Journal of Economic Growth and Entrepreneurship JEGE
Spatial and entrepreneurial development studies laboratory
Year : 2024 Vol.7 No.1 pp:57-66

A framework for circular economy (CE) implementation to drive sustainable industrial growth in the Algerian manufacturing sector

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ARTICLE INFO

Article history:
Received:19/08/2023
Accepted:25/02/2024
Online:25/02/2024

Keywords:
Circular economy; Circular strategies framework; Sustainable manufacturing; Re-manufacturing; Closed loop
JEL Code: L69; O14; O41

ABSTRACT

Manufacturing companies have been instrumental in improving global living standards, yet traditional linear production methods have shown sustainability issues. The concept of a circular economy (CE), which emphasizes resource retention, has gained momentum. Existing circular economy frameworks have limited applicability to specific business types, specially manufacturing, and aren't well-suited for Algerian manufacturing companies due to differing market conditions, culture, and policies. This paper aims to: (1) reexamine the circular economy concept in the manufacturing industry and (2) assess the current adoption of circular economy practices within Algeria's manufacturing sector. We then propose a tailored circular economy implementation framework for Algerian manufacturing firms. Our study includes a literature review to analyze existing circular economy frameworks, leading to the development of a comprehensive framework suitable for various manufacturing industries. This framework serves as a theoretical basis for future research, and we identify potential research directions for further exploration.

1. Introduction

The need for sustainability has spurred global efforts, prompting economic, environmental, and social focus (Rathi, Sabale, Antony, Kaswan, & Jayaraman, 2022). With material consumption and waste projected to double by 2050, transitioning to a sustainable production system is imperative (Liu, Trevisan, Yang, & Mascarenhas, 2022). The current linear economy often leads to structural waste, necessitating a shift to the Circular Economy (CE) model, which emphasizes repeated utilization and value creation (Blomsma, et al., 2019).

CE encompasses various circular strategies, aiming to decouple economic growth from resource depletion and environmental harm (Liu, Trevisan, Yang, & Mascarenhas, 2022). Implementing CE benefits organizations by enhancing resource utilization, meeting regulations, and fulfilling societal and investor expectations (Rathi, Sabale, Antony, Kaswan, & Jayaraman, 2022). The CE model is projected to save USD 3.7 trillion annually through resource efficiency (McKinsey). Manufacturing's significant greenhouse gas emissions can be mitigated by responsible CE practices, aligning with sustainability and corporate social responsibility (Rathi, Sabale, Antony, Kaswan, & Jayaraman, 2022).

While CE is recognized for its potential, its widespread adoption, particularly in manufacturing, remains limited (Blomsma, et al., 2019). Algeria, aiming for sustainable economic diversification, currently operates a linear manufacturing economy, leading to environmental imbalance and resource depletion (Kazi & Touhami, 2019).

One of the strategic solutions that Algerian manufacturing companies can adopt is the circular economy approach. Therefore, this paper presents a framework for circular economy implementation to drive sustainable industrial growth in the Algerian manufacturing sector. The remainder of this paper is structured as follows. The next section describes a background on circular economy as a concept, where we will determine its definition, adoption levels, and pillars. Section 3 presents an assessment of current manufacturing practices in Algeria. The research methodology of our literature review and framework building is described in Section 4. While Section 5 discusses the results. Finally, Section 6 draws some conclusions arising from the research and discusses possible future research work.

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2. Background

2.1. Key concepts of circular economy

The fundamental principle of the circular economy (CE) aims to optimize resource utilization across a product's lifecycle. This involves eliminating waste from products that are underutilized or no longer applicable. In the CE framework, the concept of recycling has replaced the traditional end-of-life phase seen in linear product lifecycles (Rathi, Sabale, Antony, Kaswan, & Jayaraman, 2022). The origins of the circular economy concept trace back to observations of natural cycles, best encapsulated by the adage, "nothing is lost, nothing is created, everything is transformed," commonly attributed to Lavoisier (Kazi & Touhami, 2019).

As the CE concept evolved, new principles emerged. In 2004, the Japanese government introduced the "3R Policy," focusing on reduction, reuse, and recycling. Subsequently, the European Union proposed CE waste hierarchy guidelines in 2008, emphasizing 4R: reduce, reuse, recycle, and recover. With further exploration by researchers and strategists, various "R" frameworks were proposed. Currently, the CE implementation often employs the 9R principles, detailed in **Figure 1** (Rathi, Sabale, Antony, Kaswan, & Jayaraman, 2022).

The circular economy scheme aims to create a virtuous economic system, extending the lifespan of materials, components, and products to maximize their value for as many users as possible. This approach seeks to benefit the economy, individuals, and the surrounding natural ecosystems (Kazi & Touhami, 2019).

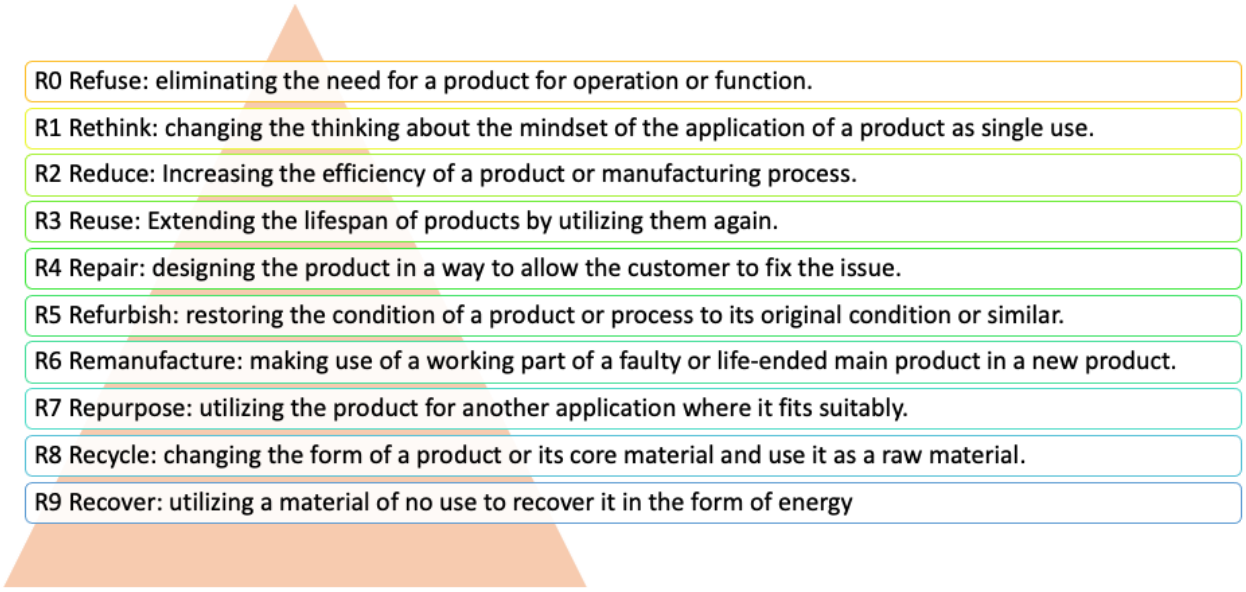

Figure 1: The 9R framework (Adopted from Rathi, Sabale, Antony, Kaswan, & Jayaraman, 2022)

2.2. Circular economy adoption level

The adoption of CE is achieved at various levels based on the scope of implementation. There are three basic levels (**Figure 2**): product-based approach, organization-based approach and regional- or national-compliance-based approach.

- The product-based approach: is generally based on designing products for refurbishment, remanufacturing and repair instead of ending the product life.
- The organizational-level approach: is derived through economic value and corporate social responsibility. Most organizations have set goals for sustainability through which they emphasize recycling natural resources in their daily operations.
- The national/regional level approach: the third level is macro-level adoption at the national or regional level where the commitment toward the environment drives the changes. (Rathi, Sabale, Antony, Kaswan, & Jayaraman, 2022)

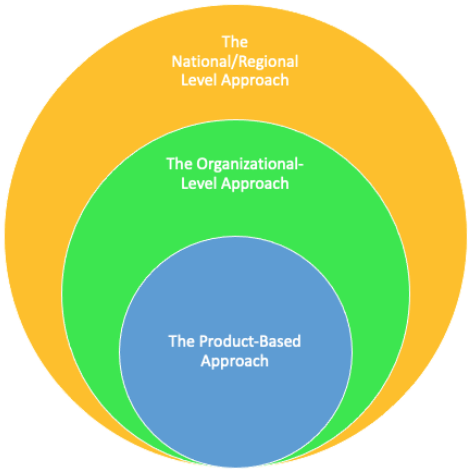

Figure 2: Circular economy adoption level (Adopted from Rathi, Sabale, Antony, Kaswan, & Jayaraman, 2022)

2.3. The circular economy pillars

The circular economy is built upon three essential pillars: effective waste management, the strategic involvement of economic actors, and influencing user behavior. To achieve substantial outcomes, it is crucial that this economic model considers all three pillars in its implementation (see **Figure 3**) (Kazi & Touhami, 2019).

A significant challenge arises from the presence of subsidies, whether direct or indirect, that promote unsustainable resource consumption on a global scale. These subsidies are currently estimated at approximately $1.1 trillion annually. In many economies, the persistence of these subsidies can be attributed to the intricate interplay between political decision-making processes and the economic interests of entities that advocate for the continuation of the existing system. Additionally, indirect subsidies result from a lack of comprehensive interdisciplinary thinking in governmental actions. This deficiency sometimes leads to instances of political inconsistency, diminishing the effectiveness of certain measures or even causing conflicting outcomes (Kazi & Touhami, 2019).

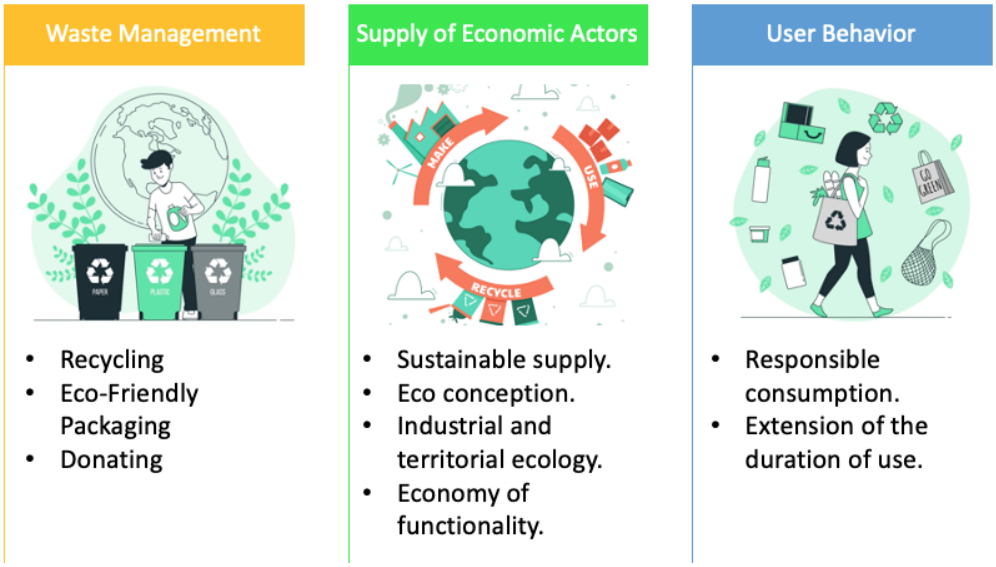

Figure 3: The circular economy pillars (Adopted from Kazi & Touhami, 2019)

3. Assessment of current circular economy practices in Algerian manufacturing

The circular economy in Algeria has primarily focused on bolstering the waste recycling sector, with limited attention to other essential aspects and foundational elements. This presents a fresh challenge to Algerian authorities in terms of effectively embracing the comprehensive principles and pillars of the circular economy, creating an integrated socio-economic system that yields highly favorable environmental and sustainable development outcomes.

The national waste management policy is an integral part of Algeria's broader environmental strategy, encompassing the National Environmental Strategy (NES) and the national environmental action and sustainable development plan. This policy led to the enactment of Law No 01/19 on December 12, 2001, specifically addressing waste management, control, and disposal. Additionally, the establishment of the public system for the recovery and valorization of packaging waste in Algeria, referred to as ECO-JEM, was outlined in Executive Decree No. 199-04 issued on July 19, 2004. This decree outlines the procedures for establishing, organizing, operating, and funding the ECO-JEM system under the supervision of the National Waste Agency (NWA).

In particular, Executive Decree No. 02-372 of 11 November 2002 concerning packaging waste (Article 03) mandates that generators and/or holders of packaging waste must choose from the following options:

- Self-valuation: Ensuring the recovery of their packaging waste independently and at their own expense.
- Specialized companies: Entrusting the recovery of their packaging waste to approved companies.
- ECO-JEM: Participating in the public packaging waste and recovery system (Benamraoui & Berrached Berbar, 2021).

4. Research methodology

4.1. Literature review

Numerous consultancy reports underscore the commitment of major organizations such as Apple, Samsung, Ford, and GE, as well as their CEOs, to adopting the CE as a means of contributing to sustainability goals. However, the benefits of CE and its implementation remain less evident for small and medium-sized enterprises (SMEs). CE is a broad concept, encompassing diverse strategies across different fields. One of these strategies, circular manufacturing, serves to enhance the ecosystem of the manufacturing sector (Rathi, Sabale, Antony, Kaswan, & Jayaraman, 2022).

When a transformative idea gains recognition, researchers and practitioners often seek to operationalize it through frameworks, tools, methods, and approaches. As a result, several CE implementation frameworks have emerged. Here, we review the following frameworks:

a) Comprehensive CE Framework

Lieder & Rashid (2015) present a comprehensive CE framework (**Figure 4**) that addresses aspects like resource scarcity, waste generation, and economic advantages. Their approach emphasizes a combined view of the environment, resources, and economic benefits. They propose a strategy utilizing both top-down and bottom-up approaches concurrently, emphasizing the necessity of joint support from stakeholders for successful large-scale CE implementation. This framework also identifies avenues for future CE research and practice (Lieder & Rashid, 2015).

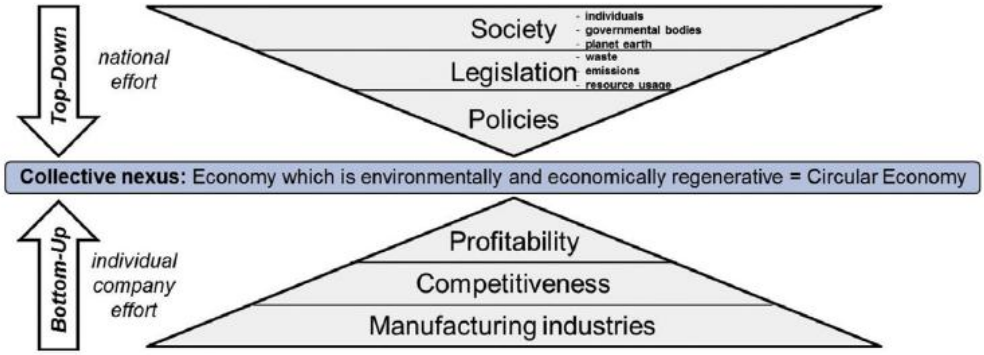

Figure 4: Comprehensive CE framework (Adopted from Lieder & Rashid, 2015)

b) Circular Economy Steering Framework

Dagiliene, Varaniut, & Bruneckiene (2021) employ Voβ et al.'s (2007) steering framework (**Figure 5**) to investigate the role of local governments in circular economy implementation. Through analysis and discussions with municipal and waste management representatives, they identify challenges related to local government contributions, including waste management, textile waste, human resources distribution, networking, and local business. They create a circular solutions framework by mapping practices from multiple perspectives (Dagiliene, Varaniut, & Bruneckiene, 2021).

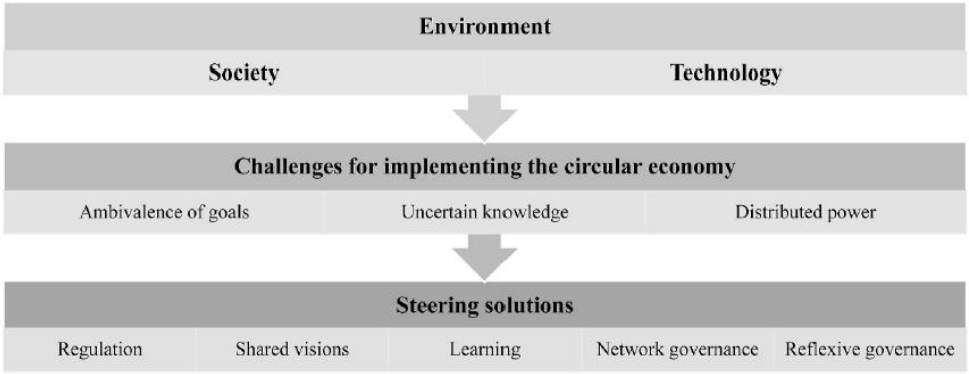

Figure 5: Circular economy steering framework (Adopted from Dagiliene, Varaniut, & Bruneckiene, 2021)

c) PESTEL Framework

Marsh, Velenturf, & Bernal (2022) utilize the PESTEL framework (Political, Economic, Social, Technological, Environmental, and Legal) to analyze contextual factors affecting CE implementation and potential synergies and conflicts arising from integration (**Figure 6**). (Marsh, Velenturf, & Bernal, 2022).

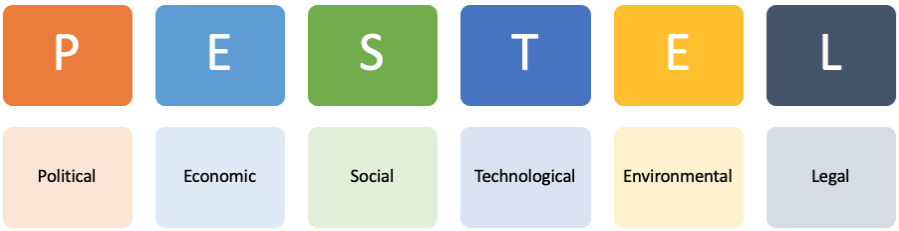

Figure 6: The PESTEL framework

d) Circular Strategies Scanner

Blomsma, et al. (2019) propose the Circular Strategies Scanner (**Figure 7**), a framework specifically designed for the manufacturing context, providing a comprehensive set of circular strategy definitions and supporting early CE-

oriented innovation (Blomsma, et al., 2019).

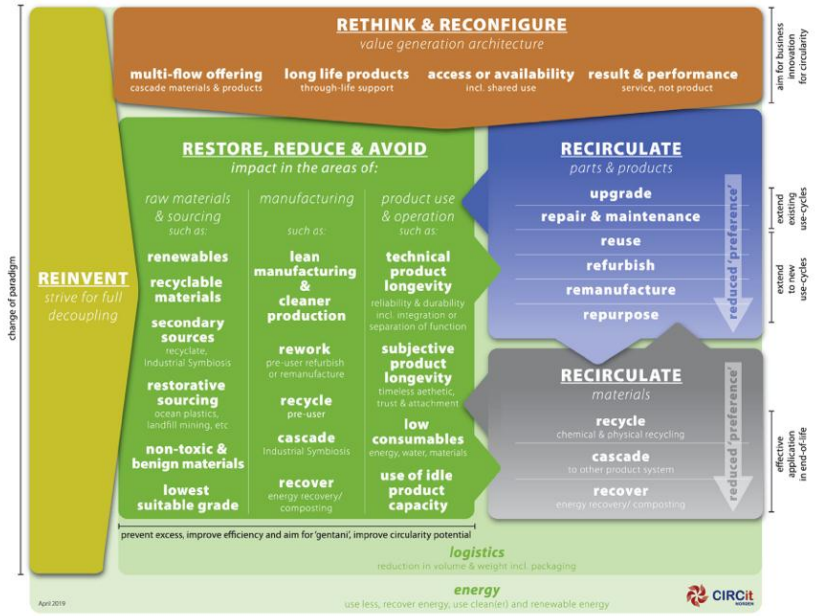

Figure 7: Circular Strategies Scanner (Adopted from Blomsma, et al., 2019)

e) Smart CE Framework

Kristoffersena, Blomsmab, Mikalefa, & Lia (2020) introduce the Smart CE framework (**Figure 8**), which aligns circular strategies with manufacturing companies' contributions to the United Nations' 12th Sustainable Development Goal (SDGs). This framework facilitates interdisciplinary collaboration and identifies strategic initiatives to close the gap between current and required business analytics (Kristoffersena, Blomsmab, Mikalefa, & Lia, 2020).

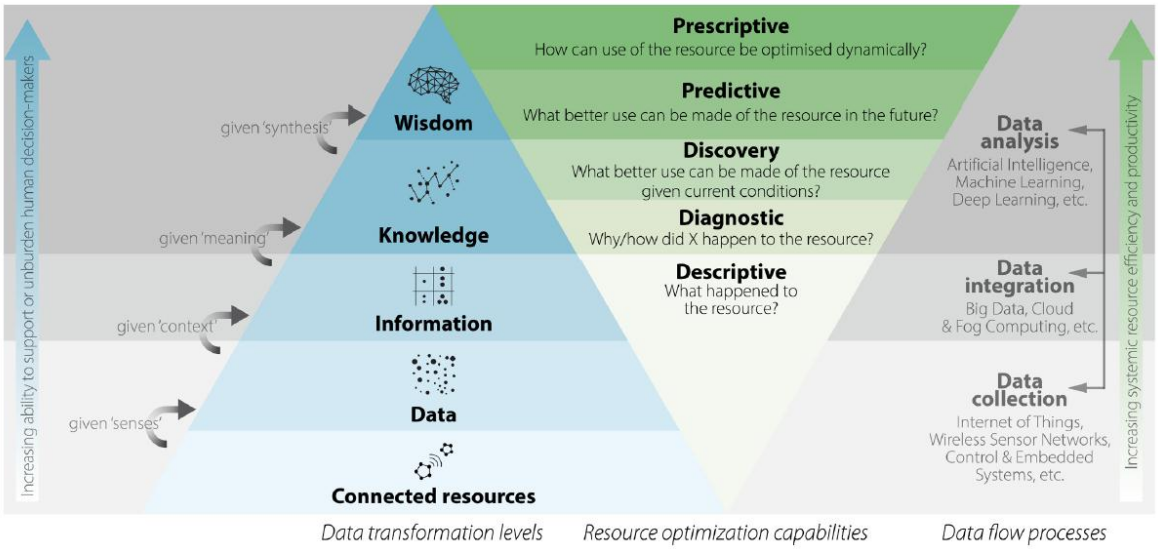

Figure 8: Smart CE Framework (Adopted from Kristoffersena, Blomsmab, Mikalefa, & Lia, 2020)

f) Circular Supply Chain Framework

Amir, Salehi, Roci, Sweet, & Rashid (2022) present a Circular Supply Chain (CSC) (**Figure 9**) guiding framework, categorizing CSC into four building blocks: systemic approach, main drivers, levels of decision making, and mechanisms for full loop closure and uncertainty minimization within the CE systemic implementation (Amir, Salehi, Roci, Sweet, & Rashid, 2022).

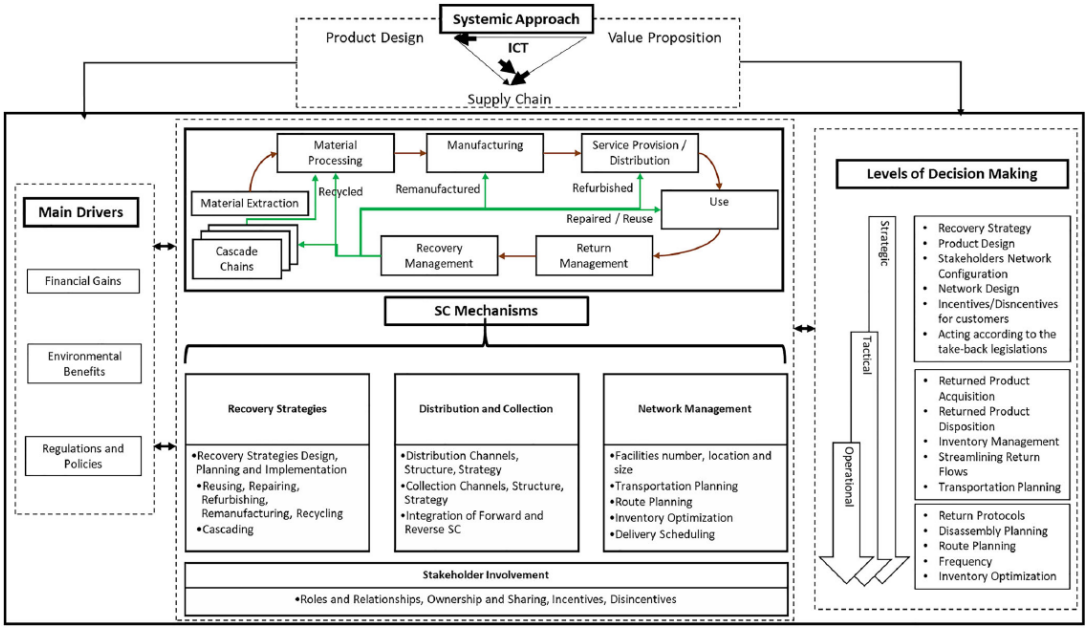

Figure 9: Circular Supply Chain Framework (Adopted from Amir, Salehi, Roci, Sweet, & Rashid, 2022)

4.2. Developing a circular economy framework for Algeria

Algeria's economy has shown consistent growth, making it a prominent player in its region. With a sizable population, it holds a significant position in consumer markets. The country's industrialization has progressed notably, leading to increased material consumption that aligns with GDP projections. However, this growth raises concerns about the sustainability of existing resources, emphasizing the need for long-term solutions.

The circular economy is a suitable approach to address these challenges and align with Algeria's growth forecasts. Raising awareness among consumers about the 9Rs principles is crucial for successful implementation. Both Algerian manufacturers and the products circulating within the country should adhere to these principles, enabling a transition towards circularity, optimizing resource utilization, and minimizing environmental impact.

However, existing circular economy frameworks may not be directly applicable to Algerian manufacturing companies due to various challenges, including policy differences, environmental issues, cultural variations among manufacturers, and limited technological resources.

To bridge this gap, we propose the "CE Framework for Algerian Manufacturing" (**Figure 10**). This framework draws from multiple sources, including the Comprehensive CE Framework, PESTEL Framework, Smart CE Framework, and Circular Supply Chain Framework, combining their insights to create a tailored solution for Algerian manufacturing companies. Given the significant role of these companies in material consumption, energy usage, waste production, employment, and GDP contribution, they serve as a key focus for circular economy implementation in Algeria.

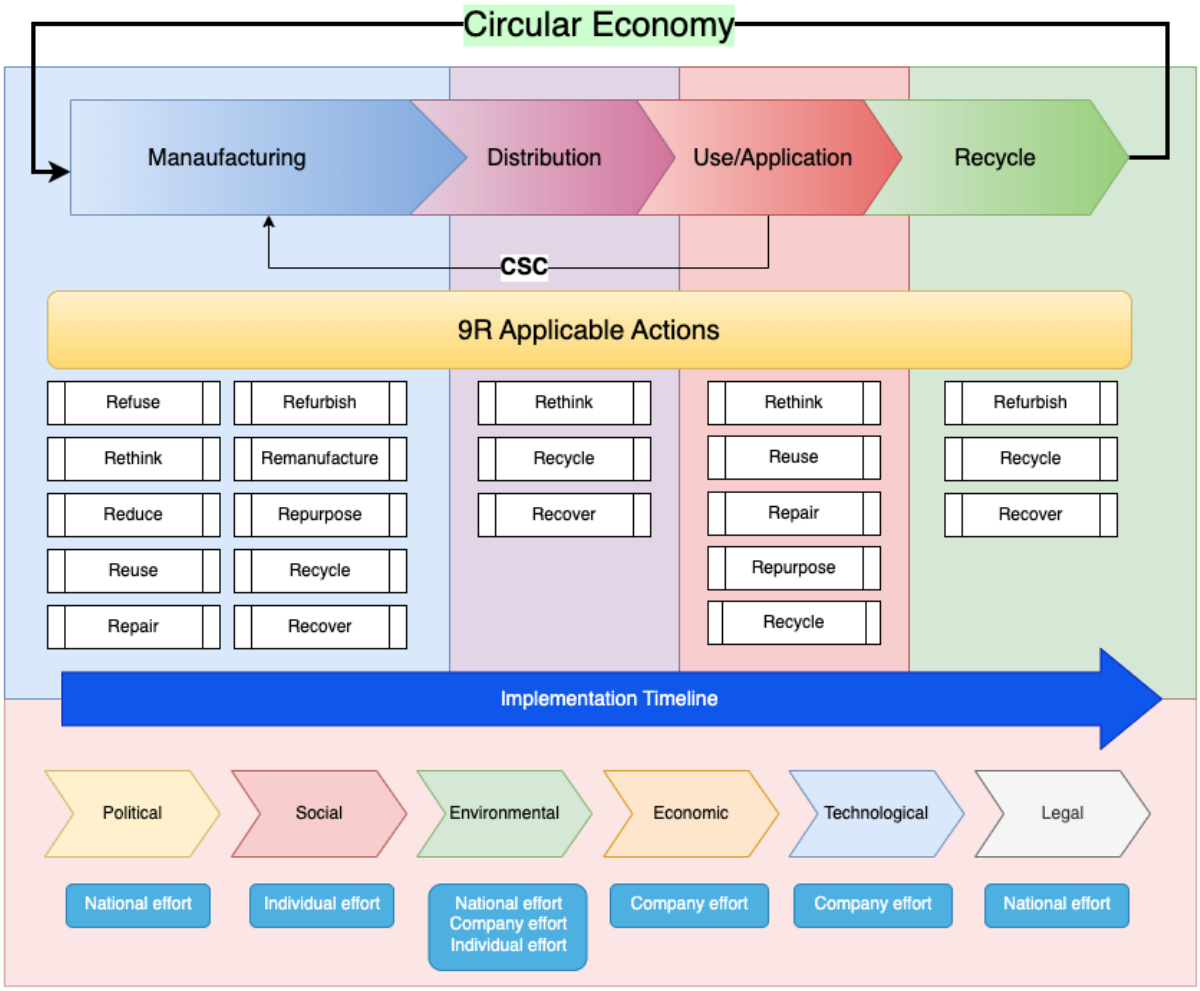

Figure10: CE Framework for Algerian Manufacturing

5. Results and discussion

In response to the intricate challenges confronting Algerian manufacturing enterprises, we have formulated the "Circular Economy (CE) Framework for Algerian Manufacturing" (as depicted in **Figure 10**). This pioneering framework draws upon a multi-faceted spectrum of resources, encompassing constituents derived from the Comprehensive CE Framework, the PESTEL Framework, the Smart CE Framework, and the Circular Supply Chain Framework. Through the amalgamation of insights from these frameworks, our bespoke solution endeavors to provide an organized and pragmatic approach for Algerian manufacturing entities to proficiently integrate circular economy principles.

The PESTEL flowchart necessitates calibration in accordance with Algeria's unique contextual requirements. This recalibration entails an initial foundation established by governmental regulations, mandating manufacturers to adopt more sustainable methodologies. Subsequently, there is a need to cultivate a societal shift towards conscientious consumption practices and heightened recycling awareness. The intervention for enhancing environmentally beneficial behaviors is entrusted to the National Waste Agency and related governing bodies, which should strategically implement measures advantageous to both society and manufacturing enterprises. This necessitates legal enforcement, given the pivotal role of regulations in securing compliance. Economically, the government's support for sustainable enterprises through incentives, such as favorable loan terms, assumes paramount importance. Furthermore, the technological dimension impels companies to adopt environmentally sound technologies, with the nation's

trajectory aligning with sustainable technical and logistical resources. Elevating Algeria's expertise and research and development investments towards contemporary advancements is equally indispensable. On the legal front, labor laws

and regulations pertinent to industrial activities warrant enhancement, encompassing aspects like permits, authorizations, and operational requisites.

A fundamental component of our approach entails dividing the product life cycle into four phases:

- Phase 1: Manufacturing
- Phase 2: Distribution
- Phase 3: Utilization.
- Phase 4: Recycling.

For each phase, specific actionable measures aligned with the 9R principles are identified. Additional measures are introduced in the distribution phase to facilitate the realization of a circular supply chain. These 9R principles encompass a range of actions, including refusal of non-essential products, rethinking single-use paradigms, reducing inefficiencies in manufacturing, reusing products, designing for repairability, refurbishing to restore condition, remanufacturing using functional components, repurposing for alternative applications, recycling by altering product form, and recovering unusable materials for energy conversion.

Our study underscores the potential of the circular economy paradigm to harmonize with Algeria's developmental ambitions, simultaneously mitigating pressing environmental challenges. The imperative of tailoring an approach attuned to Algeria's unique circumstances, as exemplified by the "CE Framework for Algerian Manufacturing," underscores our unwavering dedication to realizing efficacious and sustainable circular economy integration within the nation. The manufacturing sector emerges as a central catalyst in this transformative journey, signifying its pivotal role in steering this paradigm shift towards a more sustainable future.

6. Conclusion

The objective of this study was to elucidate the concept of the circular economy within the manufacturing industry and assess the current extent of CE adoption in Algeria's manufacturing sector. We have formulated and proposed a CE implementation framework specifically designed to align with the unique characteristics of Algerian industry and its sustainable objectives.

The implementation of CE, alongside the adoption of green technology, has introduced noteworthy changes in the management of waste, emissions, and valuable organizational resources. Our findings indicate that the incorporation of CE principles is still in its early stages in developing nations.

Algeria has approved a new national strategy, with a horizon extending to 2035, focusing on integrated waste management. This strategic plan aims to address environmental challenges, particularly those related to the circular

economy, and strives to enhance sorting and waste recycling processes. It is essential for Algeria to keep pace with evolving challenges and embrace a comprehensive approach for the future implementation of the circular economy in the manufacturing sector. This entails adopting several mechanisms and requirements: gradual elevation of waste recycling rates, adherence to the "9R" principle as a foundational CE element, reduced reliance on traditional fossil energy sources causing environmental pollution, promotion of renewable and clean energy sources, encouragement of eco-friendly inputs, commitment to producing durable and high-quality goods, and fostering the utilization of waste in energy generation.

Continued efforts should be directed towards the development, testing, and implementation of our proposed framework. Emerging technologies, particularly the Internet of Things (IoT), enable devices to communicate and

achieve diverse goals, such as automated manufacturing, home automation, and smart waste management. The potential of digital technology (DT) in advancing the transition to a circular economy is gaining increasing attention. Implementing DT presents promising avenues for the manufacturing industry, including retrofitting equipment, enhancing workers' efficiency and motivation, creating resource-efficient smart factories, and designing closed-loop manufacturing processes, all of which contribute to CE objectives. This synergy between digital technology and circular economy principles should be further explored and capitalized upon in driving sustainable manufacturing practices.

Abbreviations

- CE: Circular Economy.
- 3R: Reduction, reuse, and recycling.
- 4R: Reduce, reuse, recycle, and recover.
- 9R: Refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, recover.
- NES: National Environmental Strategy.
- NWA: National Waste Agency.
- SMEs: Small and Medium-sized Enterprises
- PESTEL: Political, Economic, Social, Technological, Environmental, and Legal.
- SDGs: Sustainable Development Goals.
- CSC: Circular Supply Chain.
- IoT: Internet of Things.
- DT: Digital technology.

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