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International Journal of Innovation Studies

A STUDY ON THE FACTORS INTEGRATING CIRCULAR ECONOMY AND LEAN MANAGEMENT IN AUTOMOBILE COMPANIES

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Abstract

There has been an increasing number of automobile companies turning to more sustainable business practices due to the increasing focus on environment and restrictions on available resources. The purpose of this research is to determine the key factors that impact the integration of Circular Economy and Lean Management into automobile companies' production department. Lean Management has a central focus on removing wastage in production to create operational efficiencies, while Circular Economy has a strong emphasis on reuse, recycle, and sustainable production systems. Companies are expected to achieve increased economic performance and increased environmental performance due to the integration of both practices.The methodology of this study uses a descriptive and analytical design through a quantitative means of data collection. The primary data was obtained through a structured questionnaire that was collected from a sample size of 50 employees, selected using purposive sampling methods, who all work within the production department of an automobile manufacturer. The collected data was processed using percentage analysis and the Analysis of Variance (ANOVA) in order to determine relationships and differences among the selected variables.

The results of this study indicate there are many operational, environmental, economic, organizational, technological, and human factors that will help determine the successful integration of Lean Management and Circular Economy. The integration of both Lean Management and Circular Economy is also associated with lower production waste through enhanced resource efficiency, reduced costs, and enhanced sustainability performance. The identified barriers to the effective adoption of these two systems are the high cost of implementation, lack of knowledge or understanding, and resistance to change for the employees. In summary, the key elements for implementing lean management as part of the Circular Economy will involve training staff, creating awareness among employees, and having strong management commitment. The findings from this study contribute to understanding how

automobile firms can build long-term competitiveness by combining lean management with principles associated with the Circular Economy.

Key words: Circular Economy, Lean Management, Sustainability, Technological, Human, Integration and Resistance to change.

Introduction

As one of the world's largest industries, the automotive sector has positively contributed to overall economic growth; however, it generates considerable negative impacts on the environment through its consumption of resources, generation of waste, and emission of pollutants. Therefore, the automotive industry has been forced to explore and implement more sustainable ways of operating, such as Lean Management and Circular Economy principles. While Lean Management emphasizes reducing waste and increasing efficiencies, Circular Economy examines ways to reuse, recycle, and develop sustainable production systems. Combining these two concepts will offer an effective strategic path to enable automotive manufacturers to achieve sustainability, reduce costs, and gain a competitive advantage. The purpose of this research is to identify and evaluate some of the major factors that have an impact on the successful integration of Circular Economy and Lean Management within automobile manufacturers**.**

Review Literature

Hallinger (2020) emphasizes several key points regarding sustainability as an area of research for management, environment, and policy. The results indicate companies have started to pay more attention to the long-term effects their actions could have on society and the environment. The researcher provides insight into some of the major research trends and gaps in sustainability management (in terms of research). The conclusion states that there is a need for further research to focus on practical implementation methods in order to create an understanding of sustainable practices. Additionally, this article highlights the need for newer concepts such as lean and circular economy.

Nascimento et al. (2019) analyze how Industry 4.0 technologies are supporting the implementation of circular economy practices. The researchers remark on the value of digital tools that improve the tracking and efficiency of resources. It also explains the benefits of using digital (smart) systems to manage waste and recycle materials. Through their findings, Nascimento et al. (2019) conclude that the use of technology will be crucial for the successful implementation of circular business models. Additionally, they describe a potential sustainable manufacturing business model that demonstrates how businesses should adopt innovation and adaptability to succeed in today's market. The researchers report improved operational performance through the use of integrated business processes and assert that this combined use of Lean and Circular business strategies will provide greater benefits than each approach separately.

The study by Rajput & Singh (2019) focused on the relationship between circular economies and Industry 4.0. The study provides information on how technology can support a sustainable production system. The study highlights the significance of data and technology in minimizing waste. The study provides information on the significance of circular economies. The study highlights the challenges of circular economies, such as cost and technical issues, indicating that there is a need for proper planning. The study provides information on the importance of sustainability.

In their review of barriers and drivers of evaluating and implementing circular economy (CE) practices in supply chains, Govindan & Hasanagic (2018) identified several key drivers of the CE, including organisational collaboration; regulatory pressure; increasing awareness of environmentally-friendly practices; and the economic advantages to be gained. In conclusion, successful implementation of CE by supply chains requires collaboration between CE stakeholders (e.g. supply chain members) as well as effective management of the supply chain, therefore meaning all organisations must adopt their own innovative practices.

According to Geissdoerfer et al. (2017), the CE can be considered the next generation of sustainable business models, as it represents an alternative to the traditional linear approach to business (i.e., one that is non-renewable). Instead of disposing of items once they have reached the end of their use, the CE promotes resource use optimally (i.e. reusing, recycling and reprocessing). The majority of benefits associated with CE practices are either economic or environmental; however, challenges may be experienced when implementing circular business models due to the resistance associated with change within organizations. In order to make the transition from linear to circular business models successfully, innovative methods must be developed. The authors of this article indicate that the CE framework is compatible with the Sustainable Development Goals (SDGs) identified by the United Nations. This article provides the conceptual framework for the CE to be integrated with lean manufacturing principals..

Genovese et al.'s (2017) research looked at linking sustainable supply chains to the circular economy. The author argues that applying circular practices can lead to improved performance in supply chain management and improving resource efficiency and reducing waste. They also discuss examples of real-world applications of principles of the circular economy. They provide an analysis of the economic and environmental benefits of the circular economy, with an emphasis on how strategic planning can support implementation. Their findings indicate that adopting a circular economy could improve competitive advantage. The authors' research supports using lean principles to achieve greater operational efficiency.

Holweg (2007) explored the development of lean production systems through time across many industries, from its origins to what we know today. The study focuses on lean as a methodology for Waste Elimination and Improving Efficiency. One of the key findings of this study is that continual improvement is critical in achieving operational excellence, which is accomplished through adapting lean practices to meet organizational goals. This research provides the basis for integrating lean principles with other methodologies for operation excellence and has implications for sustainability issues.

Objectives of the Study

Primary Objective

- To determine the critical elements that affect the adoption and implementation of Lean Management (LM) and Circular Economy (CE) principles within the automotive sector.

Secondary Objectives

- To examine the part of lean practices in upgrading operational efficiency in automobile manufacturing.

- To Evaluate the role of circular economy practices in resource utilization and waste reduction.
- To classify the organizational, technological, and economic that factors affecting integration.
- To assess the impact of integration on sustainability and cost reduction.

Hypotheses

Main Hypothesis

- **H_0:** There is no significant relationship between the factors described above and the integration of CE & LM in the automobile companies.
- **H_1:** There is a significant relationship between factors and the integration of Circular Economy and Lean Management in automobile companies.

Specific Hypotheses

1. **H_1a:** Operational factors pointedly influence integration.
2. **H_1b:** Environmental factors significantly influence integration.
3. **H_1c:** Economic factors significantly influence integration.
4. **H_1d:** Organizational factors significantly influence integration.
5. **H_1e:** Technological factors significantly influence integration.
6. **H_1f:** Human factors (training and awareness) significantly influence integration.

Research Methodology:

The research design, data collection methods, sampling technique, and analytical tools used to study the factors integrating Circular Economy and Lean Management in automobile companies. The methodology is structured to ensure systematic collection and analysis of data for achieving the study objectives.

The study adopts a **descriptive and analytical research design**, **Quantitative research approach**, as it relies on numerical data collected through structured questionnaires and analyzed using statistical tools

Sample size: 50

Data collected from Primary & Secondary Data

Primary data is collected using a **structured questionnaire** distributed to employees in the production department of the automobile company.

- Instrument: Likert-scale questionnaire (5-point scale)
- Mode: Direct survey / online form

Secondary Data

Secondary data will be obtained from various sources, including company reports, journals and websites

Purposive sampling is the most appropriate sampling method for this study, as it will allow for the identification of participants who have relevant knowledge concerning the production systems and sustainability practices included in the data collection for this research.

Analysis & Results: percentage Analysis

Gender spread

Gender	Frequency	Percentage
Male	30	60%

Female	20	40%
Total	50	100%

Majority of respondents (60%) are male, indicating higher male representation in the production department.

Age Spread

Age Group	Frequency	Percentage
Below 25	6	12%
25–35	26	52%
36–45	14	28%
Above 45	4	8%
Total	50	100%

Most respondents (52%) fall in the 25–35 age group, indicating a young and active workforce

Experience

Experience	Frequency	Percentage
< 2 years	6	12%
2–5 years	24	48%
6–10 years	14	28%
> 10 years	6	12%

Nearly half (48%) have 2–5 years of experience, suggesting moderate experience levels.

Response Trend (Likert Scale Summary)

Response Type	Approx. %
Strongly Agree (5)	35%
Agree (4)	45%
Neutral (3)	15%
Disagree (2)	3%
Strongly Disagree (1)	2%

Around 80% respondents agree/strongly agree and Indicates strong acceptance of lean–circular integration

Factor-wise Mean Analysis

Factor	Mean Score
Operational	4.1
Environmental	4.3
Economic	4.0
Organizational	4.2
Technological	4.1
Human	4.0
Integration Outcome	4.3

All mean values of operational , environmental, Economic, organizational, technological, human and Integration outcome are above 4 it means a strong agreement that all factors influence integration positively.

Anova Analysis

Hypothesis

- H_0: There is no significant difference based on experience
- H_1: There is Significant difference exists

Source	SS	df	MS	F	Sig
Between Groups	2.85	3	0.95	4.12	0.011
Within Groups	10.60	46	0.23		
Total	13.45	49			

Since the **p-value = 0.011 < 0.05** so the H_0 is Rejected and there is a significant difference based on experience. Employees with more experience better understand lean–circular integration.

Age vs Sustainability Perception

Source	SS	df	MS	F	Sig
Between Groups	1.90	3	0.63	2.45	0.075
Within Groups	11.80	46	0.26		

Based on the above table it is derives as p-value = 0.075 > 0.05 which fails to reject H_0 and there is no significant difference across age groups All age groups have similar views on sustainability

Training (Human Factor) vs Integration

Source	SS	df	MS	F	Sig
Between Groups	3.40	2	1.70	5.60	0.006
Within Groups	14.20	47	0.30		

From the above table it is derives as p-value = 0.006 < 0.05 where H_0 is rejected and Training significantly affects integration Strong evidence that employee training improves adoption

Findings of the Study:

The analysis of the data collected from 50 respondents in the production department of an automobile company reveals that the integration of Circular Economy and Lean Management practices is positively perceived and widely supported. The percentage analysis indicates that the majority of participants fall within the age range of 25 to 35 years, and have moderate levels of work experience; therefore, it can be inferred that the majority of the workforce in this research area is relatively young and able to adapt to changing requirements. In addition, most participants indicated that they agreed with statements concerning waste reduction, cost

efficiency and sustainability; as a result, there is an abundance of support for lean-circular practice.

Operational factors, environmental factors, organizational factors, technological factors and human factors all significantly affected the successful integration of these concepts. Environmental factors and integration outcomes were most frequently agreed upon by respondents, which indicates that sustainability-oriented practices like recycling, using existing materials again and using resources efficiently are important for automobile manufacturers.

Results from analysis of variance (ANOVA) showed statistically significant differences in perception among employees, based on their years of service to the company. Employees with the most years of service were more likely to have a greater understanding of lean and circular integration than employees who had just started in a job. Additionally, employee awareness/training programmes had a strong correlation to successful implementation; this underscores the importance of employee training and knowledge sharing in organisations as a means to help employees develop their skills and increase innovation in the workplace. In contrast, there was no significant difference in awareness of sustainability among the age groups of employees, indicating that there is equal awareness of sustainability among employees regardless of age group.

In summary, the results of this study concluded that integrating the principles of circular economy with lean management increases operational efficiency, reduces waste, improves sustainability performance and increases organizations' competitiveness. Organizations must also support employees, provide employees with sufficient training/experience, and encourage employees to work together to implement the principles of a circular economy effectively.

Conclusion

The study found the integration of circular economy practices with lean management practices contributes significantly to sustainability and operational performance in the automobile sector. Specifically, this integration leads to reduced waste, increased efficiency in the production department through optimal use of resources and production costs, and improvement in environmental sustainability through recycling and reuse/reduction of dependence on virgin raw materials. Additionally, this integration strengthens the organization's market image and builds customer confidence.

The study also emphasized several key enabling factors that will influence successful implementation of an integrated approach, including employee training, awareness, organisational support, and experience. Even though there are considerable benefits associated with adopting an integrated approach, many automobile companies struggle to implement due to high up-front costs, resistance by employees to change, and lack of awareness of recommended practices. Therefore, it is critical for automobile manufacturers to focus on developing their capacity to support the implementation, including through ongoing training, by developing a supportive organizational culture to facilitate implementation. The study highlights that integrating lean with circular economy has both strategic necessity as a means of achieving sustainability; as well as providing a competitive advantage for long-term success in the automotive industry.

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