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ANALYSING THE EFFECTS OF GREEN MANUFACTURING AND ECO-INNOVATION ON SUSTAINABILITY PERFORMANCE.

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ABSTRACT:
In a time where environmental pressures and limited resources are on the rise, businesses are finding themselves compelled to adopt sustainable practices. Two powerful tools that have emerged in this pursuit are green manufacturing and eco-innovation. These practices not only have a positive impact on the environment and society, but also enhance economic viability. This research paper aims to delve into the intricate relationship between green manufacturing and eco-innovation, analysing how they synergistically contribute to sustainable performance. The paper explores the theoretical foundations and diverse benefits of these practices, supported by empirical evidence that showcases their positive contributions across environmental, economic, and social dimensions. Additionally, the interplay between green manufacturing and eco-innovation is examined, shedding light on the synergy they create as well as the potential challenges in their implementation. The paper concludes by offering recommendations to businesses and policymakers on how to optimize the adoption and effectiveness of these practices, ultimately driving sustainable performance.
Keywords: Green manufacturing, eco-innovation, sustainability, environmental performance, economic performance, social performance, circular economy, closed-loop systems, resource efficiency, cleaner production, eco-design, life cycle assessment.

INTRODUCTION:

The current era poses a critical moment for businesses in the 21st century. It has become essential to strike a balance between economic growth and environmental responsibility, necessitating a significant shift towards sustainable business practices. Green manufacturing and eco-innovation have emerged as powerful tools in this transformation, providing a route towards reducing environmental footprints, improving resource efficiency, and enhancing societal well-being. Green manufacturing involves the adoption of practices and policies that aim to minimize the environmental impact of production processes throughout the entire product lifecycle. This includes strategies such as resource efficiency, cleaner production methods, closed-loop systems, and waste reduction. On the other hand, eco-innovation focuses on the creation and implementation of new technologies, processes, and products that promote environmental and social sustainability. This encompasses eco-design, circular economy models, and the integration of renewable energy sources. By embracing these approaches, businesses can achieve environmental advantages, boost economic competitiveness, and reinforce their social legitimacy simultaneously. This study explores the intricate connection between green manufacturing and eco-innovation, examining their combined influence on sustainable performance across environmental, economic, and social dimensions.

ENVIRONMENTAL PERFORMANCE:

Green manufacturing serves as the foundation for achieving positive environmental outcomes. By implementing strategies like resource efficiency, cleaner production, and closed-loop systems, tangible reductions in environmental footprints can be achieved. A study conducted by Handayani et al. (2021) revealed that small and medium-sized enterprises that prioritize green practices experience notable

decreases in energy consumption, greenhouse gas emissions, and waste generation. Similarly, Ghisellini et al. (2016) demonstrated the effectiveness of closed-loop systems in the electronics industry, resulting in reduced resource consumption and environmental pollution. To further enhance these efforts, eco-innovation plays a crucial role by introducing innovative solutions to address environmental challenges. For instance, the utilization of bio-based materials offers a sustainable alternative to conventional materials, thereby reducing dependence on finite resources and minimizing pollution. Moreover, the development of clean technologies, such as renewable energy sources and efficient transportation systems, can significantly contribute to the reduction of greenhouse gas emissions and aid in mitigating climate change.

Economic Performance:

Contrary to commonly held beliefs, the implementation of green manufacturing and eco-innovation can actually have a positive impact on economic performance. By adopting resource efficiency practices, businesses can reduce costs through material optimization and energy savings. Moreover, the incorporation of eco-design principles can streamline production processes and improve product quality, resulting in higher levels of customer satisfaction and an increased market share. Additionally, embracing eco-innovation can create new business opportunities within the expanding market for sustainable products and services. These claims are supported by empirical evidence. A study conducted by Deloitte in 2019 revealed that companies with strong sustainability practices outperformed their industry peers in terms of financial performance. Similarly, the World Business Council for Sustainable Development (WBCSD) published a report in 2020 estimating that the transition to a circular economy could generate annual economic benefits of $1 trillion by the year 2030.

Social Performance:

The benefits of green manufacturing and eco-innovation go beyond just environmental and economic advantages. These practices also have a positive impact on social performance by:

• Generating green jobs: The advancement and utilization of clean technologies and sustainable products often lead to the establishment of new jobs in sectors such as renewable energy, resource management, and circular economy.

• Enhancing employee well-being: Green manufacturing practices that prioritize the safety and health of employees can cultivate a more favourable and efficient work environment.

• Fostering community relations: Companies dedicated to sustainability can establish trust and goodwill within local communities by showcasing a dedication to environmental and social responsibility. For instance, a study conducted by the International Labour Organization (ILO) in 2019 predicts that the shift to a low-carbon economy could result in the creation of 12 million new jobs by 2030. Furthermore, a report by the Business & Social Responsibility (BSR) in 2017 revealed that organizations with robust sustainability practices observe increased employee engagement and reduced turnover rates.

Synergy and Challenges:

Green manufacturing and eco-innovation are interdependent strategies that work together to enhance their impact on sustainable performance. Green manufacturing sets the stage for eco-innovation by establishing a sustainable environment for product development and process optimization. By reducing resource consumption and waste generation, green manufacturing practices create opportunities for eco-design solutions and closed-loop systems. This encourages eco-innovation, leading to the creation of new technologies and processes that improve resource efficiency and environmental performance. Moreover, the data-centric approach of eco-innovation can optimize green manufacturing practices. Monitoring resource consumption and emissions in real-time using advanced sensors and analytics can identify areas for improvement, prompting adjustments to existing processes and the adoption of new

green technologies. This continuous exchange of information between green manufacturing and eco-innovation fosters a cycle of enhancement, driving companies towards greater levels of sustainable performance. Nevertheless, there are challenges in fully realizing the potential of this synergy. One significant hurdle is the initial investment needed for both green manufacturing and eco-innovation. Implementing new technologies, redesigning production processes, and transitioning to circular economy models can be costly, especially for smaller enterprises. To address this issue, financial incentives, tax benefits, and access to green financing options can incentivize businesses to invest in sustainable practices. Another obstacle is cultivating a culture of innovation and continuous improvement within organizations. Resistance to change and traditional mind sets may impede the adoption of new technologies and practices. Encouraging experimentation and providing employees with appropriate training can help overcome this challenge.

Literature Review

Corporate Sustainability

In recent decades, the rise in concerns regarding economic inequality, corporate social responsibility, and the rapid depletion of natural resources has brought sustainability to the forefront of business research and practice. Sustainability is defined as the ability to meet present needs without compromising the ability of future generations to meet their own needs (Hart & Milstein, 2003). This definition can be linked back to the Brundtland Report in 1987 and subsequent Earth Summits in Rio de Janeiro in 1992 and Johannesburg in 2002, where sustainability and environmental issues gained significant attention, becoming a key global concern (Ambec & Lanoie, 2008). The concept of sustainability is often viewed through the lens of the triple bottom line (TBL), which encompasses the state of the environment, society, and economy (Elkington, 1994). These three elements are widely recognized as key indicators of a company's sustainability performance at the corporate level. At the company level, economic performance refers to the impact of a company on its economic circumstances and systems at local, national, and international levels (GRI, 2006). It is no longer sufficient for a company to focus solely on financial performance and profits for long-term survival. Non-financial aspects such as social initiatives and environmental conservation must also be integrated into decision-making and strategic planning (Orlitzky, 2008). Environmental performance and reporting are defined as the outcomes of an organization's management of its environmental aspects, including its impact on natural systems such as ecosystems, land, air, and water. Ranganathan (1998) identified four key elements of environmental performance: material use, energy consumption, non-product output, and pollutant release. Social performance and reporting are related to a company's corporate performance.

Eco-Innovation

The increasing environmental pressures have elevated eco-innovation as a crucial strategic approach for achieving sustainable progress in the manufacturing sector. In the past, investments in environmental initiatives were considered unnecessary. However, stringent environmental regulations and the rise of environmental activism have reshaped the competitive landscape and business strategies. Since the late 1990s, scholars have explored eco-innovation from various perspectives. Some studies focus on identifying the factors that drive eco-innovation and the resulting performance outcomes, with recent examples including Kammerer (2009) and Dangelico and Pujari (2010). Others delve into the dimensions of eco-innovation, such as the work by Hermosilla et al. (2010). Additionally, there are studies that concentrate on measuring eco-innovation, as seen in the research by Arundel and Kemp (2009) and Cheng and Shiu (2012). According to Kemp and Pearson (2008), eco-innovation involves the development, adoption, or utilization of new products, processes, services,

or management methods that reduce environmental risks, pollution, and resource consumption throughout their life cycle compared to existing alternatives. Similarly, Jin et al. (2008) suggest that eco-innovation entails introducing new or significantly improved goods/services while minimizing negative environmental impacts. The goal of eco-innovation is to systematically embed sustainability practices into a company's overall strategy, from the inception of new products and services to their consumption by customers (Jone et al., 2008). Eco-innovation is typically categorized into three main types, collectively known as green innovation: green managerial innovation, eco-process innovation, and eco-product innovation.

Green Manufacturing

The concept of "green manufacturing," a relatively recent development, can be traced back to the 1990s. It involves a comprehensive, integrated, and economically driven approach aimed at minimizing or eliminating all waste streams associated with the design, production, use, and/or disposal of materials and products (Handfield et al., 1997). In the context of manufacturing systems, green production entails the adoption of production technologies and processes that utilize fewer resources and energy, while minimizing environmental impact. The key objectives of green manufacturing include ensuring zero safety hazards, zero health risks for workers and consumers, and zero environmental pollution, while maximizing waste recycling and minimizing waste disposal during the production process (Gao et al., 2009). Research on green manufacturing is limited and can be categorized into two main groups: those focusing on the overarching concept of green manufacturing, and those offering analytical tools and models for its implementation at various levels (Deif, 2011). Examples of the former group include the work of Mohanty and Deshmukh (1998), which emphasizes the significance of green productivity as a competitive advantage, and Jovane et al. (2003), who propose sustainable and green manufacturing as a future business model based on environmentally conscious design using advanced nano/bio/material technologies. Burk and Goughran (2007) also put forth a sustainability framework for achieving green manufacturing, based on the experiences of small and medium-sized enterprise (SME) manufacturers who have obtained ISO 14001 certification. Examples of the latter group include the work of Fiksel (1996), which compiles various analytical tools derived from research on product and process design for green manufacturing, such as Life Cycle Analysis (LCA), Design for the Environment (DfE), screening methods, and risk analysis.

Economic Performance:

Research gap

The concept of "Eco innovation" is often treated as a singular entity in existing research, disregarding the various types and intricacies involved such as product, process, and organizational innovation. It is imperative to delve into these distinctions and comprehend their distinct impacts on sustainability.

The definition of "sustainability performance" varies among different stakeholders, highlighting the need for standardized measurement methods to enhance the accuracy of research outcomes.

Further research is necessary to comprehend how internal and external factors, such as firm size, industry, or policy incentives, moderate the relationship between green manufacturing, innovation, and sustainability performance.

Current research predominantly focuses on short-term outcomes, thus necessitating a comprehensive analysis of the long-term sustainability effects of green manufacturing, including any unintended consequences. This calls for additional investigation.

Objective

- To investigate the impact of green manufacturing on the sustainability performance of businesses.
- To explore the influence of eco-innovation on the sustainability performance of businesses.
- To establish connections between variables, including eco-innovation, green manufacturing, and organizational sustainability performance.

Research Methodology

The aim of this survey is to demonstrate the relationships among many factors, including organizational sustainability performance, green manufacturing, and eco-innovation. To investigate the claims, a field survey utilizing a questionnaire will be employed.

Issues:

While there's a general consensus on the positive contributions of green manufacturing and eco-innovation to sustainability, research can delve deeper into specific complexities:

1. Measuring the Performance of Sustainability: Defining and evaluating a company's sustainability performance poses challenges as current methodologies may not adequately encompass the full scope of impact across environmental, social, and economic dimensions. The development of a comprehensive and standardized measurement framework remains an area of continuous research.
2. Understanding Causation and Effect: Although studies often demonstrate a correlation between environmentally-friendly practices and improved sustainability outcomes, disentangling causation from correlation proves challenging. External factors such as regulations and market demands may also significantly influence the observed results.
3. Balancing Short-term Expenses and Long-term Gains: The implementation of sustainable practices frequently necessitates initial investments in new technologies or processes. It is crucial to explore methods of quantifying the long-term benefits, such as reduced waste disposal costs or enhanced brand reputation, in order to validate the upfront expenditures.
4. Industry-Specific Considerations: The efficacy of green practices and eco-innovations can vary substantially across diverse industry sectors. Conducting an analysis on how these sustainable approaches should be tailored to individual industries is essential to maximize their impact on sustainability.
5. Life Cycle Assessment: A comprehensive understanding of a product's environmental impact necessitates the utilization of Life Cycle Analysis (LCA), which evaluates all stages from raw material extraction to final disposal.
6. Consumer Patterns: The demand for sustainable products is increasing among consumers, but the willingness to pay a premium can demonstrate inconsistencies. It is imperative to bridge the gap between consumer attitudes towards sustainability and their actual purchasing behaviour to encourage sustainable manufacturing practices.

Research Questions:

1. What are the main factors influencing and impeding the adoption of eco-innovation and green manufacturing techniques across various industries?
2. How can the social, economic, and environmental effects of eco-innovation and green manufacturing be quantified and evaluated?

3. In order to hasten the shift to sustainable manufacturing, what are the most effective tactics for encouraging cooperation and knowledge exchange among various stakeholders?

Hypothesis:
H01: Green manufacturing has a positive relationship with corporate sustainability performance
H02: Eco- innovation has a positive relationship with corporate sustainability performance.

Sample and Data Collection :
A survey was used in the study to collect quantitative data for statistical testing of the variables' relationship. The questionnaire was tested on employees and entrepreneurs in the manufacturing and service sectors in southern Odisha. Data obtained from those questionnaires was analysed through the SPSS statistical program and proposed relations were tested through frequency and descriptive analysis. Business entities from southern Odisha's MSME sector make up the study's population. Total sample size is 55.

Data Analysis
Frequency test
1**. What is the primary industry sector of your company?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	1.8	1.8	1.8
	2	2	3.6	3.6	5.5
	3	3	5.5	5.5	10.9
	4	3	5.5	5.5	16.4
	5	3	5.5	5.5	21.8
	6	3	5.5	5.5	27.3
	7	3	5.5	5.5	32.7
	8	1	1.8	1.8	34.5
	9	2	3.6	3.6	38.2
	10	2	3.6	3.6	41.8
	11	5	9.1	9.1	50.9
	12	3	5.5	5.5	56.4
	13	2	3.6	3.6	60.0
	14	3	5.5	5.5	65.5
	15	4	7.3	7.3	72.7
	16	4	7.3	7.3	80.0
	17	4	7.3	7.3	87.3
	18	2	3.6	3.6	90.9
	19	1	1.8	1.8	92.7

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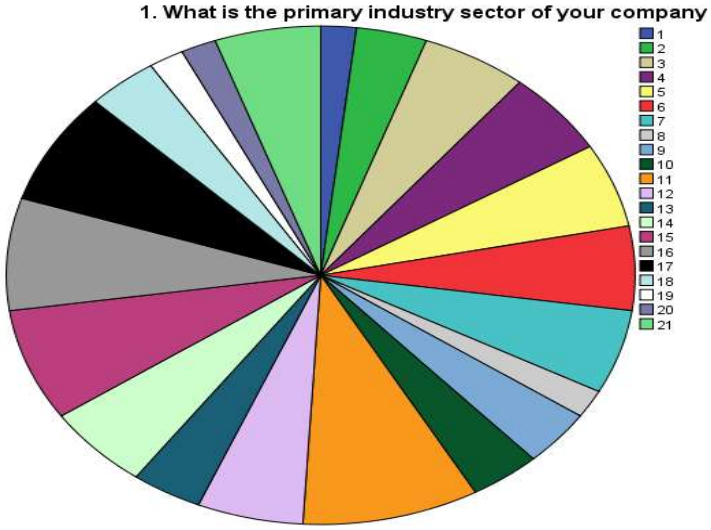
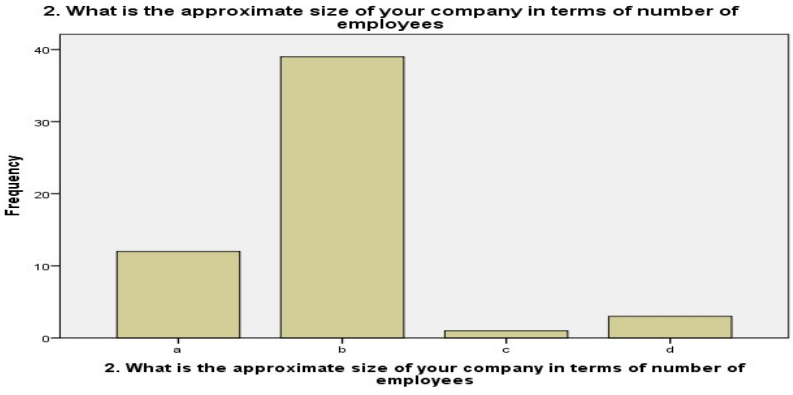
	20	1	1.8	1.8	94.5
	21	3	5.5	5.5	100.0
	Total	55	100.0	100.0	



2. What is the approximate size of your company in terms of number of employees

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	a	12	21.8	21.8	21.8
	b	39	70.9	70.9	92.7
	c	1	1.8	1.8	94.5
	d	3	5.5	5.5	100.0
	Total	55	100.0	100.0	



3.

3. Is Green manufacturing important to your company's overall strategy

	Frequency	Percent	Valid Percent	Cumulative Percent

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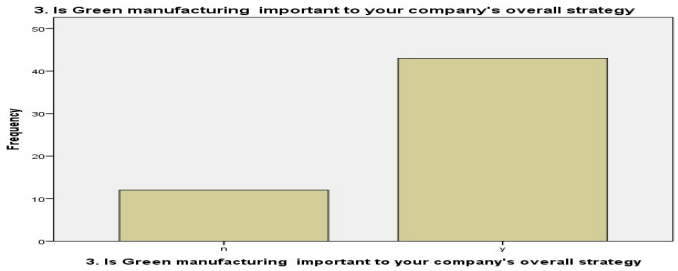
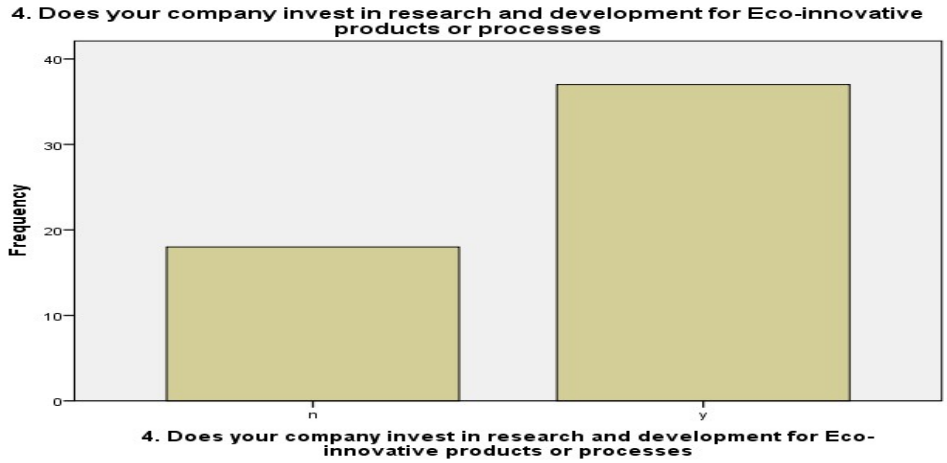


	n	12	21.8	21.8	21.8
Valid	y	43	78.2	78.2	100.0
	Total	55	100.0	100.0	

4. Does your company invest in research and development for Eco-innovative products or processes?

		Frequency	Percent	Valid Percent	Cumulative Percent
	n	18	32.7	32.7	32.7
Valid	y	37	67.3	67.3	100.0
	Total	55	100.0	100.0	



5. **Does your company have a formal sustainability policy or program?**

		Frequency	Percent	Valid Percent	Cumulative Percent
	n	22	40.0	40.0	40.0
Valid	y	33	60.0	60.0	100.0
	Total	55	100.0	100.0	

6. **Eco-innovation is necessary to achieve high levels of environmental performance"**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	2	3.6	3.6	3.6
	4	22	40.0	40.0	43.6
	5	31	56.4	56.4	100.0
	Total	55	100.0	100.0	

7. **Eco- innovation is worthwhile**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	1	1.8	1.8	1.8
	4	23	41.8	41.8	43.6
	5	31	56.4	56.4	100.0
	Total	55	100.0	100.0	

8. **Eco-innovation is necessary to improve profitability and market share**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	4	7.3	7.3	7.3
	4	30	54.5	54.5	61.8
	5	21	38.2	38.2	100.0
	Total	55	100.0	100.0	

9. **Eco-innovation helps to strengthen the brand**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	1	1.8	1.8	1.8
	3	2	3.6	3.6	5.5
	4	31	56.4	56.4	61.8
	5	21	38.2	38.2	100.0
	Total	55	100.0	100.0	

10. **Eco-innovation helps the company in entering new markets**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	1	1.8	1.8	1.8
	4	29	52.7	52.7	54.5
	5	25	45.5	45.5	100.0
	Total	55	100.0	100.0	

11. **There are barriers to your company pursuing eco innovation**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	8	14.5	14.5	14.5
	3	12	21.8	21.8	36.4
	4	18	32.7	32.7	69.1
	5	17	30.9	30.9	100.0
	Total	55	100.0	100.0	

12. It is possible to achieve competitive advantage through green concepts

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	3	5.5	5.5	5.5
	4	26	47.3	47.3	52.7
	5	26	47.3	47.3	100.0
	Total	55	100.0	100.0	

13. **The manufacturing process of a company reduces the emission of hazardous substances or waste.**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	3	5.5	5.5	5.5
	3	1	1.8	1.8	7.3
	4	24	43.6	43.6	50.9
	5	27	49.1	49.1	100.0
	Total	55	100.0	100.0	

14. **The manufacturing process of a company reduces the use of raw materials and ensures sustainability**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	2	3.6	3.6	3.6
	3	4	7.3	7.3	10.9
	4	27	49.1	49.1	60.0
	5	22	40.0	40.0	100.0
	Total	55	100.0	100.0	

15. **Has your company ever taken steps like "low energy consumption", "Use of cleaner technology and "remanufacture material" in the production process.**

	Frequency	Percent	Valid Percent	Cumulative Percent

	2	5	9.1	9.1	9.1
	3	6	10.9	10.9	20.0
Valid	4	23	41.8	41.8	61.8
	5	21	38.2	38.2	100.0
	Total	55	100.0	100.0	

16. **Green manufacturing is important to build long lasting customer relationships**

		Frequency	Percent	Valid Percent	Cumulative Percent
	2	1	1.8	1.8	1.8
	3	1	1.8	1.8	3.6
Valid	4	30	54.5	54.5	58.2
	5	23	41.8	41.8	100.0
	Total	55	100.0	100.0	

17. **It is possible to increase the company's market share through green concepts**

		Frequency	Percent	Valid Percent	Cumulative Percent
	3	4	7.3	7.3	7.3
Valid	4	29	52.7	52.7	60.0
	5	22	40.0	40.0	100.0
	Total	55	100.0	100.0	

18. **Your company has faced challenges in implementing green practices.**

		Frequency	Percent	Valid Percent	Cumulative Percent
	2	4	7.3	7.3	7.3
	3	8	14.5	14.5	21.8
Valid	4	26	47.3	47.3	69.1
	5	17	30.9	30.9	100.0
	Total	55	100.0	100.0	

19. **It is essential to incorporate environmental solutions into new product development process**

		Frequency	Percent	Valid Percent	Cumulative Percent
	2	3	5.5	5.5	5.5
Valid	4	34	61.8	61.8	67.3
	5	18	32.7	32.7	100.0
	Total	55	100.0	100.0	

20. **It is necessary to strive for continuous improvement of environmental friendliness of our products**

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		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	2	3.6	3.6	3.6
	4	21	38.2	38.2	41.8
	5	32	58.2	58.2	100.0
	Total	55	100.0	100.0	

Descriptive test

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
6. Eco-innovation is necessary to achieve high levels of environmental performance"	55	3	5	4.53	.573	-.724	.322	-.455	.634
7. Eco- innovation is worthwhile	55	2	5	4.53	.604	-1.415	.322	3.680	.634
8. Eco-innovation is necessary to improve profitability and market share	55	3	5	4.31	.605	-.255	.322	-.573	.634
9. Eco-innovation helps to strengthen the brand	55	2	5	4.31	.635	-.811	.322	1.850	.634
10. Eco-innovation helps the company in entering new markets	55	3	5	4.44	.536	-.112	.322	-1.214	.634
11. There are barriers to your company pursuing eco innovation	55	2	5	3.80	1.043	-.394	.322	-1.007	.634
12. It is possible to achieve competitive advantage through green concepts	55	3	5	4.42	.599	-.477	.322	-.618	.634

13. The manufacturing process of a company reduces the emission of hazardous substances or waste.	55	2	5	4.36	.778	-1.480	.322	2.570	.634
14. The manufacturing process of a company reduces the use of raw materials and ensures sustainability	55	2	5	4.25	.751	-1.006	.322	1.288	.634
15. Has your company ever taken steps like "low energy consumption", "Use of cleaner technology and "remanufacture material" in the production process.	55	2	5	4.09	.928	-.906	.322	.124	.634
16. Green manufacturing is important to build long lasting customer relationships.	55	2	5	4.36	.620	-.910	.322	2.299	.634
17. It is possible to increase the company's market share through green concepts	55	3	5	4.33	.610	-.310	.322	-.599	.634
18. Your company has faced challenges in implementing green practices.	55	2	5	4.02	.871	-.734	.322	.087	.634

19. It is essential to incorporate environmental solutions into new product development process.	55	2	5	4.22	.712	-1.304	.322	3.219	.634
20. It is necessary to strive for continuous improvement of environmental friendliness of our products	55	3	5	4.55	.571	-.802	.322	-.335	.634
Valid N (list wise)	55								

Crosstabs

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
1. What is the primary industry sector of your company * 6. Eco-innovation is necessary to achieve high levels of environmental performance"	55	100.0%	0	0.0%	55	100.0%

1. What is the primary industry sector of your company * 6. Eco-innovation is necessary to achieve high levels of environmental performance" Cross tabulation

Count

		6. Eco-innovation is necessary to achieve high levels of environmental performance"			Total
		3	4	5	
1. What is the primary industry sector of your company	1	0	0	1	1
	2	0	1	1	2
	3	0	3	0	3
	4	0	2	1	3
	5	0	1	2	3
	6	0	0	3	3
	7	1	0	2	3
	8	0	0	1	1
	9	0	1	1	2

	10	0	2	0	2
	11	0	2	3	5
	12	0	0	3	3
	13	0	0	2	2
	14	0	2	1	3
	15	1	1	2	4
	16	0	2	2	4
	17	0	2	2	4
	18	0	0	2	2
	19	0	0	1	1
	20	0	1	0	1
	21	0	2	1	3
Total		2	22	31	55

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	36.860[a]	40	.612
Likelihood Ratio	38.342	40	.545
Linear-by-Linear Association	.001	1	.976
N of Valid Cases	55		

a. 63 cells (100.0%) have expected count less than 5. The minimum expected count is .04.

Findings:

Frequency test

a. Majority of the respondents feel that Green manufacturing is important to their company's overall strategy
b. About 67 percent of the respondents said that their company invested in research and development for Eco-innovative products or processes.
c. 60 percent of the respondents said that their company has a formal sustainability policy or program
d. About 96 percent of the respondents agreed that Eco-innovation is necessary to achieve high levels of environmental performance
e. 97 percent of the respondents agreed that Eco- innovation is worthwhile
f. About 92 percent of the respondents felt that Eco-innovation is necessary to improve profitability and market share.
g. Around 95 percent of the respondents agreed that Eco-innovation helps to strengthen the brand.
h. 97 percent of the respondents agreed that Eco-innovation helps the company in entering new markets.
i. About 63 percent of the respondents said that there are barriers to your company pursuing eco innovation.

j. Around 95 percent of the respondents agreed that it is possible to achieve competitive advantage through green concepts.
k. 92 percent of the respondents agreed that the manufacturing process of a company reduces the emission of hazardous substances or waste.
l. 92 percent of the respondents agreed that the manufacturing process of a company reduces the use of raw materials and ensures sustainability.
m. 79 percent of the respondents agreed that their company believes in low energy consumption.
n. About 96 percent of the respondents agreed that Green manufacturing is important to build long lasting customer relationships.
o. 92 percent of the respondents agreed that It is possible to increase the company's market share through green concepts.
p. 78 percent of the respondents agreed that their company has faced challenges in implementing green practices.
q. 94 percent of the respondents felt that it is essential to incorporate environmental solutions into new product development process.
r. 95 percent of the respondents felt that it is necessary to strive for continuous improvement of environmental friendliness of our products.

Descriptive test

The minimum score observed was found to be 2 which is "disagree' and the maximum score was 5 which is "strongly agree". The mean score was found to be greater than 4 in all but one criteria. The response shows that the respondents largely agreed that eco-innovation and green manufacturing have a positive impact on sustainability.
The skewness was left tailed in all the cases. Skewness measures the symmetry of the distribution. Kurtosis refers to the peak of the distribution. Question number 6, 8,10,11,12 have a negative kurtosis while rest have a positive kurtosis.

Chi square test

Row variable: What is the primary industry sector of your company?

Column variable: Eco-innovation is necessary to achieve high levels of environmental performance

A chi-square test is a statistical test used to determine if there is a significant difference between the observed frequencies of events (what you actually measured) and the expected frequencies (what you would expect to happen if there were no relationship between the variables).
The chi-square value itself is a measure of the discrepancy between the observed and expected values. Larger chi-square values generally indicate a greater difference between the observed and expected values.

In this, the value of the chi square statistic is 36.86.
The *p*-value is (.612) appears in the same row in the "Asymptotic Significance (2-sided)" column.

- **Pearson Chi-Square (36.860a):** This value indicates a potential difference between observed and expected frequencies, but due to the low expected counts, it might not be reliable.
- **Significance (0.612):** This p-value is high (greater than 0.05), suggesting there's no statistically significant difference at a common significance level. However, with low expected counts, this might not be trustworthy either.

Conclusion

The analysis suggests that the following findings of the research are probably true:

• Eco-innovation and green manufacturing improve sustainability performance. This is expected given that these methods seek to lessen their negative effects on the environment and increase resource efficiency.

These are a few options:

For some sustainability-related factors, the impact might be greater. While eco-innovation promotes social progress in addition to environmental advantages, green manufacturing may have a greater impact on environmental performance.

The effects of various eco-innovations may differ. Product innovation that calls for customer behaviour changes may not have the same impact as process innovation that focuses on waste reduction.

Suggestions

• Examining the various forms of eco-innovation and green manufacturing, more closely the behaviours that affect sustainability the most.
• Taking the long haul into account. Examining the long-term effects of these activities on sustainability.
•Examining cost-benefit calculations i.e. the financial effects of eco-innovation and green manufacturing in addition to their advantages for sustainability.
•Conducting studies tailored to the industry.
• Examining how customers behave i.e. how product eco-innovation affects consumer decisions and sustainability in general.

Through consideration of these recommendations, the study can offer a more thorough comprehension of the ways in which eco-innovation and green manufacturing help to realize sustainable practices.

REFERENCES :

Ambec, S. and Lanoie, P. (2008). When and why does it pay to be green? Academy of Management Perspectives, 23, 45-62.
Arundel A. and Kemp, R. (2009). Measuring eco-innovation, UNI-MERIT Research Memorandum.
Burk, S., Goughran, W., 2007. Developing a framework for sustainability management in engineering SMEs. Robotics and Computer Integrated Manufacturing, 23, 696-703
Chen, Y.S., Shyh-Bao, L. and Chao-Tung W(2006), The Influence of Green Innovation Performance on Corporate Advantage in Taiwan, Journal of Business Ethics 67(4), 331 339.
Christmann, P., (2000). Effects of best practices of environmental management on cost advantage: the role of complementary assets.Academy of Management Journal 43, 663 680.
Dangelico, R.M., Pujari, D., 2010. Mainstreaming green product innovation: why and how companies integrate environmental sustainability. Journal of Business Ethics. Published online.
Frondel, M., Horbach, J. and Rennings, K. (2007). End-of-pipe or cleaner production? An empirical comparison of environmental innovation decisions across OECD countries. Business Strategy and the Environment 16, 8, 571 584.
Greeno, L. J. and Robinson, S.N. (1992), Rethinking Corporate Environmental Management, The Columbia Journal of World Business 27(3/4), 222 232

Horbach, J. (2008). Determinants of environmental innovation new evidence from German panel data sources. Research Policy 37, 163 173
Klassen, R. and Whybark, D., 1999. The impact of environmental technologies on manufacturing performance. Academy of Management Journal 42, 599 615
Mohnty, R.P., Deshmukh, S.D., 1998. Managing green productivity, some strategic directions. Production Planning and Control 9 (7), 624-633
Porter M.E. van der Linde C.. (1995). Green and Competitive - Ending the Stalemate. Harvard Business Review, Sept.-Oct., 120 134.
Rao, P. and Holt, D. (2005). Do green supply chains lead to competitiveness and economic performance? Int. J. Oper. Prod. Manage. 25, 898 916.
Ranganathan, J. (1998). Sustainability rulers: Measuring corporate environmental and social performance. Sustainability Enterprise Perspective, May, 1-11. Washington.
Shrivastava, P. (1995). The role of corporations in achieving ecological sustainability. The Academy of Management Review 20, 4, 936-961.
Taylor, S.R. (1992), Green management: the next competitive weapon, Futures, Vol. 24 No. 7, 669-80.