

## Circular Economy Supply Chain and Sustainable Sourcing

The Incorporation of McArthur Foundation's Butterfly Model into Sustainable Sourcing

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### Abstract

*In response to environmental degradation and resource depletion, achieving sustainability in supply chain management has become pivotal, with circular supply chains and sustainable sourcing emerging as critical strategies. This study, employs a questionnaire distributed to employees across three manufacturing organizations in South Africa, aiming to explore these concepts. The questionnaire is informed by the conceptual framework of the McArthur Foundation's Butterfly Model. However, integration obstacles persist, including a lack of initial costs and resistance to change. Addressing these challenges is crucial for a smoother transition to sustainability. The study also indicates a growing emphasis on social and environmental factors in supplier selection, alongside cost effectiveness. This study also finds that educational initiatives must be accessible to employees at all levels, and cross functional collaboration remains essential for holistic integration. Ultimately, organizations must recognize the ongoing nature of incorporating circular economy principles and continuously spread knowledge while navigating change management and process transformation challenges for a sustainable future in supply chain operations.*

**Keywords** circular economy, sustainable sourcing, supply chain management, suppliers, butterfly model

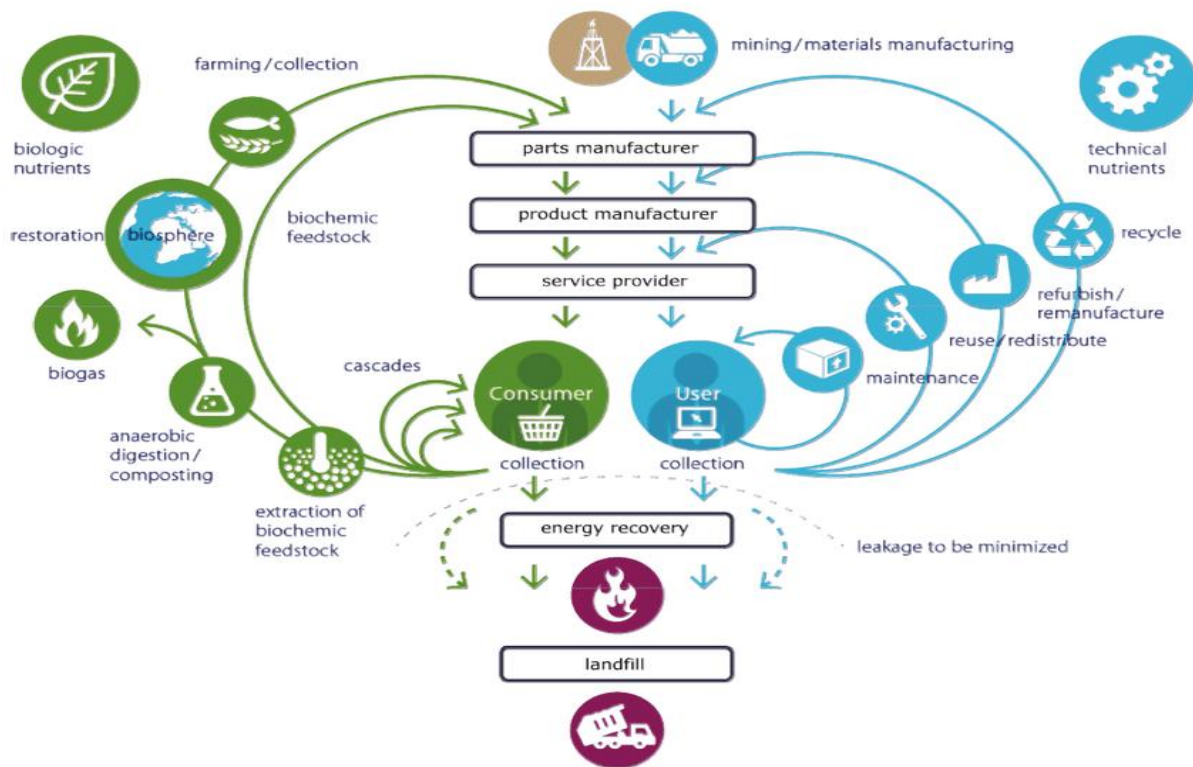
**JEL** Q50, Q59

### Introduction

Businesses and organizations are increasingly understanding the importance of incorporating circular economy concepts into their operations in an era marked by increased concern for the environment and the urgency to battle the effects of climate change. Circular economy efforts particularly in sustainable sourcing, are significant tools for driving both economic growth and environmental sustainability. (Pathak, 2023). A circular economy is a framework in which materials are never wasted and nature is replenished. products and materials are kept in circulation in a circular economy through operations such as maintenance, reuse, refurbishment, remanufacture, recycling, and composting (MacArthur, 2022; Bhandari et al, 2022). By disconnecting economic activity from the consumption of limited resources, the circular economy addresses climate change and other global concerns such as diminished biodiversity, waste, and pollution. the circular economy is based on three principles, which are eliminating waste and pollution circulating products and materials at their highest value, and regenerating nature in our current economy, we take materials from the earth, make products from them, and eventually throw them away as waste – the process is linear. in a circular economy, by contrast, we stop waste from being produced in the first place.

Environment, Social, and Governance (ESG) investors; regulators and other stakeholders continuously exert pressure on businesses to establish sustainable sourcing practices and initiatives in order to improve the safety and sustainability of their supply chains (Chen, 2022). Sustainable sourcing focuses on identifying and choosing suppliers who are dedicated to sustainability and can demonstrate that they satisfy environmental, labour, and social responsibility standards. Sustainable sourcing strives to reduce negative environmental and community consequences while simultaneously enhancing the long-term profitability of the enterprises and organizations involved (Saha et al, 2022).

The circular economy is gaining popularity as a more sustainable alternative to the classic linear "take make dispose" economic model (Corvellec et al, 2022; Akhavan, 2017). The Butterfly Diagram created by the Ellen MacArthur Foundation is one of the most well known and significant depictions of the circular economy. The model, named after Dame Ellen MacArthur, a former competitive sailor who created the foundation, visualizes the basic ideas of the circular economy in an easy-to-understand manner (MacArthur, 2022).



**Figure 1. The McArthur Foundation's butterfly model**

*Source: (MacArthur, 2022)*

The McArthur's Butterfly Model presents a visual framework depicting the transition from a linear economy to a circular economy using the metaphor of a butterfly's lifecycle. In its caterpillar stage, representing the current linear economic model, resources are extracted, utilized, and discarded, leading to waste accumulation and environmental degradation (Aydin et al, 2022). The chrysalis stage symbolizes the transitional period, during which efforts are made to minimize waste, optimize resource utilization, and redesign products and processes for durability and reuse. This phase involves the implementation of innovative initiatives and policies to facilitate the shift towards circularity (Bhandari et al, 2022). Finally, in the butterfly stage, the circular economy is realized, with resources managed sustainably, and waste minimized through practices such as recycling,

upcycling, and remanufacturing. Products and materials circulate within closed loop systems, extending their lifespan and reducing reliance on virgin resources, leading to economic prosperity, environmental resilience, and social wellbeing (Chowdhury, 2022; Khan et al,2022). The model illustrates the transformative journey towards a circular economy, emphasizing the need for systemic changes in production, consumption, and waste management to achieve sustainability (Delbaldo and D'Anghela,2020).

### ***Butterfly stage***

- –Biological Cycle (left wing): This depicts the circular economy's regenerative feature, which is inspired by natural ecosystems. Organic trash and biodegradable products are examples of biological materials that can be safely returned to the environment (MacArthur, 2022).
- –Technical Cycle (right wing): This cycle focuses on the technical aspects of the circular economy, such as nonbiological materials designed for reuse, remanufacturing, or recycling. Closed loop systems circulate these materials, minimizing resource use and waste formation (MacArthur, 2022), The Butterfly Diagram depicts several essential steps in the circular economy:
  - –Design for Longevity: Products are built with durability in mind, with an emphasis on reparability and upgradeability (Korhonen et al,2018).
  - –Reuse and Refurbishment: Products are refurbished and resold to extend their life cycle.
  - –Remanufacturing: utilization of old product components and materials to generate new products.

### ***The Application of the McArthur foundation's butterfly model in the manufacturing sector***

According to (McAloone and Hauschild,2023), the applicability of the McArthur's Butterfly Model in the manufacturing sector lies in its ability to guide industry professionals and its stakeholders in adopting sustainable practices and fostering innovation across the entire value chain. By following the stages outlined in the model and implementing corresponding strategies, manufacturers can be to align their operations with circular economy principles. (Kujanpää,2023) further adds that Manufacturers can transition from a linear, resource intensive approach to a more sustainable and regenerative model that promotes long term environmental and economic benefits.

The model notes the importance of systemic changes in production, consumption, and waste management to achieve sustainability in the manufacturing industry. The applicability of this model can encourage manufacturers to rethink traditional practices and embrace innovative solutions that prioritize resource efficiency.

In conclusion, McArthur's Butterfly Model serves as a guiding framework for manufacturers seeking to embrace the principles of the circular economy. Its relevance lies in its ability to inspire transformative change, drive innovation, and promote sustainability within the manufacturing sector. As industries increasingly recognize the importance of sustainability, the model provides a roadmap for navigating the transition towards a more circular future.

## Materials and Methods

This paper adopts a quantitative research methodology to analyse data from a sample of employees from three different manufacturing organizations in South Africa focusing on the construction equipment, apparel, and packaging industry. The primary data was gathered through a questionnaire survey administered to employees of the three manufacturing organizations. The primary research was conducted from September 2023 to early February 2024.

The questionnaire was sent out to seventy employees of different employment levels and the results were presented in a table format, descriptive statistical tables allowed access to the relationships between the degree of integration and its impacts on environmental, social, and economic performance. The method of sending out the questionnaire was in the form of Google Forms and the questions were sent out using social media platforms namely Facebook and WhatsApp. The identity of the respondents could not be revealed, owing to protecting their identity, and the names of the three organizations mentioned could not be revealed due to private and confidential reasons.

Secondary data was derived from academic journals and research papers from sources namely the Web of Sciences (WOS), Scopus, and Google Scholar that discussed circular economy concepts, sustainable sourcing strategies, and other related topics. These secondary sources provided essential context and theories to back up the study's findings. The use of recent papers in the secondary data increased the depth and comprehensiveness of the research, ensuring that the analysis represents current knowledge and expertise in the subject.

## Results

**Table 1. Age and gender ratio**

Age group	Male (in %)	Female (in %)	Mean	Standard deviation
22-35	48	52	28,5	5,7
36-50	63	37	43,0	5,8
51-65	42	58	58,0	3,5

*Source: Authors Own compilation*

**Table 2. Education level**

Matriculation	6,3%
vocational certificate	2,5%
Diploma	33,3%
Bachelor's degree	27, 1%
Bachelor honours degree	6,3%

*Source: Authors Own compilation*

Feedback from the 49 respondents was as follows based on the key questions chosen for analysis the first question asked was the education level of the employees, this was an important question to ask because it gave a brief background on how they understand the circular economy and sustainable sourcing theory, 33% of the respondents have a national diploma, followed by 27,1% of the respondents have a bachelor's degree, and 25% of the respondents have a vocational certificate This diversity suggests that individuals from various educational backgrounds are part of the sustainability conversation.

**Table 3. The participants were asked which department they work in, in their respective organizations**

<b>Production and manufacturing</b>	14,6%
<b>Finance</b>	6,3%
<b>Purchasing</b>	4,2%
<b>Marketing</b>	6,3%
<b>After sales</b>	37,5%
<b>Maintenance</b>	31,3%

*Source: Authors Own compilation*

The following question asked was which department are the respondents from their organizations. This was important to see because the circular economy and sustainable sourcing affect every department in the workplace, it was interesting to note that 37,5% of the respondents were from the aftersales department followed by 31,3% from the maintenance department and 14,6% from the production/manufacturing department. Figure 4 explored the departmental distribution of the respondents, revealing that 37,5% are from aftersales departments, 31,3% from maintenance, and 14,6% from production and manufacturing. These principles influence various aspects of an organization, and the dispersion of respondents across different departments Aftersales, maintenance, and production departments play pivotal roles in the product lifecycle, and their involvement is imperative for effective implementation.

**Table 4. Questions asked to participants if they were familiar with the circular economy concept**

<b>Yes</b>	54,2%
<b>No</b>	45,8%

*Source: Authors Own Compilation*

This was a relevant question to ask to view if the respondents were aware of the concept of circular economy and sustainable sourcing 45,8% said no and 54,2% said yes this is good because it shows that more respondents know about the concept of circular economy and sustainable sourcing. This is an encouraging finding, demonstrating that knowledge in this domain is not limited to a select few.

**Table 5. The question asked participants if circular economy principles were integrated into sustainable supply chains in their organizations**

<b>Yes</b>	14,3%
<b>Yes, but partially</b>	44,9%
<b>No</b>	40,8%

*Source: Authors Own Compilation*

Based on table 5 the question asked it was important and relevant to ask if there are any circular economy principles integrated into supply chains 14,3% responded yes fully integrated, while 44,9% responded yes partially integrated 40,8% responded not integrated at all this could be due to the concept being accepted and used in the recent years. This variation in responses suggests that circular economy principles are still in the process of adoption and implementation within organizations.

**Table 6. The question was asked on how familiar the participants with the concept of the circular economy were as depicted by the model**

<b>Familiar</b>	17,7%
<b>Not Familiar</b>	53,8%
<b>Not sure</b>	28,5%

*Source: Authors Own Compilation*

Based on Table 6 the question asked how familiar the participants were with the concept of circular economy as shown by the model. The results shown in the responses suggest that most of the participants are not familiar with the concept of circular economy as depicted in the model, this could be the result of being unfamiliar with the model.

**Table 7. The question was asked to participants about which circular economy principles they consider in their sustainable sourcing procedures**

<b>Product design and durability</b>	44,9%
<b>Materials recycling and reuse</b>	49%
<b>Product remanufacturing and re-furbishment</b>	26,5%
<b>Extended producer responsibility</b>	2%
<b>Sharing economy and product</b>	4,1%

*Sources: Authors Own compilation*

From table 7 question being asked was which principles does one consider sourcing in their sourcing procedures 49% is materials recycling and reuse, 44,9% is product design for durability and repairability, 26,5% is product remanufacturing and refurbishment, two% is extended producer responsibility and 4,1% is sharing economy and product as a service model. Notably, these results align closely with the foundational principles of the circular economy, emphasizing the importance of reducing waste, extending product lifecycles, and conserving resources.

**Table 8. The question asked to participants was the challenges in their organizations they face incorporating circular economy into sustainable sourcing procedures**

<b>Lack of awareness and understanding</b>	44,9%
<b>Limited availability of circular products and materials in the market</b>	24,5%
<b>High initial investment and implementation costs</b>	36,7%
<b>Resistance to change in traditional sourcing practices</b>	24,5%
<b>Inadequate government support</b>	44,9%

*Source: Authors Own Compilation*

Based on Table 8 above challenges in integrating circular economy principles into sustainable sourcing procedures 44,9% detailed their challenges as the lack of awareness and understanding of the concept and inadequate government support, further 36,7% is high initial investment and both 24,5% is Limited availability of circular products and materials in the market & resistance to change.

**Table 9. The question asked to participants was about the supplier selection for sustainable sourcing**

<b>Environmental certifications (e.g., ISO 14001)</b>	53,1%
<b>Social responsibility policies and practices</b>	24,5%
<b>Supply chain transparency and traceability</b>	16,3%
<b>Resource efficiency and waste reduction initiatives</b>	10,2%
<b>Cost effectiveness</b>	77,6%

*Source: Authors Own Compilation*

Table 9 addressed the factors that come into play when selecting suppliers 77,6% responded that its cost effectiveness, 53,1% responded its environmental certifications 24,5% responded its social responsibility policies, 16,3% responded its Supply chain transparency and 10,2% responded its resource efficiency Cost effectiveness stood out as the most critical factor, with 77.6% of respondents prioritizing it. However, it is encouraging to see those environmental considerations, represented by environmental certifications, were a factor for 53.1% of respondents and cost effectiveness is a crucial factor because of pricing ranges from different suppliers.

## Discussion

Based on the data analysed through the view of McArthur's Butterfly Model, several key conclusions can be drawn regarding the current state of awareness, adoption, and challenges associated with the circular economy and sustainable sourcing within organizations.

Firstly, the diverse educational backgrounds of the respondents, as evidenced by Table 2, signify that individuals from various educational paths are engaged in discussions surrounding sustainability, indicating a broadening scope of understanding across different sectors. Furthermore, the distribution of respondents across different departments, as depicted in Table 3, highlights the cross functional nature of circular economy principles, with aftersales, maintenance, and production departments playing pivotal roles in the integration of sustainable practices throughout the product lifecycle.

Additionally, the findings from Table 4 reveal a promising level of awareness among respondents regarding the circular economy concept, with over half indicating familiarity with it. However, the challenges outlined in Table 8, such as the lack of awareness and understanding, high initial investment costs, and resistance to change, underscore the ongoing transition process towards fully integrating circular economy principles into sustainable sourcing procedures.

Nevertheless, Table 5 suggests a gradual adoption of circular economy principles within supply chains, albeit partially, with a significant portion of respondents acknowledging their integration to some extent. Moreover, Table 7 highlights the specific principles prioritized by respondents in their sustainable sourcing procedures, with an emphasis on materials recycling and reuse, product design for durability, and reparability, aligning closely with the core tenets of the circular economy, Table 6 highlighted the familiarity of the participants with the concept of circular economy as shown by the model. The results shown in the responses suggest that 53,8% of the participants are not familiar with the concept of circular economy, while 17,7% are familiar and 28,5% are not sure, this could be an indication that the participants are not familiar with the model depicted.

Finally, Table 9 underscores the multifaceted considerations involved in supplier selection for sustainable sourcing, with cost effectiveness being paramount, yet environmental certifications and social responsibility policies also gaining prominence.

## **Conclusion on Results**

These findings collectively depict a dynamic sphere wherein organizations are increasingly recognizing the importance of adopting circular economy principles but are still navigating challenges in their full implementation. Moving forward, addressing these challenges, fostering cross departmental collaboration, and continuing to prioritize sustainability in supplier selection processes will be essential for organizations to progress towards a more circular and sustainable future.

A theory (Elkington J,2024) called The Triple Bottom Line (TBL) theory, proposed by John Elkington, emphasizes the importance of considering not only financial performance but also social and environmental impacts. This theory aligns well with the principles of the circular economy as depicted in the MacArthur Butterfly Model. By incorporating TBL, manufacturing organizations can assess their performance in terms of finance, environmental impact, and social well-being.

The incorporation of the McArthur's Butterfly Model Stages Biological and Technical Cycles offers a comprehensive view of this process, emphasizing both regenerative and technical factors critical to sustainability. The Biological Cycle, which represents the circular economy's regenerative component, emphasises the significance of carefully returning biological resources to the environment. This is in line with the increased emphasis on organic waste management and biodegradable product design in manufacturing. The Technical Cycle, on the other hand, focused on nonbiological materials and emphasises reuse, remanufacturing, and recycling to reduce waste generation. These cycles show the importance of comprehensive policies that address both the organic and technical aspects of sustainable sourcing.



## Conclusion

The circular economy provides a compelling alternative to the standard linear economic model, which is defined by the continuous sequence of "take make dispose." The circular economy seeks to decouple economic growth from resource consumption and environmental deterioration by prioritising waste and environmental degradation, Materials kept in circulation by employing processes such as reuse, refurbishment, remanufacturing, recycling, and composting, which reduce waste and maximize resource efficiency. Pressure from stakeholders such as ESG investors and regulators has driven organisations to implement sustainable sourcing procedures to improve the safety and sustainability of their supply chains. Sustainable procurement entailed identifying and selecting suppliers committed to sustainability, to lower negative environmental and community impacts while increasing long term profitability.

The Butterfly Diagram, created by the Ellen MacArthur Foundation, provided an important visual framework for the transition to a circular economy. This diagram depicted the transition from a linear to a circular economy, emphasising the stages of caterpillar, chrysalis, and butterfly. The circular economy promoted closed loop systems in which products and materials circulate endlessly, eliminating reliance on original resources and waste. Initiatives like design for longevity, reuse, refurbishing, and remanufacturing assist to achieve this. The adoption of circular economy principles, particularly in sustainable sourcing, shows tremendous potential for promoting both economic growth and environmental sustainability.

The research outlined in this study employed a quantitative methodology to investigate the integration of circular economy principles within the sourcing procedures of manufacturing organizations in South Africa, focusing on the apparel, construction equipment, and packaging industries. Through the distribution of surveys to seventy employees across these sectors, data was collected to assess the extent of circular economy integration and its impact on environmental, social, and economic performance. Descriptive statistical analysis facilitated the exploration of relationships between integration levels and outcomes, providing a robust foundation for evaluating the effectiveness of circular economy principles in sustainable sourcing. The analysis of demographic data revealed a diversified respondent profile in terms of age, gender, and educational background, indicating widespread participation and interest in the theme of sustainability.

## Recommendations

- Collaborative efforts between manufacturing organizations, relevant government departments, academics, policymakers, and other relevant stakeholders can make meaningful progress toward a more sustainable future. Using this suggested prospect of this study the collaboration efforts can involve sharing best practices, conducting joint research projects, and developing industry standards for sustainable sourcing.
- Educational initiatives through developing educational programmes and workshops to raise awareness and knowledge of circular economy principles, sustainable sourcing, and the model among employees from various departments and industries across the manufacturing sector. These initiatives can involve workshops, as well as practical implementation strategies.

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