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CIRCULAR ECONOMY FRAMEWORKS FOR MANUFACTURING INDUSTRY-A REVIEW

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ABSTRACT
Manufacturing industries have been played a significant role in terms of production in attempt to improve economy worldwide. However, in a traditional linear economy setting, it becomes unrealistic prove to achieve sustainable production and consumption patterns. The concept of circular economy has been proved to be the only way out in the present environmental issues and unavailability resources, it aims at eventually severing this link, through keeping resources in the loop. Through a systematic literature review, this paper attempts to revisit the concept of circular economy in the manufacturing industries in order to determine whether the body of research has improved beyond framework development and into verified implementation in manufacturing industry.

The review shows that the research field has indeed advanced from purely conceptual framework into empirical studies and research into implementation tools. However, in empirical studies and framework development the sustainability impact of CE practices is completely addressed only through the environmental issues, neglecting the social dimension, economic dimension and even the percentage of virgin material usage for production is neglected. Further, a key finding is that the generality of narrow approaches to sustainability in manufacturing results to a risk that circular economy implementation efforts will become difficult if percentage of virgin materials usage by industries are not evaluated. Holistic approaches are needed to avoid the implementation of solutions that may be framed as circular, but neglect the sustainability component.

Keywords: *Business and supply loop, circular economy, framework, indicators, Manufacturing.*

1.1 INTRODUCTION

To make it clear, circular economy (CE) is a new introduction concept which is achieving growing interest as a way to explain the practices of market agents to protect natural resources and reduce their impacts on natural resources. The main idea of this concept is to review the production and consumption patterns of the current socioeconomic system through the promotion of a series of serious interventions in the contemporary linear production process (i.e., take-make-dispose). These interventions promote a CE model whereby the consumption of raw materials and natural resources can be substantially reduced (Charalampides, Arvanitidis et al. 2014)

The CE is an economic system considered to transform the traditional linear economy and it has been accepted as a potential enabler of sustainable development (Urbinati, Chiaroni et al. 2017) . In a linear economic system, raw materials are sourced, manufactured, used and then discarded; such an end-of-life process leads to environmental degradation due to the continued exploitation of limited resources (Millar, McLaughlin et al. 2019).

CE can now be defined as "an industrial system that is restorative or regenerative by intention and design"(MacArthur 2013, MacArthur 2013) . It the replaces traditional linear economy concept with restoration, taking products and material use from 'cradle to grave' to 'cradle to cradle' (MacArthur 2013), (McDonough 2002). That is, CE considers discarded products or components as materials and resources for the input of new manufacturing processes. For manufacturing industries facing challenges of resource scarcity and environmental impact, it is important to reduce, reuse and recover resources in production and consumption processes and keep products and materials at their highest utility and value (Kirchherr, Reike et al. 2017), (Lieder and Rashid 2016).

Over the decade now serious attention had been paid worldwide to the new concept and development of framework model for Circular Economy, CE, especially in the manufacturing industries with the aim to provide a better alternative to the dominant economic development model, so called “take, make and dispose will be minimised. (Mendoza, Sharmina et al. 2017), (Reike, Vermeulen et al. 2018) and (Blomsma, Kjaer et al. 2018) pointed out that such circular strategies frameworks can identify or emphasize different (groups of) circular strategies, which can be linked to addressing different types of structural waste. (Blomsma, Kjaer et al. 2018) established the fact that little work has been carried out with regard to ensuring that frameworks are seen as relevant and useful by intending manufacturing industries. For these reasons, there is scope to further develop these frameworks to support visioning in Circular Oriented Innovation (COI). The plastic manufacturing industry in particular is important to global economic development because it provides raw materials for a variety of sectors. However, the industry's linear nature in some countries, as demonstrated by the production-consumption-disposal cycle, has resulted in extensive environmental deterioration and resource depletion. Plastic garbage, in particular, is a major hazard to ecosystems, human health, and the economy. In today's world, plastic waste is one of the environmental contaminants. According to (Karstensen, Engelsen et al. 2020), proved that manufacturing industries waste creates more environmental hazards through greenhouse gas emissions, climate change, and causing global warming. It implies that the traditional linear economy which causes environmental nuisance should be looked into and develop a framework which allows sustainable economy. The Manufacturing Industries in Nigeria is at a critical crossroads, striving with the far-reaching environmental condition of its linear production-consumption-disposal cycle. With serious concerns about plastic pollution, resource depletion, and climate change, the industry immediately needs radical action. To accomplish the circular economy in the plastic manufacturing sector, implementing this new paradigm shift also calls for new frameworks and behavioural changes. Recently research on circular economy has gained significantly attention to researchers, there is a well-established need to consider the circular economy for industrial wastes such as metals, papers, plastics when addressing the challenges of pollution. Most research on plastics focus within the context of achieving a circular economy addresses a specific technology, plastic product, material or intervention that applies to a segment of a supply chain.

1.2 CIRCULAR ECONOMY AND MANUFACTURING INDUSTRY

(Blomsma, Pieroni et al. 2019) presented a framework that introduces a taxonomy of circular strategies, developed for use by manufacturing companies engaging in circular economy (CE) oriented innovation. (De Mattos and De Albuquerque 2018) proposed a framework that analysed how organisation can develop a circular business model, identifying the feasibility factors and respective strategies. (Lanaras-Mamounis, Kipritsis et al. 2022) used a framework for evaluating the progress of firms towards the implementation of circular economy (CE) strategies by utilizing an evaluation matrix which is based on the three-level context of CE, the key “Rs” principles/strategies of CE, and material loops, an empirical analysis was carried out in a sample of plastic industries. (Di Maio and Rem 2015) presented a micro-level indicator,

evaluated the recaptured economic value of products through recycling strategies. (Park and Chertow 2014) established the reuse potential indicator (a micro-level CE strategy-oriented indicator) which estimated the reuse capability of waste materials by taking into account alternative waste management technologies. (Felicio, Amaral et al. 2016) proved a single indicator which assesses the achieved level of industrial symbiosis and the resulting presence of by-product and waste synergies in EIPs. (Saidani, Yannou et al. 2019) provided 10 criteria for classification of circular economy CE indicators linked to implementation level (i.e., micro-, meso-, macro-level) and the application level of indicators (i.e., general indicators or indicators for a specific sector). (Bocken, De Pauw et al. 2016) established three types of circular business models, namely, the first type is the closed loop which operates on minimising the use of virgin materials at the manufacturing stage and on the valorisation of materials within their useful lifetime. Another type of business model is the narrow loop which defines CE actions and core strategies that are not closed the loop but to reduce the use of virgin material and their losses. The third business model is the slow loop which intends at increasing the useful lifetime of materials and products in order to reduce the demands for new production and consequently the use of virgin materials. (Elia, Gnoni et al. 2017), (Chun-Rong and Jun 2011), (Saidani, Yannou et al. 2019) developed suitable methods, techniques, and frameworks and evaluated the progress towards CE facilitating governments, firms, and various stakeholders to set, achieve, and monitor realistic CE targets. Such measurement frameworks have been proposed for each level of CE implementation developing various types of indicators. (Felicio, Amaral et al. 2016) established a single indicator and used it to assess the achievement level of industrial symbiosis and the resulting presence of by-product and waste synergies in eco-industrial parks EIPs. (Wang, Lee et al. 2018) developed a framework on a circular composite index used group of indicators and assessed the level of circularity in a sample of 40 Chinese cities. (Pauliuk 2018) presented a framework and recorded inputs, outputs, and material stocks of selected sample firms through LCA thinking. It is based on a single-level indicator which provided interesting insights for many of the CE strategies allowing direct comparisons between them. (Genovese, Acquaye et al. 2017)applied a framework that were involved a combination of emission indicators and compared the environmental impact of linear and circular supply chains, in which the by-products from one sector are considered input for another one.

RESEARCH TRENDS IN DEVELOPMENT OF CE FRAMEWORK

In many research attempts to develop a suitable methods, techniques, and frameworks to measure the achievement towards CE, facilitating governments, firms, and various stakeholders to set, achieve, and monitor realistic CE targets. Such measurement frameworks have been developed for each level of CE implementation though the majority of these studies provide useful classifications for CE indicators. The incorporation of CE strategies into the business models (i.e., material loops) has also addressed in the literature. The shift in the orientation in measuring the frameworks with respect to the CE strategies, widely known as “Rs” models/frameworks has been investigated. With this background, a review of some of the trending works would further widen the research gap in the quest to improve circular economy framework that could be

recommended for implementation in manufacturing industries in Nigeria.

FUTURE TREND IN DEVELOPMENT OF CE FRAMEWORK

It has been affirmed that many research works have been done in efforts on developing CE transition methodology and framework from traditional linear economy that is frequently characterised by the presence of structural waste and environmental nuisance as reviewed and overviewed by many researchers. It is of worth research that CE indicators and measurement frameworks should be carefully studied in order to underline the crucial aspects, for holistic framework which will be able to define the integration of CE progress of organisation at all levels. From a waste management standpoint and managerial point of view, as well as percentage of raw material usage, such a framework could be a practical tool for managers and investors to identify the crucial points of CE performance and CE investments, providing information about investment risks and the progress of already funded CE projects. Therefore, some further analysis of plastic manufacturing industries CE indicators is necessary.

2. METHODOLOGY

This paper considered the research method of systematic literature review. An exhaustive search of the literature was performed, before combining narrative and tabular methods for synthesizing literature. The literature on the field of CE is, by now, abundant. It was therefore crucial to limit the scope of the research to only literature relevant to the research questions. A systematic approach was key. The literature review was therefore performed stepwise. This stage included stating the main goal of the study and associated research questions. A search strategy and key criteria for inclusion and exclusion of papers was developed. Thereafter, the data collection step, at which database selection and the identification of appropriate keywords were central elements. This was followed by sorting and exclusion.

Table 1: Developments in Circular Economy Frameworks for Manufacturing Industry

S/N	Conceptual Framework	Factor(s) and Enabler(s)	Production Product	Findings	Research Gap	Reference
1	Assessing the corporate CE practices in relation to all levels of CE implementation (i.e., micro-, meso-, and macro-level),	Examine the effectiveness of the proposed framework and identify key elements which can be further improved.	plastic	Firms show a better performance at the macro-level than the other levels	The frameworks were tested for plastic industry and underscored other manufacturing industries	(Lanaras-Mamounis, Kipritsis et al. 2022)
2	Developing a circular strategies framework for manufacturing companies to support circular economy-oriented innovation	Inappropriate mapping strategies currently applied. Lack of Finding solution for improving circularity across a range of business processes.	Manufacturing companies	It provided guidance in identifying what business areas eco-innovation for CE is possible or necessary.	A tool for inspiring, motivating and aligning people should be further study.	(Blomsma, Pieroni et al. 2019)
3	Performance indicators for a circular economy	Environmental challenges	Post-industrial plastic waste	The results show that the indicator can be a very useful approach to guide waste streams towards their optimal valorization.	Thermosets material or other material types were not addressed	(Huysman, De Schaepmeester et al. 2017)
4	Companies innovate business models and supply chains for a circular economy.	Product/Process/Service innovation.	Manufacturing industries	The findings strengthen the understanding of interlink between the two major types of innovation.	Setting for circular innovation strategy was not addressed.	(Kaipainen, Urbinati et al. 2022)
6	Evaluation of Factors Affecting the Transition to a Circular Economy.	Climate change and reduction carbon emissions.	Both business model and manufacturing processes.	The results of empirical research showed that the factors attention to the environment and attitude towards intention.	Framework model limited to planned behavior but not manufacturing process industries.	(Trần, Phan et al. 2022)
7	Facilitating Circular Economy Strategies Using Digital Construction Tools: Framework Development	Resource constraints, human health and climatic change.	Construction sector.	Framework offers practical insights for construction industry practitioners and helps to investigate several critical barriers.	Framework was not considering other stakeholders in the construction process.	(Jemal, Kabzhassarova et al. 2023)
8	Moving from Linear to Circular Economy: Life-Cycle Assessment on Plastic Waste Management	Environmental issues	Plastic materials	Study revealed that the combined mechanical recycling and pyrolysis with incineration of residuals scenario has the lowest environmental impact.	The model did not provide solution to transitioning to circular economy.	(Almadhi, Abdelhadi et al. 2023)
9	Value-addition to plastic waste towards achieving a circular economy.	Unsustainable waste management practices and environmental issues	Plastics	The new technologies need to employ to close the waste generation loop.	Further research need to be looking into how to expand reuse models, new business models.	(Kumar, Bhujbal et al. 2024)
10	Circular economy for the built environment: a research framework	Sustainability of the built environment	Manufacturing industries	The result shown that the greatest challenges ahead lie not in further technological innovation but rather in the role of people, both as individuals and as a society.	The research undermine the circular economy at macro level.	(Pomponi and Moncaster 2017)
11	Assessment of plastic waste generation and management	Environmental issue and unsustainable waste disposal practices	Plastic	The result shown that the facility to segregate, recycling, and up cycling of plastic waste were not provided	The research only focused plastic materials, however, undermined other materials.	(Oladipupo, Ayanshola et al. 2024)

12	Plastic circular economy framework using hybrid machine	Environmental issues	Plastics	The results shown the maximum recycling rate for the case study.	The research framework focused on plastics waste while other industrial wastes were unexplored.	(Chin, Varbanov et al. 2022)
13	Plastic Pollution, Waste Management Issues, and Circular Economy Opportunities	Plastics management	plastic pollution effects on rural communities and Waste Management Issues	The results revealed that rural communities need to be enlightening the economy opportunities on circular economy through generation of plastics wastes.	The study underexplored other industrial wastes.	(Mihai, Gündoğdu et al. 2021)
14	Understanding circular economy awareness and practices in manufacturing firms	Manufacturing industries	Environmental issues	The research findings shown that with the growing emphasis on CE across the globe by governing bodies, firms are becoming more aware of CE practices.	The study provides manufacturing firms with a thorough understanding of the state of CE practices.	(Liakos, Kumar et al. 2019)
15	Implementation of circular economy approaches in the electrical and electronic equipment (EEE) sector	Electrical Manufacturing industries	Due to large untapped potential in the Electrical Manufacturing industries.	The findings indicate that no single instrument alone from a specific policy domain can address the variety of existing barriers and gaps.	The study covered only Electrical Manufacturing industries understudied other manufacturing industries.	(Rizos and Bryhn 2022)

CONCLUSION

The aim of this research paper was to provide a review of the empirical literature on CE framework in manufacturing industry and to identify the research findings and research gaps taking place between industrial actors and academics to promote further studies. It was found that most published literature from before 2015 was conceptual; this review study finds that literature based on case studies has grown. All case studies reviewed are from after 2015, showing that there is progress towards more empirical research on manufacturing companies relating to CE framework implementation.

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