TRANSCENDING SUPPLY Chains in Circular Economy: A Multi-Disciplinary Approach

Edited by:
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Dr. Ashu Sharma

SVKM'S NMIMS Deemed to be UNIVERSITY

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Preface

The book attempts to convey circularity in extant supply chains in a multi-disciplinary environment. The concept of circularity refers to the ways of reducing the waste in the environment and intelligently using this waste by reuse and recycling. The popular five 'R' associated with circularity apart from the aforementioned are Reducing, Refurbishing and Repairing. Rather than being squandered, a product, service, or resource is replenished or regenerated. Knowledge of these practices acts as a double sword for enhancing the market performance of the product especially considering the environment conscious customers and reducing the carbon footprint. Through these incremental improvement in business operations practitioners and academia both can achieve the 11th Sustainable development goals (SDG) put forth by the United Nations that emphasises *"Sustainable cities and communities"*. The book focuses on the relevant practices and theories that are important for ensuring a circular economy in the supply chain and in the project context. The improvement projects conceptualized in several spheres need to be aligned with the objectives of a circular economy that will emphasize reducing waste and pollution, circulating products and materials (at their most valuable), and rejuvenating nature. The industry cases and academic perspectives will greatly help the professionals practice circularity to ensure a robust system that benefits businesses, people, and the environment. The chapters will also address climate change and other global issues such as biodiversity loss, waste, and pollution. The chapters are devoted towards designing and applying models/frameworks for implementing a closed loop in diverse supply chains with a major emphasis on future implications. The book will generate an interest among academia and industry practitioners in making their processes circular.

The case studies are widely spread across topics such as alumina to automotive industries, solid waste management to cement industry and healthcare to semiconductor manufacturing. Book chapters will help managers embrace a circular economy model that can deliver multifaceted benefits to industries, transcending short-term supply chain

gains to establish long-term sustainability and resilience while aligning with societal and environmental concerns. The research works on circular economy cover various spheres such as fresh food supply chain to luxury hotels and an emerging topic of sustainability projects. These chapters provide a comprehensive framework that can be adopted by industry practitioners to address sustainability challenges by fostering innovation, interdisciplinary collaboration, policy development, and holistic approaches for resource management.

I wish to acknowledge the support and enthusiastic cooperation of all the authors, my colleagues and my students for their dedication and hard work.

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Chapter 1

RESILIENCY AND CIRCULARITY IN FRESH FOOD LOGISTICS

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Abstract
The study operationalizes the important practices which could help achieve resilient operations in fresh food logistics and create a closed-loop supply chain. Practices were identified through rigorous literature review and expert validation. The interrelationships among the practices has been determined using the Fuzzy interpretive structural modelling (FISM) approach. The hierarchy among the practices and categorization into groups i.e. linkage, driver, dependence and autonomous practices, differentiated these based on their dependence and driver powers, using MICMAC analysis. IT integration was identified as the most crucial driver variable and proper fleet management was the linkage variable in the study. Certain sustainable practices such as reverse logistics discussed as a part of fleet management, instigates waste reduction in the logistics practices. This information will guide managers to achieve resilient operations in fresh food while reducing the wastage and considering circularity in all logistics operations.

Keywords: Fuzzy interpretive structural modelling (FISM), Resiliency, Circularity, Fresh Food Logistics, Sustainability.

1. Introduction

No component of daily existence is more important than the ways by which the world is nourished (Bourlakis and Weightman 2004). Logistics is critical in feeding the planet. For the last 20 years, food has been a topic of the logistics study, and interest in these aspects has increased in recent years due to evolving, vital societal matters such as globalisation, quality alerts, and increased demands of quality, and changes in the relationships and dynamics of food supply chain structures (Dani and Deep 2010). Because food logistics is becoming increasingly important and a contributor of the majority of the food wastages, it is crucial to evaluate the current status of logistics operations.

Various research works related to food logistics are widely disseminated because they can be analysed from the perspectives of food research or logistics research. The skeptic may wonder why academics feel compelled to investigate logistics for food. Reason are many, few of these include the perishability nature of food , sensitivity to the surrounding environment, demand and supply seasonality, and reliance on natural conditions for production. Food products differ from other non-edible products in that they place unique demands on logistics (Jharkharia and Shukla , 2013). As a result, logistics experts must adapt and trigger solutions that meet the special requirement of food sector.

During the various logistic operations lot of product and energy wastages happen. In India, these wastages are tremendous leaving the logistics firms to rethink and redesign the various logistics operations. The slow growth in logistics profits could be asserted to the challenges faced in the field. These are in terms of fragmentation, technology, poor infrastructure, and poor roads. Therefore, it's crucial to identify the solutions that create an integrated approach for logistics players to address the waste and enhance resiliency.

2. Literature review

Food supply chain (FSCs) is one of the most impacted SCs, and it needs to be more resilient against SC disruptions because their susceptible structure such as seasonality and perishability. Thus, uncovering drivers that play a critical role in FSC resilience while ensuring the circularity is of utmost importance. Food logistics investigates logistical operations within the context of a food supply chain by problematizing food product attributes and investigating the constellation of food supply chain participants. Logistics systems, i.e. food logistics operations according to Banomyong et al. (2022), involves procurement, manufacturing, distribution, and relationship management. It is encompassing all systems and processes that enable the movement of material and non-material flows. Forward logistics involves the movement of food from origin to the point of consumption while and reverse logistics includes flows from the point of consumption to the point of disposal, destruction, reuse, remanufacturing, recycling, etc. timely discussed under the umbrella of circularity in food. Procurement majorly is considered as an important activity in SCs as it influences the quality of the products received. This activity is all about determining the best product, receiving it and approving the same. The procured product could be then stored in warehouses and later distributed to the final consumer directly through retailers. The logistics practices also encompass the coordination with the members in the chain responsible for procurement, storage and distribution.

With fresh produce, logistical challenges are immense. As timing is a crucial parameter that defines the final quality of the product delivered at several stages of the SC. The extent of product safety issues, and natural conditions intervenes with the quantity and quality of harvest. In this regard, various technologies like air-conditioned transportation and storage have been evolving and impacting the way the product quality is maintained (Vasilakakis and Sdrali, 2023). Sharma et al. (2023) attempted to establish the various activities in FFSC using an MCDM approach presenting a multi-dimensional perspective in the context. Various practices in FFSC were identified and relationships were established. Though this was for the whole SC, logistical activities were poorly explored. Hence, fresh food especially

present a unique background for FFSC actors to consider specific conditions under which the fresh produce to be transported and handled.

This uncertainty in product when combined with uncertain environment create a havoc in the management of these products. Thus, designing the present SCs with the aspect of resilience have been able to overcome the uncertain losses in SCs. Resilience is adaptability of systems and processes of organization towards disruptions. Resilience leads to optimal utilization of resources and hence achieve sustainability. The studies done so far in different economies reveals the important dimensions to be considered for designing a sustainable FFSC while being resilient. The pandemic has left the SCs to rethink the critical dimensions to be studied while making important strategic, tactical and operational decisions. The details of the dimensions to be considered while designing SCs in the dynamic environment are listed and explained in the Table 1.1. Table 1.2 unwinds a closer look into the economies emphasising on such studies. The majority of the studies have looked into MCDM approaches which involve qualitative data. This helps in exploring new arena where the research is still not matured.

Table 1.1: Variables influencing sustainability in logistics for fresh food

Enablers	**Definition**	**References**
IT integration	Use and promotion of Information technology among logistics users. These can include block chain technology, AI and ML.	Jagtap et al. (2021)
Redundancy	Multiple sourcing / logistics /fleets/ modes help create alternatives during a pandemic	Stewart and Ivanov (2019)
Risk Management	Proper identification and prioritization of risk in food logistics.	Mishra et al. (2018)
Stakeholder Collaboration	Exchange of ideas and information while decision making depicts the collaboration among SC partners. These could be enhanced by the effective and productive use of tools.	Dubey *et al.* (2020)
Adaptability/ flexibility	Flexibility is a powerful dimension that ensures the ability of SC partners to change the process	Dubey (2019), Aramyan *et al.*

Enablers	Definition	References
	or product specifications through the existing systems.	(2006)
Agility	Agility keeps a check on the quickness with which the organisations change.	Zang et al. (2019)
Sustainability	Food supply chain players focus on the optimal resource use while serving the customers safe and healthy food and ensuring it for future generations.	Pérez-Gladish *et al*. (2021)
Resilience	the capability of the supply chain to prepare for unexpected events, recover from the disruption while maintaining continuity of operations at the desired level of connectedness. Organisations also continue to have a good control over its structure and function post the recovery.	Ponomarov and Holcomb (2009)
Readiness	Preparation of the organisation by actively anticipating human, technological performance problems.	Jeffcott, et al. (2009)
Awareness /Anticipation / opacity	Organisation aware of economic, workload, and safety pressures and where effort needs to be invested to ensure that defences are not degraded	Manning and Soon (2016)
Responsiveness	Responding to sudden and abrupt market changes	Sawyerr and Harrison (2020)
Flexibility	Ability to respond and accommodate variations in number of patients. Ability to respond to and accommodate periods of medicine stock out Ability to respond to and accommodate periods of non-availability of medical staff Ability to respond to and accommodate periods of non-availability of instrument	Chakraborty et.al. (2019)
Proper fleet	Management of trucks for forward and reverse logistics providers to avoid delays in	Erenoğlu et al.

Enablers	Definition	References
management	distribution.	(2022)

Table 1.2: Snapshot of selected articles reviewed in the study

Authors (year)	Country	Title	Journal	Sector/ industry
Zhao et al. (2018)	Developed (Argentina , France, Italy, UK and Spain)	Building theory of agri-food supply chain resilience using total interpretive structural modelling and MICMAC analysis.	International Journal of Sustainable Agricultural Management and Informatics	Agri-food supply chain
Ramos et al. (2021)	Peru	A model ISM-MICMAC for managing risk in agri-food supply chain: An investigation from the Andean region of Peru.	Int. J. Value Chain Manag	Agri-food supply chain
Al-Refaie et al. (2020)	Jordan	Modelling relationships between agility, lean, resilient, green practices in cold supply chains using ISM approach.	Technological and Economic Development of Economy	Pharmaceutical-cold chain
Yadav et al. (2020).	India	Internet of things (IoT) based coordination system in Agri-food supply chain: development of an efficient framework using DEMATEL-ISM	Operations management research	Agri-food supply chain
Jedermann , et al. (2014).	USA	Reducing food losses by intelligent food logistics.	Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences,	Agri-food

Following are the key takeaways from the analysis of literature:
Very few studies focused on understanding the current requirement in making fresh food logistics resilient and circular. Majorly studies have contributed towards designing and developing resiliency for a general supply chain. Only handful of studies have provided a nascent approach towards SC design under an uncertain environment. An integrated view of waste management and resilient fresh food logistics contributing towards sustainable food design considering the logistics, is the existing void in the literature. Studies have not identified the interplay between the various decision variables leading to sustainable fresh food logistics performance. The current study addresses the two related research questions:

- RQ1: What are the factors influencing resiliency and food waste management in fresh food logistics practices?
- RQ2: How do these different factors interrelate with each other to achieve resiliency and enhance the concept of circularity?

3. Methodology
The study utilizes the mixed-methodology wherein a qualitative method was carried for exploring the variables essential for the logistics operations equipped for a circular and resilient SC intended to fulfil the first research objective. This was followed by the quantitative approach (i.e. MCDM) wherein the interpretive structural modelling (ISM) approach was adopted to meet the second research objective. The literature review involved the analysis of the latest developments in food logistics motivating practices that instigate the reuse and recycle of food waste. The review aided in revealing eleven essential food logistics activities for preparing the Indian food logistics in creating a closed loop. These eleven variables along with the dependent variable i.e. sustainability in food logistics were studies together to understand their interaction to establish a framework for the logistics providers. These relationships were developed using an interactive discussion among the logistics players in and around Mumbai region. The focus group discussion and brainstorming session with five logistics managers helped develop the structure among the variables to reveal the directional relationships and explore the impact of a decision on the each other. These

logistics managers were approached through LinkedIn and their experience, expertise and willingness to participate resulted in their selection. The ISM methodology proved to be the best way of representing the interrelationships amongst the variables with the given scope of the study. Figure 1.1 presents the detailed steps followed during the data collection and analysis.

4. Results and findings

The initial results entailed the input from the five logistics managers on the relationships among the variables under study. This initial VAXO table is presented in Annexure (Refer Table A1). The table was later converted to the binary matrix and the transitivity among the variables was determined. This is called the source to destination mapping. The final structure was formed using the hierarchical levels identified using the reachability, antecedent and intersection set. This final structure is presented in Figure 1.2. The relationships amongst all the important variables considered in the study is revealed in the structural model. This unidirectional relationship directs towards several decision making variables to be considered towards designing a sustainable logistic in Indian fresh food. The same variables are also clustered into four important categories which provides an important information regarding their relative influence when all the variables are considered as a system. Figure 1.3 clusters all the variables clearly into linkage, driver and dependent variables. This grouping also implies the relative importance of each in the whole system. The absence of autonomous variables presents a very interesting phenomenon that is played between the variables and this is their completeness in achieving sustainability. All the variables are found to be crucial in achieving sustainability and promoting circularity in fresh food logistics.

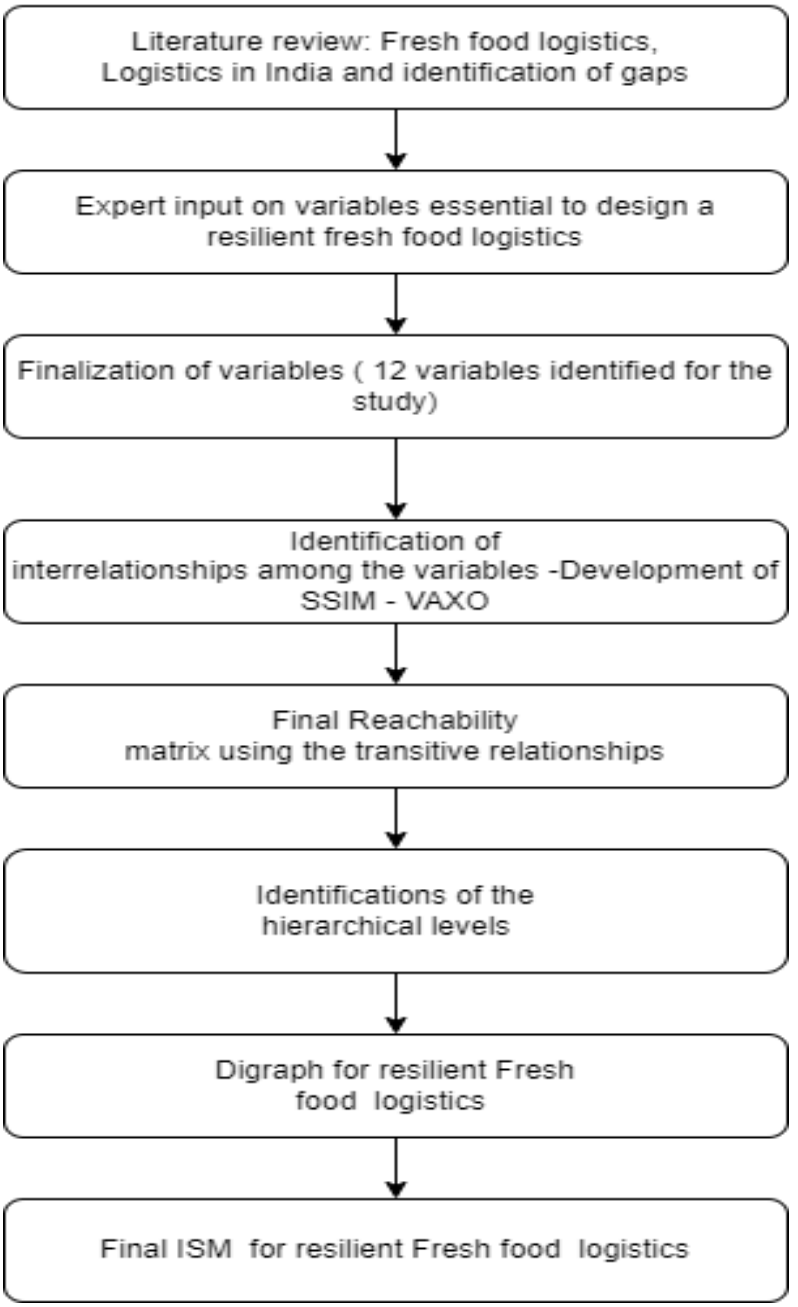

Figure 1.1: Methodology followed in the study

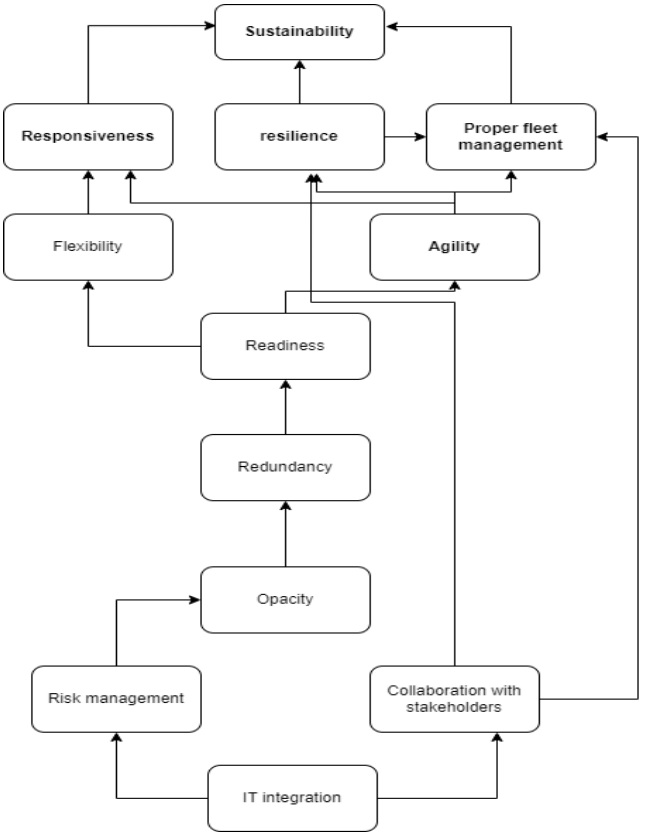

Figure 1.2: Sustainable-Circular Model for Fresh food Logistics

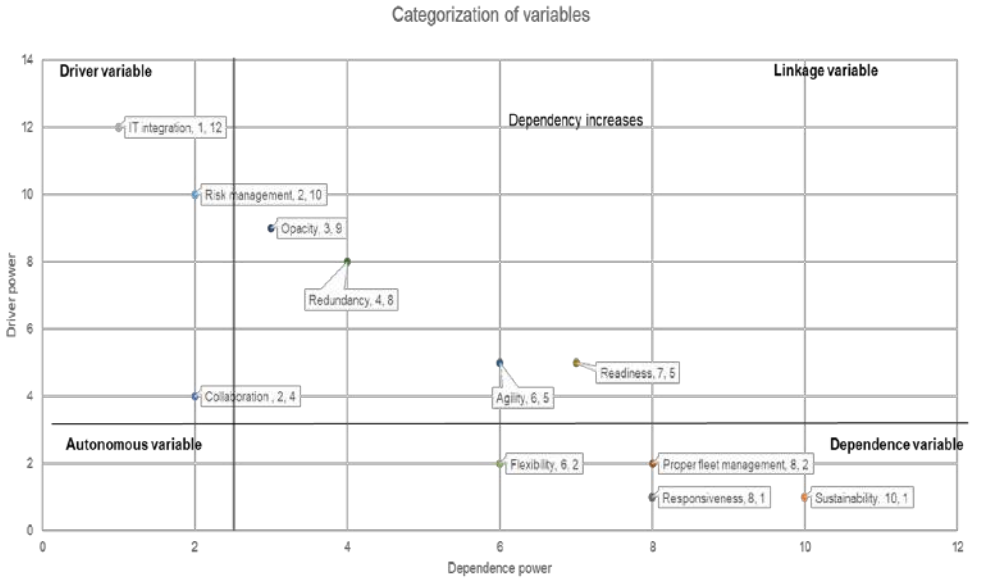

Figure 1.3: MICMAC analysis for sustainability factors in fresh food logistics

5. Discussions

Real-time information and interconnectedness, combined with breakthrough technology, will revolutionize and enhance food logistics (Jagtap et al., 2020). The practices given in figure 1.4 enhances visibility of all the logistic operations. The driver variable forms the actuators in the system that include: IT integration, risk management and collaboration. These belong to the lowest levels in the ISM. Risk management is considered to be a prerequisite in organizations and is embedded in its culture. (Ramos *et al.*, 2021; Zhao *et al.* 2018). It fosters an environment of readiness to absorb any calamity that may cause production delays in the systems. Agility and resilience found to be important concerns in the food logistics corroborates the studies of Al-Refaie *et al.* (2020) cold supply chain. IT integration (use of smart technologies) confirms the studies of Ralston and Blackhurst (2020) which also provides a concern regarding the learning curve of employees resulting in lags.

The linkage variables such as opacity, redundancy, agility, readiness belong to the middle level in the hierarchy. Readiness is recognised as the ability to keep up with constantly changing business conditions. Software development and integrating with the latest IT services leads to planning for risk management in the organisations and helps collaborate with different stakeholders internally as well as externally.

Linkage variables	Driver variables	Autonomous variables	Dependent variables
•Opacity •Redundancy •Agility •Readiness	•IT integration •Risk management •Collaboration	•Nil	•Flexibility •Proper fleet management •Responsiveness •Sustainability

Figure 1.4: Important groups for decision making in fresh food logistics

Remaining factors fall into the dependence cluster which are sustainability, flexibility, proper fleet management and responsiveness that form the upper level of the ISM structure. In the existing literature integration among several stakeholders was also found to be a driving variable in the studies of Zhao *et al.* (2018). Proper management of the fleets is the core of any logistics business.

Managing them is challenge and when handled well, will enhance the productivity of logistic activities. These aspects are not discussed much in literature along with the variables presented in the study. Intelligent food logistics with the use of technology can also reduce the fresh food wastages in the supply chain (Jedermann, 2014). Absence of autonomous factors imply that all the variables are important in achieving the outcome variable (here sustainability in food logistics activities).

6. Conclusions

Developing a carbon-free, circular, and sustainable food logistics system entails addressing various stages of the supply chain, from production to warehousing practices and distribution. Logistics managers need to understand the strategies such as sustainability and circularity, efficient packaging and optimal transportation routes will create a greater impact on the way logistics is currently handled in cities in India. Sustainable logistics practices that minimize the waste in-transit, including space utilisation, use of renewable energy sources, will reduce the harmful environmental impact. Eco-friendly packaging materials such as biodegradable or compostable materials reduce carbon footprint. Through optimal routes and investment in energy-efficient vehicles, such as electric or hybrid trucks reduces emissions and thus making logistics practices more environmentally sustainable and ensures socially responsible behaviour. Thus, firms should optimize transportation routes to reduce fuel consumption and emissions. These could also be achieved by encouraging multi-mode transport such as the use of rail and sea transportation for longer distance, as they have lower carbon footprints.

7. Limitations and future directions

The study also presents several limitations and opportunities for future research. There are geographical and sampling limitations in the study. The study results cannot be generalized for the country as a whole, as there are varying terrains and cultural attitude differences among the businesses of different regions. For generalizability, the model needs to be developed and tested using a similar or different method. Moreover, the interrelationships

among the several variables identified in the study need to be validated using the secondary data.

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structural modelling and MICMAC analysis. *International Journal of Sustainable Agricultural Management and Informatics*, *4*(3-4), 235-257.

Annexure:

Table A1: Initial Structured Self interaction matrix (SSIM) for sustainability drivers in food supply chain

	1	2	3	4	5	6	7	8	9	10	11	12
1	1	A	V	A	O	A	A	A	A	A	A	A
2	1	1	V	V	V	O	V	V	V	O	V	V
3			1	A	A	A	A	A	A	A	A	A
4				1	V	O	V	V	O	O	V	V
5					1	O	O	O	A	O	O	O
6						1	A	0	0	A	V	V
7							1	A	A	A	V	V
8								1	A	A	V	A
9									1	O	V	V
10										1	V	V
11											1	A
12												1

Chapter 2

CORPORATE GOVERNANCE: A DRIVER FOR SUSTAINABLE SUPPLY CHAIN AND FINANCIAL GROWTH

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Abstract
This study looks into how a company's efforts to build a sustainable supply chain, financial performance, and corporate governance all relate to each other. Using data from Bloomberg's Environmental, Social, and Governance (ESG) and Financial Analysis (FA) databases, the authors conducted an empirical evaluation of the links. The study aims to contribute to the body of literature on sustainable supply chain management (SSCM) by being one of the first in India to use a secondary data source to examine the relationship between financial and corporate governance (CG) benefits and social and green supply chain management practices. We first looked at the connection between the three ESG factors-environmental, social, and governance—and the financial performance of the Indian manufacturing companies listed on Bloomberg's ESG terminal. The study also investigated if corporate social responsibility (CSR) practices inside businesses influence the relationship between Green Supply Chain Management (GSCM), Socially Responsible

Supply Chain Management (SRSCM), and Economic Returns (ER). The study discovered that whereas CG activities have a minor mediating role in the relationship between GSCM and ER, they do so in the case of SRSCM and ER.

Keywords: Environmental, Social, Governance, Economic, Returns, Supply Chain

1. Introduction

This study looks into how a company's efforts to build a sustainable supply chain, financial performance, and corporate governance all relate to each other. Using data from Bloomberg's Environmental, Social, and Governance (ESG) and Financial Analysis (FA) databases, the authors conducted an empirical evaluation of the links. The study aims to contribute to the body of literature on sustainable supply chain management (SSCM) by being one of the first in India to use a secondary data source to examine the relationship between financial and corporate governance (CG) benefits and social and green supply chain management practices. We first looked at the connection between the three ESG factors—environmental, social, and governance—and the financial performance of the Indian manufacturing companies listed on Bloomberg's ESG terminal. The study also investigated if corporate social responsibility (CSR) practices inside businesses influence the relationship between Green Supply Chain Management (GSCM), Socially Responsible Supply Chain Management (SRSCM), and Economic Returns (ER). The study discovered that whereas CG activities have a minor mediating role in the relationship between GSCM and ER, they do so in the case of SRSCM and ER.
Growing institutional, societal, and legal limitations are forcing manufacturing companies to refocus their efforts on creating more sustainable supply chains (Wang and Sarkis, 2013). Businesses have started to invest a lot of money in sustainable supply chain management (SSCM) techniques, so it is essential to understand how these practices relate to an organization's financial health.

Companies often implement environmental, social, and governance (ESG) policies in response to external demands from various stakeholders without first considering whether or not these activities will be lucrative (Byeong-Yun Chang et al., 2013). For example, statutory constraints imposed by local

governments have pushed the implementation of Socially Responsible Supply Chain Management (SRSCM) and Green Supply Chain Management (GSCM) strategies in certain countries (Mudgal et al., 2009). Furthermore, many companies have consciously embraced the GSCM and SRSCM methodologies (Christmann, 2000), either to gain a financial advantage (Luthra et al., 2011) or for competitive reasons (Hsu et al., 2013).

Since ESG expresses a company's worries about the environment, society, and governance directly, it is recommended for a company's economic returns (ER) above "corporate social responsibility" (CSR) (Huang, 2021). Aguinis (2011) recognized the convergence between ESG and CSR. They characterized CSR as "context-specific organizational actions and policies that consider stakeholders' expectations and the triple bottom line of economic, social, and environmental performance." Generally, profit and loss statements do not clearly show the benefits and expenses of either ESG activities, or do balance sheets show their cumulative worth or depreciation. Therefore, the company's financial statements must make the case for ESG action clear. Even after decades of scholarly attention, there are still a lot of unanswered questions about how ESG is conceived, why it is undertaken, which stakeholders benefit, how those advantages are expressed, and where it might go. Businesses are facing more significant pressure to "do Good"—acting in a way that prioritizes ethics over profits (Huang, 2021).

The corporate governance (CG) literature examined a wide range of CG measures and examined the impact of these measures on business performance (Bhagat and Bolton, 2019). To create the Gompers, Ishii, and Metrick (GIM) (2003) governance measure, an equally-weighted index, the Investor Responsibility Research Centre (IRRC) gathered 24 corporate governance (CG) provisions, including poison pills, golden parachutes, classified boards, cumulative voting, and supermajority procedures to authorize mergers. According to Bebchuk et al. (2009), some of these 24 needs might be more significant than others, and some of these regulations might be related. They created an "entrenchment index" with six provisions as a result. Brown and Caylor (2006) utilized Institutional Shareholder Services data to build their governance index, whereas IRRC data was used in the research

mentioned above. This index considers 51 CG features, such as stock ownership rules, corporate charter issues like poison pills, board makeup and processes, and management and director salaries. Using the Bloomberg ESG terminal, we employed the "Governance Disclosure Score" for our study, which comprises seven CG characteristics: board size, number of meetings, attendance at board meetings, percentage of independent directors, duration of the board, and political donations.

2. Review of Literature

Previous research has indicated that ESG practices favourably affect the economy (Ariely et al., 2009). The results of previous studies have also led to inconsistent conclusions, depending on the focus, intensity, and geographic location of the investigation (Barnett and Salomon, 2012). Most of these studies have focused on internal enablers, such as internal environmental management, Green Information Systems (GIS), internal Corporate Social Responsibility (CSR), and environmental responsibility practices. These studies are usually conducted within the organization's close control sphere (Green Jr. et al., 2012).

The study and analysis of more important factors, like the Triple Bottom Line (TBL) approach (DeGiovanni, 2012), organizational and economic performance (Johnson and Templar, 2011), and Sustainable Supply Chain Management (SSCM) practices (Varsei et al., 2014), have received comparatively less attention in the literature. By looking at how SSCM practices—such as social, governance, and environmental practices—affect an organization's financial performance, our study seeks to close more of these gaps and limitations. Practical evidence of the importance of these challenges is provided by the various recent industry-based studies showing how greening supply chains are prevalent and how they continue to be one of the significant sustainability concerns for firms (Hsu et al., 2013). While there are several trends, the most widely used strategy that backs the SSCM and TBL methods mixes social responsibility, environmental preservation, and economic growth (Fabbe-Costes et al., 2011). The present global energy and financial crisis will probably make sustainable development more critical in

terms of corporate and governmental strategic goals. The interest of academia and industry in sustainable development approaches has grown.

3. The theoretical framework

This study looked at the financial standing of Indian manufacturing companies with SSCM integration. We hypothesized that companies who use SSCM have more reliable ER. The literature defines GSCM and SRSCM in various ways (Sarkis et al., 2011). According to earlier research, we define GSCM and SRSCM as organizational actions carried out to manage the supply chain system in an environmentally and socially responsive way, from material procurement to customer service, respectively (Seuring and Muller, 2008). GSCM and SRSCM will be viewed in this study as components of the larger SSCM concept. Hoejmose and Adrien-Kirby (2012) state that compared to the SRSCM and linkage, the GSCM and organizational, economic performance connection has gotten more attention in the research literature. The latest research indicates a positive and evident relationship between an organization's ER and GSCM procedures (Green Jr. et al., 2012). In specific research (Zhu et al., 2013), GSCM processes and organizational ER were not directly connected with significant associations; nonetheless, relevant outcomes were achieved through indirect mediation interactions. A few studies found negative correlations. For example, Kim and Rhee's (2012) study on Korean manufacturers found a poor link between corporate ER and GSCM practices. According to existing studies, there are direct and significant beneficial links between environmental practices and the economic performance of organizations.

H1. Environmental performance is directly and positively related to corporate financial performance.

The impact of SRSCM practices on an organization's ER has received little attention in the literature (Seuring and Gold, 2013). One of the earliest studies to look into the relationship between organizational SRSCM practices and businesses' ER found that, although there was no direct correlation, SRSCM practices could indirectly impact economic performance through intermediaries like organizational learning. Vachona Klassen (2007) found a

link between the financial performance of the business and CG in the supply chain. As a result, we put up the hypotheses that goes as follows:

H2. Social performance is directly and favourably correlated with business financial performance.

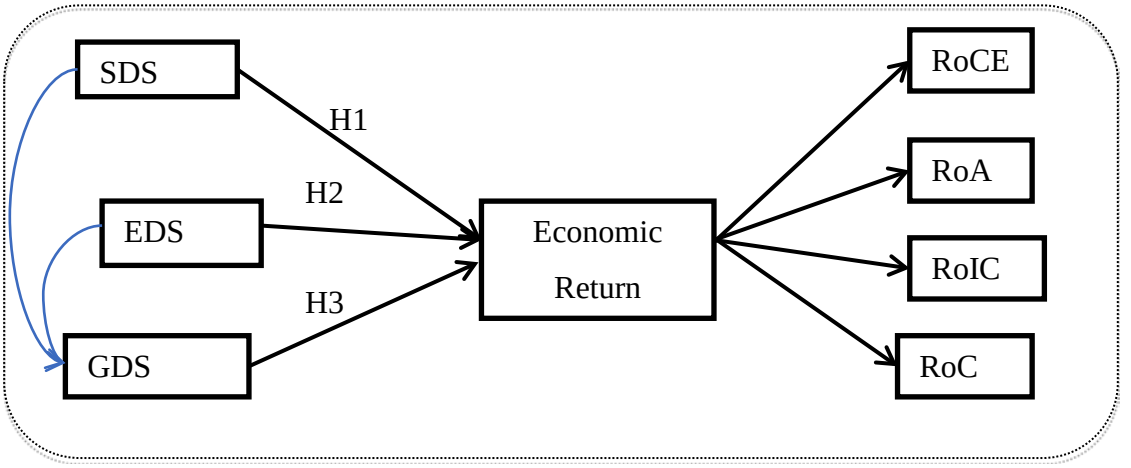
H3. A direct and enduring relationship exists between corporate governance and a company's financial performance.

Testing was done to find indirect associations through the mediation effect in cases where GSCM and SRSCM practices were not directly related to organizational ER (Zhu et al., 2013). Crifo et al. (2016) state that a company's CG practices can moderate the interaction between its ER and GSCM procedures. Additionally, CG practices enable businesses to operate successfully and achieve business sustainability while being socially and ecologically responsible. (Williamson et al., 2006). So, we propose the following hypotheses:

H4a. Corporate governance acts as a mediator in the link between environmentally friendly behaviour and economic performance.

H4b. Corporate governance acts as a mediator in the connection between social behaviour and economic performance.

Thus, the research model (refer to Figure 2.1) was developed. The Bloomberg ESG scores (Environmental Disclosure Score (EDS), Social Disclosure Score (SDS), and Governance Disclosure Score (GDS)) were the independent variables in this analysis, and ER was the dependent variable. EDS, SDS, GDS, and ER were used as stand-ins for the environmental practices, social practices, corporate governance practices, and financial performance, respectively, and are the sources of the latent variable ER. These four financial ratios are Return on Common Equity (ROCE), Return on Assets (ROA), Return on Capital (ROC), and Return on Invested Capital (ROIC).



Source: The authors

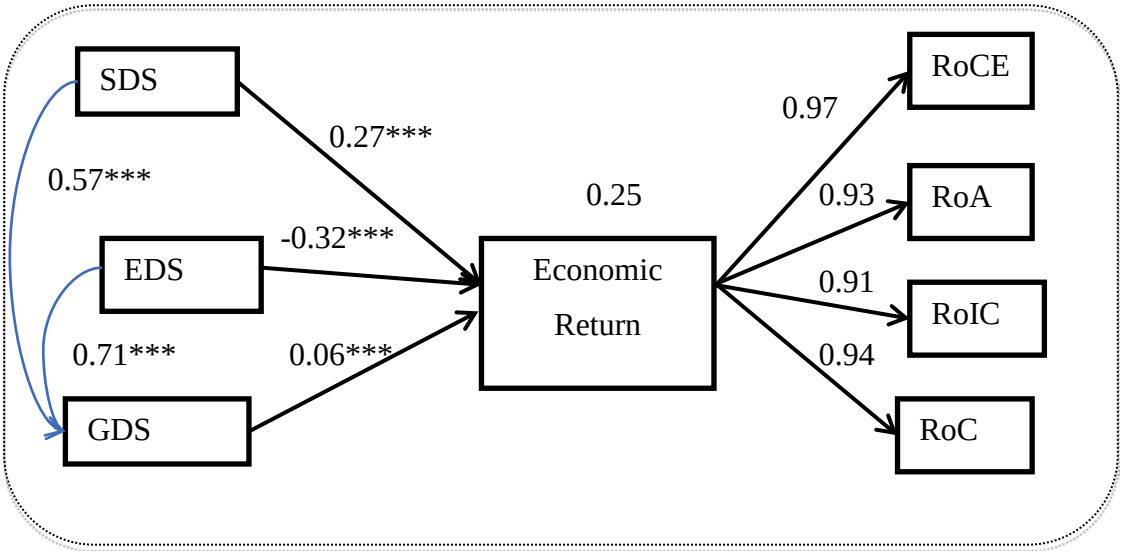
Figure 2.1: Research Model

4. Data analysis and Hypothesis testing

The primary objective of this study was to develop and experimentally assess a model for investigating the impact of SSCM techniques, such as GSCM, CG, and SRSCM, on ER in manufacturing organizations. The FA ESG function was utilized to retrieve secondary data for this study from Bloomberg's terminal. Large-cap and mid-cap businesses with manufacturing operations in India listed on the BSE-100 ESG index of the Bombay Stock Exchange (BSE) and the Nifty 100 ESG index of the National Stock Exchange (NSE) were selected for the study. For this analysis, companies in the service sector were excluded. The AMOS 23 program and structural equation modelling (SEM) allowed for empirically validating the suggested causal lines' orientation. Figure 2.2 displays the path coefficients for the model testing. These results categorically validated H1 ($b= 0.27$, $p<0.001$), which asserts that social activities enhance the organization's financial performance. The result validated the role of SRSCM in SSCM as well. According to the model, the company's financials and GSCM procedures have a weak association (H2: $b = -0.32$, $p<0.001$).

This suggests that investments in greening the supply chain must result in comparable or higher financial returns, which could account for India's slow adoption of GSCM techniques. Kim and Rhee's (2012) study on Korean manufacturers indicated a negative link, even though environmental supply chain initiatives and corporate financial success have generally shown a

positive correlation. Previous studies have shown that CG is critical to a business's long-term survival (Preuss, 2005). According to this study, CG improves a company's ER (H3: b= 0.06, p 0.001), although it has a negligible independent effect on its financial success. Consequently, it is feasible to investigate CG practices' function in more detail to determine whether they can work as a mediator to enhance the effect of GSCM and SRSCM practices on the financial performance of organizations.



Source: The authors

Figure 2.2: Hypotheses testing and Path Analysis

The AMOS output indicated an adequate model fit with the data (see Table 2.1), with CMIN/DF = 2.216, RMSEA = 0.081, GFI = 0.924, AGFI = 0.815, CFI = 0.973, RMR = 3.439, and NFI = 0.949. The fit indices at all three levels of measurement—absolute fit measures, incremental fit measures, and parsimonious fit measurements—indicate that the model fits the data well.

Given that the correlations between the several sustainability metrics ranged from 0.53 to 0.78, there is a significant association between the different SSCM techniques. Furthermore, the most influential component of the three sustainability variables is EDS (environmental practices), which has a strong correlation with SDS (social practices) and GDS (corporate governance practices), with correlation values of 0.72 and 0.76, respectively.

Table 2.1. Model fit indices

Index	Score	Recommended Value	Reference
Absolute Fit Measures:			
CMIN/DF	2.216	1.0 to 5.0 is an acceptable fit	Hair et al., (2010)
RMSEA	0.081	RMSEA <0.08 acceptable fit and <0.06 is good fit	Hair et al., (2010)
GFI	0.924	NFI >0.9 means satisfactory fit	Hair et al., (2010)
Incremental Fit Measure:			
NFI	0.949	NFI >0.9 means satisfactory fit	Hair et al., (2010)
Parsimonious Fit Measures:			
PNFI	0.515	Acceptable, over 0.50	Hair et al., (2010)
CFI	0.973	CFI >0.95 means satisfactory fit	Hair et al., (2010)

Source: The authors.

Test for mediation

Since CG shown a poor correlation with the company's financial performance, we further investigated its function as a mediator to impact the linkages of GSCM and SRSCM practices with corporate ER. To understand and validate the mediating role of CG practices on the relationship between GSCM practices and SRSCM practices with corporate ER, three independent studies were conducted (Hadi et al., 2016). Baron and Kenny's (1986) mediation analysis was used to look at the mediation connection.

Corporate economic performance and Environmental performance

- EDS → ER (β= -0.32); EDS → GDS (β= 0.71); GDS → ER (β= - 0.19)

H4a: The correlation between GSCM practices and company ER has not changed significantly. There is therefore no indirect effect, just a direct effect. Therefore, CG does not mediate the link between GSCM practices and ER.

Social practices and corporate economic performance

- SDS → ER (β= -0.37); SDS → GDS (β= 0.62); GDS → ER; (β= - 0.22)

H4b: A considerable shift in the value for the association between corporate ER and SRSCM procedures. No direct effect, only indirect influence, as a result. So, CG acts as a mediator between SRSCM procedures and ER.

The relationship between GSCM practices and corporate ER is not mediated by CG practices, per Baron and Kenny's (1986) mediation analysis. Furthermore, CG practices operate as a mediator in the link between corporate ER and SRSCM practices.

5. Conclusions and Recommendations

This study discovered that the sustainability parameters EDS, SDS, and GDS only account for 15% of the variance in the ER of the companies. This indicates that the SSCM practices have relatively little influence over the corporate ER. However, each of the three variables also significantly affects the company's financial performance. The ER of the companies is favorably correlated with SRSCM and CG. The company's ER is adversely affected by GSCM procedures.

Despite several plausible explanations for the outcomes, the mixed results are consistent with prior research on the association between ESG practices and organizational financial success (Barnett and Salomon, 2012). One of our most convincing and reliable findings was the significant adverse relationship between GSCM practices and organizational ER. For several reasons, Wang and Sarkis (2013) claim that there is a negative relationship between an organization's financial success and green practices.

1. Organizations were not motivated to implement environmentally friendly supply chain practices;
2. To lower risk and liability, organizations may be responding to external constraints, especially economic pressures, by shifting their environmental responsibilities to the customer and

3. Organizations may be responding to internal pressures.

According to Carter's (2005) research, there was little direct impact of SRSCM practices on the ER; however, the relationship greatly enhanced when CG acted as a mediator. CG effectively mediated the performance of SRSCM and the company's financial performance. The link between GSCM practices and economic success, however, still needs to be mitigated by CG. This was in contrast to previous studies by Babiak Trendafilova (2011) and Crifo et al. (2016), which found that CG practices mediated the association between GSCM practices and the firm's ER. Furthermore, the leading causes of these variations in the results can be better understood with a thorough analysis involving data from several geographic regions.

6. Implications and Scope for future research.

This research aimed to understand better the relationship between Indian manufacturing businesses' economic success and environmental performance, social management initiatives, and corporate governance standards. The findings were based on secondary data analysis from Bloomberg's Environmental, Social, and Governance (ESG) and Financial examination (FA) databases. Using secondary data sources makes it easier for researchers to replicate the study in the future using the same data source in different areas. Scholars wishing to investigate the relationship between a firm's ER and GSCM, SRSCM, and CG can undertake comparative research among different locations. By utilizing Bloomberg's database, researchers can also avoid common problems associated with survey research, such as data collection and sampling bias.

In developed countries, a company's competitive advantage, investment decision-making, expansion strategy, and brand reputation are all significantly impacted by ESG disclosure (Tamimi and Sebastianelli, 2017). Kotsantonis et al. debunked several long-standing myths regarding integrating ESG with corporate finance management in 2016. They assert that only some industries sector have made the practice of considering environmental factors when making regular decisions. A study by Tamimi and Sebastianelli (2017) found that because most countries have laws

requiring businesses to disclose information about corporate governance (CG) and financial performance measures, firms are the most transparent regarding CG disclosures. Remarkably, CG had minimal effect on the ER of Indian manufacturing firms in this study. These two attributes correlate strongly with the companies' financial performance despite notable gaps in the information they disclosed about their social and environmental initiatives. Comparing the results for Indian manufacturing companies with those of Tamimi and Sebastianelli's (2017) study on US manufacturing companies, the latter found that environmental measures had a negligible impact on a firm's ER. Multinational companies (MNCs) hoping to grow in India must create a different ESC strategy.

This study broadens the body of literature in many areas. Firstly, it is more comprehensive, based on criteria encompassing all three ESG aspects. Secondly, Indian manufacturing enterprises are the subjects of the first test of CG's function as a moderator for investigating the relationship between GSCM, SRSCM, and a firm's ER. The study's findings will help practitioners focus on and put different strategies into practice to increase ER in their organizations. Businesses may gain from this study if it exerts pressure on GSCM and SRSCM but fails to produce the expected outcomes. The managers of these companies can also benefit from the analysis by using it to help prioritize their efforts to enhance ER.

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Chapter 3

JIT TO AUTO-NULLIFY BULLWHIP EFFECT IN CEMENT SUPPLY CHAIN: IMPLICATIONS TO CIRCULAR ECONOMY

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Abstract
The cement industry in India stands as one of the largest sectors globally, securing a commendable position next to China in terms of production and consumption. The cement industry is a process-based industry running on full capacity utilization, so it is challenging to cater to any additional demand. Due to this highly sensitive characteristic, warehousing becomes an essential component following Just-In-Time (JIT) practices for the distribution and sale of material from any cement plant to the warehouse and further to different locations. Whenever a shortage of cement arises, an artificial demand is created, and bullwhip effect takes place. However, following the peculiar characteristic of the cement industry, almost the entire demand is fulfilled,

which auto nullifies this bullwhip effect. The study shows how implementing JIT improves the bottom line of cement companies that practice it, thereby improving not only profitability but also reducing quality deterioration. Additionally, the study examines the approach towards auto nullifying bullwhip effect, which applies to India's cement industry. Lastly, the study seeks to underscore the benefits for the Indian Cement Industry supply chain through circular economy practices.

Keywords- JIT, Bullwhip effect, Circular Economy, Cement Industry, India.

1. Introduction

To have a better understanding of the structure of the Indian cement industry, it is necessary to explore its features. Since it was delicensed in 1991, the cement business in India has grown remarkably. India now produces more cement than any other nation in the world, behind only China. In the construction material industry, cement is the most significant and lucrative commodity; by 2020, India's cement demand has reached 600 million tonnes. With a consumption CAGR of almost 10%, India is one of the cement markets with the quickest growth rate in the world. Ambuja Cement, Ultratech Cement, JK Cement, ACC Cement, and Shree Cement are significant companies in the Indian cement industry. For most of these enterprises, inventories make up the largest portion of their current assets. For businesses in India, inventory typically makes up about 60% of their current assets. Ignoring inventory management will put a company's long-term profitability at risk and could lead to its demise. With basic inventory planning and management procedures, a business may lower its stock levels significantly by about 10 to 20 percent without having a negative impact on sales or output.

A company's profitability is favourably impacted when excess inventory is reduced. The notion of Just in Time (JIT) is well recognized, whereby processes are coordinated to ensure that necessary materials arrive at their destination precisely when needed. This concept strongly emphasizes avoiding waste in all its manifestations while maintaining a high standard of quality, total dependability, and a quick enough turnaround time for

converted resources. Although the concept was first created for manufacturing processes, JIT's use has grown over time. The idea of Just-In-Time (JIT) is not particularly new; in the 1920s, Henry Ford's massive industrial complex at River Rouge, Michigan, operationalized it in his automotive assembly line. Toyota Motor Company, located in Japan, examined and gained knowledge from Ford Motors' operational procedures and methods. They created the assembly method, formerly known as the Toyota Production System (TPS). Over time, the system changed to the point that, in 1980, Toyota produced a more affordable product and far higher quality than its American competitors. Because inventory takes up space and resources, Japanese people are known to be very sensitive to waste and rework.

Strategically speaking, just-in-time refers to process flow optimization such that the desired component arrives on the assembly line exactly when needed. The Bullwhip effect in the supply chain arises from distorted upward and downward information flow (Lee et al., 1997a). In certain industries, this effect is alternatively referred to as the "whiplash" or "whipsaw" effect (Lee, 1992). Its impact is pervasive across industries, albeit with varying degrees. The repercussions of the Bullwhip effect manifest in increased inventories, compromised quality, heightened capital and inventory costs, escalated raw material expenses, overtime expenditures, augmented shipping costs, diminished customer service, extended lead times, and other associated challenges.

India is one of the world's fastest-growing economies, demonstrating resilience against external factors. However, the prevailing narrative around resource use has largely been dominated by economies of scale, relegating principles of circularity and resource efficiency to the background. While the long-term growth outlook remains promising, there is a concomitant rise in resource demand, placing immense strain on the country's natural resources. Therefore, a critical imperative emerges for enhancing resource efficiency. The circular economy offers a transformative approach that propels the country to new heights without exacerbating resource strain. In the circular economy

context, waste is redefined to encompass any underutilization of resources or assets rather than being confined to the traditional interpretation of junk material (NITI Aayog, 2019).

2. Literature Review

When it comes to the manufacturing sector, JIT is not a novel idea. One of the first books on using JIT to boost productivity in the construction sector was authored by (Low and Ang, 2003). The book stressed that although there are still important distinctions between the manufacturing and construction sectors, the construction industry may still benefit from some of the core JIT concepts. The work of (Low and Ang, 2003) was expanded upon by other researchers to highlight how successfully the JIT theory could be applied to other businesses whose nature is virtually identical to that of the manufacturing industry, while (Low and Ang, 2003) provided a comprehensive review of the JIT idea in the construction industry. Numerous thorough studies were conducted on certain facets of Just-In-Time (JIT) in the construction sector. Kannan and Tan (2005) focused on the accounting processes for material and time waste to determine quantitative JIT measures. In order to successfully reduce waste, (Tay et al., 1996) examined the function of human resource management in the modified JIT principles. (Cua et al., 2006) concentrated on enhancing efficiency and quality of work by incorporating the JIT concept into the site architecture. It also outlined how minimizing equipment utilization, regulating inventory movement, and reducing site waste may contribute to a seamless workflow. (Fan and Chong, 1999) investigated if JIT principles may be based on ISO 9000. They tried to learn about the issues practitioners were having with the JIT system. Later they also included the concepts of 5S and JIT, which might raise output and quality. Sharma and Sharma (2012) developed the application of JIT principles by demonstrating how a light factory design could double the handling of goods during transportation, reduce waiting times, and ensure smooth delivery of goods to each unit with little to no degradation in quality. It promoted the use of Just-In-Time (JIT) in the building process by demonstrating cost reductions of 20–30% of the entire contract value. JIT has also been the subject of several non-academic writings.

Furthermore, Lee et al. (1997b) identified diverse effects of the Bullwhip effect, including fluctuations in pricing, inaccurate forecasting, incentive schemes, sales promotions, freight incentives, industry-specific issues, abrupt fluctuations in demand, and competitor-related concerns. Proposals by Clark (1994), Gill and Abend (1997), Hammond (1993), and Towill (1997) advocate addressing the Bullwhip effect through the enhancement of communication quality. This improvement, they argue, can be achieved by conducting a thorough assessment and accurate judgment of actual requirements within the supply chain. Lee et al. (1997) emphasized the substantial inefficiencies that can arise in a supply chain due to distorted information transmission. Fransoo and Wouters (2000), in their exploration of measuring the bullwhip effect in the supply chain, addressed conceptual measurement challenges and shared experiences in tackling these issues within an industrial context. Dejonckheere et al. (2003) highlighted that when production is inflexible and frequent changes in production quantities incur significant costs, order-up-to policies may become impractical or undesirable. Geary et al. (2006) provided a historical review, current practices, and anticipated impacts of the bullwhip effect, while Warburton and Disney (2007) focused on replenishment rules as a solution to the bullwhip problem. This array of studies collectively contributes to a comprehensive understanding of the evolution and challenges associated with the bullwhip effect in various contexts.

The Indian cement industry stands as a benchmark for excellence among various industrial sectors, showcasing commendable performance in energy consumption, quality control, environmental sustainability, and adaptability to embrace new technological advancements. Recent achievements in the industry include a substantial reduction in the CO2 emission factor, decreasing from 1.12 t of CO2/t of cement in 1996 to 0.670 t of CO2/t of cement in 2017. Additionally, the industry has made noteworthy progress in enhancing blended cement production, increasing from 68% in 2010 to 73% of total cement production in 2017. Cement plants have proactively adopted advanced technologies to comply with stringent emission norms, focusing on reducing Particulate Matter (PM) and NOX emissions. These initiatives involve the installation of high-efficiency bag filters, Electrostatic Precipitators

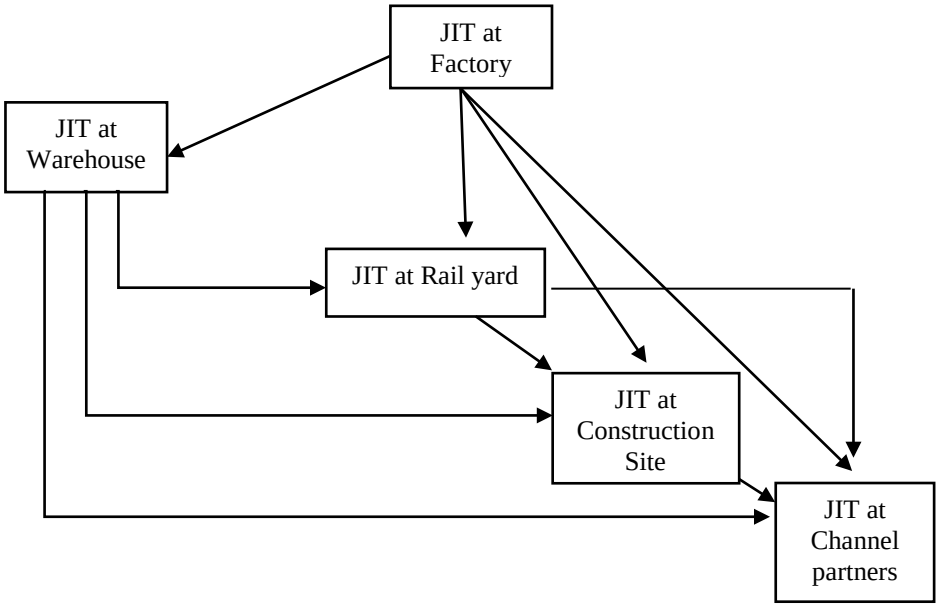
(ESPs), hybrid filters to control dust emissions and implementing secondary control measures such as Selective Non-Catalytic Reduction (SNCR) for NOX reduction. All cement plants have diligently installed continuous emission monitoring systems in adherence to the Central Pollution Control Board guidelines. The Indian cement sector's global distinction in energy efficiency is attributable to the implementation of modern technologies in plants and vigilant daily monitoring, with a dedicated focus on energy conservation and CO2 emissions reduction. The growth prospects for the Indian cement industry in the next decade appear highly promising, with projected demand reaching 550 to 600 MTPA by 2025, representing a growth of 2.5 to 2.7 times the current volumes (WBCSD, 2018). Per capita consumption is expected to rise from 210 to 580 kg, aligning with the global average.

Lastly, implementing circular consumption faces challenges that can be effectively addressed using the 3R Principle—Reduce, Recycle, and Reuse (Ghosh, 2017). Several streams of circular economy models have been identified: Circular Supply Chain, Recovery and Recycling, Product Life Extension, Sharing Platform, and Product as a Service (FICCI, 2017). These models encompass strategies such as providing renewable energy, utilizing bio-based or fully recyclable input materials, recovering resources from disposed products, extending the working lifecycle of products through repair and upgrading, facilitating shared use or ownership through sharing platforms, and offering products as a service to internalize the benefits of circular resource productivity. The cement industry, considered a pillar of growth for nations, plays a crucial role in India's circular economy. As the second-largest cement producer globally, after China, the Indian cement industry boasted an installed capacity of 509 MTPA (million tonnes per annum) in 2018 (PIB, 2018).

3. Analysis of the study

The transportation process for channel partners in the cement industry for India can be seen in the model given below, which depicts that the cement industry has a very flexible network to manage the inventory requirements as and when they arise. The interlinkages between channel partners are so strong

that demand with any channel partner can be satisfied using Just-in-time (JIT) approach. It is always viable for companies to manage inventory in a business-to-customers (B2C) setting by keeping it as small as possible so that the chain would lead to reduced transportation costs, as add-on margins in the network would not be added. Figure 3.1 shows the scope of JIT in the Storage of Cement.



(Source: Developed by author)

Figure 3.1: A model showing the scope of JIT in the Storage of Cement

3.1 Storage of Cement at Factory

The grey cement business is one with a huge volume of sales. About 300 million tonnes of domestic capacity are anticipated in India this year. Most of the time, 50-kilogram filled sacks are used to deliver cement to consumers. The bulk of consumers in the domestic market use rail and surface transportation, even if it is supplied loose to bulk buyers who have their own storage systems, such as silos, etc. Companies operate and maintain warehouses in many locations to ensure continuous supply.

3.2 Storing of Cement at Warehouses

To cater to the trade demand, all the companies have single or multiple godowns in the city. Material arrives there directly from the factory on a stock

transfer basis. It reaches the city from the factory mostly by trucks and sometimes by rakes. From the rail yard, it is shifted to the warehouse by trucks. Transportation of material by a rake is very common in the cement industry. Much infrastructural cost is involved in laying the line at the cement plants to make it suitable. It is cost-effective, especially for long distances and carrying a good load. Usually, cement bags are transported through closed wagons; however, during peak times, cement bags are also transported through open wagons as per the specific requirements of the companies. On the one hand, it is convenient and cheap, especially for long distances; however, timings are uncertain. Considering the rake arrival, planning the construction activities at a typical construction site is challenging. Mostly, this mode is adopted and utilized so inventories can be built at the destination to fulfil the demand at need-based timings. There are a few destinations for some companies where the companies dispatch one rake on a daily basis, or in other words, the daily requirement of that market is a minimum of one rake load. In those markets, even supplies made by rakes can support the JIT concept. In other cases, it will not support the JIT concept; however, the rest of the things and economies would depend on a case-to-case basis.

As a practice, some of the material received by rakes is transhipped to another vehicle for onward delivery, and the rest of the material is unloaded into the godown through manual methods. It is appropriately stacked in the godown after unloading. It is loaded back to the vehicles for onward deliveries based on requirements. In case of arrival by rakes, most of the material that reaches the warehouse is generally unloaded as the customer's direct demand is met from the rail yard itself. There is a lot of involvement of human resources in handling the material as the process is long and manual. Each bag requires at least three laborers as two people hold the bag and place it on the head or back of the third person. The person counting and having the record of it is separate.

3.3 Storing of Cement at Rail Yard

When the material arrives through the rake, it is first unloaded at the rail yard, and further dispatches are made. All the rail yards have different

infrastructures, and they are unloaded in the open yard in many places. The ideal situation for any company is that either all the material be directly dispatched from the railway siding, or it is stored in the covered godown at the siding itself; however, such infrastructure and facility are not available always and everywhere. At some locations like Delhi, Ghaziabad, etc, the subsidiary of Indian railways has created such kind of warehousing infrastructure; however, it is not there at all railway good sheds. Also, the companies have time limitations for unloading the material from the wagons and clearing the rail yard and goods shed within the specific time frame. Any additional time attracts a financial penalty, and if such a thing happens, the material can only be taken from the rail yard after paying the penalty charges. Whenever there are unloading delays from the wagons, it is called the demurrage charges, and whenever there is a delay in clearing the rail yard or goods shed, it is called the wharfage charges. At any given time, hardly any rake gets cleared within specific time limits, and each rake attracts some penal charges. One of the main reasons is the manual operations at most places, and the other is the unavailability of required infrastructure. Still, at many destinations, it remains a cheap mode of transport compared to dispatches by road.

3.4 Storing of Cement at Construction Sites

Typically, the environment at construction sites is not ideal for storing or managing materials. Cement, being a delicate product, demands special care. Its shelf life is considerable and highly sensitive to water/moisture. Additionally, the cost of each bag is significant. Moreover, there was initially no storage facility on any construction site at the commencement of construction activities. If it is a regular individual house kind of site where new construction has to occur, the initial cement requirement is generally fulfilled through the nearby cement retail shop as the requirement remains low. When the work picks up, and daily cement consumption increases at the site, bulk cement purchases occur. In such cases, a temporary godown is initially constructed, or some nearby covered space is used. Proper storing is vital due to maintenance of quality, timely requirement fulfilment, and cost. At the site where there is an existing structure, and only repair of expansion

work is taking place, limited storing facilities remain available within the premises.In standard practice, the initiation of any substantial project involves the establishment of storage facilities. The specifications of these storage spaces are contingent upon the scale and nature of the project. Notably, the construction of these storage units itself necessitates the use of cement. While the process remains fundamentally the same in smaller residential or building projects, practitioners often resort to nearby retail shops or available rental structures to fulfil cement requirements. An optimal scenario for these project sites is the daily procurement of the required cement. This approach offers several advantages, including eliminating storage needs, a consistent influx of fresh materials, and mitigating risks such as damages, pilferages, or theft. Nevertheless, given cement's indispensable role in civil construction, the unavailability of this essential material could impede progress, resulting in work stoppages and associated productivity losses.

3.5 Storing of Cement by Channel Partners

The significance of Just-In-Time (JIT) extends beyond manufacturing processes and resonates equally with dealers and retailers. Efficient JIT management not only enhances competitiveness but also influences product pricing, which is typically determined on a Free On Rail (FOR) destination basis. Loading and unloading materials at the shop, followed by their subsequent transportation to the customer, incur additional costs. This additional logistical layer can erode overall profitability, as customers are typically not inclined to bear these supplementary expenses. Major consignments are dispatched directly from the company's factory or warehouse to the customer's site. In cases where JIT practices are not optimally implemented, the onus for ensuring timely material delivery rests with the established network. Given the impracticality of having manpower and resources idling at construction sites, effective JIT adoption emerges as a cost-reducing strategy that provides convenience to all stakeholders involved in the supply chain. The seamless integration of JIT practices not only curtails unnecessary costs but also streamlines the delivery process, enhancing overall operational efficiency.

Another aspect of storing capacity is essential concerning the price volatility of cement. Whenever there is a price increase trend, all traders try to keep maximum inventory with them; as communication reaches the customers, they also try to keep the material at their site to the maximum possible level. This becomes a good time for the companies and those with maximum stock with them to push it into the market to earn the faith of their channel partners and increase their market share in the respective markets. In the reverse situation, everybody tries to keep as little stock as possible when there is a price reduction trend, delaying the buying decision. In those situations, the company needs to hold the maximum stock. All these situations occur as the cement companies in trade operate a daily price mechanism. Sometimes, it goes up, sometimes down, and sometimes remains stable for several days. Season plays a vital role in governing the prices, and local and regional issues are also important. There is another challenge in the growing cities as the geographies of cities are expanding, which poses an additional threat to having multiple warehouses to cover the geographies better. No entry for oversized vehicles in municipal areas at specific times makes operations more complicated. A list of major operational cost components in cement warehouse is given below:

1. Godown rental.
2. Variable expenses like electricity, etc.
3. Hiring charges.
4. Material handling cost (Labor charges).
5. Inventory carrying cost.
6. Quality deterioration cost.
7. Security of material cost.
8. Manpower and other administrative cost.
9. Material shifting cost in case of vacating and rehiring.

3.6 Impact of the Bullwhip Effect on the Indian Cement Industry

The grey cement industry in India operates cyclically, with the capacity of a typical greenfield project exceeding 2 million tons. The journey from

conceptualization to operationalization spans several years. Plant establishment in a region disrupts the local equilibrium, taking months before the increased capacities align with market dynamics. Cement consumption exhibits non-consistent patterns in specific regions, although national-level data reflects consistent growth over recent years. Like other major industries, growth factors hinge on both domestic and global economic conditions, with governmental policies playing a pivotal role. The supply chain's channel structure assumes significance, primarily relying on channel partners for trade sales. Multiple layers of channels facilitate the routing of materials to customers. The bullwhip effect manifests as an exaggerated demand in the upper layers of the supply chain, surpassing actual requirements. In the cement trade, customers, especially in low-supply situations, visit numerous shops, leading each trader to perceive the demand as genuine and consequently placing orders with companies. This results in larger warehouse orders compared to actual needs.

Geographically, the industry is demarcated into five zones, with the northern zone making a substantial contribution, partially catering to the central zone. Comprising global, national, and regional players adhering to Bureau of Indian Standards (BIS) specifications, the industry's primary plants are strategically clustered near limestone reserves, a key raw material in cement production. Cement logistics, being a cornerstone of the industry, underscores the extensive scope for supply chain management. Within the supply chain of the cement industry, the bullwhip effect arises due to information flow gaps across different layers. The costs associated with this phenomenon are considerable, necessitating effective management for sustained industry viability. This study delves into the impact and self-correcting dynamics of the bullwhip effect within the cement industry. Despite consistent growth in cement consumption, regional demand patterns remain variable. The cement industry, characterized by continuous production and fluctuating demand due to various factors, requires meticulous balance. The perishable nature of packed bags, coupled with storage limitations, heightens the risk of deterioration. Overall, storage functions as a temporary buffer to manage fluctuations in demand effectively. When demand surges, the industry cannot

increase production, leaving little room for a buffer. As consumption spans from the smallest village to major metropolitan areas, demand pressures can escalate significantly, leading to a bullwhip effect.

4. Findings of the study

The Indian cement industry stands at the intersection of dynamic forces, where operational efficiency, supply chain management, and sustainability intertwine to shape its trajectory. This study delves into three pivotal aspects that significantly influence the industry's functioning. Firstly, we scrutinize the Role of Just-In-Time (JIT) principles in warehousing operations within the Indian Cement Industry, unraveling the intricate ways in which JIT practices contribute to streamlined processes and resource optimization. Subsequently, we scrutinize the impact of the Bullwhip Effect on Cement Production in India, dissecting the ramifications of supply chain volatility and the amplification of demand fluctuations in the context of cement manufacturing. Finally, we delve into the evolving landscape of the Indian Cement Industry through the lens of the Circular Economy.

4.1 Role of JIT in warehousing operations for Indian Cement Industry

Warehousing poses a formidable challenge for cement companies, particularly in light of escalating space costs commensurate with corporate needs. This challenge assumes paramount significance in the competitive landscape, where services are a prerequisite, and the premiums charged often diverge from the associated costs. The expanding geographies of cities further compound the challenge, making the establishment of multiple warehouses to cover these expansive areas a potentially inefficient and costly endeavor. A strategic approach to managing warehouses involves optimizing their capacities by exerting control over the inflow and outflow of materials. Such control promises numerous cost advantages and associated benefits for companies, including:

Cost-Efficient Space Utilization: Managing warehouses with relatively lower capacities translates to reduced rental costs.

Enhanced Material Movement: Facilitating faster material movement mitigates the risk of damage to goods.
FIFO Maintenance Simplicity: Easier maintenance of First-In-First-Out (FIFO) inventory practices.

Streamlined Transshipment: Improved transshipment processes lead to cost reductions in dual operations, namely loading and unloading.

Damage Mitigation: A reduction in operations correlates with minimized damage to bags during handling.

Pilferage Reduction: Fewer operations contribute to a decrease in material pilferages.

Lower Inventory Carrying Costs: Maintaining a leaner stock reduces overall inventory carrying costs.
Now, analyzing the critical components of cement warehousing, particularly in the context of adopting Just-In-Time (JIT) inventory management, unveils significant opportunities to enhance the bottom line of companies. While effective operations management remains indispensable, leveraging technological advancements and improvements in communication further holds the potential to yield substantial cost savings, if not in their entirety. Table 1, given below, illustrates the direct monthly expenses in warehousing operations following certain assumptions mentioned at the end of the table.

Table 3.1: Direct monthly expenses in warehousing operations

Total Volume	Handling expense	Godown expense	Cost of inventory	Interest	Total
from warehouse	Dual operation			@12%	Cost (Rs)
(MT)	Rs 40 PMT	Rs 10 PSF	Rs 5500 PMT		
160000	6400000	177778	220000000	2200000	10377778
		1777778			
(Source: Developed by author)					

Considering the assumptions made by authors:

1. The total volume considered for analysis is 160,000 metric tons, managed through warehouses located in Jaipur, Rajasthan, India.
2. Bag handling costs are computed at Rs. 1 per bag (on average) for each operation at the warehouse, with loading and unloading constituting two separate operations. This results in a per metric ton cost of Rs. 40.
3. Standard practice dictates a storage density of 0.225 metric tons per square foot for cement.
4. The prevalent market price for cement is set at Rs. 275 per bag.
5. The average rental cost for godowns is estimated at Rs. 10 per square foot.
6. It is assumed that, on average, companies maintain a one-week inventory in godowns.
7. The total cost analysis explicitly excludes additional expenses such as administrative costs, damages, pilferages, insurance costs, and quality deterioration, among others.

4.2- Role of Bullwhip Effect on Cement Production in India

In the cement trade, the material typically follows a route from the factory to the company's warehouse, then to stockists, retailers, and finally, the consumer. However, this flow may deviate based on various situations, potentially skipping one or more stages. The material might even bypass intermediaries, going directly from the factory to the customer. Notably, brand loyalty in the cement industry is dynamic, shifting rapidly in response to factors such as the non-availability of a preferred brand. Customers readily switch to alternative brands despite multiple brands with differential pricing. However, brand loyalty, particularly among trade customers, tends to be low in high-demand scenarios, making the cement industry susceptible to the bullwhip effect. Theoretically, the impact of the bullwhip effect appears significant; however, practical constraints, such as capacity limitations and high logistics costs, tend to auto-nullify its effects. In periods of high demand, construction sites may procure material from multiple sources due to

shortages, exacerbating the bullwhip effect upstream. Larger construction sites typically source directly from manufacturers and may resort to the retail market to maintain operational pace during shortages. Traders also capitalize on the situation, demanding more material than needed to secure extra margins or expedite recovery.

The present study aims to understand the cycle during high-demand scenarios comprehensively. Direct interactions were conducted with end consumers whose buildings were under construction during a cement shortage. Subsequent visits were made to channel partners, including those approached by the consumers and others, for a broader perspective. Discussions were held with industry experts and influencers who play a role in cement purchasing decisions. The assessment revealed that actual material requirements were significantly lower than the estimated demand. Despite the opportunity to maximize sales and market share, companies faced constraints due to their own capacity limitations. Interestingly, during repeated studies under similar conditions, the behavior and stocking patterns remained consistent, illustrating the auto-nullifying nature of the bullwhip effect in the cement industry.

Taking an example of the city of Jaipur with multiple dealers and retailers, the study observed that a single customer visiting several shops in high-demand situations could lead to an inflated demand estimate. Retailers, in turn, escalate this demand to the respective dealer, creating a cumulative effect as multiple retailers contribute to an exaggerated order. This process continues up the supply chain, with additional anticipatory demand being added at each stage. In situations of scarcity, non-trade customers may also procure material from trade channels, further inflating demand. However, the capacity constraints within the industry prevent overstocking at selling points, contributing to the auto-nullifying nature of the bullwhip effect.

4.3- Role of Circular Economy in Indian Cement Industry

Within the circular economy framework, the Indian cement industry is pivotal in advancing Renewable Energy utilization for electrical power generation.

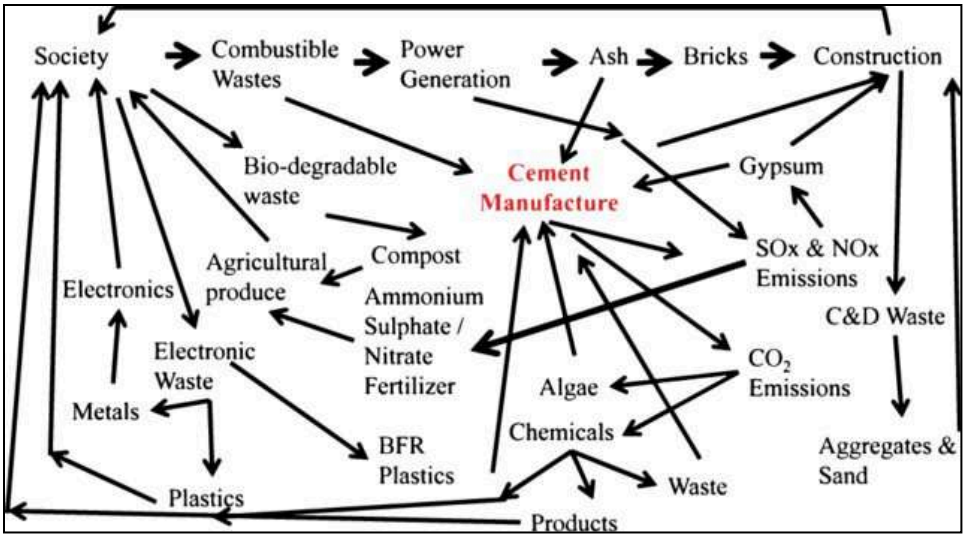
Notably, the installed capacity of renewable energy, encompassing wind and solar sources in cement plants, has witnessed a remarkable surge, escalating by over 40% to reach 276 MW between 2010 and 2017. This capacity comprises 42 MW from solar power and 234 MW from off-site wind installations. Leading industry players such as UltraTech Cement have set ambitious targets, aiming for a 25% share of their total power consumption through green energy technologies by 2021 (The Hindu Business Line, 2019). Beyond the solar photovoltaic route, the cement industry is actively exploring avenues to harness solar energy through the thermal route. A study has been conducted in Europe on designing a solar reactor operating at temperatures between 800–1000 °C. This innovative approach employs a rotary kiln and a horizontal bubbling fluidized bed for cement manufacturing (Moumina et al., 2019; SolarPACES, 2019). Additionally, feasibility studies have been conducted to implement Concentrated Solar Thermal technology in the cement industry (Gonzalez and Flamant, 2014).

The Indian cement industry is pivotal in advancing the circular economy through its substantial contributions to resource efficiency and waste management. Embracing circular economy principles, the industry has significantly reduced its environmental footprint by implementing innovative practices. The adoption of alternative raw materials and fuels, such as industrial waste and biomass, not only minimizes the reliance on traditional resources but also curtails landfill disposal, thereby fostering a more sustainable approach. Additionally, the industry has made strides in enhancing the recyclability of its products, promoting the use of recycled aggregates in concrete production. These initiatives mitigate environmental impact and contribute to the conservation of natural resources. Figure 3.2 below shows how the cement industry contributes to the circular economy.

5. Conclusions of the study

In the intricate landscape of the Indian cement industry, the pursuit of operational excellence and efficiency remains paramount for sustained growth and competitiveness. JIT, recognized for its capacity to minimize excess inventory and enhance operational efficiency, is examined in the context of

cement warehousing to discern its impact on streamlining supply chains and optimizing resource utilization. Moving beyond inventory management, the present study collectively investigates the novel concept of auto nullification of the Bullwhip Effect in India's cement production context. The Bullwhip Effect, characterized by the amplification of demand fluctuations as they move upstream in the supply chain, poses unique challenges for production planning and control within the cement industry. As sustainability assumes a central role in contemporary industrial practices, understanding the industry's role in fostering a Circular Economy in India becomes imperative. Therefore, towards the end, the study delves into the nuanced examination of the contribution made by the Indian cement industry to the circular economy.



(Source: Kukreja et al. 2020)

Figure 3.2: Contribution of the cement Industry to circular economy

5.1- Implementing JIT in warehousing operations of Indian Cement Industry

The study analysis focused exclusively on a single city, albeit a sizable one, offering substantial opportunities for both cost reduction and quality enhancement. Introducing a concept akin to a mobile warehouse, where only transshipment space is required, holds the potential to reduce overall costs significantly. This reduction stems from a streamlined operation involving only transshipment activities and minimal expenditures on vehicle placement space. Given the current circumstances, it is essential to note that this scenario

may be somewhat hypothetical. Nevertheless, achieving a 50% reduction would yield substantial savings for the industry. Key factors contributing to this potential efficiency improvement include advanced order planning, the implementation of a dedicated fleet for both inbound and outbound material flow, regulated material movement processes, and the establishment effective communication channels. These components collectively form the crux of a strategy that can enhance operational efficiency, reduce costs, and contribute to overall industry savings. Indeed, all the warehousing costs cannot be saved due to different operational factors and service parameters; however, savings would depend upon the operational efficiencies of respective companies as individuals and the whole industry. If a similar thing is replicated in other places as well, there would be considerable cost savings considering the vast size of the industry. Effective warehouse management plays a pivotal role in the cement industry. The imperative of maintaining well-organized storage facilities is undeniable in the contemporary business landscape. The presence of adequately managed warehouses is not only a necessity for the survival of any company but also a determinant of its operational efficiency. Embracing the Just-In-Time (JIT) concept emerges as a strategic avenue for enhancing the profitability of companies operating in this sector. By aligning operational processes with JIT principles, organizations can streamline their inventory management, reduce excess holding costs, and optimize resource utilization, thereby contributing to improved financial performance.

5.2- Auto Nullifying Bullwhip Effect in Cement Production of India

Being largely treated as a commodity, grey cement allows for easily substituting one company's product with another's, except in exceptional cases. When a company or dealer supplies an initial material requirement, it fulfils the requirement, rendering the additional orders surplus. Consequently, the orders from others might be automatically cancelled, potentially exacerbating the situation from a mathematical perspective. However, this bullwhip effect tends to self-correct, as cement companies generally lack the capacity to produce more. This limitation becomes apparent during periods of excess demand. In practice, there is always a loss of capacity compared to the actual capacity due to various reasons such as breakdowns,

operating at reduced capacities during lean periods, routine maintenance, mid-year capacity additions (theoretically increasing total capacity), major transportation issues, force majeure measures, and more. Considering all these factors, it becomes evident that there is an inherent auto-nullifying effect of the bullwhip in the cement industry in North India when examining it upstream. While the bullwhip effect remains a discernible factor in the upstream dynamics of the cement channel trade, its reflection is often obscured by prevailing capacity limitations, giving rise to a novel concept termed "auto-nullification." This study delves into the impact of the bullwhip effect in the upstream segment, specifically focusing on selected geographies in northern India.

While the present study scrutinizes the upstream bullwhip effect, there remains scope for parallel investigations into its occurrence in the downstream stream of the cement trade. In particular, the downstream stream exhibits a notable push effect, particularly during lean periods and in areas characterized by excess capacities. Additionally, disturbances in one region may reverberate, directly impacting adjacent areas. Not all heads can be removed in the prevailing situation; optimizing operations and inventory levels will help reduce costs. The study is done at a place where maximum operating companies have their manufacturing capacities within the state. The future scope of research can be at those places where there is a mix of local and outside players and also at those places where there is no cement plant within the state.

5.3- Contribution of the Cement Industry to the Circular Economy in India

The Indian cement industry is poised to assume a pivotal role as a catalyst for resource conservation and a driving force for the circular economy in the future. A concerted effort from all stakeholders, including cement plants, research organizations like the National Council for Cement and Building Materials (NCB), and government bodies such as Pollution Control Boards and Municipal Corporations, is imperative to work towards the circular economy's common goals collectively. In the upcoming years, the momentum of the circular economy is expected to intensify within the Indian cement

industry through many strategic initiatives; for instance, the concept of "product as a service" could be pursued, wherein the cement industry explores the possibility of procuring compressed air and other utilities instead of investing in compressors and pumps. This approach may open avenues for futuristic technologies such as oxy-fuel combustion. Companies could potentially sell pure oxygen to clusters of cement plants at a reasonable price, introducing an innovative aspect to the circular economy within the cement industry. Another intriguing yet underexplored dimension of the circular economy in the context of the cement industry is product life extension. The increasing momentum in the utilization of Construction and Demolition (Cand D) waste is a notable trend, contributing to the extension of the product life cycle in the industry. As the industry progresses, further exploration of these untapped areas promises to bring about transformative changes aligned with circular economy principles.

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Chapter 4

CIRCULAR SUPPLY CHAIN PRACTICES IN THE HEALTHCARE INDUSTRY: A REVIEW AND FUTURE RESEARCH AGENDA

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Abstract
The healthcare industry is multifaceted, encompassing many critical aspects such as cost, quality, access, and population health outcomes. There is a growing recognition of the importance of incorporating a supply chain management perspective to improve the efficiency and effectiveness of healthcare services. One of the key factors in optimizing healthcare services is fostering collaboration among stakeholders within the healthcare supply chain. This collaboration is essential for promoting transparency and facilitating swift responses to the dynamic nature of healthcare demands. Efficient healthcare supply chains are pivotal for ensuring the timely and cost-effective delivery of essential medical goods and services. The global COVID-19 pandemic has further underscored the importance of the healthcare supply

chain. It has forced the medical industry to address immediate challenges while also rethinking its strategies for future disruptions. As healthcare providers transition into the "new normal", there is a growing emphasis on the development of efficient Healthcare Supply Chains (HSCs). The strategic shift entails constructing resilient supply chains, prioritizing localization efforts, implementing dependable reverse logistics processes, and breaking down existing supply chain silos in order to achieve end-to-end visibility. A well-organized supply chain is critical in optimizing waste collection, segregation, transportation, and treatment processes in the field of biomedical waste recycling. This not only ensures regulatory compliance but also allows for the efficient recovery of valuable resources. Real-time tracking, smart sorting, and data analytics are examples of innovative supply chain technologies that can significantly increase recycling efficiency. Furthermore, the incorporation of digitalization via data analytics, automation, and technological advancements has enormous potential for optimizing distribution networks, procurement procedures, and inventory management. This optimization not only lowers operational cost but also improves resource allocation, which benefits both healthcare providers and patients.

Keywords: Healthcare, Healthcare Supply Chains, Digitalization, COVID-19

1. Introduction

The healthcare system in India is in a constant state of flux, with a multitude of dynamics at play. Being a nation of 1.4 billion people, India boasts a diverse and intricate healthcare system that blends public and private sectors. Increased income levels, heightened health consciousness, reduced bureaucratic constraints, and price liberalization are driving profound transformations in the healthcare industry. To ensure patient safety, elevate the quality of care, and maintain cost control, India's healthcare system is evolving. This is a significant step towards creating a healthcare environment that is safer, more effective, and better regulated. India is also setting the standard for healthcare innovations, not just keeping up. There is a plethora of creative solutions available, from inexpensive medical equipment that increases treatment accessibility to innovative healthcare delivery models that completely alter the way care is provided. Furthermore, India's reputation as a medical tourism hub is on the ascent. By offering the allure of cost-effective

treatments, a pool of highly skilled medical professionals, access to advanced medicine options, and ease of travel, India has emerged as a popular destination for medical tourists from around the world. While progress is evident, addressing the rising healthcare demand to ensure equity to healthcare services for all through a robust healthcare supply chain, is of utmost importance (Kumar A, 2023) (Ghia C, Rambhad G, 2023) (Kapoor et al., 2023).

The interaction between the supply and demand for goods in cantered around chain of events that must occur to facilitate the movement of goods to the end consumer. The healthcare supply chain (HSC) is a intricate system encompassing the processes and resources that facilitate the procurement, storage, distribution, and management of healthcare-related products and services, including pharmaceuticals, healthcare providers, medical equipment, and supplies The challenges include coordination of operations, warehouses, and transportation, administration, personnel, governance, economics, instruction, and data resources, instruments, and cultural and environmental concerns. The strength and efficiency of this network safeguard the healthcare organizations from unforeseen events and have access to the essential resources facilitating high-quality care, reducing costs and minimizing waste (Okeagu et al., 2021).

A diverse skill set is necessary for effective supply chain management in healthcare settings, including space utilisation, inventory forecasting, and cost management. One essential part of this is management of inventories, which demands a thorough comprehension of the complex financial and logistical aspects of stock control. The ramifications of improper inventory management are severe and extensive for healthcare institutions. It has a direct impact on the standard of patient care; it's not just a question of numbers. Poor inventory control can cause significant financial losses and make it more difficult for the company to provide top-notch medical care (Balkhi et al., 2022).

Overstocking is one risk that arises from keeping excess inventory on hand. When cash flow is restricted, resources that are needed for important needs like hiring qualified personnel or making technology investments are

unavailable. The organisation may experience knock-on effects that limit its ability to grow. Conversely understocking is detrimental resulting in shortages. Patients may experience delays or inadequate care, putting their wellbeing at risk. Efficient cost management and space utilization are equally critical, contributing to the financial stability and overall effectiveness of healthcare organisations (Balkhi et al., 2022).

In response to mounting cost pressures and heightened competition, the healthcare supply chain has recognized the imperative for enhanced efficiency and deeper interconnectedness. This increased complexity, observed in HSCs, has amplified susceptibility to disruptions, as vividly demonstrated during the COVID-19 pandemic. Severe shortages of essential medicinal supplies, ventilators, and other consumables, placed hospitals worldwide in a crisis mode, underscoring the urgent necessity for more resilient and adaptable

HSCs to confront unforeseen challenges.
In the healthcare sector, cutting expenses while raising standards of care is critical. Consequently, a lot of HCOs are searching for cutting-edge technologies that will enable more effective supply chain procedures, assisting in cost reduction without compromising the calibre of their services.

2. Healthcare Supply Chain Management: A Review
Access to healthcare is regarded as an essential requirement for sustaining human life and consequently, evaluating the robustness of a healthcare supply chain can assist a nation in developing strategies to address healthcare crises. The pandemic imposed a sustained pressure on the healthcare supply chain (HSSC) throughout the world, resulting in shortages of fundamental healthcare essentials. It became evident that disruptions in the supply chain and increased demand resulted in inadequate access to essential medical supplies required for effective patient care. Therefore, it is imperative to recognize the pressing need for the development of intelligent and smart supply chains solutions.

Several major problem categories, such as waiting times, patient safety, integration, and communication, have been identified in healthcare

organizations which stem from a review of patient experiences in various nations wherein the interactions and collaborations between healthcare providers are frequently where the biggest vulnerabilities and challenges arise and as a result, efficient supply chain management can be a useful instrument to lessen these issues (Meijboom et al., 2011). A multifaceted strategy is needed to address this problem such as expanding provider performance data transparency and making individual patient medical records more accessible (Meijboom et al., 2011).

Industry 4.0 technologies have been able to increase the interconnectivity at various stages of supply chain among enterprises, transitioning from a solitary, local, and corporate adoption to a comprehensive supply chain implementation (Longo et al., 2023). The advent of digital transformation has compelled supply chain management to transition from a linear framework to a more interconnected model enabling data flow in various directions. Efficient supply chain management is critical and can improve customer service while cutting costs by increasing product availability and cutting down on order cycle time. It can also reduce the overall resources needed to deliver optimal level of customer care. The relevance of supply chain management is increasing since it requires cooperation and coordination among channel partners across the value chain. Healthcare supply chain differ from standard industrial supply chain in several ways (Mathur et al., 2018).

2.1 Smart Health Supply Chain Management

The term "transformation" signify application of technology to enhance efficiency, effectiveness and resilience. Artificial Intelligence, Internet of Thing, Big Data and Blockchain have revolutionised how medical supplies are tracked, traced and handled, reducing errors and optimising inventory management. Decision makers can optimize supply chain by implementing data analytics, by gaining essential insights into supply and demand patterns. As a part of dynamic transformation, sustainability, e-commerce and lean principles are also being adopted, ensuring resilience and sustainability along with efficiency, ultimately contributing to better patient outcomes. The notion of an intelligent supply chain signifies a noteworthy advancement in contemporary manufacturing procedures. Through the use of a cloud-based

IT platform, it seamlessly combines logistics and industrial processes, making it easier for supply chain partners from various regions and businesses to integrate. Transport orders are automatically sent to the assigned service partner via this cutting-edge IT platform, and they are promptly collected by them in strict adherence to the predetermined production schedule (The Intelligent Supply Chain, n.d.).

2.1.1 5G

5G is powering the fourth industrial revolution. Beyond meeting people's demand for communication, 5G is a driving force behind digital transformation and a catalyst for the advancement of enterprises, government, societies and individual lives. Next–generation technologies including metaverse, IoT, augmented reality, virtual reality, cloud computing, and artificial intelligence are all fuelled by 5G. Characteristics of 5G such as ultra–reliable low latency communications (URLLC) and massive–machine type communications (mMTC) allows seamless connectivity and industrial IoT applications to take place. Its high speed, low latency capabilities unlock new possibilities for industries, enabling the development and integration of innovative applications and services. 5G facilitates the rapid and efficient exchange of data, fostering digital transformation across industries (The Digital Dominance, n.d.)

2.1.2 IOT – Internet of Things

Internet of Things is an inter–connected network of physical objects, also referred as "smart objects" or "smart devices," these are equipped with software, sensors, and internet connectivity to facilitate data collection and exchange. The devices are connected with each other through Wi – Fi, internet, Bluetooth or other technologies, forming a digital network of devices enabling easy exchange of data. The sensors can track and monitor parameters such as temperature, humidity, motion, light, pressure, air quality, and machine performance, these capabilities are crucial in ensuring safe transportation and distribution of vital medicinal supplies such as medicines, vaccines, and laboratory tests (Topics | IBM, n.d.).

The Internet of Things is a three-layered structure, which facilitates effective data flow and communication between people and devices. These are – personal layer, network layer, and application layer. Internet-enabled gadgets that are able to recognise, track, gather, and share object-related data make up the personal layer. These devices include, RFID, sensors, and GPS. Data is moved from the user's personal layer to an application layer through the network layer, which serves as a middleman. It easily establishes connections with a variety of things, facilitating information sharing. The interface for user-to-application communication is provided by the application layer. The IoT is based on RFID technology, which enables physical objects to communicate with end users over a common network (Desingh and R, 2021). IoT produce massive volumes of data offering valuable insights for innovative business model and decision making. The data is stored, processed and analysed on cloud. Cloud computing platforms provide essential infrastructure and tools necessary for data storage and analysis. Opening up new avenues for growth and efficiency. IoT sensors, in conjunction with Artificial Intelligence or Machine Learning along with data analytics, enables seamless integration into the fabric of digital factories and warehouses. The integration empowers organizations to operate with intelligence. Security concerns persist as IoT devices are attractive targets for cyberattacks. Additionally, the vulnerability of data integrity within IoT systems raises the risk of counterfeit products infiltrating healthcare supply chains (Supply Chain and IoT Risks Pose Healthcare Cybersecurity Challenges, Report Reveals, n.d.). Integration of IoT with Blockchain technology decentralizes ensuring security, integrity and authenticity of data.

2.1.3 Blockchain in Healthcare

A decentralized digital ledger called blockchain is employed over a computer network to record and authenticate secured transactions. Transactions are recorded only once as a block of data in a ledger, the data block records the information – such as temperature of a vaccine during transportation. As assets move from one location to another with change in ownership, transactions are added to blocks forming a chain of data. Secured linkage between the transactions are ensured by encryption via unique, tamper resistant hashes. These encrypted data blocks are intricately chained to one

another, creating an immutable chain that records transactions sequentially and indefinitely. The majority of nodes in the network must work together to valid the authenticity of newly added data. This process is controlled by consensus mechanisms. A new block is created and seamlessly added to the existing chain once a consensus is reached. Each node across the network is updated to the latest state of the blockchain ledger. To expedite transactions and automate processes, a set of predefined rules, named "smart contracts", is securely stored within the blockchain. Smart contracts are programmes that execute when specific criteria are satisfied. This innovation not only accelerates transaction processing but also enhances transparency and trust in a wide range of applications in supply chain management. For the timely access to medical supplies the flow of information is crucial across the supply chain. Hospitals, a downstream element, significantly influences the demand for healthcare supplies. However, the challenges lie in the opacity of data within hospital systems. Hospitals are hesitant and prudent about sharing information due to the sensitive nature of healthcare data. This lack of openness and information sharing often leads to inefficiencies and delay in healthcare supply chain. Blockchain technology can greatly enhance the flow of information in the healthcare supply chain. All the stakeholders in the supply chain can access real – time, verified data regarding medicine demand, availability, and distribution, ensuring timely accessibility to essential medical resources. Integrated IoT–Blockchain technology empowers hospitals and other stakeholders in the upstream supply chain to securely share and access real–time data on medicinal inventory, encompassing the type of medicine, batch number, quantity and the storage location of stock.

2.1.4 Industry 4.0

Industry 4.0 initiatives have emerged as a powerful force in shaping the future of industries, offering much more than just operational efficiency. These initiatives are instrumental in fostering environmental protection and control while simultaneously mitigating risks within supply chains, transforming them into sustainable supply chains. This transformation also extends to the sphere of biomedical waste supply chain management. Internet of Things (IoT), data analytics, and automation, can enhance organisation resource management and reduce waste, ultimately lowering their environmental

footprint. In the context of biomedical waste, real-time monitoring and data-driven insights enable more efficient and environmentally responsible handling, transportation, and disposal of biomedical waste. Furthermore, the visibility provided by Industry 4.0 contributes to resilience of supply chain in this specific context as well. Proactive identification and management of potential risks and challenges, including those related to hazardous biomedical waste, enhance both the environmental protection and the sustainability of the supply chain. This convergence of technology and sustainability not only drives industries and healthcare facilities towards more eco-conscious practices but also enhances their competitiveness and long-term viability in the realm of biomedical waste supply chain management.

3. Discussion

In the ever-evolving landscape of the healthcare industry, the objective function of supply chain management has become increasingly pivotal. This book chapter explores the intricate interaction between supply chain management and healthcare, covering several important facets of this evolving field.

Healthcare supply chain management is now a strategic requirement rather than a logistical one. The healthcare supply chain has historically been marked by inefficiencies, duplications, and a lack of transparency. However, the current situation is characterized by a paradigm shift brought about by creative thinking, new tactics, and a growing focus on cost effectiveness. Healthcare companies are now able to improve patient care, cut expenses, and streamline operations due to the development of blockchain, integration of artificial intelligence and data analytics.

A well-managed supply chain lowers the risk of shortages and minimizes waste by ensuring that healthcare facilities have the right resources at the right time. The COVID-19 pandemic has highlighted the significance of having a flexible and robust healthcare supply chain. This is because it is critical to respond quickly and distribute essential healthcare products which have a direct influence patient outcomes and safety and is not just about reducing costs.

This book chapter also explores the innovations and policy reforms that have influenced the evolution of healthcare supply chains. Around the world, governments and regulatory agencies have realized that structural changes are necessary, which has prompted efforts to improve accountability and transparency. The implementation of contemporary supply chain practices by healthcare organizations has been greatly aided by this policy reforms, allowing them to provide better services to their communities.

There is a strong narrative thread running through the chapter which contrasts the traditional and modern healthcare supply chain management scenarios. It has been an incredible journey to move from manual procedures, paper-based records, and compartmentalized decision-making to a networked, data-driven, and cooperative approach this chapter offer is important insights into the ongoing efforts to optimize healthcare supply chains by examining the difficulties, successes and lessons learned in this transformation.

4. Conclusion

The healthcare industry serves as a cornerstone of modern societies, playing an indispensable role in preserving the well-being of individuals. However, recent years have presented a multitude of challenges for healthcare organizations, encompassing legislative and regulatory hurdles, though pervasive influence of globalization, reductions in state funding, heightened competitive pressures, and escalating operational cost. These factors have placed significant pressure on healthcare providers worldwide to streamline their operations, reduce expenses, all the while upholding the high standards of quality expected by healthcare service users. One transformative solution that has emerged in response to these challenges is supply chain management. Effective supply chain management has assured in a new era for healthcare providers resulting in numerous improvements across their operations.

The outbreak of the COVID-19 pandemic brought in an unparalleled surge in global healthcare demand, imposing substantial challenges for procurement of medical products on manufacturers and healthcare organizations. In such demanding times, the significance of a well- functioning healthcare supply

chain system became even more pronounced. Additionally, the progression of technology has played a pivotal role in reshaping the healthcare supply chain landscape. The adoption of cloud-based solutions has equipped healthcare organizations with the flexibility and scalability required to manage their supply chains effectively. Inventory management has also stood out as another critical component in the healthcare supply chain ecosystem wherein effective inventory management systems enable healthcare organizations to strike a balance between ensuring the availability of essential medical supplies and avoiding excess stockpiles, which can be both costly and inefficient. Data-driven inventory management strategies can help healthcare providers in optimizing stock levels, eliminate waste, and react to fluctuating demands, ultimately improving their overall cost effectiveness.

In conclusion, supply chain management with regards to healthcare delivery, technological advancements, cloud-based solutions, and strategic inventory management are essentially in addressing healthcare industry challenges. They collectively enhance patient care quality, increase operational efficiency, and enable adaptation to the evolving healthcare delivery landscape.

5. Future Healthcare Supply Chain Frameworks

Future technological developments could allow the construction of simpler and less expensive hybrid system that employs just in time methodology, resolving potential shortcomings of the HSC. The integrated HSCs will further have the capability to estimate future inventory control and facilitate in tracking the average level of supply consumption (Spieske et al., 2022).

In recent times, the chain of things (CoT) network has garnered significant interest from both researchers and organizations. It is seen as a catalyst for substantial innovation, introducing a novel dimension to enhance the resilience of the HSC. This is made possible through its remarkable attributes, which includes decentralization, seamless data sharing, persistency, anonymity and auditability (Sathiya et al., 2023).

Green Operations and Supply Chain Management (Green OSCM) is gaining momentum due to increasing pollution, environmental regulations, and

consumer awareness. Companies are incorporating eco-friendly practices like waste reduction, lowering the emission of greenhouse gases, green sourcing, sustainable packaging, and reverse logistics. The rise of green OSCM will reflect a significant shift towards sustainability and innovation in supply chain and operational practices (Benzidia et al., 2023).

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Chapter 5

SUPPLY CHAIN DISRUPTION FOR SEMICONDUCTOR CHIPS IN THE AUTOMOBILE INDUSTRY: A STUDY

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Abstract

Semiconductor chips are used in almost every industry and in everyday products. The chips are primarily made of silicon and play an essential role in the development of integrated circuits (ICs) and microchips, which power today's modern world. The automobile industry is changing, with a focus on automation and electric vehicles, and this shift has further increased the demand for semiconductor chips, causing further strain on an already affected industry. This study focuses on the global chip shortage that started in early 2020 when the COVID-19 pandemic hit and demand outweighed supply. The study analyzes the root causes of the global shortage, which include factory closures in Asian countries and exponentially increasing demand. The study further considers its implications on the automobile industry in China, India, and the United States of America. The study also focuses on how the pandemic further exposed the existing vulnerabilities in the global semi-conductor supply chain. Furthermore, the study investigates the impact of multiple country lockdowns and the resulting trade frictions on

semiconductor chip production and the supply chain. Furthermore, the study looks into the solutions implemented by the automobile industry and their success. This study will also look into chip technology and technical aspects of the supply chain, as well as methods for assisting supply chains in adapting to a shortage.

Keywords: Semiconductor chips, supply chain disruption, global shortage, automobile industry

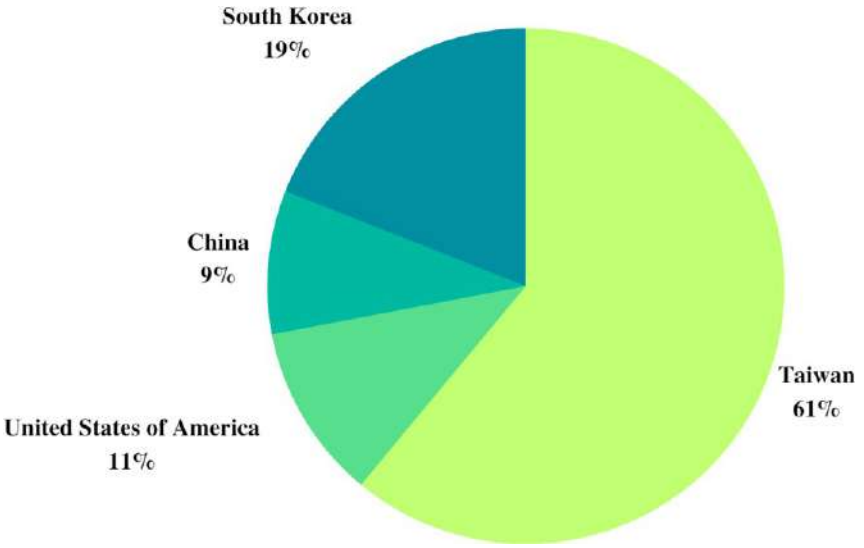
1. Introduction

The global semiconductor industry was valued at $412.3 billion, just before the COVID-19 pandemic caused a significant decline in output, eventually heading to a worldwide shortage of semiconductor chips. This has hampered manufacturing and sales in a number of nations for which there was no immediate remedy. Several industries have expressed their concern about the situation since the beginning of the pandemic. Since chip demand is exceeding supply and several automakers and consumer electronics companies throughout the world announced that the production would be impacted, businesses are zealously working to increase production. However, the supply limitations was further worsened by COVID-19 and its safety restrictions. According to the Semiconductor Industry Association (SIA), the semiconductor market was valued at $573.44 billion in 2022. By 2029, it is expected to grow at a CAGR of 12% and reach $1380.78. (Frieske and Stieler, 2022). Several industries were affected but a significant setback was reported in the automobile industry followed by other relevant industries.

2. Background

Semiconductors, often known as chips, are a cross between conductors and insulators. They are typically composed of silicon and are used to power a wide range of devices, including automobiles, laptop, computers, smartphones, home appliances, and game consoles. These tiny devices are responsible for a variety of tasks, including powering screens and conveying data. As a result, a supply shortage has an influence on sales of automobiles,

refrigerators, laptops, televisions, and other electrical devices. The following figure (Figure 5.1), depicts the leading semiconductor chip manufacturing countries in the world and their market share. As per a study conducted in 2020, three companies account for 75% of the world's chip fabrication and manufacturing (Figure 5.2). As a result, major companies from several other industries purchase chips only from these companies, making it difficult for new players to enter the market.

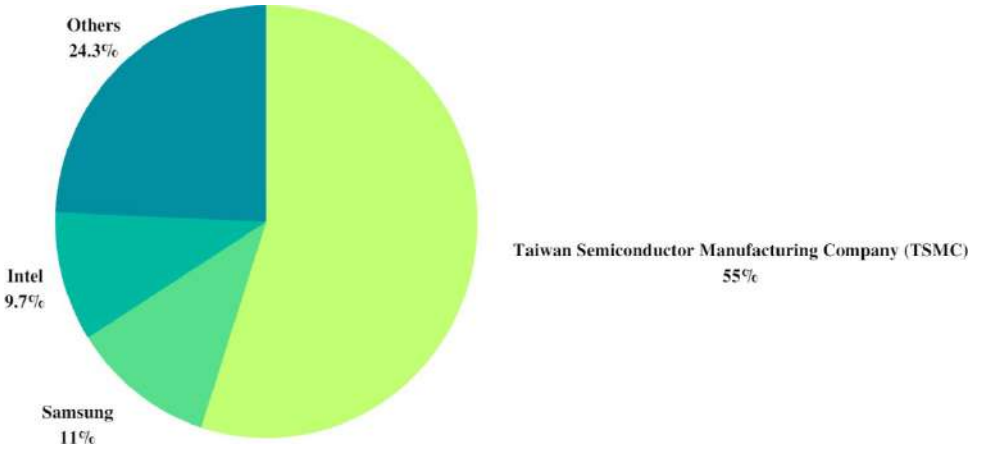


[Source: Casper et.al (2021)]

Figure 5.1: Leading Semiconductor Chip Manufacturing Countries

About 75% of the manufacturing capacity and needed key materials are in China and East Asia. In addition, 92% of the world's most advanced manufacturing capacity of semiconductors is located in Taiwan. Also, more than 60% of the world's assembly, packaging, and testing capacity is accounted for by China and Taiwan. The automobile industry accounts for 11% of annual semiconductor chip demand, according to a 2020 study conducted by the Semiconductor Industry Association (SIA), and relies heavily on the companies and countries to meet its demand for semiconductor chips. The automobile industry suffered massive losses as a result of its

inability to obtain an adequate quantity of semiconductor chips required for vehicle production. According to a study conducted by Bloomberg, manufacturing a chip typically takes more than 3 months and involves giant factories, molten tin and lasers, dust free rooms and million dollar machines. Hence, sudden increase in production would be difficult to achieve.



[Source: Casper et.al (2021)]

Figure 5.2: Largest Chip Manufacturing Companies

The COVID-19 pandemic witnessed an increased demand for electronic devices and components, particularly in the technology and automotive industries, which disrupted the supply chain resulting in a shortage. It had negatively impacted the automotive industry, which heavily relied on semiconductors for a variety of components such as navigation systems, driver assistance systems, entertainment systems etc. Since India and China are major automobile producers, their markets were impacted by a decrease in production caused by the shortage. This resulted in a decrease in supply, raising the prices and reducing the availability. The study explores the causes of the shortage, to identify the industries that are impacted and also to identify the steps taken by the governments and businesses. The findings of this study can help policymakers, industry leaders, and consumers understand the importance of diversifying supply chains, investing in local manufacturing capabilities, and adapting to changing market conditions. The study can

further help to advance the ongoing debate about the impact of digitization and technology advancement in the automotive industry and its impact on sustainability and resilience.

3. Objectives

The study explores the causes of the shortage, to identify the industries that are impacted and also to identify the steps taken by the governments and businesses. To investigate the effects of the global semiconductor chip shortage on China's, India's and the US's automobile industries.

4. Significance

Research in this topic is critical for policy makers, industry leaders and consumers to understand the problem and to identify its solutions to minimise the impact. Since the global shortage affected the automobile industry in India, China and the U.S, it's economic, technological and sustainability implications need to be explored. It further significantly affects the following areas (https://www.semiconductors.org/):

4.1. Economic Impact

The automobile industry contributes significantly to the global economy. The global automotive market was worth more than $3.5 trillion in 2020. The semiconductor shortage has reduced vehicle production and sales, resulting in a significant economic impact on the industry. This research can help identify ways to revive production and sales and provide insights into the extent of the industry's economic impact.

4.2. Technological Implications

The automobile industry has rapidly changed as new technologies such as electric vehicles, connected cars, and autonomous driving have been integrated. The semiconductor shortage has hampered these technologies' deployment in the market by disrupting their supply chain. The impact of the semiconductor shortage can be studied to determine the extent of the disruption and the impact on the deployment of new technologies.

4.3 Sustainability

The automotive industry's transition to electric vehicles and alternative modes of transportation is critical to achieving sustainable mobility. The semiconductor shortage has slowed the adoption of electric vehicles by disrupting the supply chain. The impact of the semiconductor shortage on sustainability research can provide insights into the extent of the disruption and help identify ways to accelerate the transition to sustainable mobility.

4.4 National Security

The semiconductor shortage has highlighted the global supply chain's vulnerabilities, with most semiconductor production concentrated in a few countries. This concentration endangers national security because supply chain disruptions can affect critical industries such as defense, healthcare, and transportation. To improve national security, research on the impact of the semiconductor shortage can provide insights into the need for supply chain diversification and investment in local manufacturing capabilities.

5. Literature Review

To address the root causes of the global shortage, its impact on the automobile industries in India, China, and the USA along with its impact on major automobile companies, and the solutions implemented by countries and companies to tackle the issue, a literature review was done. It was observed that the pandemic has disrupted global supply chains, making it difficult for companies to obtain raw materials and equipment required for semiconductor manufacturing. Due to the shortage, production has been reduced and lead times for electronic devices, automobiles, and other products requiring semiconductors have increased. The shortage has been caused by a complex set of factors, including the COVID-19 pandemic, increased demand for electronic devices and automotive semiconductors, and trade tensions between different regions. The review critically analyzed the literature, including published resources in the form of journal articles as well as newspaper and magazine articles, which were very limited due to the

uniqueness of the scenario. While selecting the resources, the focus was to obtain maximum articles referring to the shortage; hence newspaper articles were also considered. The gathered literature was organized as follows:

5.1. Problems Caused by the Global Semiconductor Chip Shortage

The global semiconductor chip shortage had a significant impact on the automotive industry, causing a slew of issues affecting every aspect of the industry, from manufacturing to sales. The following are some of the major issues:

5.1.1. Production Delays and Plant Closures

The shortage of semiconductor chips has caused production delays and even plant closures at some automobile manufacturing plants. This has resulted in a shortage of new cars as well as lower revenue for automakers.

5.1.2. Reduced Vehicle Production and reduced sales

Automobile manufacturers have had to reduce vehicle production due to a shortage of semiconductor chips. This has resulted in a shortage of new cars, which has increased demand for used cars, causing their prices to rise.

5.1.3. Increased Costs

Automobile manufacturers' costs have risen as a result of the semiconductor chip shortage. The cost of semiconductor chips has risen, which has increased the cost of manufacturing vehicles. This has resulted in an increase in the price of new cars, affecting sales.

5.1.4. Shift in Focus

The semiconductor chip shortage has forced automakers to shift their focus from vehicle production to semiconductor chip sourcing. This has resulted in a reduction in the production of certain models as well as a delay in the introduction of new models.

5.1.5. Increased Lead Time

Automobile manufacturers' lead times have increased because of the semiconductor chip shortage. This has resulted in longer wait times for customers who have placed orders for new vehicles, lowering customer satisfaction.

5.1.6. Lockdowns Due to the COVID-19 Pandemic in Multiple Countries

Lockdowns imposed in multiple countries as a result of the COVID-19 pandemic disrupted global supply chains, resulting in a reduction in semiconductor chip production. The closure of factories and reduced workforce capacity as a result of social distancing measures had an impact on chip manufacturing. Furthermore, the increase in demand for electronics and home appliances during the pandemic strained the already scarce supply of chips. The global semiconductor chip shortage was exacerbated by a combination of reduced supply and increased demand.

5.1.7. Trade Frictions and Geopolitical Tensions

Trade frictions and geopolitical tensions have all played a role in the global semiconductor chip shortage. For starters, the trade war between the United States and China reduced the semiconductor chip trade between the two countries, disrupting the global supply chain. Second, US sanctions against Chinese tech companies such as Huawei caused a shortage of chips for their products, increasing demand for chips from other companies. This increased demand put additional strain on the already scarce supply of chips. Finally, geopolitical tensions, such as those between the United States and North Korea, have reduced chip production in some countries, contributing to the global shortage.

5.2. Impact on the Automobile Industry in India, China, and the USA: Current Scenario

The global semiconductor chip shortage, which began in 2020, has had a significant impact on a variety of industries worldwide. The automobile industry, which relies heavily on semiconductor chips for vehicle production,

is one of the most affected industries. These chips are found in various modern car systems, such as power steering, entertainment systems, safety features, and even engine management. Production delays, reduced vehicle production, increased costs, decreased sales, a shift in focus, and increased lead time have all resulted from the shortage. This has resulted in a scarcity of new cars, an increase in used car prices, and a delay in the introduction of new models.

The global shortage of semiconductor chips had a significant impact on India's automobile industry. India is the world's fifth-largest automobile manufacturer, and the industry's supply chain has been disrupted by a shortage of semiconductor chips, resulting in production delays, reduced vehicle production, and increased costs. The shortage of semiconductor chips has caused a delay in the delivery of components needed for automobile production, disrupting the supply chain of major automakers. Tata Motors and Maruti Suzuki had to reduce their production output due to the shortage, resulting in a shortage of new cars and a decline in sales. The shortage of semiconductor chips has caused Tata Motors and Maruti Suzuki to delay the release of new models. (https://www.marutisuzuki.com). Tata Motors reported a 25% drop in sales in April 2021 compared to the previous year. According to the company, one of the main reasons for the sales decline is a shortage of semiconductor chips. Due to the shortage, the company has also had to reduce its production output, resulting in a shortage of popular models such as the Tata Nexon and the Tata Altroz.

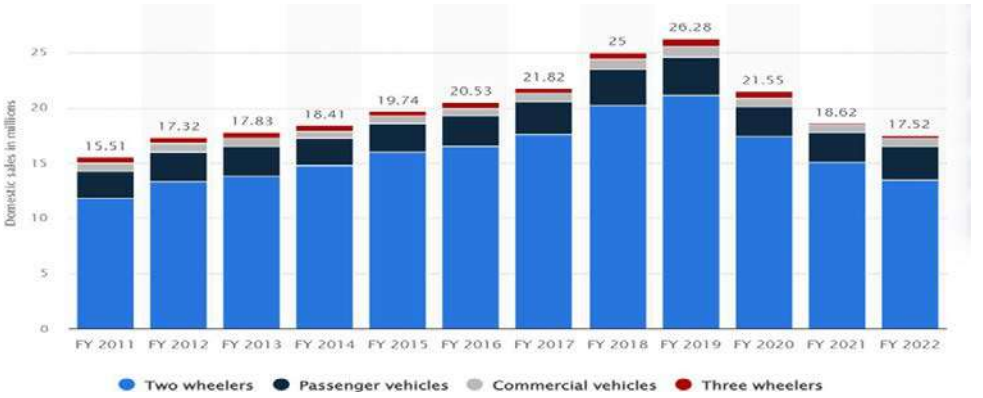
Rapidly rising production costs were witnessed since semiconductor chip shortage has reduced production volumes, resulting in the closure of factories and production lines. This decrease in production volumes has resulted in lower economies of scale, causing manufacturers' production costs to rise. The shortage of semiconductor chips has caused delays in the delivery of critical components required for automobile production. As a result, idle machinery and decreased productivity have resulted in higher production costs. The shortage has caused automobile manufacturers to shift their focus

from vehicle production to the procurement of critical components. Due to the shortage, manufacturers have been forced to redirect their resources towards sourcing semiconductor chips rather than producing cars, resulting in a delay in the introduction of new models and reduced production volumes, thereby raising production costs, which has also increased consumer vehicle prices. This price increase has resulted in a decrease in demand for automobiles in India, contributing to the drop in sales. Thus, the shortage of semiconductor chips has resulted in production delays, higher production costs, and a shift in automotive manufacturers' focus, resulting in a drop in sales. Figure 5.3 depicts Indian automobile sales from 2011 to 2022. Sales began to decline around the year 2020. Automobile sales in India began to decline in 2020, coinciding with the emergence of a semiconductor chip shortage. Furthermore, the COVID-19 pandemic compelled organizations to impose constraints, resulting in production delays and factory closures. The sourcing of semiconductor chips at higher prices from alternative suppliers resulted in increased costs that have made it more difficult for automobile manufacturers to keep up with demand for their products, resulting in additional production backlogs

The figure 5.4 depicts the rate of automobile production in India from 2010 to 2021. The manufacturing rate fell precipitously after 2018 and then increased slightly in 2021 (https://auto.economictimes.indiatimes.com/news). This was caused by the COVID-19 pandemic. Countries were forced to impose restrictions to ensure the safety of their citizens as a result of the pandemic. This resulted in factory closures and production shutdowns, resulting in decreased pace of manufacturing.

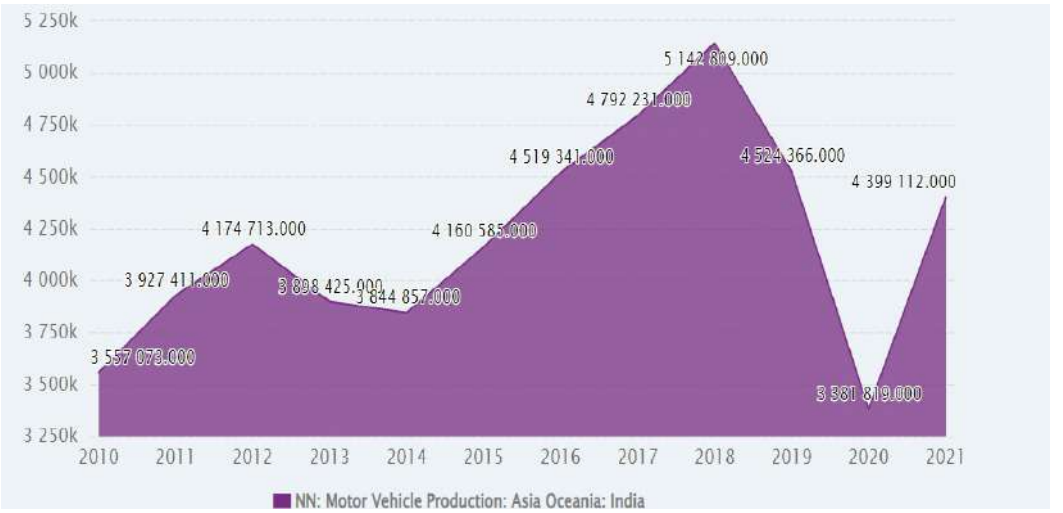
China: The global semiconductor chip shortage had a significant impact on the Chinese automobile industry, which is one of the world's largest producers and consumers of automobiles. Volkswagen, one of China's largest automakers, has been forced to halt production at several of its factories due to a shortage of semiconductor chips. The production halts have had a significant impact on the Chinese automobile industry, as Volkswagen and

Ford are two of the country's largest automakers. The halts have resulted in a backlog of customer orders, resulting in a year-on-year decline in Chinese automobile sales. Customers have had to wait several months in some cases to receive their vehicles. As a result, consumer confidence has declined, and demand for alternative modes of transportation, such as electric bikes and scooters, has increased.



[Source: **https://economictimes.indiatimes.com**]

Figure 5.3: Automobile Sales in India from 2011 to 2022



[Source: (**https://auto.economictimes.indiatimes.com/news**]

Figure 5.4: Automobile Manufacturing in India from 2010 to 2021

The shortage has also resulted in higher automobile prices in China, as automakers are forced to pass on increased production costs to consumers. The Chinese government has attempted to mitigate the impact by providing subsidies for new energy vehicles and encouraging the development of the domestic semiconductor industry. The chip shortage has impacted China's entire automotive supply chain, including suppliers, manufacturers, and dealerships. Suppliers have been forced to raise their prices to compensate for the shortage, which has resulted in higher costs for manufacturers. Manufacturers have been forced to reduce production capacity, resulting in lower dealership sales.

China's vulnerability in the semiconductor industry is severe, owing to technological shortcomings in critical value-chain components. One of the major challenges confronting China's electric vehicle industry is the inability to meet the high demand for EVs due to semiconductor chip shortage. Automakers have been forced to delay vehicle deliveries, resulting in customer dissatisfaction and sales losses. Given the scarcity, EV prices have risen, discouraging potential buyers even more. Another challenge confronting China's EV industry is increased competition for semiconductor chips from other industries, such as the consumer electronics industry, which is also affected by the chip shortage. This has resulted in a scarcity of chips, exacerbating the problem for the EV industry.

In addition, the Chinese government's push for EV adoption has been hampered by a shortage of semiconductor chips. The government has set a target for EVs to account for 25% of new car sales by 2025, but the shortage has made meeting this target difficult for automakers. The government has attempted to address this issue by providing subsidies for domestic semiconductor chip production, but it is unclear how effective these measures will be in the long run.

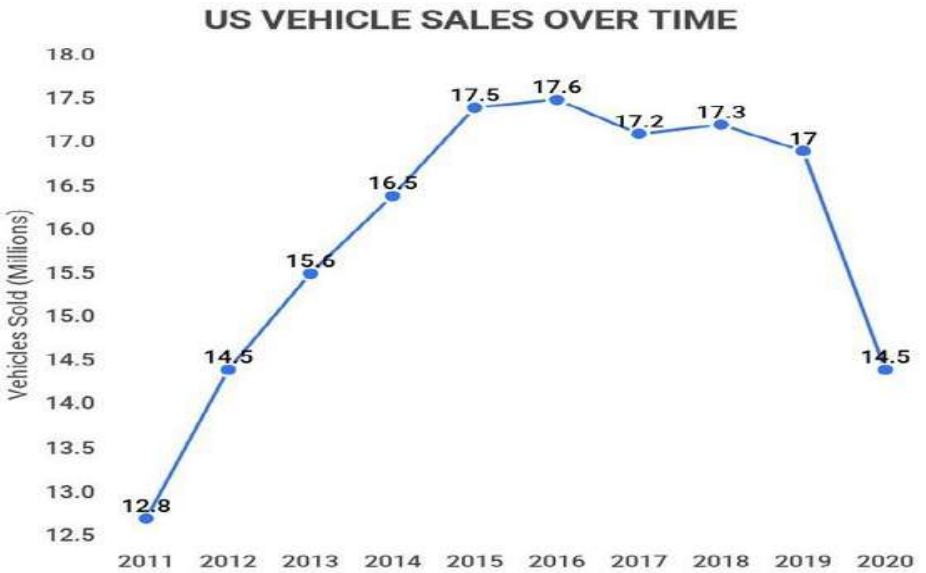
USA: The global semiconductor chip shortage had a significant impact on the automobile industry in the United States, causing production delays, price

increases, and sales declines for some manufacturers. The shortage has impacted every aspect of the industry, from new vehicle production to the supply of replacement parts. Vehicle semiconductor chips are highly specialized and cannot be easily replaced, resulting in higher prices and longer wait times for these components. This has resulted in significant increases in manufacturing costs for many manufacturers, which are passed on to consumers in the form of higher prices. Further, the shortage has also hampered the production of replacement parts, resulting in longer repair and maintenance wait times. As a result of longer wait time for repairs, customers are less satisfied and may switch to another brand for their next vehicle purchase.

The high demand for semiconductor chips, which has outstripped supply, is one of the primary factors contributing to production delays. The COVID-19 pandemic increased demand for electronic devices that use semiconductor chips, such as laptops and smartphones. As a result, semiconductor manufacturers shifted their focus to producing chips for these devices, resulting in a reduction in supply for the automotive industry. A series of unexpected events, such as a winter storm in Texas in February 2021, has also exacerbated the shortage. The storm caused power outages and damage to the state's semiconductor manufacturing facilities, causing a temporary halt in production. (https://www.reuters.com). Due to the shortage, production has been delayed, inventory levels has been reduced, prices have risen, and certain models are no longer available, all of which have contributed to a drop in sales. Furthermore, the shortage has hampered the production of replacement parts, making it more difficult for consumers to get their vehicles repaired. As a result, some consumers have delayed making purchases, contributing to the sales decline.

One of the primary reasons for product redesigns is the use of semiconductor chips in a wide variety of systems in modern vehicles. They are used in engine management systems, safety features, entertainment systems, and other applications. Many of these systems cannot function properly without these

chips, causing production delays. Some manufacturers have redesigned their products to eliminate or reduce their reliance on semiconductor chips in order to mitigate the impact of the chip shortage. Some, for example, have simplified their vehicle designs by removing features that rely heavily on semiconductor chips. Others have substituted simpler mechanical systems for complex electronic systems.



[Source: **https://www.reuters.com**]

Figure 5.5: Automobile Sales in the USA from 2011 to 2020

6. Discussion:

6.1 Approaches adopted by affected countries

Countries have implemented a variety of solutions to combat the shortage and to ensure a steady supply of semiconductors to the automotive industry. Increased investments in domestic chip production and development, as well as collaborations between industry stakeholders and government bodies, are among the proposed solutions. Furthermore, some countries have implemented policies to encourage the use of alternative components or to prioritize chip allocation to the automobile industry. India has increased

domestic chip production and attracted foreign investment in the semiconductor industry to address the issue. Some of the steps planned by India include:

6.1.1. Production-Linked Incentive Scheme:

The Indian government announced a $6.65 billion Production-Linked Incentive (PLI) scheme in February 2021 to boost local manufacturing of electronics, including semiconductors, over the next five years. The scheme aims to make India a global hub for electronics manufacturing while also creating jobs.

6.1.2. Semiconductor Fabrication Facilities:

The Indian government has been encouraging the development of semiconductor fabrication facilities, also known as fabs, which are required for the production of advanced chips. The government approved a proposal in March 2021 to build two semiconductor fabs in India for a total investment of approximately $8.8 billion. A consortium of Indian and foreign companies, including the state-owned Bharat Electronics Limited (BEL), will construct the fabs, which will produce chips for a variety of applications, including 5G technology, the Internet of Things (IoT), and automotive electronics.

6.1.3. Incentives for Foreign Investment:

The Indian government has been offering various incentives to attract foreign investment in the semiconductor industry, such as tax breaks, subsidies, and faster clearance procedures. In addition, the government launched a program called "Make in India for the World" in 2020 to encourage foreign firms to set up manufacturing units in India and export their products globally. To improve the country's semiconductor industry, the government further announced a new policy in February 2021 to support research and development in the electronics sector, including semiconductors, with a $2.3 billion budget over five years.

6.2 Approaches by China:

China plans to waive off import tariffs on certain types of semiconductor chips in order to encourage imports and meet the country's growing demand for chips. The import tax on specific chips has been reduced from 8% to 0%. China has been promoting collaboration between domestic semiconductor companies and foreign chipmakers in order to improve the capabilities of the country's semiconductor industry. Chinese tech giant Huawei announced a collaboration with Dutch chipmaker NXP Semiconductors to develop chips for automotive applications.

6.3 Approaches by USA:

The US government has offered financial incentives to companies that invest in chip manufacturing facilities in the country. The US government has been investing in workforce development programs to prepare workers for high-tech jobs such as semiconductor manufacturing. Further, automakers are considering a variety of solutions to the shortage, such as diversifying their supply chains and increasing investments in domestic semiconductor production. (Frieske and Stieler 2022).

6.3.1. Other approaches:

Redesigning products was one of the approaches adopted by many companies. Changing production schedules also help to relieve strain on the semiconductor chip supply chain. By lowering the production volume of vehicles that require many semiconductor chips, demand for chips is reduced, easing the overall strain on the supply chain. Automobile manufacturers can prioritize the limited supply of semiconductor chips for their best-selling models or those with the highest profit margins by delaying launches. This ensures that, despite the chip shortage, they can continue to produce these models and meet customer demand. Manufacturers can further focus on producing vehicles with the highest demand and profitability by limiting their variety options. This enables them to better allocate available semiconductor chips and maximize production line output. It also aids in the simplification of the manufacturing process, the reduction of costs, and the optimization of

supply chain logistics. Manufacturers can also reduce or postpone the production of lower-profit vehicles that require more semiconductor chips, such as electric or hybrid vehicles, which enable them to devote more semiconductor chips to the development of profitable vehicles. Another way for the industry to invest in chip manufacturing is to build in-house chip manufacturing capabilities. While this may necessitate a significant investment, it may provide greater control over the manufacturing process and reduce reliance on third-party suppliers.

7. Conclusion

The analysis highlighted that global semiconductor chip shortage had a significant impact on China, India, and the USA's automobile industries. The shortage highlighted China's reliance on foreign suppliers for semiconductor chips, as well as the need for the country to develop its domestic semiconductor industry. In India, the shortage has led to a significant decrease in automobile exports, particularly in the two-wheeler segment. In USA, the shortage has led to a surge in used car prices, with consumers turning to the second-hand market due to the unavailability of new cars. The semiconductor chip shortage has highlighted the importance of supply chain resilience and the need for countries to reduce their reliance on foreign suppliers for critical components. The shortage has also provided an opportunity for countries to invest in their domestic semiconductor industries, thereby increasing their self-sufficiency and reducing their vulnerability to global supply chain disruptions. It is crucial for companies and governments alike to collaborate and develop strategies that promote supply chain resilience and mitigate the impact of future disruptions. In conclusion, the global shortage of semiconductor chips has had a significant effect on the US, Chinese, and Indian auto industries. The Covid-19 pandemic has increased the demand for semiconductor chips, causing production capacity gaps, reliance on a single source, poor inventory management, effects on the supply chain, and uneven distribution of semiconductor chips which also are just a few of the factors that have contributed to the shortage. As a result of these gaps, there have

been significant delays in the supply chain, losses in revenue, and higher prices for consumers.

To address the shortage and improve the resilience of the automobile industry, there is a need for collaboration among key stakeholders. Governments and industry participants can work together to invest in domestic semiconductor chip manufacturing facilities, diversify supply sources, encourage industry innovation, and create efficient inventory management procedures.

Additionally, companies in the automobile industry can explore alternative technologies and reduce their dependence on semiconductor chips. However, it has also provided a chance for cooperation and innovation. The semiconductor chip shortage has had a significant impact on the automobile industry in India, China, and the USA. Stakeholders can improve the competitiveness of the auto industry, foster economic growth, and create a more resilient supply chain by filling the gaps mentioned identified by this study.

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Chapter 6

NEED ASSESSMENT FOR MUNICIPAL SOLID WASTE MANAGEMENT: A CASE OF DCM SHRIRAM FOUNDATION

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Abstract
In both urban and rural environments, municipal solid waste management (MSWM) is a major concern, especially in developing nations like India. While urban MSWM has drawn attention, rural areas are frequently neglected, which has negative effects on the environment and public health. To serve the communities associated with DCM Shriram in rural India, DCM Shriram Foundation started a need assessment study, which is presented in this document. The study focused on the neighborhoods surrounding their facilities. The study places a strong emphasis on the value of community involvement, cultural influences on behavior change, and the implementation

of a circular economy strategy. The city of Hardoi's baseline assessment uncovered issues with waste segregation, disposal methods, and community awareness. The study identifies the root cause of improper municipal solid waste management practices in Hardoi City thereafter suggesting a plan of action for community engagement, incentives, penalties, and educational campaigns in achieving sustainable MSWM. A four-pronged approach consisting of waste recovery, door-to-door pickup, waste segregation, and safe disposal is recommended. The proposed strategies aim to create a cleaner and wealthier neighborhood while serving as a model for scalability to other towns.

Keywords: Waste Management, circular economy, baseline survey

1. Introduction

Municipal solid waste management (MSWM) is a critical issue in both urban and rural areas, particularly in developing countries like India In both urban and rural locations, municipal solid waste management (MSWM) is a crucial issue, especially in emerging nations like India. While MSWM in metropolitan regions has gotten a lot of attention, rural MSWM is still generally ignored, which leads to subpar collection, treatment, and disposal methods that hurt the environment and public health (Bhandari and Kumar, 2020). Initiatives for MSW management cannot succeed without community involvement. According to Gupta and Garg (2016), integrating local populations in recycling and garbage segregation enhances waste management results and cultivates a sense of accountability. However, cultural and behavioral factors may influence the effectiveness of community engagement strategies (Kaza et al., 2018). This paper essentially talks about the need assessment study, with which DCM Shriram created a baseline survey report that would act as a starting point for MSWM strategies to be developed and implemented for a cleaner and wealthier neighborhood surrounding DCM Shriram's facilities located in rural India. The intent was to first assimilate the current state, understand the nuances, implement the thought-out strategies and thereafter scale the model to other towns.

2. Literature Review

2.1.Circular economy and solid waste management:

The circular economy emphasizes closing the loop of material flows, moving away from the linear "take, make, dispose" model (Kirchherr et al., 2017). Through principles like product life extension, material recovery, and eco-design, the circular economy strives to reduce environmental impact and promote long-term resource sustainability (Bocken et al., 2016). Scholars argue that a circular economy can contribute to decoupling economic growth from resource depletion and fostering a regenerative system (Stahel, 2016). And it has become imperative that the waste manufacturers take the responsibility of managing it. In the theory of extended producer responsibility (EPR), product makers are accountable for the full lifecycle of their goods and are urged to design with recyclability in mind. Research indicates that efficient EPR regulations can encourage a change towards a more sustainable and circular economy (Framer, 2020). Solid waste management processes are changing a fundamental principle of EPR since it holds manufacturers responsible for the full lifecycle of their products. EPR encourages producers to design with end-of-life concerns in mind, minimising their environmental footprint, by internalising the costs involved with product disposal. This strategy is aligned with the broader sustainable waste management objectives. Though conventionally applied to manufacturing setups, this can be extended to humans too. Humans produce their waste and hence should be responsible for effective waste management. Traditionally again this has been explored and researched for plastic and e-waste generated in tier 1 cities, but it can be easily extended to rural populations ad well wherein they are responsible for the solid waste they generate and hence need to consider mechanisms for waste disposal and management.

2.2.Municipal Solid Waste Management in India

India has grown at a fast pace and its rapid urbanization and growing population have led to a significant increase in municipal solid waste (MSW) generation and management. Though MSW gets significant attention in urban areas, rural MSWM is largely neglected or mismanaged (Kaur et al., 2021). There are scanty reports/research on the same. Bhandari and Kumar, 2020

state that the rural MSWM is characterized by several challenges like limited infrastructure and resources, limited awareness, and lack of participation further aggravated by the financial constraints that the rural masses have. The communities very often lack awareness about proper waste segregation and recycling practices, leading to mixed waste streams that hinder efficient treatment (Kaur et al., 2021). To add to the complexity, the scattered nature of rural settlements makes waste collection and transportation more difficult and costly (Kaur et al., 2021).

However, there are a few common MSWM practices in rural India that are widespread. Rural households regularly compost organic waste within their premises, reducing the amount of waste requiring disposal (Bhandari and Kumar, 2020). Another practice which is detrimental yet very commonly seen is open dumping and burning of wastes (Kaur et al., 2021) which poses serious environmental and health risks. Non-edible organic waste is quite often disposed of by feeding it to livestock and diverting it from landfills (Bhandari and Kumar, 2020). With an ever-increasing awareness of managing municipal solid wastes better, the DCM Sriram group intended to develop mechanisms wherein they analyze the situation in the neighbourhoods of their plants and thereafter strategize for optimal MSWM.

3. Baseline Survey

For local bodies, choosing an adequate waste management plan can be a difficult and complex task. The amount and composition of waste produced in the area, the existing waste management and recycling systems, the needs of the community and their willingness to pay for improved services, as well as larger policy, institutional, and cultural contexts, are just a few of the factors that the authorities must take into account when making decisions and developing solid waste management strategies. In order to support proper decision-making, a solid waste management assessment (baseline survey) of local conditions can produce vital information and data. But in order to accomplish this, a thorough analysis of the current MSW handling situation is vital.

Thus, a baseline assessment was proposed to be carried out to provide a situational analysis of Hardoi. This was a purposive sampling of city and wards that were done to address the necessities of the community that directly engages with DCM Shririam.it was envisaged that through its results, this baseline study would serve as a benchmark for all future activities needed to be carried under MSWM activities. Since the project has several objectives to be met, it is extremely crucial to establish priority areas. The baseline assessment report will consist of key indicators required to monitor the efficiency of MSWM regularly. It can also be considered to use these indicators at a later time to investigate project effects and its subsequent impacts.

4. Understanding the objectives of the study

The primary objective of the study was to understand the current status and challenges with regard to the MSWM practices of Hardoi City and thereafter to assess the effectiveness of the current solid waste management system so as to recommend and implement sustainable interventions on community-based solid waste management. The study also aimed at determining the existing practices of waste generators of the respondents in the study area, current waste generation, handling and treatment volumes; and the procedures used in collection, disposing, storing and recycling solid waste at all levels in Hardoi. Thereafter, recommend alternative solutions to improve the current solid waste management processes.

5. Methodology Adopted

DCM Shriram Foundation first observed the processes adopted by the community for MSWM. The initial observations provided them a lot of insights on the day-to-day operations vis-a-vis the publicly available assessment reports on MSWM. Hardoi city based on the results from the household survey. To gain deeper insights, 326 households were selected at random from 3 of the 35 wards of Hardoi (ward no. 5, 15 and 21). The choice of these three wards bas based on the understanding of looking at people in the ecosystem of DCM Shriram's plants. In the sample considered a total of 966 males and 871 females were there and a typical household had 5 members. A structured questionnaire which was pretested with a pilot group was

administered. The questions were on demographic characteristics of the households, information on waste generation by types, waste disposal practices, and door-to-door collection systems, education level etc. The questions were filled by visiting the selected households' door-to-door during the month of May 2021. Primary data was collected from the sample households using a structured questionnaire through computer assisted interviewing to reduce non response rate and incompleteness of data.

Additionally, two municipal officials were interviewed using a semi-structured questionnaire. Detail review of several published documents and reports were also done through online research as a part of secondary data collection. Secondary data were collected from published sources and also information gathered from the municipality.

6. Observations

Majority of the households stayed in the homes that they owned and only 9% of the total sample lived on rent. This was one of the checks to control for the behaviour towards municipal waste management owing to home ownership. In terms of housing, 94% were single storied premises while 6% were multi storied buildings. When the respondents were asked about the Government of India initiatives of Swachhta Sarvekshan (A government initiative to survey and promote practices for cleanliness, hygiene and sanitation in villages, towns and cities in India for a Clean India) only 25% of the respondents were aware.

When asked about the frequency of waste collection, it was observed that only 69% respondents stated that there were facilities for daily waste collection. While 24% of the respondents stated that there was no waste collection facility at all. 91% of this 24% was from a specific ward indicating that this ward might have not received the treatment like rest of the wards.

One of the biggest findings was that only 1 household regularly resorted to segregating the wastes and 53% stated that they did not follow any segregation practices at all. Upon probing further 48% of the total population

stated that they were not aware of the need to segregate the wastes, while 34% felt that there was no point in segregation as it gets mixed during collection. When probed if they would be willing to participate in the clean drive campaigns, it was also surprising to note that 34% were not interested at all. On being asked about how have they seen the city transform because of the clean drive initiatives, they responded by stating that open dumping spots have been removed, waste collection is happening daily, citizens have become more aware and participate, waste collection timing has improved and plastic use has reduced

With the initial primary research and interviews of the green workers it was it was observed that the pre-existing assessment reports are a good starting point to initiate the project. However, one major inaccuracy is that the green workers are mentioned to be paid 10k/month. But the structured interaction with them during the field visit revealed it to be 4.2k/month. The difference in pay is significant and adds a whole new dimension as a full time worker being paid 10k/month have very different behavioural practices than a part time worker with 4.2k/month pay. The drivers are part time workers and have all the incentives to finish their work quickly, and in order to finish quickly they rush the vehicle without making all the stops.

7. Conclusion and Recommendations

Based on the survey it was identified that a 4 pronged approach should be adopted to address the current challenges faced for municipal solid waste management: Segregation of waste at source, door to door collection, waste recovery and safe disposal.

For segregation, it was proposed that a 3 bin system be proposed where in it gets segregated to dry wastes, wet wastes and hazardous wastes. Dry wastes would comprise of paper, cardboard plastic and other dry wastes and could go to a white bin. Wet would comprise of all food and compostable wastes and could be put in a green bin, while the household hazardous wastes may go to a black bin. Construction and debris wastes should be kept in the own premises and disposed as per the Cand D waste management rules of 2016.

The frequency of the collection may be less, depending on the Cand D activities in the wards.

But as noted from the initial survey it was imperative that the population was made aware of the need for proper waste disposal, its short term and long term impact on all. Hence it was also proposed that the DCM Shriram foundation should not only aid in physical infrastructure creation but also help in creating awareness and training the citizens in proper MSWM. There needs to be a social and behavioural change if we want to see the MSW being efficiently and effectively managed. A crucial step in fostering behavioural change is the dissemination of information. Community members must be informed about the environmental impacts of improper waste disposal and the benefits of sustainable waste management practices (Smith, 2018). Educational campaigns through community workshops, school programs, and public service announcements can play a pivotal role in increasing awareness. Active community involvement is paramount for the success of any waste management initiative. DCM Shriram foundation along with the local governments, NGOs, and community leaders could collaborate to engage residents in decision-making processes (Jones et al., 2020). Community-based initiatives, such as clean-up drives and recycling competitions, can encourage residents to take ownership of waste management practices. Community leaders and influencers can play a vital role in shaping perceptions about waste management practices (Miller, 2017). Emphasizing the social benefits of responsible waste disposal and highlighting positive examples within the community can create a ripple effect, influencing others to adopt similar practices. Though creating awareness is paramount, rewards for proper waste disposal, such as discounts or recognition, can inspire positive actions (Thompson, 2021). Conversely, penalties for littering or improper waste disposal can act as a deterrent. It was exemplary to note that when almost all the households were handing over all their waste to the collector, there was one household which had been practicing recycling and composting. They segregated their wet waste and fed the food leftovers to the cows and other animals, which is a common practice in these towns and villages. They also used animal wastes as compost. The household also segregated the plastic

wastes because it was aware of the hazardous effect it brought on to the landfills. May be such examples from the community could be rewarded and exemplified to create further awareness. Striking the right balance between positive and negative reinforcement is essential for sustained behavioural change. After discussing with the communities such measures can be taken by the community itself for aiding proper segregation.

The second most important observation was on waste collection. As observed, there were certain wards where door to door collection was not as frequent and planned as in some other wards. In case a door to door collection was not possible because of the logistical challenges for the ward, it would be beneficial if community bins could be placed at public places. In certain wards, wastes were collected door to door as well as from intermediary recyclers.

Source: DCM Shriram Foundation internal reports

Figure 6.1: Four pronged strategy for Municipal Solid Waste Management of Hardoi

The waste handlers who took the wastes from the households were not trained and lacked proper gear too. Awareness and training camps could be done for them and they could be supported with appropriate gear so that they have a safer environment and motivation to work rather than doing it voluntarily and on a part-time task completion-based compensation structure. In fact the parameters for their pay and performance could be discussed with the local bodies and structured to aid proper collection, composting and recycling as appropriate.

It is estimated that around 65% of the total waste generated is organic while 35% is inorganic. The wet waste comprises organic materials such as leftover food, discarded vegetables, fruits flowers etc and dry waste includes paper, plastic, glass and other inorganic materials. A total of 32 tonnes of solid waste was generated per day, wet wastes accounting for 20 tonnes while the rest was 11 tonnes of dry waste. To manage such amounts of waste, landfills are not the only solution. Currently, there are two dumping sites at the outskirts where all the wastes are dumped. A common small recycling facility may be constructed and sanitary landfilling practices may be adopted instead of the open dumping grounds at present.

In conclusion, this study underscores the pressing need for comprehensive municipal solid waste management (MSWM) strategies in rural India, exemplified by the case of Hardoi. The baseline survey conducted by DCM Shriram Foundation has revealed critical challenges in waste segregation, collection, and community awareness. The proposed four-pronged approach, focusing on waste segregation, door-to-door collection, waste recovery, and safe disposal, offers a holistic solution to address these challenges. Emphasizing the importance of community engagement, incentives, and educational campaigns, the study advocates for a behavioural shift towards responsible waste management practices.

Furthermore, the integration of circular economy principles and extended producer responsibility (EPR) highlights the potential for transformative change in waste management. By internalizing environmental costs and promoting sustainable practices, the study suggests that EPR policies traditionally applied to urban areas, can be extended to rural communities. This aligns with the broader goals of a circular and sustainable economy.

The scope for future work lies in refining and expanding the strategies proposed in this study, taking into account the unique characteristics of different rural contexts and advancing our understanding of sustainable waste management in these settings.

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Chapter 7

GREEN SUPPLY CHAIN MANAGEMENT PRACTICES AND ITS IMPLICATIONS TO ENVIRONMENTAL PERFORMANCE AND THE FINANCIAL PERFORMANCE OF LUXURY HOTELS

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Abstract
The paper explores the factors influencing the green supply chain practices and its impact on the Environmental Performance (EP) and Financial Performance (FP) of luxury hotels. The study first investigates the factors for green supply chain management through an in-depth literature. Post that the items are vetted and validity is established to be used for the CFA. The study ascertains the relevance of five items in each of the constructs of Green supply chain management, Environmental performance and financial performance. The items related to the green supply chain management encompasses the material, resource, and employee training. The second construct in the study

involves the environmental performance captured in terms of waste generation, energy consumption, carbon emissions, water usage, and biodiversity conservation initiatives. The third construct consists of the financial performance that consists of the return on investment from GSCM practices, revenue from green products/services, employee satisfaction and retention, cost savings from sustainable practices reputation and brand value. This chapter will aid luxury hotels to improve their sustainability and achieve better financial and environmental outcomes.

Keywords: Green Supply Chain Management, Financial Performance, Environmental Performance, Hospitality Industry.

1. Introduction

The hospitality industry has been increasingly adopting Green Supply Chain Management (GSCM) practices due to the growing demand for sustainable and responsible tourism. Environmentally friendly practices can lead to cost savings and competitive advantages. This study evaluates hotels' financial and environmental performance by measuring revenue, cost savings, return on investment, carbon emissions, water consumption, and waste reduction. Luxury hotels have faced mounting pressure to commit to sustainability, especially as environmentally conscious consumers demand eco-friendlier options. Luxury hotels have a considerable ecological footprint due to their high consumption and service offerings. Thus, luxury hotels must understand the impact of GSCM practices on their financial and environmental performance to respond effectively to these demands while staying competitive.

Several studies have found that adopting GSCM practices positively affects the environmental performance of luxury hotels. A survey by Jabbour et al. (2014) found that such practices reduce greenhouse gas emissions, energy consumption, and water usage. Similarly, a study by Klassen and Whybark (2013) found that waste reduction and recycling positively affect environmental performance. A study by Lee and Hsu (2016) concluded that GSCM practices positively affect cost reduction, revenue enhancement, and

operational efficiency. Another study by Song and Chen (2020) found that GSCM practices positively impact financial and environmental performance in Chinese luxury hotels. A study by Ho et al. (2019) found that while GSCM practices positively impact environmental performance, the relationship with financial performance was insignificant, and a study by D'Amato et al. (2018) found that the relationship between GSCM practices and financial performance was insignificant. In conclusion, the literature suggests that GSCM practices can positively impact the environmental performance of luxury hotels and, in some cases, financial performance.

2. Literature Review

2.1. *Green supply chain management (GSCM)*

Collaboration with suppliers on environmental initiatives reduce waste, greenhouse gas emissions, and water usage, improving environmental performance. According to a study by Dubey, Gunasekaran, Childe, Papadopoulos, and Wamba (2017), this collaboration is essential. They found that companies that work with their suppliers on environmental initiatives experience cost savings and increased innovation. Using renewable energy sources is another observed variable that can positively impact a company's environmental performance. Research by Chen, Chen, and Xu (2018) suggests that this strategy can enhance a company's reputation and brand image.

Companies can reduce their environmental impact by using environmentally friendly packaging materials. A study by Rana and Singh (2018) found that sustainable packaging materials could reduce waste, energy consumption, and greenhouse gas emissions. They also noted that environmentally friendly packaging could enhance a company's brand image and increase customer loyalty. Monitoring and reporting environmental performance is also crucial for companies that want to improve their environmental performance. Research by Hahn and Kühnen (2013) suggests that this strategy can enhance a company's reputation and improve stakeholder trust. Finally, providing environmental training to employees can increase their awareness and knowledge of environmental issues and encourage them to adopt environmentally friendly behaviours. According to a study by Wu and Dunn

(2017), environmental training can enhance a company's reputation and improve employee engagement and job satisfaction. Figure 7.1 presents the year wise distribution of the articles reviewed in the study.

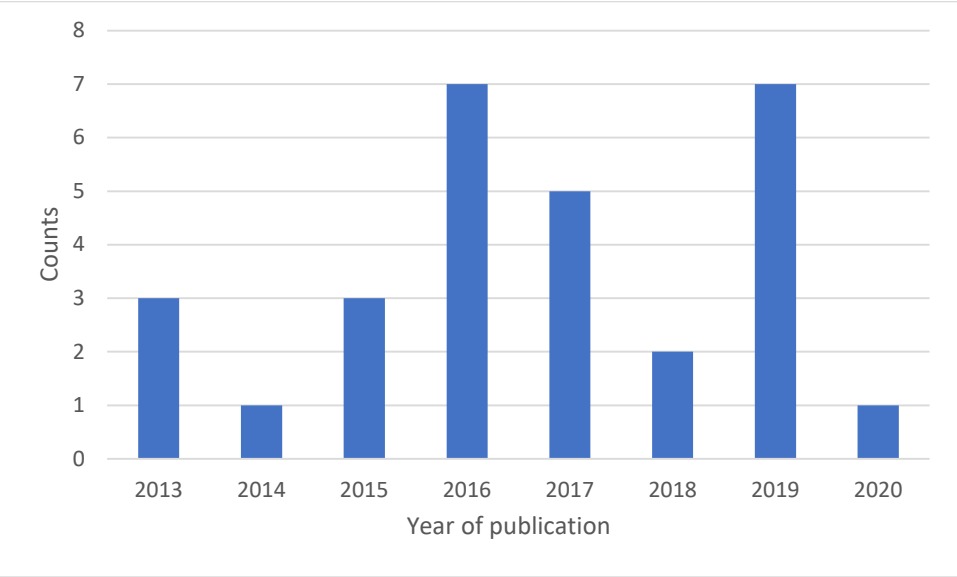

Figure 7.1 : Year wise distribution of articles reviewed

2.2.Environmental performance (EP)

Sharma et al. (2017) found that reducing waste generation is necessary for companies to improve their environmental performance. The study noted that waste generation could result in environmental pollution. Companies could reduce waste generation by adopting lean manufacturing practices and implementing eco-friendly products and packaging. Another critical factor in improving environmental performance is reducing energy consumption. Research conducted by Gokmenoglu and Tasgetiren (2019) suggests that companies can achieve this by using energy-efficient technologies, implementing energy management systems, and promoting energy conservation behaviour among employees. The study found that reducing energy consumption could reduce carbon emissions, save costs, and enhance a company's reputation. Greenhouse gas emissions also significantly impact the environment and human health. According to a study by Liu, Zhao, and Li (2017), reducing greenhouse gas emissions is essential for companies to

improve their environmental performance. The authors suggested that companies could achieve this by using sustainable transportation practices.
Water scarcity is becoming a significant issue worldwide, and companies can contribute to addressing this issue by reducing their water usage. Sarin et al. (2018) suggests that reducing water usage is critical for companies to improve their environmental performance. The authors recommended that companies reduce water usage by implementing water-efficient technologies, reducing water losses, and promoting water conservation behaviour among employees.
Lastly, biodiversity conservation initiatives can positively impact a company's environmental performance. According to a study by Mulholland, Brodsky, and Kozar (2017), biodiversity conservation initiatives can enhance ecosystem resilience, support sustainable resource management, and promote stakeholder engagement. The authors suggested that companies can promote biodiversity conservation by implementing sustainable land use practices, supporting conservation programs, and engaging in biodiversity-friendly supply chain management.

2.3. Financial Performance (*FP)*

2.3.1. Revenue

Offering green products and services can attract environmentally conscious consumers, create new market opportunities, and improve customer loyalty, increasing revenue. Companies can track sales figures, market share, and customer feedback to measure the revenue from green products and services.
Employee satisfaction and retention: Improving employee satisfaction and retention can lead to reduced turnover costs, increased productivity, and improved customer satisfaction, resulting in higher profits. Companies can track employee turnover rate, absenteeism, and job satisfaction surveys to measure employee satisfaction and retention.

2.3.2. Cost savings

Sustainable practices improve operational efficiency, lowering costs. Companies can measure cost savings from sustainable practices by tracking metrics such as reduced energy consumption, waste reduction, and material usage.

2.3.3. Reputation and brand value:

A positive reputation and brand value increase revenue. Companies can measure their reputation and brand value by tracking customer satisfaction, brand recognition, and brand loyalty metrics.

The latent variables represent underlying constructs that are not directly observable but inferred from other measurable indicators. For example, environmental performance infers from greenhouse gas emissions, energy consumption, water usage, and waste generation indicators. Similarly, financial performance infers cost reduction, revenue enhancement, and employee satisfaction and retention indicators. The adoption of GSCM practices infers from other measurable indicators such as sustainable packaging, collaboration with suppliers on environmental initiatives, and use of renewable energy sources practices.

3. Methodology

The study investigates the items necessary to measure the green supply chain management practices, environmental performance and financial performance in the hospitality industry. For the same the analysis of literature was carried. To identify the same the study enlists the items from the literature and attempts to explore any additional measures in the context of the luxury hotels. The thorough literature review identifies the relevant measures under each construct and test the face validity and content validity. The face validity is carried using the experts vetting the scale items for the three constructs while the content validity has been taken care of the content validity index (CVI). In the CVI the experts were asked to present the ratings on a scale of four for each item.

4. Findings and discussions

We have identified collaboration with suppliers on environmental initiatives, use of renewable energy sources and environmental training for employees as the three most critical observed variables for GSCM in the context of luxury hotels.

Collaboration with suppliers on environmental initiatives: A study conducted by Saeed et al. (2016) found that collaboration with suppliers on environmental initiatives positively impacts the environmental performance of hotels. The study also found that such collaboration improves the hotel's reputation and customer loyalty, leading to improved financial performance.

Use of renewable energy sources: A research article by Kim and Cha (2016) found that using renewable energy sources in hotels significantly reduces energy costs and greenhouse gas emissions. The study also suggested that hotels that adopt renewable energy sources are perceived as more environmentally friendly, which enhances their brand image and reputation.

Environmental training for employees: Research by Rahman et al. (2015) found that providing environmental training to hotel employees is an effective way to improve the environmental performance of hotels. The study found that trained employees were more likely to engage in environmentally friendly practices, improving environmental performance.

We have identified the importance of greenhouse gas emissions, energy consumption, and water usage as the three most critical observed variables for EP in the context of luxury hotels, which are in line with earlier research papers illustrated below:

Wang et al. (2018) found that implementing GSCM practices positively impacted reducing greenhouse gas emissions, improving energy and water efficiency, and improving the financial performance of luxury hotels in China.

Yang and Wall (2016) examined the adoption of GSCM practices in upscale hotels and found that energy-efficient lighting and water-saving measures were among the most commonly adopted methods. The study also found that hotels that implemented GSCM practices had significantly lower energy and water consumption and greenhouse gas emissions than those that did not.

Chiarini and Vagnoni (2016) examined the relationship between GSCM practices and environmental performance in the Italian hospitality industry and found that hotels that implemented GSCM practices had significantly lower greenhouse gas emissions, energy consumption, and water usage than those that did not.

We have identified revenue from green products/services, cost savings from sustainable practices, and employee satisfaction and retention as the three most critical observed variables for FP in the context of luxury hotels, which are in line with earlier research papers illustrated below:

Lee et al. (2016) found that hotels that implemented green practices, such as using energy-efficient lighting and water-saving measures, had higher customer satisfaction and loyalty, translating into higher revenues from green products and services.

Choi et al. (2015) examined the impact of green practices on hotel performance in South Korea and found that hotels that implemented green practices had lower operating costs, translating into cost savings from sustainable practices.

Kim and Park(2015) examined the impact of GSCM practices on hotel performance in South Korea and found that hotels that implemented GSCM practices had higher levels of employee satisfaction and retention, translating into improved financial performance.

5. Conclusions

Social Implications

Study aims to help luxury hotels understand the benefits of GSCM practices and encourage them to implement such procedures to improve their environmental and financial performance. Firms adopting GSCM practices may also improve their reputation and enhance their image of social responsibility. This can be beneficial for building and maintaining relationships with customers, employees, and stakeholders. An improved reputation can lead to increased trust and loyalty among stakeholders, which

can have long-term benefits for the firm's social and financial performance. GSCM practices can also have positive social impacts on the supply chain. They promote sustainable practices among suppliers and encourage them to adopt environmentally friendly practices, contributing to the overall sustainability of the supply chain and promoting sustainable development.

Practical Implications

To improve environmental and financial performance, luxury hotels can consider using environmentally friendly packaging materials, collaborating with suppliers on environmental initiatives, using renewable energy sources, and monitoring and reporting environmental performance. Green supply chain management (GSCM) practices can significantly improve environmental performance, providing financial benefits. Therefore, firms should consider adopting GSCM practices to improve their environmental and financial performance. The study emphasizes the importance of measuring and monitoring environmental performance to evaluate the effectiveness of GSCM practices. Firms in the hospitality industry should consider developing and implementing environmental performance metrics to help assess their GSCM practices' impact on environmental performance. The study suggests that the relationship between GSCM practices and financial performance is complex, and various factors influence financial performance in the hospitality industry. Therefore, firms should adopt a holistic approach, including GSCM and other financial strategies, to improve performance.

Economic Implications

Adopting GSCM helps hospitality industry firms reduce costs by increasing efficiency, reducing waste, and improving resource utilization. Additionally, firms that adopt GSCM practices may benefit from increased customer demand for sustainable products and services, which can create new business opportunities and revenue streams, further improving their financial performance. GSCM practices also help firms comply with environmental regulations, potentially avoiding fines or legal liabilities associated with non-compliance. Compliance reduces the risk of financial losses and thus improves financial performance. To assess the effectiveness of GSCM practices, it's

essential to measure and monitor environmental performance. Measurement helps firms identify areas for improvement, optimize resource utilization, and improve their financial performance. Ultimately, these benefits can increase profitability and competitiveness in the marketplace.

6. Limitations and future research

Firstly, the measures developed through the papers reviewed are few, that is restricted to hospitality industry. The future study can explore the relationship between the three constructs that has gone through a rigorous content and construct validity. Hotels in different regions and segments could be considered for future research. Future studies could use objective measures of environmental and financial performance, such as energy consumption and revenue, to validate the findings of any structural modelling done among these constructs.

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Chapter 8

PYROLYSIS AND CIRCULARITY IN THE AUTOMOTIVE INDUSTRY

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Abstract
Tires being indispensable in the assembly of vehicles can play an important role in achieving circularity in the automotive industry. With an estimated over 60% of the 275000 tires being scrapped every day in India being disposed off, through illegal dumping, stockpiling, landfilling or incineration, end-of-life tires (ELTs) can contribute significantly towards achieving circularity in the automotive industry. Currently, in India, circularity with tires is achieved either by direct reuse of the whole end-of-life tires (ELTs) by regrooving and retreading, mechanical or cryogenic modification to shred the end-of-life tires (ELTs) and use them as crumb rubber for various applications, thermos-chemical decomposition i.e., pyrolysis of the end-of-life tires (ELTs) to produce oil, gas and carbon black, and combustion of the end-of-life tires (ELTs) to produce tire derived fuel (TDF) to be used as a cheap supplement to traditional fuels such as coal or wood used in industrial heating, burning and combustion operations. Additionally, during the pyrolysis processing of the end-of-life tires (ELTs) steel braid is also obtained which can be sold as scrap to scrap dealers. While in India there have been concerns regarding health, safety and environmental impacts of tire pyrolysis plants, these can be overcome with appropriate process design, plant layout, material selection, equipment fabrication and installation, implementation of SOPs for creating

and maintaining the right operating conditions to make tire pyrolysis with no material health concerns for workers.

Keywords: Pyrolysis, End-of-Life Tires (ELTs), light diesel oil (LDO), Tire derived fuel (TDF)

1. Introduction

The Industrial Revolution of the 18th century has propelled economic activity and production capacities to levels never experienced before in contemporary human history. Before the Industrial Revolution, production was characterized by craft manufacturing, where apprentices, typically eight or ten, worked under the guided supervision of a skilled craftsperson using simple, flexible tools to produce customized goods. Production in the craft manufacturing era was confined to cottages, and hence the term cottage industry, with a very small scale of production.

The onset of the Industrial Revolution in the latter half of the 18th century ushered in several innovations including substitution of machine power for human power, invention of steam engines, and establishment of the factory system. These innovations along with development of infrastructure and railroads, and developments in the science of management and in production techniques - division of labor, shop system, time and motion studies, standardized product designs, interchangeable parts, mechanized assembly lines, etc. - in the 19th and early 20th centuries spawned an era of mass production setting the stage for the great product explosion of the 20th century.

The automobile industry is a classic example of the effect of the mass production system resulting from all the developments during the Industrial Revolution. Ford Motor Company, which was amongst the first companies to incorporate many of those developments, including the moving assembly line, of the Industrial Revolution, came to epitomize all the advancements in production management till then. Assembly time at its factory for producing the iconic Model T cars was reduced from 728 worker-hours to only 93 worker-minutes. This led to tremendous cost saving for Ford thereby

increasing its cash balance from USD 2 million to USD 673 million and also allowing it to reduce the price of the car to less than half from USD 780 to USD 360. With more than 46000% increase in productivity (in worker-hours alone) cars simply poured off the assembly line. The world had never seen anything remotely like this.

While the developments of the mass production era have been unprecedented in their scale and scope, their pace has also been mind-boggling. An illustration of this is found in the energy consumption trends that reveal an exponential growth in energy consumption, and therefore, in human economic activity. Dr. Homi Bhabha, the late Indian atomic scientist who chaired the first International Conference on the Peaceful Uses of Atomic Energy, in 1955, once analyzed, this trend and said, "To illustrate, let us use the letter Q to stand for the energy derived from burning some 33000 million tons of coal. In the eighteen- and one-half centuries after Christ, the total energy consumed averaged less than one half Q per century. But by 1850, the rate had risen to one Q per century. Today, the rate is about ten Q per century." So nearly half of all the energy consumed by humans in the past 2000 years has been consumed in the last one hundred years.

As the energy consumption trends exemplify, the unprecedented scale and scope of the developments since the dawn of the mass production era have amplified exponentially the volume of human activity in the social and economic spheres. And while this has led to an increase in global economic output, the largely linear nature of this increased economic activity is also having far-reaching implications on the environmental and ecological state of our planet.

The exponentially rising trend in the level of carbon dioxide in the atmosphere of our planet signifies the severe adverse effects of the linear economy that has been propelled by the mass production era. According to the National Aeronautics and Space Administration (NASA) of the United States government, human activities have been responsible for raising the atmosphere's carbon dioxide content by 50% in less than 200 years. The amount of CO_2 in the atmosphere is now 150% of its value in the year 1750. To

put this in perspective, this human-induced rise in atmospheric CO_2 is greater than the natural increase in atmospheric CO_2 observed at the end of the last ice age 20000 years ago. This exponentially increasing trend in atmospheric CO_2 encapsulates both the unprecedented scale and scope of the developments of the Industrial Revolution and the mind-boggling pace of those developments.

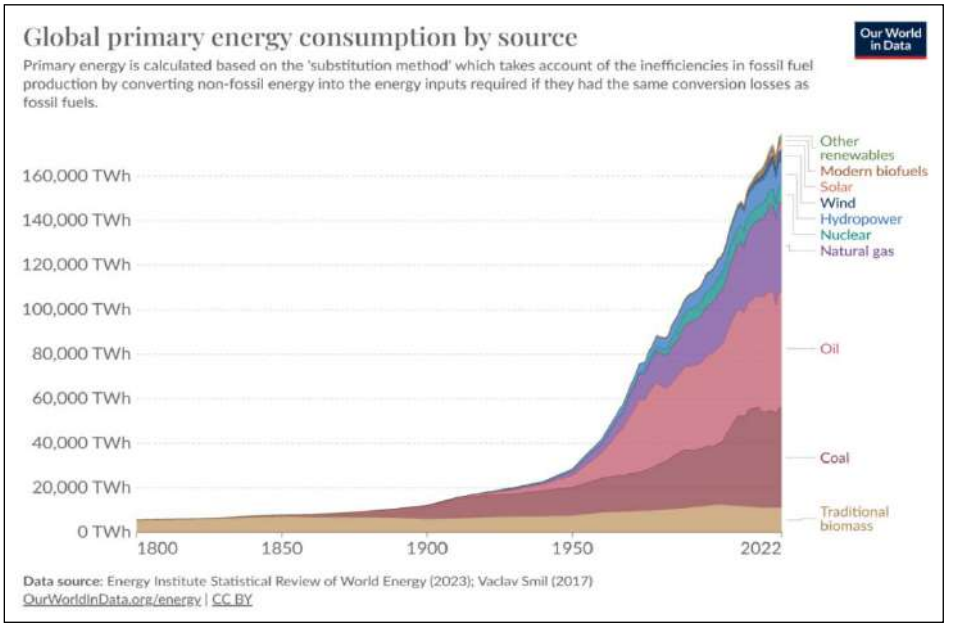

FIGURE 8.1: ENERGY CONSUMPTION TRENDS

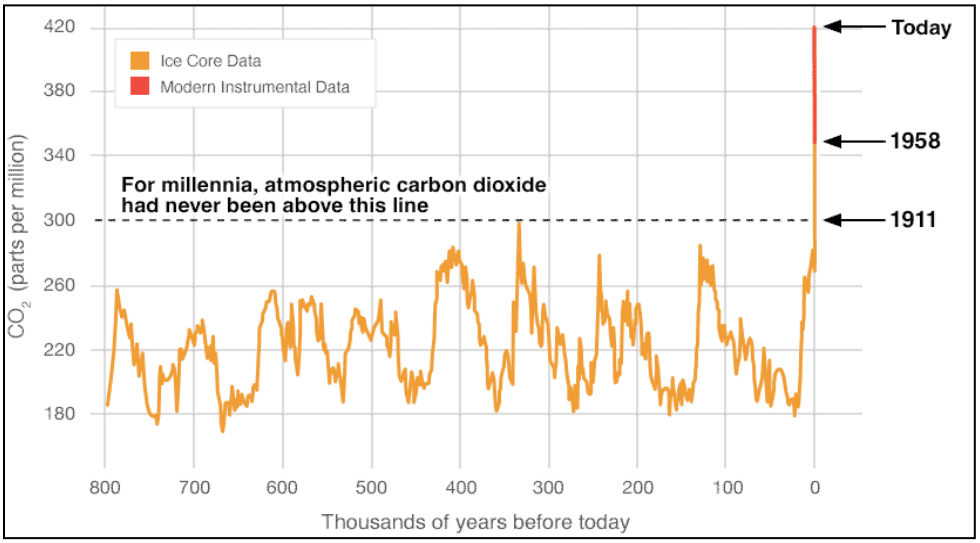

FIGURE 8.2: ATMOSPHERIC CARBON DIOXIDE TRENDS - TODAY REPRESENTS OCTOBER 2023

This linear economy approach has been characterized by extreme exploitation of natural resources to produce goods of all types which are distributed and sold to consumers (across the globe, ever since the onset of globalization) who consume them and dispose them off, in environmentally unfriendly ways, at the end of their useful lives.

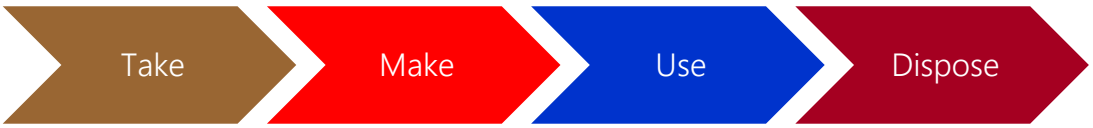

FIGURE 8.3. LINEAR ECONOMY APPROACH

Such an open-ended, linear approach to economic activity, that is both energy-intensive and resource-intensive, is unsustainable. According to the United Nations (UN), whose Sustainable Development Goals (SDGs) include Responsible Consumption and Production (SDG No. 12), in order to sustain our current lifestyles, by 2050 we will need the equivalent of almost three earths to provide the required natural resources if the total global population increases to 9.8 billion. And hence, the current production and consumption patterns underlying the existing economic system need immediate and large-scale changes to be more sustainable. A closed-loop, circular economy approach built on sustainable production and consumption habits and patterns is therefore the need of the hour.

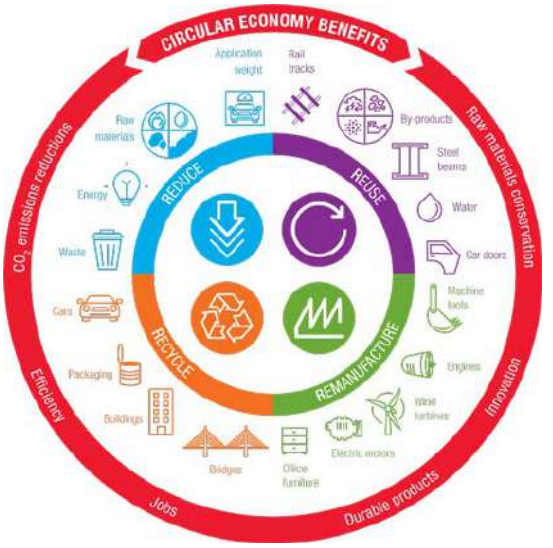

FIGURE 8.4. CIRCULAR ECONOMY

The United Nations Conference on Trade and Development (UNCTAD) defines a circular economy as one that entails markets that give incentives to reusing products, rather than scrapping them and then extracting new resources. All forms of waste, such as scrap metal, clothes, and obsolete electronics, etc. are returned to the economy or used more efficiently in such a circular economy.

The goods of today are the resources of tomorrow at yesterday's resource prices.

- UNCTAD

Circularity in the economy cannot just provide us a way to protect the environment, but it can also help us use natural resources more judiciously, develop new sectors, create new and more jobs, and develop new capabilities, ushering in new business models.

Circularity in the economy can be achieved by closing the open-ended take-make-use-dispose linear process by approaches of extending use, intensifying use, dematerializing, reusing, refurbishing, remanufacturing, and recycling.

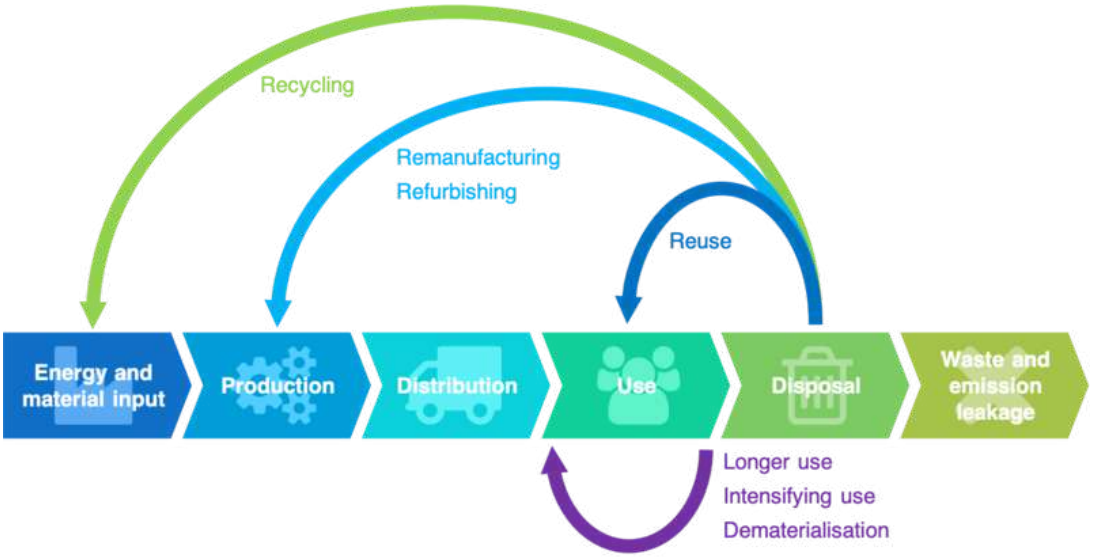

FIGURE 8.5. APPROACHES TO CIRCULAR ECONOMY

Extending Use (Longer Use) involves elongating the use phase of a product through long-lasting and timeless design, marketing, maintenance, and repair. Intensifying Use involves boosting or augmenting the use of a product through solutions that increases its efficiency, capacity, and effective utilization. E. g. - public transport, sharing economy solutions like carpooling, etc.

Dematerializing involves providing the product utility without the physical, tangible hardware through substitution with service and software solutions. E. g. - dematerialized share certificates, etc.

Reusing involves using a product again without any reprocessing or treatment. The product may be used again for the same purpose it was originally intended for or for a different purpose, in which case it can be referred to as repurposing. E.g. - shirts used by a consumer being used again as shirts by some other users or being used as cleaning cloths by the same or other users.

Refurbishing involves restoring products or components to a functional or satisfactory state to the original specifications by replacing or repairing non-functional components of the product. E. g. - repairing, renovating and

redecorating the dilapidated sections of a building while keeping the overall structure intact, etc.

Remanufacturing involves restoring products to the original, new-like state such that the product does not feel previously used and meets the customer expectations, including regarding full, original warranty, the same way as a brand new product does. A remanufactured product may make use of refurbished and recycled components.

Recycling involves collecting and processing products disposed of by consumers or waste material generated during production that would otherwise be thrown away as trash to turning them into new products or to capture or recover pure or original materials used in making them.

2. AUTOMOTIVE INDUSTRY

Ever since the onset of the Industrial Revolution in the 18th century, the automotive industry has been one of the most important drivers of economic growth. It was amongst the first industries to implement the developments of the Industrial Revolution and benefit from economies of scale. Various studies have reported that the global automotive industry contributes between 3-5% of the global GDP employing close to 5% of the global labor force, directly and indirectly. Data regarding production statistics sourced from the International Organization of Motor Vehicle Manufacturers (OICA) reports production of more than 85 million vehicles (excluding two-wheeled and three-wheeled vehicles) in the year 2022 alone. The global automotive manufacturing industry generated gross revenues close to USD 3 trillion in 2022, which would earn it a place amongst the 10 largest economies of the world, if it were a country.

With such a significant contribution to the global economy, the global automotive industry has also been responsible for the environmental and ecological degradation of our planet. Data, sourced from the International Organization of Motor Vehicle Manufacturers (OICA), about man-made CO_2 emissions indicate a significant contribution of the global automotive industry (road transport) to the overall man-made CO_2 emissions.

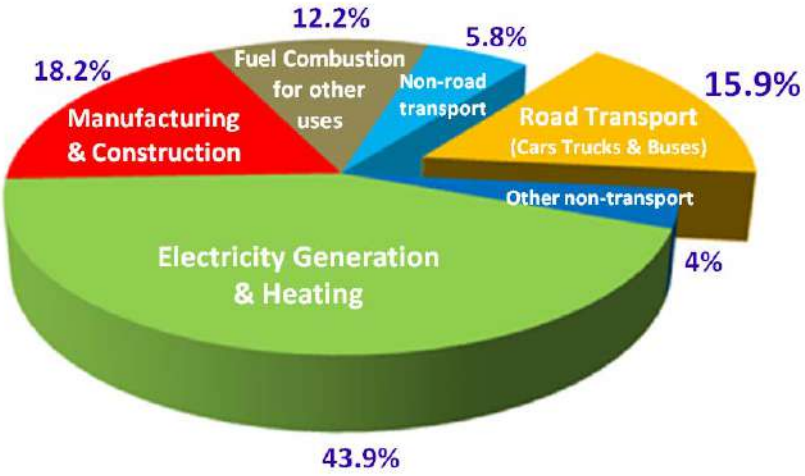

FIGURE 8.6. SOURCES OF MAN-MADE CO_2 EMISSIONS

But this does not reveal the full impact of the global automotive industry on our environment and ecology as the manufacturing and distribution supply chain of the global automotive industry remains largely excluded from the above data analysis. For e. g., the automotive industry is a major consumer of water with some estimates surpassing 180000 liters of water being consumed per car manufactured, depending on whether tire production is included.

In India too, the automotive industry has been and continues to be one of the main pillars of the economy. In the financial year 2021-22, its contribution to national GDP was about 7.1%, rising from 2.77% in 1992-93, and it provides employment opportunities to more than 19 million people, directly and indirectly. It contributes close to 50% to the overall manufacturing sector, which contributes around 15-17% of the national GDP. And given India's mission to increase manufacturing's contribution to national GDP to 25%, the automotive industry holds great significance for the economic outlook of the country, while at the same time pointing towards the need to make the industry more sustainable.

Globally, efforts being undertaken to reduce the adverse environmental and ecological impacts of the automotive industry include:

- Developing more fuel-efficient vehicles using internal combustion engines (ICEs)
- Developing new hybrid vehicles
- Developing hydrogen-based fuel cell electric vehicles (FCEVs)
- Developing solar electric vehicles
- Developing alternate fuels (ethanol-blended fuel, biodiesel, etc.)

Besides, there exists tremendous potential in implementing circularity in the automotive industry. In India, a young population with high aspirations and rising incomes has led to a booming used-car market (pre-owned vehicles or second-hand vehicles). In addition to this opportunity for reusing, recycling of components, particularly recycling of waste tires, and remanufacturing of vehicles also hold great promise.

3. WASTE TIRES

It is estimated that globally over 1.5 billion tires reach their end of life each year, of which about 6% are in India. That translates to approximately about 275000 tires being discarded every day in India. Disposal of such a large volume of tires is a major source of environmental degradation and pollution. It is estimated that over 60% of the end-of-life tires (ELTs) are disposed off through illegal dumping, stockpiling, landfilling or incineration causing land pollution in both urban and rural areas while also exposing local communities to additional environmental and health-related risks (epidemics such as malaria, dengue, etc. due to water stagnation in stockpiled areas, leaching of toxins in the surrounding soil and water bodies, fires etc.). Less than 10% of the end-of-life tires (ELTs) are estimated to be recycled or reused in India. These end-of-life tires (ELTs) are either recycled or reused depending on the condition of the tires. There are four major approaches through which these end-of-life tires (ELTs) are recycled or reused in India:

1. Direct reuse
2. Mechanical or cryogenic modification
3. Thermo-chemical decomposition
4. Combustion

Direct reuse of the end-of-life tires (ELTs) is done through two ways: regrooving, and retreading. Regrooving is a largely manual process that involves use of a special knife to carve grooves in the tires. Retreading is a more mechanized process than regrooving and involves replacement of the worn-out tread of an end-of-life tire (ELT) with a relatively new newer tread.

Mechanical or cryogenic modification also involves reuse but not of the entire tires. Instead, in the mechanical modification approach, the end-of-life tires (ELTs) go through a grinding process that reduces the tires into smaller and smaller pieces separating the steel and fiber from the rubber. Whereas in the cryogenic modification approach, the rubber is frozen using liquid nitrogen and then shattered into small pieces. Both these approaches produce and separate the tires into small pieces of rubber, known as crumb rubber, and the steel and fiber originally used in producing the tires. Crumb rubber has manufacturing application in:

Sports surfaces (playgrounds, sports and recreation areas in kindergartens, schools, colleges and universities, athletic tracks, basketball and tennis courts, etc.)

- Automotive industry (fenders and splash guards, vehicle floor liners and floor mats, bumpers, etc.)
- Construction industry (foundation waterproofing, floor tiles, dam, silo and roof liners, home, industrial, and hospital flooring, particularly bathroom flooring, etc.)
- Plastic and rubber products (garbage cans, lining and insulation in pipes, cable and wire insulation, shoe heels and soles, etc.)
- Safety and shock absorption products (abrasion lining in mining equipment, sound barriers for roads and highways, shock absorbing pads for machinery and rails, etc.)
- Adhesives and sealants (non-slip and textured non-slip paints, waterproofing and roof coating, adhesives and sealing compounds, etc.)

- Geotechnical and asphalt applications (drainage pipes, rubber-mixed asphalt for roads, road construction and repair, porous irrigation pipes, soil conditioner, etc.)

In India, amongst the best alternative reuse of crumb rubber is as an additive to bitumen for road surfacing as roads made with Crumb Rubber Modified Bitumen (CRMB) have proven to be superior in properties compared to those made with regular bitumen.

Thermo-chemical decomposition of the end-of-life tires (ELTs) involves pyrolysis of the end-of-life tires (ELTs) to produce fuel gas, oils, and solid residue including char or carbon black and metal (steel) wires. Each of these materials has different applications in various industries depending upon the purity, grade, and other specific properties of each individual material obtained through the pyrolysis process.

The end-of-life tires (ELTs), either whole or in shredded form, when burnt in a combustion device produce a fuel known as tire derived fuel (TDF) which is used as a cheap supplement to traditional fuels such as coal or wood that are used in brick kilns, concrete kilns, power plants, paper mills, and other industrial facilities. Using tires as a fuel has several advantages over the use of fossil fuels:

- Amount of energy produced by tires produce is the same as that produced by oil and up to 25% more than that produced by coal,
- The content of heavy metals in the ash residue from tire derived fuel may be lower than that in the ash residue of some coals, and
- NO_x emissions using tire derived fuel (TDF) are lower than many coals, particularly those with high sulfur content.

4. PYROLYSIS OF WASTE TIRES

Pyrolysis as a process is the thermal decomposition of an organic material at high temperatures in an inert atmosphere (in the absence of oxygen). It has applications in several industries and sectors such as agriculture (where biomass undergoes pyrolysis to produce syngas), chemical (where it is used to produce ethylene, or to convert methane into hydrogen), etc.

Pyrolysis can offer a more environmentally friendly way to handle end-of-life tires (ELTs) than illegal dumping, stockpiling, landfilling or incineration. When end-of-life tires (ELTs) undergo pyrolysis, the primary products obtained include hydrocarbon gases (5-30%), referred to as pyrolysis gases, fuel oil (35-55%), referred to as tire pyrolysis oil (TPO), carbon black (30-40%), and steel braid (10-15%). The hydrocarbon gases obtained can be processed and purified to be used as heating fuel for the pyrolysis process itself. And the carbon black obtained can be further processed through a briquetting unit to form briquettes or it can be converted into secondary value-added products such as activated carbon by processing through an activation unit. The broad overview of the products obtained through the pyrolysis of end-of-life tires (ELTs) is shown in the schematic in Figure 8.7.

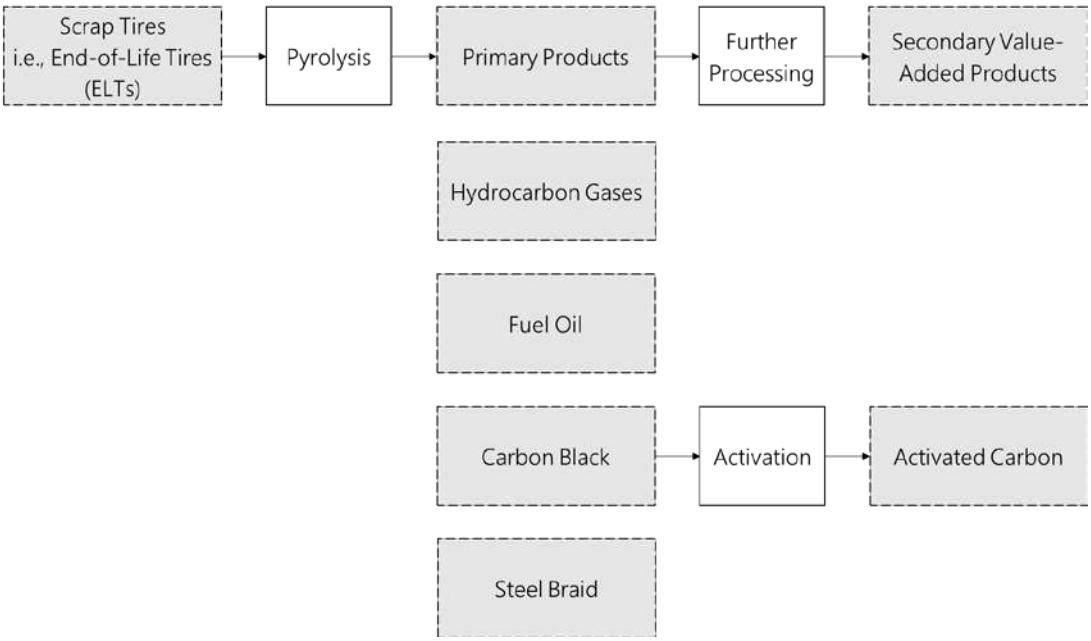

FIGURE 8.7. END-OF-LIFE TIRES (ELTS) PYROLYSIS OUTPUTS

The pyrolysis of end-of-life tires (ELTs) can be carried out either as a batch feed process or as a continuous feed process. The typical continuous pyrolysis process of end-of-life tires (ELTs) can be detailed as shown in Figure 8. It begins with the separation or removal of the steel wires from the scrap or end-of-life tires (ELTs) followed by shredding to reduce the scrap or end-of-life tires (ELTs) to small pieces which are fed continuously to the pyrolysis reactor

(which may be of different types; vertical, horizontal, rotary, fixed-bed, etc.). A furnace superheats the shredded end-of-life tires (ELTs) in the pyrolysis reactor in the temperature range of 500°C - 800°C. Some pyrolysis processes make use of a catalyst during this superheating operation. The pyrolytic superheating produces sync gases, a major portion of which are condensed in the condenser to produce the liquid fuel oil whereas the remaining uncondensed combustible gases, after further processing such as de-sulfurization and purification, are used as fuel in the furnace to heat the pyrolysis reactor. Also, carbon black is obtained as the other output from the pyrolysis reactor in form of a solid residue which can be further reduced and processed to make it saleable.

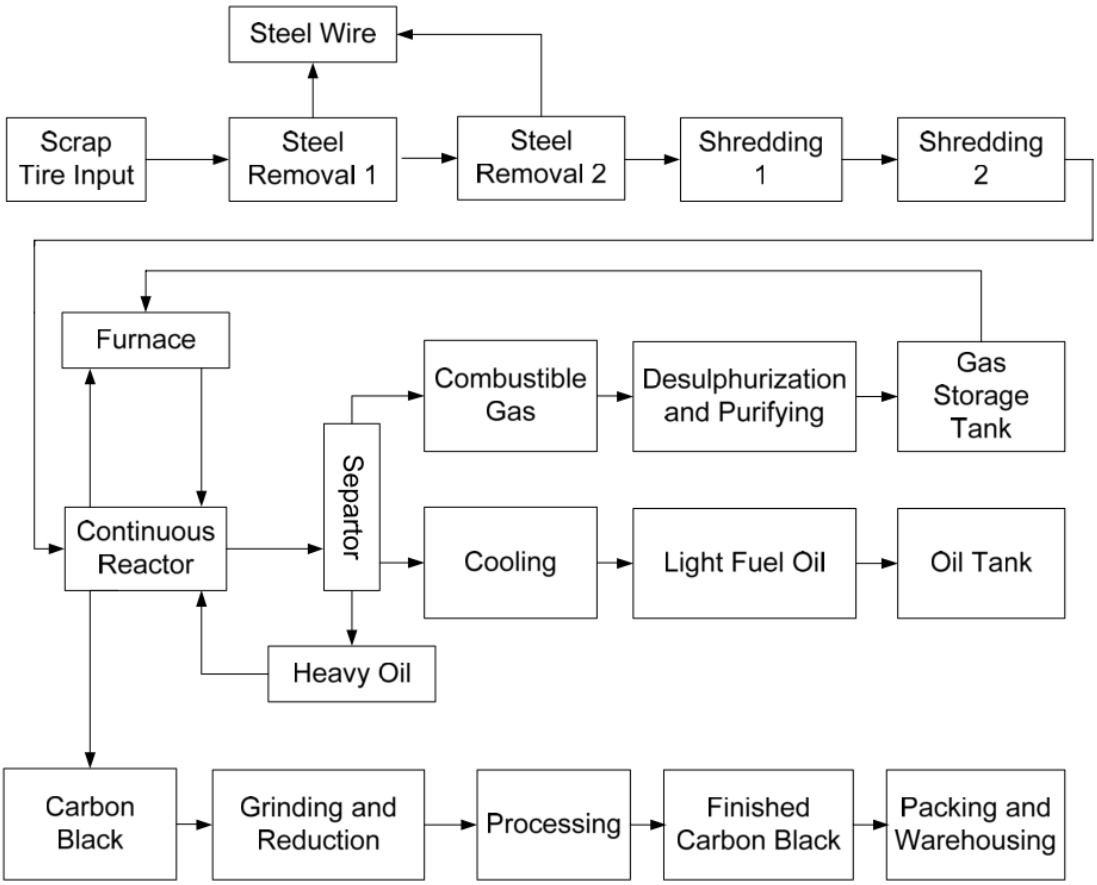

FIGURE 8.8. TYPICAL CONTINUOUS PYROLYSIS PROCESS OF END-OF-LIFE TIRES (ELTS)

The exact yield of the output hydrocarbon gases, fuel oil and carbon black from this pyrolysis of end-of-life tires (ELTs) depend on the actual operating

temperature in the pyrolysis reactor. The output hydrocarbon gases can be further channelized to fuel the pyrolysis process. Two types of fuel oil are obtained from this pyrolysis of end-of-life tires (ELTs): heavy oil and light fuel oil. The quantum of heavy oil obtained is very small as compared to that of light fuel oil. The light fuel oil can be further refined and purified to meet the requirements of various kinds of industrial burners and diesel engines and can be used as a substitute to light diesel oil (LDO) that is used as fuel for industrial furnaces. Carbon black obtained from the pyrolysis of the end-of-life tires (ELTs) is usually of better quality than that of petroleum carbon black, and it can be further channelized for use as a chemical strengthener in rubber industries and also as a coloring agent in paints and pigment industries. The various uses of carbon black depend on the actual pigment properties, chemical composition, adsorption activity, state of subdivision, and other colloidal properties of the carbon black obtained. It can also be further processed through an activation unit to produce activated carbon which different grades of which are widely used in purification of liquids and gases. The steel braids obtained from the pyrolysis of the end-of-life tires (ELTs) are usually sold as scrap to scrap dealers.

In India there have been concerns about the negative environmental impacts of tire pyrolysis plants emitting carcinogenic pollutants such as oxides and dioxin, furans of nitrogen, polycyclic aromatic hydrocarbons (PAH), etc. that are harmful to human health and the environment. In 2022, the Central Pollution Control Board (CPCB) in India compiled a report from 17 states where 757 tire pyrolysis plants were located and found that only 349 i.e., 46% of those tire pyrolysis plants were in compliance with the then existing pollution control norms and the consent conditions and SOPs of the Union Ministry of Environment, Forest and Climate Change (MoEFCC), with 213 tire pyrolysis plants not being in compliance, and the other 192 being closed. However, these concerns are usually associated with low-technology pyrolysis plants using cheap and sub-standard equipment with little or no investments in mechanisms to reduce or eliminate the potential negative impacts. De-sulfurization of hydrocarbon gases produced by the pyrolysis of end-of-life tires (ELTs) before emitting them into the environment can substantially reduce the negative impact of these tire pyrolysis plants. Also, re-using the de-

sulfurized hydrocarbon gases as fuel in the furnace to heat the pyrolysis reactor, as in the case of many continuous feed pyrolysis plants, can eliminate such harmful emissions from the tire pyrolysis plants. Health concerns arising from handling of the powdery carbon black obtained from the pyrolysis of end-of-life tires (ELTs) can also be addressed by using appropriately designed slag discharge devices to minimize human handling and reduce discharge of carbon black into the environment. Instances of explosions in tire pyrolysis plants have also been reported in India, and the key causes for such explosions stem from the sub-standard and poor quality of material used in fabrication of the pyrolysis reactor (to reduce cost), and poor design of the pyrolysis process that fails to create an inert atmosphere to carry out the pyrolysis process and plant. So, with a well-designed pyrolysis process carried out under the right operating conditions in a well-fabricated pyrolysis reactor housed in a well-constructed tire pyrolysis plant with the necessary health, safety and environment (HSE) considerations accounted for, tire pyrolysis can be a very clean operation with nearly no waste or emissions being discharged into the environment and with no material health concerns for workers.

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CHAPTER 9

MAKING PROJECTS FUTURE READY: A REVIEW ON SUSTAINABILITY PROJECTS

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Abstract
The present chapter focuses on the evolving landscape of global urban development, emphasizing the increasing importance of environmentally friendly, socially responsible and economically beneficial projects. The literature review underscores the significance of projects in driving urban sustainability and reveals gaps in understanding stakeholder roles and perspectives. An in-depth literature review is carried to dissect the sustainability efforts made in a project environment in different articles. The review of ten articles published in high graded journals emphasize divergent approaches, the critical role of stakeholder involvement, and the need to address gaps in power dynamics, circular economy concepts, and sustainability. The study identifies key factors influencing sustainability

outcomes, including clear objectives, stakeholder engagement, team training, life-cycle assessment tools, sustainable procurement, monitoring and evaluation systems, and effective communication. In conclusion, the research contributes valuable insights to the discourse on sustainability, guiding future research endeavours and refining initiatives for environmentally conscious urban development.

Keywords**:** Sustainability, Urban Development, Circular Economy, Power Dynamics, Stakeholder Engagement, Life-Cycle Assessment, Sustainable Procurement, Sustainability Initiatives

1. Introduction

In the dynamic context of global urban development, the emphasis on cultivating environmentally friendly projects is progressively gaining traction. As cities across the world expand and undergo rapid modernization, there is an increasing acknowledgment of the critical need for sustainability on an international scale. This acknowledgment serves as the catalyst for the initiation of innovation and forward-thinking projects within urban organizations, all unified by the common goal of fostering an eco-friendlier environment. The shift towards environmental sustainability is not merely an isolated objective; it transcends borders, encompassing a global commitment (Francesco and Sabini, 2023). When cities worldwide aim for greater ecological consciousness, the involvement and engagement of diverse stakeholders and local communities play pivotal roles in shaping the trajectory of these sustainability projects. This international outlook and cooperation lay the foundation for a comprehensive investigation into a multitude of critical research themes. These themes encompass vital elements and a variety of approaches essential for enhancing sustainability and promoting the circular economy worldwide. Their impact is poised to significantly shape the future of global urban landscapes on an international scale (Lehtimäki et al. 2023).

The gap between the international and national markets in terms of sustainability initiatives and urban development primarily lies in the scale and

the depth of collaboration and implementation. On an international level, the emphasis is on broad and globally impactful strategies. Initiatives are designed to encompass a wide range of cities and regions, considering the diverse needs, resources, and approaches on a global scale. Collaborations often involve cross-border partnerships, global agreements, and shared best practices among countries. The focus is on setting standards, sharing innovative technologies and practices, and creating frameworks that address common sustainability challenges faced by urban areas worldwide. The scope extends beyond local confines to tackle issues that have implications across borders. Conversely, at the national level, the focus tends to be more localized and tailored to the specific needs and capacities of a particular country. Sustainability initiatives are influenced by the country's unique socio-economic, cultural, and political context. These initiatives might include policies, regulations, and projects that are specifically designed to address the environmental and developmental challenges within the national borders. The engagement with stakeholders and local communities is more direct and specific to the national context, focusing on the immediate impact within the country. While both levels share the overarching goal of sustainability, the approach and scale of implementation vary. International efforts focus on broader collaboration and guidelines that have implications across multiple nations, whereas national efforts are more targeted and tuned to the specific needs and challenges within a particular country's boundaries. The interplay between these two levels is vital to address global sustainability while acknowledging and integrating localized requirements (Kroh and Schultz, 2023).

2. Literature Review

2.1 Background

A comprehensive investigation encompassing various scholarly works focuses on critical themes in sustainability, urban development, and the circular economy. Lehtimäki et al. (2023) accentuates the central role of projects in steering urban sustainability initiatives. The author highlights the importance of stakeholder involvement and micro-level project activities, signifying their crucial role in instigating change in public organizations for urban

sustainability transitions. Similarly, Francesco and Sabini (2023) addresses challenges in incorporating external stakeholders, predominantly local communities, within major construction projects, underscoring limitations in generalizability and subjectivity in data illustrates the positive influence of sceptical stakeholders in early-stage urban innovation projects, along with the need for a balanced approach due to complexities arising from excessive involvement. Kroh and Schultz (2023a) sheds light on the significance of multiple stakeholders and digital tools, yet reveals gaps in understanding unforeseen influences and complex stakeholder interactions. Kroh and Schultz (2023b) also emphasizes power dynamics and strategic practices in inter-organizational projects, while noting gaps in understanding middle management impact and long-term effects of failed projects. Arruda et al. (2021) reveals gaps in concept formulation and geographical limitations and identifies barriers to environmental sustainability and academia-practice discrepancies. Choudhuri (2019) highlights disparities in exploring various Sustainable Development Goals (SDGs) within the Indian context and exposes temporal biases and methodological constraints. The collective insights from these studies emphasize the intricacies, challenges, and research gaps in the domains of sustainability, urging further nuanced exploration to address these critical areas (Camacho-Otero et al., 2018).

Table 9.1: The findings of the literature review of ten articles selected for the study

Paper title	Authors	Findings
Project-based practices for promoting a sustainability transition in a city organization and its urban context	Lehtimäki et al. (2023)	The significance of projects in driving urban sustainability initiatives. In the research paper, the authors explore the role of projects in promoting sustainability transitions within city organizations and their urban contexts. The authors also discuss the significance of projects in driving urban sustainability initiatives.
Very important, yet very neglected: Where do local communities stand when	Maddaloni and Sabini (2023)	Major Construction Projects (MCPS) face challenges in effectively including external stakeholders, such as local communities, due to rapidly changing regulations and limited resources. Project organizations often exhibit a "means-ends

Paper title	Authors	Findings
examining social sustainability in major construction projects?		decoupling" phenomenon, where they create stakeholder engagement policies but struggle to implement them, leading to compliance-driven rather than genuinely inclusive practices. Despite normative pressures for greater stakeholder inclusion in MCPS, the study reveals that normative practices in these projects are not yet mature, with social considerations often being detached from strategic priorities, hindering comprehensive stakeholder inclusion.
In favor or against: The influence of skeptical stakeholders in urban innovation projects for green transformation	Kroh and Schultz (2023a)	Skeptical stakeholder involvement positively influences early-stage urban innovation projects, enhancing innovativeness and implementation intention. There is a threshold where excessive involvement of skeptical stakeholders may impede final project implementation due to complexities in decision-making and coordination efforts.
The more the better? The role of stakeholder information processing in complex urban innovation projects for green transformation	Kroh and Schultz (2023b)	The author explores the significance of stakeholder involvement in complex urban innovation projects focused on green transformations within urban spaces The author emphasizes that successful implementation of innovative solutions in urban settings relies heavily on engaging a wide range of stakeholders, addressing their diverse needs and perspectives
Shaping inter-organizational strategic projects through power relations and strategic practices	Van Marrewijk et al. (2022)	The author conducts a detailed exploration of inter-organizational strategic projects, emphasizing the intricate interplay between power dynamics and strategic practices within collaborative efforts involving multiple organizations. The paper integrates an 'order view' and a 'conflict view' to comprehend the intricate nature of these collaborations, advocating for a more comprehensive approach.
Circular economy:	Arrudaa et al.	The author's objective is to present an overview of

Paper title	Authors	Findings
A brief literature review (2015–2020)	(2021)	the evolution and current status of CE by analysing recent scientific literature, stressing the need for further research to evaluate the transition to a circular economic model. The author explores the concept of Circular Economy (CE) as a solution to environmental challenges caused by traditional economic models. They highlight the need for a shift from the linear economy to a circular model for sustainability.
Sustainability in Construction Projects: A Systematic Literature Review	Kiani et al. (2021)	The author's exposition delineates the paramount significance of sustainability within the construction industry, driven by its substantial contributions to global GDP, while simultaneously accounting for a significant portion of global energy consumption and carbon emissions.
A Research on Sustainable Development in India	Choudhuri (2019)	The author is conducting a systematic review of sustainable development initiatives in India for the year 2014 to 2019.
Sustainability and Sustainable Development Research around the World	Ozili (2022)	The paper defines the concepts of sustainability and sustainable development, emphasizing their importance in both academic studies and policymaking. It underscores the broad significance of sustainable development as a universal goal with enduring socio-economic benefits for people and the environment.
Consumption in the Circular Economy: A Literature Review	Camacho-Otero et al. (2018)	The author is addressing a significant gap in the current literature surrounding the concept of the circular economy. The author is aiming to fill this gap in understanding by conducting a comprehensive review of existing literature on the circular economy, specifically emphasizing consumption and consumer acceptance.

2.2 Analysis of Literature

The thorough analysis of the literature review in sustainability, urban development, and the circular economy highlights significant gaps and limitations in these spheres. These gaps pinpoint crucial areas that need

further exploration and refinement. Several studies emphasize the importance of stakeholder involvement but reveal a lack of in-depth understanding regarding the diverse roles, perspectives, and influences of stakeholders, including skeptical stakeholders and micro-level project activities. The reliance on region-specific or industry-specific samples limits the broader applicability of their findings, emphasizing the need for more diverse and comprehensive research representation. Temporal biases, conceptual ambiguities, and methodological constraints are identified, affecting the completeness and credibility of the research outcomes. Furthermore, the oversight of intersectionality, involving middle management roles, power dynamics, and long-term impacts of project failures, restricts a holistic understanding of their effects on sustainability and project success. Addressing these gaps is crucial for future research to provide more thorough, pertinent, and widely applicable insights, driving the advancement of more effective and inclusive sustainability initiatives.

3. Methodology

The study aims to comprehend the intricate landscape of sustainability in global and national urban development contexts while analysing gaps and limitations in existing research. The qualitative study primarily focus on in-depth review of ten articles published in top journals with highest impact factor. The study involve a systematic literature review to comprehensively examine critical themes within sustainability, urban development, and the circular economy. A wide array of scholarly works were scrutinized to gather insights. The exploration encompass diverse perspectives, including studies like sustainability transition in a city organization, Circular economy, Sustainability in Construction Projects. This enables a deeper understanding of stakeholder involvement, micro-level project activities, and barriers to sustainability, and discrepancies between academia and practical application. The qualitative data is meticulously analysed to identify common themes, gaps, and limitations in current research.

4. Result and Findings

The study provides an intricate exploration into the dynamics of sustainability within the global and national contexts of urban development, offering insights into distinctive features at both international and national levels. Globally, there is a pronounced emphasis on fostering extensive collaboration and implementing strategies with global impact. Initiatives are crafted to encompass a multitude of cities and regions, taking into account diverse needs and resources on a global scale. This involves cross-border partnerships, global agreements, and the exchange of best practices among nations. The study emphasizes the establishment of standards, sharing innovative technologies and practices, and creating frameworks to address common sustainability challenges faced by urban areas worldwide. It recognizes the global scope of issues, transcending local boundaries. In contrast, at the national level, the study reveals a more localized focus, tailored to the unique socio-economic, cultural, and political contexts of specific countries (Lehtimäki et al., 2023). Sustainability initiatives within nations are significantly influenced by contextual factors, including specific policies, regulations, and projects designed to tackle environmental and developmental challenges within national borders. Engagement with stakeholders and local communities is depicted as more direct and specific to the national context, concentrating on immediate impacts within the country. Despite the shared goal of sustainability, the study indicates divergent approaches and scales of implementation between international and national efforts (Francesco and Sabini, 2023).

Stakeholder involvement emerges as a linchpin in both international and national sustainability initiatives. The study underscores the pivotal role played by diverse stakeholders and local communities in shaping the trajectory of sustainability initiatives. While recognizing the importance of stakeholder engagement, the study points to a significant gap in understanding the nuanced roles, perspectives, and influences of stakeholders (Kroh and Schultz, C., 2023). This gap highlights the need for further comprehensive research to untangle the complexities surrounding stakeholder involvement, including the dynamics of skeptical stakeholders and micro-

level activities within projects. The literature review in the study draws attention to challenges in sustainability initiatives, such as the incorporation of external stakeholders in major construction projects and the navigation of the influence of skeptical stakeholders in urban innovation projects. The positive influence of skeptical stakeholders is acknowledged, but the study identifies a threshold where excessive involvement may impede final project implementation due to decision-making complexities and coordination efforts (Kroh, J., and Schultz, C., 2023).

The exploration of inter-organizational projects in the study underscores the significance of power dynamics and strategic practices. The research advocates for a more comprehensive approach, integrating an 'order view' and a 'conflict view' to comprehend the intricate nature of these collaborations (Alfons et al., 2022). The circular economy emerges as a transformative concept; however, the literature review reveals gaps in concept formulation and geographical limitations.

Arrudaa et al. (2021) put forth that the construction industry is acknowledged for its substantial contributions to global GDP but also poses challenges in terms of environmental sustainability. Barriers to sustainability within the construction sector and academia-practice discrepancies are identified, suggesting the need for interventions to align construction practices with sustainability goals (Kiani et al., 2021). Choudhuri (2019) carried a systematic review of sustainable development initiatives in India, revealing disparities in exploring various SDGs within the Indian context. This underscores the need for a more comprehensive and integrated approach to sustainable development within the country. The universal importance of sustainable development is highlighted, emphasizing enduring socio-economic benefits for people and the environment. Ozili (2022) assertained that consumer acceptance in the circular economy emerges as a critical aspect, with the research aiming to address a significant gap in the current literature. Understanding consumer behaviour and acceptance is deemed crucial for the successful implementation of circular economy initiatives. The analysis of the literature review points to significant gaps and limitations in current research,

signalling the need for more diverse and comprehensive research representation. Addressing temporal biases, conceptual ambiguities, and methodological constraints is identified as crucial for the effectiveness and inclusivity of sustainability initiatives. Camacho-Otero et al. (2018) presented a comprehensive understanding of the current landscape of sustainability, revealing crucial areas for further exploration and refinement.

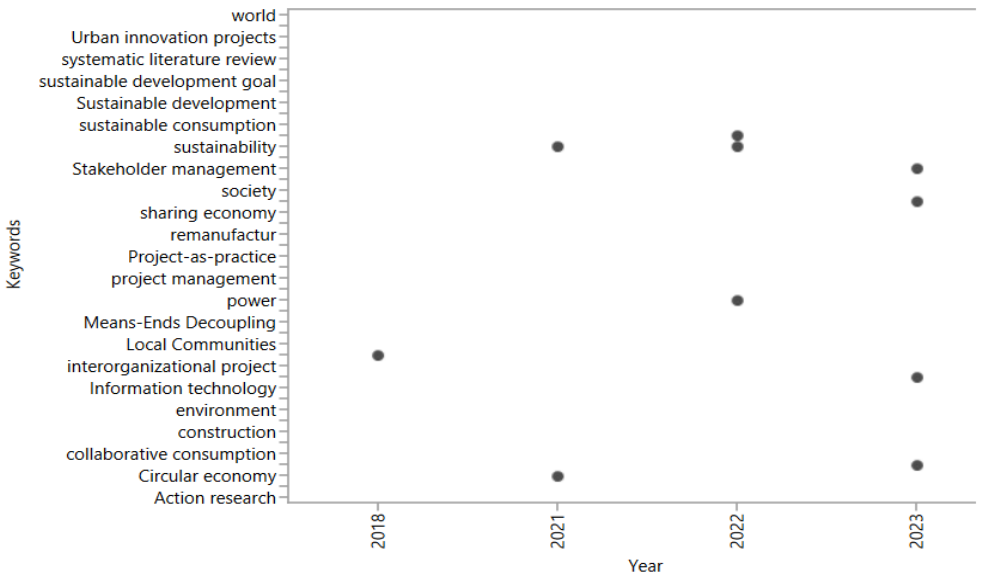

Figure 9.1: Yearwise analysis of the keywords used

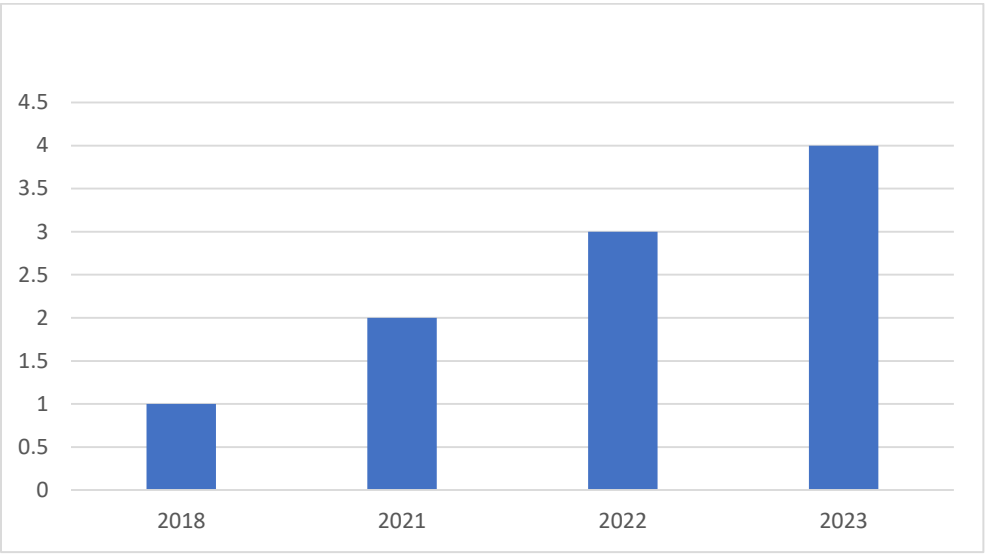

Figure 9.2: Distribution of the papers published year wise

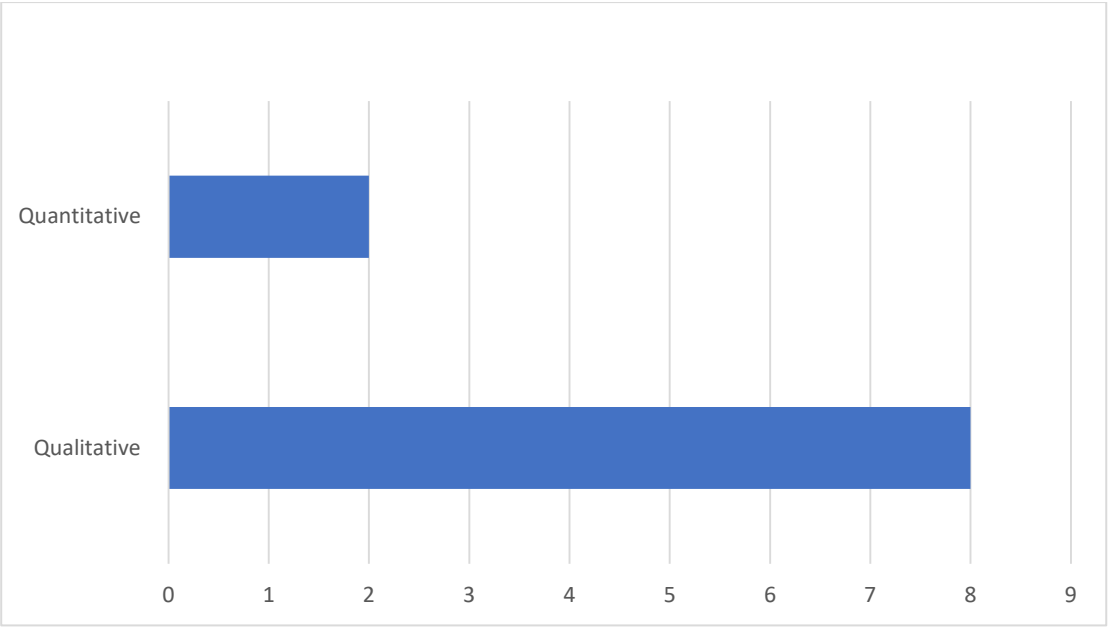

Figure 9.3: Distribution of the method used in reviewed articles

Figure 9.2 depicts the year wise distribution of the papers reviewed in the study. While Figure 9.3 shares the methodologies adopted in the articles reviewed. The need for further research to evaluate the transition to a circular economic model is emphasized. The studies are increasing on sustainability projects while the methodology adopted is mostly qualitative. The keyword analysis (Given in Figure 9.1) reveals some important information regarding the dimensions mostly studied are sustainable consumption and management while circular economy are meagre. The literature review identified several key factors that impact sustainability outcomes in projects. These factors can be broadly categorized into seven main areas:

A. **Clear and Measurable Sustainability Objectives:** Projects that have clear and measurable sustainability objectives are more likely to be successful. These objectives should be aligned with the overall goals of the project and should be quantifiable so that progress can be tracked.

B. **Stakeholder Engagement:** Stakeholder engagement is essential for successful sustainability in projects. Stakeholders should be involved in the planning, execution, and monitoring of sustainability initiatives. This will

help to ensure that their concerns are addressed and that their support is gained.

C. **Training for Project Teams:** Project teams should receive training on sustainability principles and practices. This training should cover topics such as life-cycle assessment, sustainable procurement, and communicating sustainability performance.

D. **Use of Life-Cycle Assessment (LCA) Tools:** LCA tools can help project teams to assess the environmental impacts of their projects. This information can be used to identify opportunities to reduce the project's environmental footprint.

E. **Incorporation of Sustainability into Procurement Practices:** Procurement practices should be designed to promote the use of sustainable materials and products. This can be done by sourcing from suppliers with strong sustainability commitments and by using life-cycle assessment to evaluate the sustainability of different products.

F. **Implementation of Monitoring and Evaluation Systems:** Monitoring and evaluation systems can help project teams to track their progress towards sustainability goals. This can be done by measuring metrics such as energy consumption, water usage, and waste generation.

G. **Communication of Sustainability Performance:** Project teams should communicate their sustainability performance to stakeholders. This can be done through reports, presentations, and other means.

5. Discussion

The research article delves into the evolving landscape of global urban development, focusing on the increasing importance of environmentally friendly practices. The introduction highlights the global commitment to sustainability and the integral role of stakeholder engagement in shaping sustainability initiatives both at the international and national levels. It emphasizes the need for innovative projects to foster eco-friendly environments on a global scale.

The critical themes reveal the central role of projects in driving urban sustainability initiatives. The literature review underscores the significance of stakeholder involvement, micro-level project activities, and challenges in incorporating external stakeholders in major construction projects. It also explores the influence of skeptical stakeholders in urban innovation projects and the role of information processing in complex urban innovation projects. The study identifies gaps in understanding power dynamics in inter-organizational projects, the circular economy, and sustainability in the construction sector, emphasizing the need for further research.

The detailed analysis of individual papers provides a comprehensive understanding of the findings, methodologies, and limitations of each study. Lehtimäki et al. (2023) stresses the importance of projects in driving urban sustainability, while Maddaloni and Sabini (2023) reveals challenges in incorporating local communities in major construction projects. The positive influence of skeptical stakeholders in early-stage urban innovation projects is highlighted in the studies of Kroh and Schultz (2023a) and Kroh and Schultz (2023b) underscores the significance of stakeholder information processing in complex urban innovation projects.

A deeper understanding of stakeholder roles, perspectives, and influences, addressing regional and industry-specific biases, and overcoming temporal biases and methodological constraints have long been neglected. The importance of intersectionality, considering middle management roles, power dynamics, and long-term project impacts are majorly discussed.

The methodology adopted in the papers are mostly a mixed-method approach involving qualitative and quantitative techniques. The qualitative component includes a systematic literature review, while the quantitative approach incorporates surveys and case studies to gauge stakeholder perspectives and analyze specific sustainability projects. The data analysis will identify common themes, gaps, and limitations in current research.

Acknowledging the limitations of the research methodology, such as inherent biases in the literature and potential subjectivity in survey responses, the

studies reviewed have attempted to bridge the gap between international and national sustainability levels. The combination of qualitative and quantitative methods is expected to provide a comprehensive understanding of the current sustainability landscape and guide future research. The studies emphasizes the importance of consumer acceptance in the circular economy and the need for more diverse and comprehensive research to refine sustainability initiatives.

The discussion extends to key factors impacting sustainability outcomes, categorizing them into seven areas that includes clear and measurable sustainability objectives, stakeholder engagement, and training for project teams, use of life-cycle assessment tools, sustainable procurement practices, monitoring and evaluation systems, and communication of sustainability performance are identified as crucial elements for project success.

In summary, the research article provides an insight into the sustainability in projects, offering a nuanced understanding of global and national dynamics. However, also lays an interesting arena to explore through the identifies gaps in existing literature. The findings contribute to a deeper comprehension of the current sustainability landscape, guiding future research endeavours and refining sustainability initiatives.

6. Conclusion

The research article provides a comprehensive examination of the global and national dynamics of urban development with a focus on environmentally friendly perspectives in projects. The reviewed articles discloses a growing international commitment to sustainability and emphasizes the critical role of stakeholder engagement in shaping initiatives on both global and national scales. Through an in-depth literature review, the research identifies gaps in understanding stakeholder roles and perspectives, urging for more inclusive research representation. Studies in the construction industry portrays the divergent approaches at different levels, the pivotal role of stakeholder involvement, and the need to address gaps in power dynamics, circular economy concepts, and sustainability.

In recognizing key factors influencing sustainability outcomes, the study underscores the importance of clear objectives, stakeholder engagement, team training, life-cycle assessment tools, sustainable procurement, monitoring and evaluation systems, and effective communication of sustainability performance. In summary, this research contributes valuable insights to the discourse on sustainability in project context. By identifying areas for further exploration and proposing a comprehensive research methodology, it sets the stage for refining sustainability initiatives and advancing the global pursuit of environmentally conscious urban development.

7. Limitations and future research

The reviewed papers though reveal very important aspects to be considered while designing sustainability projects, but through a handful of published articles. The future studies could explore more papers in these directions and understand the direction of research and determine the critical factors that impact the decision making for such projects. Future studies could bridge the gap between the international and national levels of sustainability by understanding the roles of stakeholders, the effectiveness of sustainability projects, and the varied implementation approaches. The combination of qualitative and quantitative methods will provide a comprehensive understanding of the current landscape of sustainability, identifying crucial areas for further exploration and the refinement of sustainability initiatives.

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Chapter 10

RED MUD INCORPORATING CIRCULAR SUPPLY CHAIN IN ALUMINA INDUSTRY

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Abstract
This study explores the waste management processes in one of the biggest players in Alumina industry. The data was collected through qualitative interviews of the managers involved in the Alumina extraction process. They have implemented the waste management in certain processes. The respondents of the study included Area Incharge, Shift Operator, Operations Manager, and Area Manuals. The water is utilised back in the refinery along

with other important minerals. Comparison with Utkal alumina, Hindalco, Maden refinery and Alcoa refinery. This process will help stakeholders like small industries looking for optimizing the waste by advanced technology, environmentalist and research scholar in ESG domain. More research on latest advanced tools are still being explored.

Keywords: Red Mud, Alumina Industry, Circular Supply Chain, Waste Management

1. Introduction

Metals can be recycled, but recycling of metals is considered to be ineffective due to its limitations levied by social behaviour, design of product, technology used, and the techniques used for separation (Reck and Graedel, 2012). Aluminium has various characteristics like formability and resistance to corrosion and hence, it is used in manufacturing of various products. Therefore, with the increase in global demand sustainable management of aluminium has become very essential (Soo et al., 2018).

In order to gain sustainable management of aluminium, implementing circular economy is an important practice to address the issues related to scarcity of resources and increase in waste (Murray et al., 2017). In circular economy, the key enablers for its implementation is supply chain (Lahane et al., 2020) and supply chain in circular economy is different from linear supply chain (Vegter et al.,2020). In circular supply chain, the activities included are value creation, delivery and retention (Roci et al., 2022). It is a model for production and consumption to reduce waste and increase the materials possibility of reusing and recycling. Circular supply chain in an alumina refinery is one that is designed for waste reduction and reuse and recycle materials to its optimum potential. Following are few strategies that can be used to achieve this:

- Sourcing sustainable raw materials: Alumina refineries can source raw materials from sustainable sources, such as bauxite mines that are certified by the Responsible Mining Initiative.

- Reducing energy consumption: Alumina refineries are energy-intensive operations, but there are a number of ways to reduce energy consumption, such as using more efficient equipment and processes.
- Reducing waste: Alumina refineries can reduce waste by improving process efficiency and recycling by products. For example, Red Mud is the by-product of Bayer Process that can be recycled to produce iron and other metals.
- Closed-loop water systems: Alumina refineries use large amounts of water in their production processes. Closed-loop water systems recycle and reuse water, which can reduce water consumption by up to 90%.
- Red Mud from the Bayer process is disposed of in landfills. However, red mud can be recycled to produce iron and other metals. This reduces waste and creates new revenue streams for alumina refineries.
- Spent caustic recycling: Spent caustic is another by-product of the Bayer process that is typically disposed of in landfills. However, under Bayer Process, recycling and reusing of spent caustic is possible. This reduces the cost of waste.
- The by-product of combustion of coal is Fly Ash and other fossil fuels. Fly ash can be used to produce geopolymers, which are a type of concrete. This reduces waste and creates new markets for fly ash.

The objective of this research is to understand the contribution of circular supply chain in improving the sustainability of recycling aluminium.

2. Literature Review

The goal of Circular Economy is to gain maximum productivity by using resources that are renewable, extend the lives of the products and helps to remove waste (Ellen, 2017). It contains system which is regenerative in nature where inflow of original resources are decreased for recirculation of materials, and the product value is maintained for long (Schilkowski et al., 2020). It is

opposite to linear production in which the flow of material is in one direction leading to removal of waste after consumption (Elia et al., 2017).

The consumption rate is drastically increasing with increase in population which may lead to non-availability of natural resources to this ever increasing population (Esposito et al., 2018). Such an approach is not sustainable. Hence, Circular Economy emerges as a key resource for sustainable development requiring balance of economic performance, social inclusiveness, and environmental resilience (Geissdoerfer et al., 2017). It also creates sustainability by using renewable energy resources and creating sustainable production system wherein the materials can be used continually (Genovese et al., 2017). Thus, sustainable environment can be created by Circular Economy, by linking environmental, social and economic activities.

For the implementation of circular economy, supply chain sustainability plays a crucial role (Van Buren et al., 2016) in which the complete supply chain should be sustainable (Abbasi and Nilsson, 2012). Sustainable Supply Chain indicates strategic combination of material, information and flow of capital in order to attain the goal of sustainable development (Carter and Rogers, 2008). Sustainable Supply Chain helps in sustainable development by concentrating majorly on environment, economic and social stability. In all Circular Supply Chain is advantageous by adding value to used products treated as waste and reusing it in the production of secondary products (Genovese et al., 2017).

In Alumina Industry, waste management is crucial reducing environmental impact and promoting sustainability. The alumina industry generates a variety of waste, which includes residue from bauxite (also called as red mud), spent pot lining and other by-products. Some of the key considerations for effective waste management in the alumina industry can be:

a. Management of Bauxite Residues by reusing bauxite residue in construction materials such as cement and bricks or for land reclamation. Investing in research and development to find innovative ways to use bauxite residue for useful applications. Implement

techniques to solidify or stabilize bauxite residue in order to reduce its environmental impact.

b. Management of Spent Pot Lining (SPL): Investigate methods for recovering valuable materials such as carbon and fluoride from spent pot lining. Creating environmentally friendly methods for treating and disposing of spent pot lining.

The Alumina Industry worldwide is reducing the volume of waste by fifty percent and recovery of valuable raw materials are done by eliminating the risk of storage (Jones and Boger, 2012). In Western Australia, the alumina industry separates fine particles from sand and recently is able to find a market for reusing the sand and the fine particles in agriculture. An application of very basic rheological principles involving measurements made with instruments specifically developed for the purpose is needed to reduce the risk, recover water and reduce the footprint of the suspension waste produced in the minerals industry (Boger, 2009).

In the Bayer process the insoluble product generated is called 'red mud' or 'bauxite residue'. This waste is highly alkaline in nature and is disposed of in mostly clay-lined land-based impoundments. The alkaline element in red mud creates environmental problems, like soil and air pollution. Neutralization of red mud using different techniques is the best solution to make the bauxite residue environmental friendly. Hence, neutralization techniques, such as using mineral acids, acidic waste (pickling liquor waste), coal dust, superphosphate and gypsum as amenders, CO2, sintering with silicate material and seawater for treatment of red mud have been studied in detail. (Rai et al., 2017).

According to Dentoni et al. (2014), the red mud resulting from the alumina refining process is classified as non-hazardous waste. However, the pollution risk for soil and water of the Red Mud does not allow it to get classified as inert waste. The Directive specifies that the protection of soil, groundwater and surface water is to be achieved by the combination of a geological barrier and a bottom liner, during the operational/active phase, and by the

combination of a geological barrier and a top liner, during the passive phase/post closure.

Rayzman et al. (1998) produced sodium aluminate solution from alumina-bearing intermediates and wastes including spent pot liner and salt cake resulting from aluminium-dross recycling. Pradhan et al. (2001) developed a process for production of superfine white aluminium trihydroxide powders from actual plant Bayer liquor. Barakat et al. (2005) removed aluminium and regenerated caustic soda from the spent washing liquor of aluminium etching using lime neutralization processes. Gurel and Altun (2009) produced fine reactive alumina powder using Bayer gibbsite as a starting material.

Recycling of waste beverage cans is an important aspect of waste management by reducing the necessity for incineration or landfilling of these enormous solid wastes and exploiting them in an alternative feasible way. Rahman, et al. (2023) reports a successful extraction of single-phase alumina from easily obtainable waste beverage cans through a facile chemical precipitation technique at different calcination temperatures.

3. Methodology

The study is a qualitative study where the interviews and interaction with area managers in red mud and red 2 areas were done. The study has been conducted through a detailed open ended questionnaire where the respondents were asked to explain the alumina extraction in detail. The qualitative interviews of three experts involved in the process was done in detail. There was about three days that was spent with the respondents to understand the whole process in detail. The interview was analysed and the transcripts were prepared to capture the processes. Timely mapping using the pictorial representation was done to capture the process particulars. The next section explains the process in detail.

4. Process

For Alumina Refineries, management of Red mud which is a residue of bauxite is a serious issue. For every ton of Aluminium Oxide produced, the

management of 2.5 tons of red mud is required. Depending upon the Bauxite Ore grade and the geographic location of alumina refinery, the quantity of Bauxite residue varies. The recent practice at various refineries is to store Red Mud in Mud Lakes or captivated areas. The alumina industry is looking forward to reduce risk by investing in studies for developing strategies to handle red mud.

Various process for integration of red mud for circular supply chain are listed below:

- Red mud can be recycled to produce Iron: Iron is a valuable metal that is used in a wide variety of industries. By recycling red mud to produce iron, alumina refineries can reduce their dependence on mined iron ore and create a new revenue stream.
- Red mud can be recycled to produce titanium: Titanium is another valuable metal that is used in a variety of industries, such as aerospace and automotive. By recycling red mud to produce titanium, alumina refineries can reduce their dependence on mined titanium ore and create a new revenue stream.
- Red mud can be recycled to produce rare earth elements which are a group of 17 metals that are important for many high-tech applications, such as electric vehicles and smartphones. By recycling red mud to produce rare earth elements, alumina refineries can reduce their dependence on mined rare earth ores and create a new revenue stream.
- Red Mud is also used to produce a variety of materials used for construction, such as tiles, bricks and cement. This can help to reduce the demand for virgin raw materials and reduces waste.

5. Conclusion:

Red mud recycling is a key enabler for a zero waste, zero discharge, and circular supply chain in the alumina industry. By recycling red mud, alumina refineries can reduce waste, reduce emissions, create new revenue streams, improve resource efficiency, and close the loop in the alumina supply chain.

In future, red mud recycling is expected to show an even more significant role in the alumina industry. As the world moves to a more circular economy, alumina refineries will be under increasing pressure to reduce their environmental impact and improve their resource efficiency. Red mud recycling can help alumina refineries to meet these challenges and achieve their sustainability goals.

Here are some specific ways in which red mud recycling can contribute to a zero waste, zero discharge, and circular supply chain in the future:

New technologies for red mud recycling are being developed, which will make it more efficient and cost-effective to recycle red mud. This will make it more feasible for alumina refineries to recycle all of their red mud, rather than just a fraction of it.

Alumina refineries are partnering with other industries to develop new products and applications for recycled red mud. This will create new markets for recycled red mud products and help to speed up the movement to a circular economy. Government regulators are developing policies to support red mud recycling and the circular economy. This will help to create a more supportive environment for red mud recycling and other circular economy initiatives. Overall, red mud recycling has the possibility to play a major role in creating a zero waste, zero discharge, and circular supply chain in the alumina industry. By recycling red mud, alumina refineries can reduce their environmental impact, improve their resource efficiency, and create new revenue streams. This will make the alumina industry more sustainable and resilient in the future.

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About the Editors

Dr. Rose Antony is an enthusiastic researcher and has five years of academic experience and 2 years of industry experience. She did her PhD from IIM, Mumbai. She is currently working with NMIMS, SBM as an Assistant Professor in the Operations and Data Sciences area. She was recognized for her research work and was conferred with the best research output award in 2023. Her research interest spans across the realm of supply chain management, sustainability, circular economy and project management. She has taught many courses such as total quality management, operations strategy, project management, supply chain management, statistics, operations research and risk management. She received the best paper award for her study in fresh food supply chain for the Journal Category: World Journal of Management during the "8th Global Business Research Conference" conducted by World Business Institute, Australia held in Milan, Italy. She was also associated with IIT Madras for a government-funded project in Palar river basin where she published papers in several renowned peer-reviewed journals. She also worked as a corporate planner at a firm in special economic zone, Cochin and have managed various software development projects. She has also conducted various managerial development programs for executives on supply chain management, total quality management, and project management.

Dr. Ashu Sharma has twenty-five years of work experience with industry and academia. She has joined SBM NMIMS in August 2014 and is presently working as Professor in the area of Operations and Data Sciences. She was conferred the Best Faculty Award for the academic year 2019-20 by School of Business Management, NMIMS University, Mumbai and also awarded with the Prof Indira Parikh Women in Education Leaders by World Education Congress in 2023. She has also received the 30th Business School Affaire and Dewang Mehta National Education Leadership Award in 'Most Influential Professor' category in 2023. Dr. Sharma has an expertise in teaching courses like Operations Management, Supply Chain Management, Optimization Modelling for Business Decisions, Industry 4.0 and Quality Management. Other than being a postgraduate in Mathematics and Management she is also a PhD in the area of Operations. She has qualified her UGC-NET exam in 2003 and has also completed faculty development program from IIM Ahmedabad and Harvard Business School, Boston, USA. Along with her academics Dr Sharma has also handled many administrative portfolio like Area Chairperson for Operations and Data Science Area and also Programme Chairperson for Executive MBA at SBM, NMIMS, Mumbai. Dr Sharma is also an active researcher and is a supervisor for Ph.D. scholars, has presented papers in the National and International conferences organized by reputed institutions, edited books and also published number of articles in double blind peer reviewed Scopus journals. She has conducted Management Development Programmes on Supply Chain Management for Competitive Advantage, Problem Solving, Total Quality Management, Decision Making and Group Dynamics and Strengthening Operational Excellence for Executives and Senior Managers of leading corporates. She is a Life Member of ORSI, ISTD and IIM Ahmedabad Alumni Association.

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