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Towards sustainable business: Leading change from the bottom-up

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Abstract

The principles of sustainability and circularity are gaining ground in business, driven by market uncertainty and instability. Although many policies and strategies promote the circular economy from the top-down, there are few tools to help businesses, especially small and medium-sized enterprises, overcome the challenges that hinder its implementation from the bottom-up. This article provides a structured bottom-up framework to accelerate the adoption of initiatives to achieve sustainable goals while transitioning to circularity. It adopts a conceptual framework development using a representation of the circular economy - the funnel metaphor - as a 'method' for exploring sustainability and circularity initiatives. The article categorises specific patterns in which initiatives can support the transition from traditional linear approaches to production and consumption to a more circular approach. By adopting a multidisciplinary and multi-stakeholder approach, this framework introduces a novel way of characterising sustainable and circular initiatives that allows for minimising rebound effects and balancing trade-offs. As a result, companies can better articulate their actions to future-proof their operations and mitigate unsustainable impacts in a context of resource constraints.

Keywords; *sustainability, circularity, bottom-up, framework, small and medium-sized enterprises*

1. Introduction

In recent years, the global business landscape has become increasingly fraught with uncertainty and instability, posing significant challenges to companies worldwide. Issues such as supply shortages, escalating commodity prices, and energy crises have created formidable obstacles for businesses striving to thrive in this volatile environment.

Moreover, the escalating concerns surrounding climate change, pollution, economic inequality, and the depletion of natural resources have galvanised international efforts towards sustainability, exemplified by initiatives like the Sustainable Development Agenda 2023 (United Nation, 2015). This heightened focus on sustainable development has intensified pressure on leading companies to pursue strategies that not only ensure their viability but also foster competitive advantage.

Despite notable advancements aimed at reducing energy consumption, resource intensity, and emissions per unit of production, these efforts have proven insufficient in offsetting the escalating resource use and environmental impacts driven by a burgeoning global population (Bocken et al., 2014). Furthermore, efficiency improvements, while beneficial, may inadvertently exacerbate environmental degradation through the "rebound effect," wherein increased efficiencies at the product level lead to amplified impacts at the macro-level (Harris et al., 2021). In other words, energy and material efficiency can reduce environmental impact, but if the consumption of goods increases beyond a certain level, this benefit may be outweighed by the net impact (Scheel & Bello, 2022).

Consequently, the concept of a circular economy has emerged as a more holistic and sustainable economic paradigm. While sustainability aims to benefit the environment, economy and society as a whole (e.g. Elkington, 1997), the circular economy, rooted in the principles of regenerative systems and resource conservation, seeks to minimize waste and pollution while maximizing resource efficiency (Foundation Ellen MacArthur, 2015). However, the adoption of circular economy principles presents inherent trade-offs, as improvements in circularity may inadvertently elevate environmental impacts across the product life cycle (Thakker & Bakshi, 2021).

Policies, regulations, and strategies at local, regional, and national level promote the top-down CE as a way to balance environmental and social concerns with a rapid economic development (Bigano et al., 2016). Despite this growing policy support for circular economy initiatives, global recycling rates remain dismally low, with only a fraction of minerals, fossil fuels, metals, and biomass being recycled annually (Franco et al., 2021). This underscores the need for a nuanced approach to promoting circularity that transcends top-down mandates and embraces bottom-up initiatives within companies.

In advocating for a bottom-up approach, we underscore two fundamental principles: the aggregation of marginal gains and the multiplier effect. The former emphasises the cumulative impact of incremental improvements, highlighting the transformative potential of modest advancements over time. For example, even marginal reductions in toxic raw materials across product lines can yield substantial environmental benefits when aggregated across a company's operations. The latter principle, rooted in economic theory, posits that small changes in input can catalyze significant transformations in output. By reducing the presence of toxic materials in product designs, companies can substantially lower the costs associated with end-of-life recycling processes.

Transitioning to sustainable and circular business practices can be a formidable challenge, especially for small and medium-sized enterprises (SMEs) that do not have the necessary human and financial resources to implement generic and complex methods internally or through consultants (Prieto-Sandoval et al., 2019). To our knowledge, there is limited work that enables circular economy implementation through a formalised bottom-up approach that integrates proactive measures across different levels of the enterprise and its value chain, and fosters an innovative mindset conducive to sustainable development. Our research bridges this critical gap between research and practice. In this article, we aim to provide a practical framework to expedite the adoption of sustainability practices within companies. By categorising initiatives and actions into three proposed patterns at different organisational levels, this framework aims to facilitate the transition to circularity, thereby enabling companies to future-proof their operations and mitigate non-sustainable impacts amidst resource constraints.

This article is structured as follows: Section 3 presents the theoretical framework. Section 4 elaborates on the resulting patterns. Section 5 presents the discussion and finally the article concludes.

2. Methodology

The methodology used to develop this paper is firstly based on the in-depth study of a recent bibliographic review (Esteban-Amaro et al., 2023). This review focuses on the circularity and sustainability of the photovoltaic sector. We consider it fundamental to understand how the academic community addresses the issues of sustainability and circularity in important industries such as solar energy.

The bibliographic review complies with the guidelines for systematic literature reviews of Marin-Garcia, (2021). A 'state of the art' search is carried out by systematically searching two of the most important scientific databases available: Scopus and Web of Science. In order to ensure that as many papers as possible related to our research topic are included, there are no limitations on publication date and language. A search is carried out by title, abstract and keywords according to the search order in Table 1, yielding a total of 1,033 results.

Table 1. Search string

Scopus	TITLE-ABS-KEY ((("supply chain*" OR "value chain*") AND ("photovoltaic*" OR "solar" OR "pv") AND ("circular economy" OR "CE" OR "sustainable" OR "sustainability" OR "decarbon*")))
Web of Science	Topic ((("supply chain*" OR "value chain*") AND ("photovoltaic*" OR "solar" OR "pv") AND ("circular economy" OR "CE" OR "sustainable" OR "sustainability" OR "decarbon*")))

The results are imported into two Excel files, which are combined to extract the duplicate papers. The following exclusion criteria, related to our objective and refined after a first sampling, are then applied:

- Papers outside the scope that focus on other sectors, deal with renewables in a broad sense or focus on another energy, whether renewable or not, are excluded.

- Papers from outside the EU within the scope are excluded, with the exception of those that are part of the value chain (China), as well as works related to specific applications of photovoltaics, such as building-integrated photovoltaics (BIPV).

Filtering according to the exclusion criteria leads to a total of 149 articles. Finally, the references cited in these articles serve as a second additional source for the analysis. Cross-referencing results in a total of 5 articles being added to the final database, resulting in a total of 154 to be analysed.

For each of these articles, a reading of the summary and conclusions of each of them is carried out in order to discard those that have not been adequately filtered in the previous stages. Of the remaining 148 articles, a complete reading is performed and a first classification is made according to whether they deal with sustainability and/or circularity and/or their evaluation.

This classification makes it possible to structure the articles and better focus the results. In addition, this first reading leads to the grouping of the articles according to 5 research approaches of the scientific community, which are: 1) barriers, risks and opportunities of photovoltaic energy, 2) circularity with a special focus on recycling, 3) sustainability of the supply chain, 4) decision making or evaluation tools and finally 5) critics of solar energy.

As key conclusions, we find that a recurring theme in the academic debate is the lack of a robust methodology for targeting and prioritising initiatives to accelerate the adoption of responsible business practices (Scheel and Bello, 20-22). There is also a notable gap in the effectiveness of sustainable development strategies (Bocken et al., 2016).

To address this pertinent issue, we adopt an action research approach with the dual aims of validating existing methodologies and devising alternative ways to support small and medium-sized enterprises (SMEs) in their transition to circularity. This approach integrates the results of the bibliographic review with over 23 years of experience in operations management by one of the authors, who has led organizational change and strategy implementation projects in seven multinational corporations and small and medium-sized enterprises (SMEs). A qualitative analysis has been performed to identify how existing methodologies can be successfully integrated into real cases, overcoming the barriers and risks identified by academic literature.

The theoretical framework presented in this paper is the result of combining best practices in operations management from seven leading companies in their sectors with the challenges of transitioning to sustainability and circularity in one of the most promising sectors: solar energy.

3. Theoretical Framework

3.1 The Funnel Metaphor

The value chain, a concept defined as a sequence of activities facilitating the movement of a product or service from production to consumption (Porter, M. E. 1985), traditionally operates within a linear economic model characterised by the "take, make, dispose" paradigm. Conversely, the circular economy model advocates for a continuous cycle of resource preservation and regeneration, aiming to optimize resource utilisation and minimise waste (Foundation Ellen MacArthur, 2015). Although the circular economy concept is often depicted through visual representations such as the Ellen MacArthur Foundation's butterfly diagram (see fig 1), we propose an alternative metaphor—the funnel metaphor—to address certain limitations. While not all waste generated along a value chain can be indefinitely reintroduced, opportunities exist to exchange resource flows between different value chains, which can be as valuable for circular economy objectives as the recirculation of resources within the same value chain. The funnel metaphor, bridges these gaps and provides a more nuanced portrayal of the economy (Esteban-amaro et al., 2024).

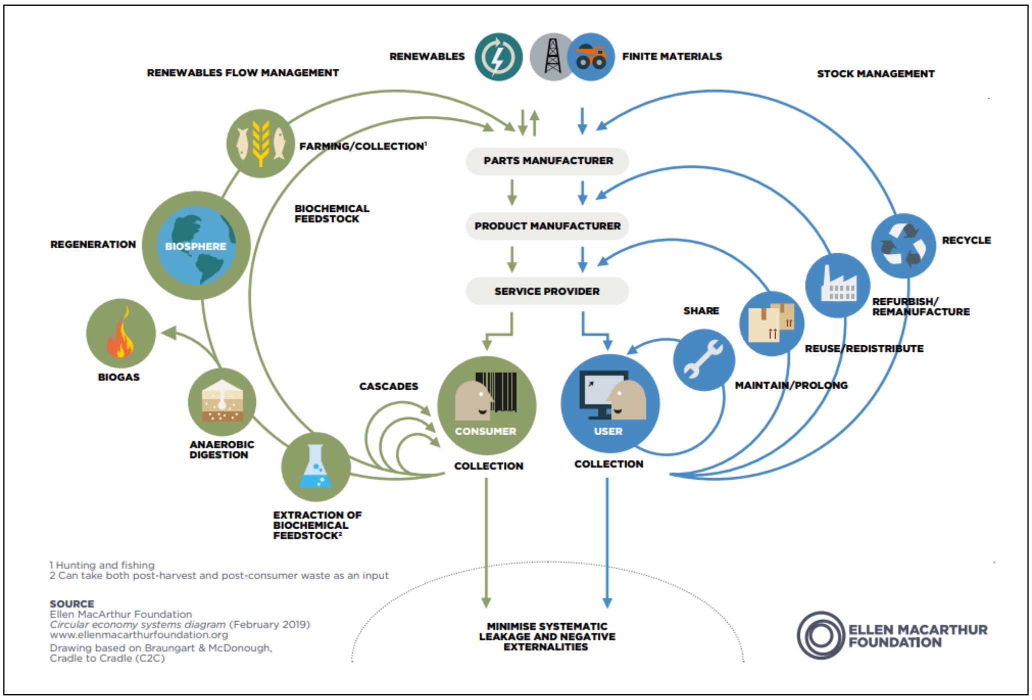


Figure 1. The Ellen MacArthur Foundation butterfly diagram.

The top of the funnel symbolises the inception of a value chain, where significant quantities of resources, including materials, energy, and labour, are utilised. As products progress through various stages of their life cycle, such as production, distribution, utilisation, and end-of-life, the width of the funnel diminishes, reflecting sales, consumption, or waste generation. The outlet at the bottom of the funnel represents the culmination of the process, where waste products exit the system (see fig. 2).

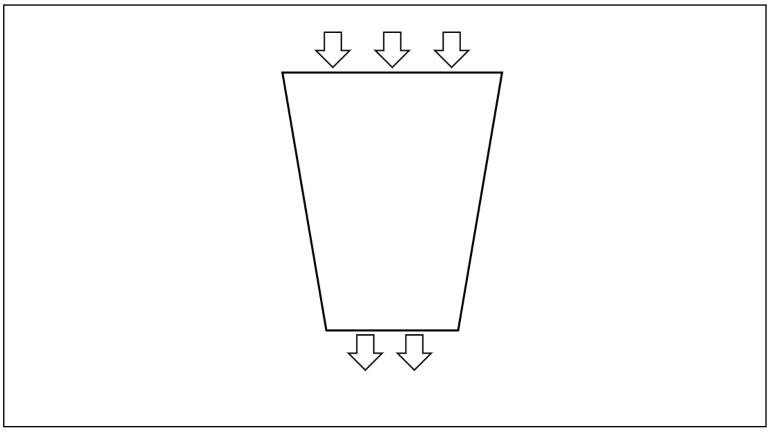


Figure 2. The Funnel metaphor. ***(Source: Author's elaboration)***

Acknowledging the theoretical impossibility of achieving a fully circular system, we align with scholars such as Geissdoerfer et al., (2020), who advocate for viewing the circular economy as a dynamic perspective—a continuous journey towards circularity—rather than an attainable static state devoid of material and energy leakage. To illustrate this evolutionary process, we adopt a three-step configuration of the funnel metaphor, drawing inspiration from the works of Stahel, McDonough and Braungart (Bocken et al., 2016).

Firstly, the optimisation of resources entails reducing the reliance on raw materials and non-renewable energy, depicted by a narrowing funnel representing the transition from the current economic process (in grey in fig. 3a) to an optimised model (in blue in fig. 3a). Secondly, the preservation of product value involves slowing the flow of resources, visualised by extending the length of the funnel while reducing its diameter (see fig. 3b). Finally, the pinnacle of circularity is illustrated through the interconnection of multiple funnels, emphasising the importance of collaborative networks where resources are recycled and repurposed across value chains (see fig. 3c).

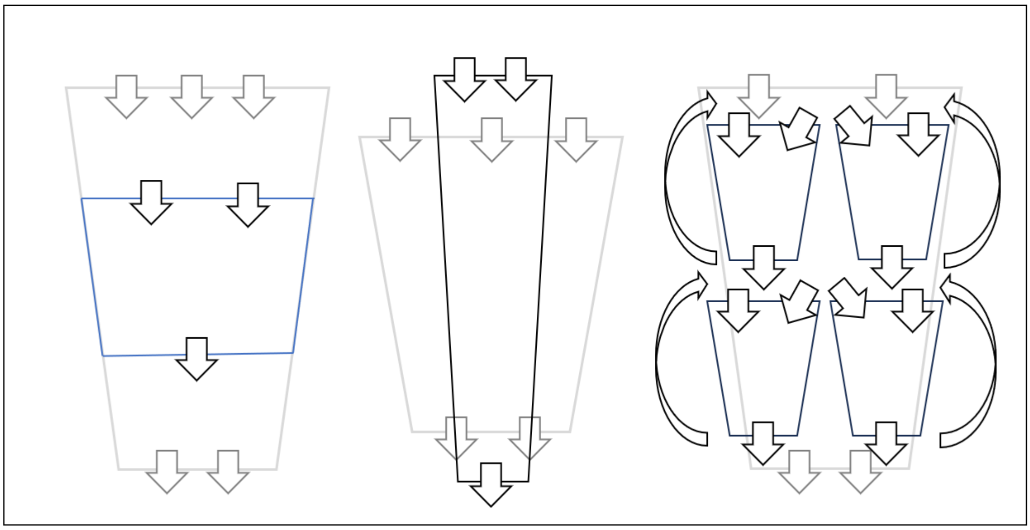


Figure 3. 3a Resource optimisation 3b. Slowing resource flow 3c. Cycling resources
(Source: Author's elaboration)

In essence, a company progresses towards a more sustainable and circular value chain by implementing initiatives that either reduce resource consumption, extend product lifespan, or facilitate resource recycling.

3.2 The pattern categorisation

We classify the initiatives and actions into three distinct patterns. The concept of a pattern, borrowed from design research and architecture, entails a generalised problem-solving approach. As articulated by Alexander and colleagues (Alexander, C. 2018), a pattern identifies a recurring problem in our environment and proposes a core solution that can be applied repeatedly without duplication. The three patterns align with the main impacts of an initiative on the value chain: narrowing, extending, or cycling.

Each pattern is delineated by ten attributes, carefully selected from a multitude of variables to best encapsulate the pattern's characteristics. These attributes, in conjunction with the corresponding funnel metaphor figure, collectively constitute what we refer to as the pattern's concept card. The concept cards for the three patterns are depicted in figure 4a, 4b and 4c.

Value Creation and Delivery: This attribute focuses on how a company creates and delivers value to its customers, encompassing its position in the value chain, key operations, suppliers, partners, and customers. Value creation involves all parts of the business and considers the entire value chain.

Strategy: Strategy refers to the approach adopted by a company to create superior value for customers and outperform competitors. Drawing on the work of Stahel, McDonough and Braungart (Bocken et al., 2016), we identify three main strategies within this attribute:

1. Narrowing resource flows: This strategy focuses on reducing resource use associated with the product and production process, aiming to enhance resource efficiency and minimise waste generation.
2. Slowing resource loops: By designing long-life goods and facilitating product-life extension through repair and remanufacturing, this strategy aims to prolong the utilisation period of products, resulting in a deceleration of resource consumption.
3. Closing resource loops: Through recycling, this strategy seeks to close the loop between post-use and production, fostering a circular flow of resources and reducing dependence on virgin materials.

Target: The target attribute corresponds to the primary objective shared by initiatives within each pattern category. While various objectives may be considered, the target represents the overarching goal driving actions within the pattern.

Focus: The focus attribute characterises each pattern according to one of the three dimensions of sustainability, also defined as the Triple Bottom Line; environmental, economic or social. The environmental dimension of the TBL concept is based on the relationship between the use and the renewal of natural resources. Referring to manufacturing industries, this dimension is manifested only in the use of renewable natural resources with zero emissions. This dimension is therefore linked to the concept of recycling and regeneration of resources. The social dimension refers to all those actions that make it possible to better preserve and contribute to human well-being, social equity and justice. The third economic dimension refers to the ability to create value with a business strategy capable of balancing costs and revenues while ensuring its viability. It includes both the management of the economic and financial performance of the industry (Contini & Peruzzini, 2022).

Level: Actions may take place at micro, meso, or macro levels. The micro level includes products, companies, and consumers. The meso level refers to the development of an eco-industrial network that benefits regional production systems and the environment. Finally, the macro level means acting in global, national, or regional contexts (Franco et al., 2021).

Timing: Timing is the average time that elapses between an action being presented for approval at the appropriate management level and its full implementation within the organisation. Actions related to efficiency are typically short-term, while initiatives to extend product life may require more time for design changes or customer engagement. Recycling actions often entail long-term cooperation and investment.

Leader: The leader attribute identifies the organisational function best suited to spearhead the implementation of specific actions, ensuring alignment with value creation, strategy, and target objectives. Successful implementation is highly dependent on the leader's ability to lead and manage organisational change. Leaders who are motivated and attracted by sustainable value propositions will be better able to change behaviours and mindsets.

Technology: Technology plays a crucial role in enabling circularity, particularly in product design and manufacturing processes. Innovative technologies can enhance resource efficiency and facilitate closed-loop systems. Design stage is recognised to influence up to 80% the sustainability performance of products (Benini et al., 2022).

Ratio: The ratio attribute serves as a mechanism for measuring and communicating the positive impacts of implemented actions and their beneficial impacts created within the life cycle of products, services, processes, companies, organisations or individuals. It quantifies positive changes or benefits relative to input resources, fostering transparency and accountability. The positive change, also called a handprint, can be created either by preventing or avoiding negative impacts (footprints), or by creating positive benefits that would not have occurred. Generating handprints is about actions that increase sustainability and well-being and reduce harmful activities and impacts on people and the planet (Pajula et al., 2017). We seek to communicate positive changes throughout the value chain, from factories to customers, by using an output/input ratio. The nominator is a useful output from the value chain, that coincides with the positive change or benefit achieved within the organisation. The dominator can be of two main types, depending on whether the positive change is the result of creating a positive benefit or avoiding a negative impact. The first type of dominator is an inventory flow, such as natural resources, industrial resources, waste or emissions. The second type of dominator corresponds to the footprint avoided by the positive change (Moraga et al., 2022).

Critical Aspect: This attribute identifies the most critical aspect to monitor in order to facilitate the implementation of actions that, together with factors such as compliance with internal governance, external regulations, financial resources and support from sustainability experts, will lead to a successful transition to circularity and sustainability.

Overall, these attributes provide a structured framework for analysing and implementing sustainability and circularity initiatives within organisations. They encompass various dimensions and levels of action, highlighting the multifaceted nature of sustainable business practices.

The three patterns outlined in this section progress from an eco-efficiency approach in the first pattern to an eco-effectiveness approach in the third. Eco-efficiency involves minimising and dematerialising material flows by reducing their volume, velocity, and toxicity (Kalmykova et al., 2018). In contrast, eco-effectiveness focuses on transforming products and their associated material flows to establish a supportive relationship with ecological systems and future economic growth. The aim of transitioning to a circular economy is not simply to minimise the linear flow of materials from “cradle to grave”, but to create cyclical, “cradle-to-cradle” metabolisms that enable materials to maintain their status as resources (Foundation Ellen MacArthur, 2015).

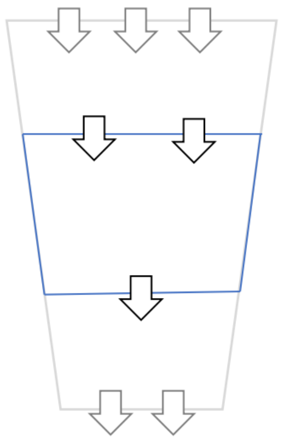
Although a purely efficiency-oriented approach may seem contradictory to the principles of circularity, many companies have spent decades optimising forward supply chains that follow a linear "cradle-to-grave" model (Lüdeke-Freund et al., 2019). However, there is now a growing interest in enhancing reverse flows and establishing more circular production or "cradle-to-cradle" systems, which poses significant challenges, especially for small and medium-sized enterprises (SMEs).

These three patterns collectively integrate the sustainability principles of responsible production and consumption by achieving more with less, decoupling economic growth from environmental degradation, increasing resource efficiency, and promoting sustainable lifestyles (Johnston, 2016). They offer a simple and accessible framework for application.

4. Results

4.1. Pattern A. Resources optimisation

Pattern A, as illustrated in figure 4a, is centred on the concept of resource optimisation. This leads to a streamlined value chain characterised by fewer entry and exit points, resembling a funnel. Optimisation is not just about reducing resources but also about severing the link between resource scarcity and economic activity. This is achieved by using resources that regenerate for productive use or are directly sourced from bio-materials. These sustainable resources can be continuously replenished, contributing not only to efficiency but also to perpetual availability.



VALUE CREATION:	Increase value per production unit
STRATEGY:	**Resource optimisation**
TARGET:	Efficiency and risk mitigation
FOCUS:	Economic
LEVEL:	Micro level
TIMING:	Short Term
LEADER:	Production function
TECHNOLOGY:	Design for eco-efficiency and eco-design
CRITICAL:	Supply disruptions
RATIO:	output/resources

Figure 4a. Concept card: Pattern A. Resource optimisation. ***(Source: Author's elaboration)***

Value creation, on the other hand, focuses on increasing the value per unit of output. It involves achieving more with less, mainly at the micro level. Strategies like lean management, eco-efficiency, zero waste, and cleaner production aim to reduce resource usage and waste, thereby improving resource efficiency. This pattern, akin to the Bocken et al., (2014) archetype, seeks to reduce the environmental impact of industry by decreasing the demand for energy and resources, thus lessening primary extraction, resource depletion, and waste and emissions (including waste to landfill, CO_2, and other pollutants). As a result, it contributes to an overall reduction in resource consumption.

Similarly, industrial symbiosis is a process-oriented strategy occurring at both process and product levels. It primarily focuses on converting waste outputs from one process into feedstock for another process or product line (Islam et al., 2022).

In addition to enhancing efficiency, this pattern aims to stabilise supply chains by reducing volatility and bolstering security of supply. This entails a shift towards using fewer new materials and more recycled inputs, which may involve higher labour costs. By adopting this approach, companies can mitigate the impact of fluctuating prices and maintain operations even amidst challenges like natural disasters or political disruptions, as decentralised operators offer alternative material sources (Foundation Ellen MacArthur, 2015).

Pattern A significantly impacts the economic dimension of sustainability, enabling companies to save costs or boost profit margins through pollution reduction, decreased reliance on primary materials, fostering industrial symbiosis, and facilitating the sharing of underutilized assets and skills. Moreover, it fosters innovation, driving higher rates of technological advancement and enhancing material, labour, and energy efficiency, thereby increasing companies' chances of success.

This pattern is supported by emerging technologies such as eco-design and eco-efficiency, which aid in producing goods with fewer resources. Common approaches include minimising raw material and energy usage, recycling waste and energy generated during the production process, and adopting renewable energy sources and recycled materials. Most initiatives associated with this pattern can be implemented in the short term, fuelled by the compelling economic benefits they offer.

The production function at the product/process interface appears to be the most suitable to drive this pattern's implementation. However, it's crucial to prevent supply disruptions resulting from resource optimisation changes from causing significant issues for ongoing processes, potentially hindering or halting initiative implementation.

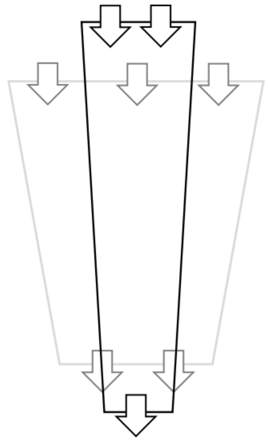
The most effective metric for evaluating the outcomes of these pattern actions is resource efficiency, which gauges the attainment of greater benefits or outputs with fewer resources or inputs. This ratio compares the value of output as the numerator against resource consumption as the denominator.

The strategy of "doing more with less" represents the initial and most commonly employed approach for enhancing competitive advantage. However, it primarily serves to mitigate the adverse effects of inadequate design, rather than fully capitalising on the innovation prospects presented by the subsequent two patterns for sustainable development (McDonough & Braungart, 2003).

A clear example of this is the action taken by the REC Group, which has eliminated lead from all solar module components, including cell connections, cross connectors, and junction box soldering. Eliminating lead from all components not only enhances the circularity of the photovoltaic modules, it also enables a minimal environmental footprint (Benchmark, n.d.).

4.2. Pattern B. Slowing resources flows

Pattern B, depicted in figure 4b, corresponds to slowing resource loops, characterised by an increase in funnel length and a decrease in diameter. Two main ideas drive this pattern. Firstly, it aims to prolong the economic lifespan of products, allowing them to satisfy more demand and provide greater benefits without requiring additional resources. Secondly, it seeks to minimise the idle time of products in the market, thereby increasing the number of users benefiting from the same volume of goods.



VALUE CREATION:	Retain product value
STRATEGY:	**Slowing resource flow**
TARGET:	Customer engagement
FOCUS:	Social
LEVEL:	Meso level
TIMING:	Medium Term
LEADER:	Marketing function
TECHNOLOGY:	Design for durability, standardisation, maintenance and repair
CRITICAL:	Consumer education as user
RATIO:	output/resources (over time)

Figure 4b. Concept card: Pattern B. Slowing resource flows. ***(Source: Author's elaboration)***

The value created and delivered in this pattern revolves around retaining the value of the product. Unlike Pattern A, where value creation is straightforwardly tied to the processing of raw materials into sellable products, assessing the "value retained" of a used product, its components, and materials requires a novel understanding of value creation that integrates both value added and value retained (Lüdeke-Freund et al., 2019).

Strategies for extending product life include repair and maintenance, reuse and redistribution, and refurbishment and remanufacturing. This leads to the creation of durable or reusable products, enhancing both financial budgets and quality of life. For customers, overcoming premature obsolescence results in significantly reduced total cost of ownership and increased convenience by avoiding repair hassles and returns (Foundation Ellen MacArthur, 2015). However, it requires a heightened level of engagement with how customers use and dispose of products, shifting revenue generation from selling physical products to providing access or optimising performance along the entire value chain (Accenture Strategy, 2014).

The objective of this pattern is to shift the focus from product ownership to functionality, viewing customers as users rather than mere consumers. Emphasis is placed on the social dimension of sustainability, improving customer service, and enhancing the quality of activities, resources, and partnerships. Sustainability thus becomes a distinguishing element of corporate reputation and a (green) marketing feature, fostering customer loyalty and increasing brand value (Rosa et al., 2019).

The actions within this pattern extend across multiple organizations and their material and immaterial flows, occurring at the meso level. Services for reuse, repair, and remanufacturing require a segmentation of business activities, often best suited for localised areas accessible to both customers and end-of-life specialists who can maintain product quality (McDonough & Braungart, 2003).

Establishing a network of local and regional partners and engaging customers as users rather than consumers requires a medium-term timeframe and should be driven by marketing efforts. Understanding diverse market needs and effectively changing behaviours and mindsets are critical for customer engagement. Educating customers about their role as users is paramount for successful implementation.

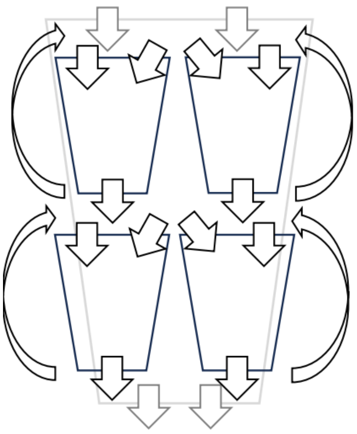
The slowing resource loops pattern can be supported by technologies focused on design for durability, standardisation, re-assembly, maintenance, and repair. This includes design innovations aimed at maximising value retention, such as modular customisation allowing for multiple product uses.

Pattern B seeks efficiency, but unlike Pattern A, it evaluates efficiency over time. This time perspective can easily be incorporated into existing ratios by correlating the result with the product's lifetime, number of uses, or consumption levels.

Following the example of photovoltaic modules, Covestro's Solar Coatings Solutions BV (formerly DSM Advanced Solar) applies an anti-reflective coating to the cover glass of older solar parks in Europe (especially pre-2013), which immediately increases the energy yield of the modules (~3%) without having to dismantle them or disconnect the park from the grid (Benchmark, n.d.).

4.3. Pattern C. Cycling resources

This pattern of closing resource loops (see fig. 4c) aims to minimise the loss of resource value within a value chain by recuperating and integrating waste outputs as useful inputs into subsequent production processes, whether within the same value chain or across others. It necessitates connecting the downstream and upstream ends of value chains, requiring comprehensive reverse logistics organisation linking users, raw material suppliers, and parts manufacturers. Value creation processes based on this cascading process rely on the extraction and recovery of biological nutrients contained in product components, used materials, and waste. Similarly to the previous pattern, assessing the "retained value" of a used product, its components, and materials requires a new understanding of value creation that integrates both value added and value retained (Lüdeke-Freund et al., 2019).



VALUE CREATION:	Retain material value
STRATEGY:	**Cycling resources**
TARGET:	Collaboration agreement
FOCUS:	Environmental
LEVEL:	Macro
TIMING:	Long Term
LEADER:	Supply Chain function
TECHNOLOGY:	Design for dis-assembly, end of life sorting and recyclability
CRITICAL:	Data reliability
RATIO:	output/footprint

Figure 4c. Concept card: Pattern C. Cycling resources. ***(Source: Author's elaboration)***

Value is no longer generated solely by companies acting autonomously, but by companies collaborating through informal arrangements or formal alliances (Bocken et al., 2014). It entails constructing a value network of motivated stakeholders contributing to economic viability, environmental enhancements, social issues, and the resolution of long-term business challenges. This involves partnering with stakeholders along the value and supply chain, enabling the regeneration and restoration of natural capital through closed loops (Foroozanfar et al., 2022).

Strategies included in this pattern necessitate a systems perspective, interlinking at regional, national, or global levels and participation in reverse logistics networks or other systems (Foundation Ellen MacArthur, 2015). Recycling and using recovered or recycled materials result in a circular flow of resources. A distinction is made between “upcycling” and “downcycling”. While “upcycling” focuses on maintaining or improving material properties, “downcycling” involves reprocessing material into a “low” value product. Some authors argue that downcycling only delays the linear flow of resources from production to waste and emphasise maintaining material quality in a circular process (Bocken et al., 2016). However, we consider both as part of this pattern, differentiating between “cradle to gate” and “cradle to cradle” initiatives, although ideally, upcycling returns to a purer circular flow of resources.

Circularity necessitates rebalancing the current geographical layout of networks to effectively circulate products and materials while enhancing resilience and reducing emissions. Thus, fostering networks becomes the primary focus. Ideally, meso-level actions will strengthen a network of local or regional partners capable of responding more rapidly and effectively to the demand for circular inputs and processes, facilitating cost-effective and low-emission circulation of products and materials in local markets. However, if value chains are to be linked, macro-level actions are necessary to foster global networks that can better respond to unforeseen disruptions in local supply chains by providing access to alternative flows of circular inputs (Hassiotis, 2020). Establishing this global network requires a long-term timeframe and can be led by the supply function, which is already responsible for the majority of suppliers and partnerships.

Technologies supporting this pattern include design for disassembly, manufacturing, sorting, end-of-life, recycling, traceability, and transparency. These technologies consider potential beneficial applications of by-products and waste and help ensure that a product can be reused. Designing products using virgin and high-quality materials also promotes recyclability.

Primarily focusing on the environmental dimension of sustainability, the central concern can be expressed as a ratio: output or intended benefit divided by the environmental impacts generated (footprints).

The availability and reliability of data are crucial for the success of this pattern, as it involves multiple actors and generates multidirectional flows of resources and information (Hassiotis, 2020). Traceability and transparency of information along a circular value chain enhance confidence in multidirectional flows, facilitating the sourcing of circular inputs by making it easier to identify their availability and access information on the material composition and quality of an item. This, in turn, increases trust among partners, fostering transformative collaboration towards more ambitious circular value chains.

To finish with the solar value chain example, Fronius, an Austrian inverter manufacturer, has reduced its carbon footprint by using more than 90% recycled aluminium in the main metallic component of the inverter (Benchmark, n.d.).

The most desirable outcome for a company arises from the combination of three pattern actions, which minimises rebound effects and balances trade-offs. This integrated approach functions as a feedback system, where the positive outcomes of implemented actions reduce the investment needed to implement others that would be discarded if addressed in isolation. Aligning value chains with these patterns contributes to the objective of decoupling global economic development from finite resource consumption. The transformation mindset permeates the organisation, driving change and raising awareness to facilitate the successful adoption of a more global, sustainable, and circular economic model. Additionally, companies are preparing for an anticipated increase in environmental legislation, which professionals need to be vigilant about as it affects their day-to-day operations and poses risks (Sustainability, 2023).

5. Discussion

The categorisation of patterns presented in this article is rooted in the fundamental principles of sustainability and circularity. Sustainability, as defined by the Brundtland Commission, involves development that meets present needs without compromising the ability of future generations to meet their own needs (Brundtland, 1987). It encompasses environmental preservation, economic prosperity, and social equity (e.g., Elkington, 1997), with a focus on aligning stakeholder interests toward sustainability goals.

The circular economy, as outlined by the UNEP, is among the current sustainable economic models where products and materials are designed for reuse, remanufacture, recycling, or recovery to prolong their lifespan within the economy (UNEP/EA.4/Res.1). This model aims to minimise waste generation, especially hazardous waste, while preventing or reducing greenhouse gas emissions.

While many conceptualizations of the circular economy prioritise economic benefits and overlook the social dimension, the pattern categorisation in this article aims to provide a more comprehensive and holistic view (Geissdoerfer et al., 2017). It acknowledges the historical roots of circularity, which have manifested in various forms throughout human history, from traditional sustainable consumption practices driven by nature's carrying capacity to modern-day circular industrial economies (Stahel, W.R., 2020).

By categorising patterns that integrate sustainability and circularity principles, this approach bridges the gap between economic, environmental, and social dimensions. It recognises that the circular economy is not an end in itself but rather a means to achieve greater sustainability outcomes when combined with other strategies. Emphasising a "going circular" approach, this framework acknowledges the dynamic nature of sustainability challenges and seeks to manage externalities such as pollution and climate change while addressing the uncertainties of global markets. Ultimately, it advocates for a balanced and integrated approach to sustainability that considers the interplay between economic, environmental, and social factors.

The limitations of this study primarily stem from the novelty of the approach employed. While the article presents a robust theoretical framework, its credibility and applicability could be further enhanced by incorporating real-world case studies or empirical data. Additionally, future research could benefit from including examples of companies or industries that have successfully implemented the proposed framework, thereby offering valuable insights for practitioners.

Moreover, involving stakeholders from diverse sectors, including businesses, governments, and non-profit organisations, in the development and validation of the framework could enrich its content and increase its relevance and acceptance within the broader community.

Lastly, an extension of this work could involve integrating insights from other fields such as sociology, psychology, and political science, given the interdisciplinary nature of sustainability and circular economy initiatives. This holistic approach has the potential to provide a more comprehensive understanding of the complexities involved in promoting sustainability.

6. Conclusions

The main contribution of this article is to assist small and medium-sized enterprises (SMEs) by providing practical insights aiming to integrate sustainability practices into their operations.

The framework presented in this article offers a structured bottom-up approach to understanding and implementing sustainable practices in the context of the circular economy. By categorising initiatives into three distinct patterns - optimising resources, slowing resource loops and closing resource loops - this framework provides clarity and guidance for organisations seeking to integrate sustainability principles into their operations, while fostering a change mindset within the organisation.

Each pattern addresses different aspects of sustainability and circularity, ranging from resource efficiency to product life extension and waste reduction. By recognising the interconnectedness of economic, environmental, and social factors, these patterns offer a holistic approach to sustainable development.

Furthermore, the framework emphasises the importance of collaboration and innovation in driving sustainable change. Whether through lean management practices, product redesign, or building networks of local partners, organisations can leverage various strategies to achieve their sustainability goals.

Moreover, this approach highlights the need for a dynamic perspective on sustainability, one that adapts to changing market conditions and evolving societal needs. By embracing a "going circular" mindset, organisations can navigate uncertainties and mitigate risks while contributing to global sustainability efforts.

Overall, the framework presented here serves as a valuable guidance for organisations, especially small and medium-sized enterprises (SMEs), looking to transition towards more sustainable and circular business models. By integrating sustainability principles into their operations, businesses can not only reduce their environmental footprint but also enhance their resilience, competitiveness, and long-term viability in a rapidly changing world.

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Conflict of interests

Authors declare no conflicts of interest.

Author Contributions

Rosa Esteban-Amaro: Conceptualization, Methodology, Formal Analysis, Investigation, Writing - Original Draft, Writing - Review & Editing. Sofia Estellés-Miguel: Formal Analysis, Supervision, Validation. Ismael Lengua: Supervision, Validation.

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