logistic Integration	.356	222	<.001

Technology Integration	.356	222	<.001
Dependent Variables			
Sustainable Performance	.332	222	<.001

4.6 Correlation Analysis

Table 10 shows the correlation between supplier integration and sustainable performance. There was a significant correlation between supplier integration and sustainable performance with $r(222) = 0.91, p < 0.01$. Thus, there is a significant correlation between supplier integration and sustainable performance.

Table 10 Correlation between supplier integration and sustainable performance

			OM_SupplierInt egration	OM_Sustainable Performance
Spearman's rho	OM_SupplierIntegration	Correlation Coefficient	1.000	.913**
		Sig. (2-tailed)	.	.000
		N	222	222
	OM_SustainablePerformanc e	Correlation Coefficient	.913**	1.000
		Sig. (2-tailed)	.000	.
		N	222	222

** . Correlation is significant at the 0.01 level (2-tailed).

Table 11 shows the correlation between customer integration and sustainable performance. There was a significant correlation between customer integration and sustainable performance with $r(222) = 0.92, p < 0.01$. Thus, there is a significant correlation between customer integration and sustainable performance.

Table 11 Correlation between customer integration and sustainable performance

			OM_Custome rIntegration	OM_Sustaina blePerforman ce
Spearman's rho	OM_CustomerIntegration	Correlation Coefficient	1.000	.920**
		Sig. (2-tailed)	.	<.001
		N	222	222
	OM_SustainablePerform ance	Correlation Coefficient	.920**	1.000
		Sig. (2-tailed)	<.001	.
		N	222	222

** . Correlation is significant at the 0.01 level (2-tailed).

Table 12 shows the correlation between internal integration and sustainable performance. There was a significant correlation between internal integration and sustainable performance with $r(222) = 0.94$, $p < 0.01$. Thus, there is a significant correlation between internal integration and sustainable performance.

Table 12 Correlation between internal integration and sustainable performance

			OM_InternalIntegration	OM_SustainablePerformance
Spearman's rho	OM_InternalIntegration	Correlation Coefficient	1.000	.940**
		Sig. (2-tailed)	.	<.001
		N	222	222
	OM_SustainablePerformance	Correlation Coefficient	.940**	1.000
		Sig. (2-tailed)	<.001	.
		N	222	222

** . Correlation is significant at the 0.01 level (2-tailed).

Table 13 shows the correlation between logistic integration and sustainable performance. There was a significant correlation between logistic integration and sustainable performance with $r(222) = 0.91$, $p < 0.01$. Thus, there is a significant correlation between logistic integration and sustainable performance.

Table 13 Correlation between logistic integration and sustainable performance

			OM_LogisticIntegration	OM_SustainablePerformance
Spearman's rho	OM_LogisticIntegration	Correlation Coefficient	1.000	.913**
		Sig. (2-tailed)	.	<.001
		N	222	222
	OM_SustainablePerformance	Correlation Coefficient	.913**	1.000
		Sig. (2-tailed)	<.001	.
		N	222	222

** . Correlation is significant at the 0.01 level (2-tailed).

Table 14 shows the correlation between technology integration and sustainable performance. There was a significant correlation between technology integration and sustainable performance with $r(222) = 0.91, p < 0.01$. Thus, there is a significant correlation between technology integration and sustainable performance.

Table 14 Correlation between technology integration and sustainable performance

Correlations

		OM_TechnologyIntegration	OM_SustainablePerformance
Spearman's rho	OM_TechnologyIntegration	Correlation Coefficient	1.000
		Sig. (2-tailed)	.906**
		N	<.001
OM_SustainablePerformance	OM_SustainablePerformance	Correlation Coefficient	.906**
		Sig. (2-tailed)	1.000
		N	<.001

** . Correlation is significant at the 0.01 level (2-tailed).

5. Conclusion

The most chosen dominant practices in implemented GSCI is the practices of the customer integration and the least chosen is the practices of the technology integration. According to this result, the second highest mean value that the practices of the supplier integration gained a mean value of 3.5056. The practices of the logistic integration and the internal integration had the mean value of 3.5045 and 3.5034. Consequently, the manufacturing firms in Johor Bahru should implemented more in GSCI practices. For instance, manufacturing firms in Johor Bahru can implement Green Supply Chain Integration (GSCI) practices by adopting eco-friendly packaging, utilizing renewable energy sources for production and collaborating with suppliers who prioritize sustainable materials and waste reduction.

The results showed that the highest mean value is reduction in waste water caused by firm's manufacturing activities, reduction in solid wastes caused by firm's manufacturing activities and decrease in frequency for environmental accidents of the firm with the both same mean value of 3.52 respectively. Meanwhile, reduction in air emission caused by firm's manufacturing activities and decrease in consumption for hazardous/ harmful/ toxic materials had the lowest mean with the both same mean value of 3.49 respectively. Consequently, the manufacturing firms in Johor Bahru should improve the sustainable performance. For example, focusing on reducing air emissions by transitioning to energy-efficient machinery and utilizing renewable energy sources. This shift not only aligns with sustainability goals but also reduces operational costs in the long run. Furthermore, prioritizing the use of non-toxic materials in their manufacturing processes. By sourcing safer alternatives and minimizing hazardous substances, they can significantly decrease their environmental impact while ensuring compliance with regulatory standards.

Based on the result, the highest Spearman's Correlation Coefficient, r is 0.940 which a strongest relationship between the internal integration and sustainable performance. The lowest Spearman's Correlation Coefficient, r is 0.906 which was a strongest relationship between the technology integration and sustainable performance. Based on the result of this study, we know that the internal integration will give more impact that is positive on sustainable performance. This indicates that well-coordinated internal processes, such as cross-departmental communication, collaboration and environmental management systems which are crucial in enhancing sustainability. By aligning internal operations with green practices, manufacturing firms can effectively reduce waste, optimize resource utilization and achieve both environmental and economic benefits. This finding emphasizes the importance of fostering internal collaboration to drive sustainable performance successfully.

In conclusion, this research contributes to a deeper understanding of GSCI practices within the Malaysian manufacturing sector, addressing the gaps in existing literature and offering a foundation for future exploration. These findings not only benefit industry practitioners aiming to enhance sustainable performance but also serve as a guide for policymakers seeking to promote green initiatives. By fostering a culture of sustainability and innovation, manufacturing firms can effectively align with global sustainability goals while maintaining competitive advantages in a dynamic market.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** Low Kun Wai and Fazian Hashim; **data collection:** Low Kun Wai and Fazian Hashim; **analysis and interpretation of results:** Low Kun Wai and Fazian Hashim; **draft manuscript preparation:** Low Kun Wai and Fazian Hashim. All authors reviewed the results and approved the final version of the manuscript.

References

- Abdul-Rashid, S. H., Sakundarini, N., Raja Ghazilla, R. A., & Thurasamy, R. (2017). The impact of sustainable manufacturing practices on sustainability performance: Empirical evidence from Malaysia. *International Journal of Operations and Production Management*, 37(2), 182–204. <https://doi.org/10.1108/IJOPM-04-2015-0223>
- Afum, E., Osei-Ahenkan, V. Y., Agyabeng-Mensah, Y., Amponsah Owusu, J., Kusi, L. Y., & Ankomah, J. (2020). Green manufacturing practices and sustainable performance among Ghanaian manufacturing SMEs: the explanatory link of green supply chain integration. *Management of Environmental Quality: An International Journal*, 31(6), 1457–1475. <https://doi.org/10.1108/MEQ-01-2020-0019>
- Ahmed Khamis al Naqbi, R., Bin MD Yusoff, R., & Binti Ismail, F. (2018). Supply Chain integration and Sustainable supply chain performance: A case of Manufacturing firms from UAE. *International Journal of Engineering & Technology*, 7(4.7), 424. <https://doi.org/10.14419/ijet.v7i4.7.23041>
- Alreahi, M., Bujdosó, Z., Dávid, L. D., & Gyenge, B. (2023). Green Supply Chain Management in Hotel Industry: A Systematic Review. *Sustainability (Switzerland)*, 15(7). <https://doi.org/10.3390/su15075622>
- Aziziankohan, A. (2017). *Green-supply-chain-management-using-the-queuing-theory-to-handle-congestion-and-reduce-energy-consumption-and-emissions-from-supply-chain-transportation-fleet_2017_Universitat-Politecnica-de-Catalunya-editorjiemorg.pdf*. 10(2), 213–236.
- Basnet, C. (2013). The measurement of internal supply chain integration. *Management Research Review*, 36(2), 153–172. <https://doi.org/10.1108/01409171311292252>
- Bokrantz, J., Skoogh, A., Berlin, C., & Stahre, J. (2020). Smart maintenance: instrument development, content validation and an empirical pilot. *International Journal of Operations and Production Management*, 40(4), 481–506. <https://doi.org/10.1108/IJOPM-11-2019-0746>
- Chen, Q., Huang, C., Castro, A. R., & Tang, S. (2021). Instruments for measuring nursing research competence: A protocol for a scoping review. *BMJ Open*, 11(2), 1–5. <https://doi.org/10.1136/bmjopen-2020-042325>
- Dadzie, K., Dadzie, C., Johnston, W. J., Winston, E., & Wang, H. (2023). The integration of logistics and marketing practice into baseline supply chain practices in the emerging markets. *Journal of Business and Industrial Marketing*, 38(2), 367–383. <https://doi.org/10.1108/JBIM-01-2022-0002>
- Duoming, H., & Chin, T. A. (2022). A Systematic Review for Supply Chain Integration and Risks. *International Journal of Academic Research in Business and Social Sciences*, 12(1), 715–729. <https://doi.org/10.6007/ijarbss/v12-i1/11856>
- Ghanad, A. (2023). An Overview of Quantitative Research Methods. *International Journal of Multidisciplinary Research and Analysis*, 06(08), 3794–3803. <https://doi.org/10.47191/ijmra/v6-i8-52>
- Guo, X., & Long, X. (2023). Research on the Development Strategy of E-Business Green Logistics Based on AHP. *E3S Web of Conferences*, 372. <https://doi.org/10.1051/e3sconf/202337202003>
- Halili, M., & Fernando, Y. (2019). A Reflection of Local Supplier Development towards Sustainable Social Supply Chain. *KnE Social Sciences*, 2019, 726–735. <https://doi.org/10.18502/kss.v3i22.5084>
- Hassan, M. G., Abindin, R., & Nordin, N. (2018). The impact of customer integration on manufacturing firms sustainable performance. *International Journal of Engineering and Technology(UAE)*, 7(2), 119–122. <https://doi.org/10.14419/ijet.v7i2.15.11366>
- Hassan, M. G., Akanmu, M. D., & Yusoff, R. Z. (2018). Technological integration and sustainable performance in manufacturing firms. *International Journal of Technology*, 9(8), 1639–1650. <https://doi.org/10.14716/ijtech.v9i8.2747>
- Hoekstra, R., Vugteveen, J., Warrens, M. J., & Kruijen, P. M. (2019). An empirical analysis of alleged misunderstandings of coefficient alpha. *International Journal of Social Research Methodology*, 22(4), 351–364. <https://doi.org/10.1080/13645579.2018.1547523>

- Holmberg, S. (2015). Integrating environmental into supply chain: A systematic literature review and theoretical framework. *International Journal of Physical Distribution & Logistics Management*, 45(1/2), 43–68.
- Hou, W. (2022). Green Supply Chain Management and Performance: A Bibliometric Analysis Based on CiteSpace. *Journal of Management and Humanity Research*, 07(May), 119–132. <https://doi.org/10.22457/jmhr.v07a102247>
- Hsu, C. C., Tan, K. C., Zailani, S. H. M., & Jayaraman, V. (2013). Supply chain drivers that foster the development of green initiatives in an emerging economy. *International Journal of Operations and Production Management*, 33(6), 656–688. <https://doi.org/10.1108/IJOPM-10-2011-0401>
- Jakhar, S. K., Bhattacharya, A., Rathore, H., & Mangla, S. K. (2020). Stakeholder pressure for sustainability: Can ‘innovative capabilities’ explain the idiosyncratic response in the manufacturing firms? *Business Strategy and the Environment*, 29(6), 2635–2653. <https://doi.org/10.1002/bse.2526>
- Jamaluddin, F., & Saibani, N. (2021). Systematic literature review of supply chain relationship approaches amongst business-to-business partners. *Sustainability (Switzerland)*, 13(21). <https://doi.org/10.3390/su132111935>
- Karmaker, C. L., Ahmed, T., Ahmed, S., Ali, S. M., Moktadir, M. A., & Kabir, G. (2021). Improving supply chain sustainability in the context of COVID-19 pandemic in an emerging economy: Exploring drivers using an integrated model. *Sustainable Production and Consumption*, 26, 411–427. <https://doi.org/10.1016/j.spc.2020.09.019>
- Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement*, 30(02), 607–610.
- Leech, N., Barrett, K., & Morgan, G. A. (2013). SPSS for Intermediate Statistics. In *SPSS for Intermediate Statistics* (Issue March 2019). <https://doi.org/10.4324/9781410616739>
- Memon, M. A., Ting, H., Cheah, J. H., Thurasamy, R., Chuah, F., & Cham, T. H. (2020). Sample size for survey research: Review and recommendations. *Journal of Applied Structural Equation Modeling*, 4(2), i–xx. [https://doi.org/10.47263/jasem.4\(2\)01](https://doi.org/10.47263/jasem.4(2)01)
- Mingaleva, Z., Shironina, E., Lobova, E., Olenov, V., Plyusnina, L., & Oborina, A. (2022). Organizational Culture Management as an Element of Innovative and Sustainable Development of Enterprises. *Sustainability (Switzerland)*, 14(10). <https://doi.org/10.3390/su14106289>
- Munir, F., Mochamad Yani, Y., Dharma Negara, S., Widya Setiabudi Sumadinata, R., & Widya Setiabudi, R. (2021). Strengthening Of Substate Actors in Comparative Advantage of Sijori (Singapore-Johor-Riau Islands) Border Areas Collaboration-Palarch's. *Journal of Archaeology of Egypt/Egyptology*, 18(08), 2585. <https://www.slideshare.net/FransDione/sustainable>
- Nazir, S., Zhaolei, L., Mehmood, S., & Nazir, Z. (2024). Impact of Green Supply Chain Management Practices on the Environmental Performance of Manufacturing Firms Considering Institutional Pressure as a Moderator. *Sustainability (Switzerland)*, 16(6). <https://doi.org/10.3390/su16062278>
- Nowak, M., Martineau, S., Sobottka, T., Ansari, F., & Schlund, S. (2024). An indicator scheme for improving measurability of Sustainable Development Goals in manufacturing enterprises. *Procedia Computer Science*, 232(2023), 655–664. <https://doi.org/10.1016/j.procs.2024.01.065>
- Omar, H. A. M. B. B., Ali, M. A. M., & Jaharadak, A. A. Bin. (2019). Green supply chain integrations and corporate sustainability. *Uncertain Supply Chain Management*, 7(4), 713–726. <https://doi.org/10.5267/j.uscm.2019.3.001>
- Oy, H. L., & Kamthunzi, E. (2014). *Analysis of logistic process*.
- Rahi, S. (2017). Research Design and Methods: A Systematic Review of Research Paradigms, Sampling Issues and Instruments Development. *International Journal of Economics & Management Sciences*, 06(02). <https://doi.org/10.4172/2162-6359.1000403>
- RANI, D. S. (2019). Impact of Sustainable Manufacturing Practices on Financial Performance of MSME in Coimbatore District. *International Journal of Engineering and Advanced Technology*, 9(1s4), 1033–1036. <https://doi.org/10.35940/ijeat.a1222.1291s419>
- Setyadi, A. (2019). Does green supply chain integration contribute towards sustainable performance? *Uncertain Supply Chain Management*, 7(2), 121–132. <https://doi.org/10.5267/j.uscm.2018.10.012>
- Shabbir, M. S., & Kassim, N. M. (2018). Supply chain management drivers and sustainability of green initiatives in manufacturing enterprises: A case in Pakistan. *International Journal of Entrepreneurship*, 22(Special Issue).
- Swalehe, R., Odock, S., & Wainaina, G. (2020). Sustainable Operations Management Practices and Competitive Advantage of Manufacturing Firms in Kenya. *European Scientific Journal ESJ*, 16(28), 241–262. <https://doi.org/10.19044/esj.2020.v16n28p241>
- Taherdoost, H. (2021). Data Collection Methods and Tools for Research; A Step-by-Step Guide to Choose Data Collection Technique for Academic and Business Research. *International Journal of Academic Research in Management (IJARM)*, 2021(1), 10–38. <https://hal.science/hal-03741847>
- Tarigan, Z. J. H., Siagian, H., & Jie, F. (2021). Impact of enhanced enterprise resource planning (Erp) on firm performance through green supply chain management. *Sustainability (Switzerland)*, 13(8). <https://doi.org/10.3390/su13084358>

- Utama, D. M., Baroto, T., & Widodo, D. S. (2020). Energy-Efficient Flow Shop Scheduling Using Hybrid Grasshopper Algorithm Optimization. *Jurnal Ilmiah Teknik Industri*, 19(1), 30–38. <https://doi.org/10.23917/jiti.v19i1.10079>
- Williams-Mcbean, C. T. (2019). The value of a qualitative pilot study in a multi-phase mixed methods research. *Qualitative Report*, 24(5), 1055–1064. <https://doi.org/10.46743/2160-3715/2019.3833>
- Wlzlak, P., Säfsten, K., & Hilletoft, P. (2019). Original equipment manufacturer (OEM)-supplier integration to prepare for production ramp-up. *Journal of Manufacturing Technology Management*, 30(2), 506–530. <https://doi.org/10.1108/JMTM-05-2018-0156>
- Wong, S. Y., Wah, L. W., & Wong, A. S. M. (2023). Barriers of Green Supply Chain Management Implementation in Malaysian Construction Industry. *Journal of Surveying, Construction & Property*, 14(1), 1–13. <https://doi.org/10.22452/jscp.vol14no1.1>
- Xia, W., Li, B., & Yin, S. (2020). A prescription for urban sustainability transitions in China: Innovative partner selection management of green building materials industry in an integrated supply chain. *Sustainability (Switzerland)*, 12(7). <https://doi.org/10.3390/su12072581>