Comparison of Linear and Circular Economy and Their Impact on the Product Life Cycle

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Abstract

This article analyzes the differences between the linear and circular economy, focusing on their impact on the product life cycle. It explores how each of these economic models influences the environmental and economic aspects of the product cycle, emphasizing the stages of production, use, and disposal. The linear economy, based on the traditional "take-make-dispose" model, often leads to resource depletion and environmental harm, with limited opportunities for material reuse and recycling. In contrast, the circular economy prioritizes resource efficiency, waste reduction, and the reuse of materials, aiming to close material loops and promote sustainability throughout the product life cycle. The article compares the advantages and disadvantages of both models, assessing their implications for environmental conservation and economic sustainability. Through a SWOT analysis, the study identifies the strengths of the circular economy, such as its potential for reducing waste, creating new job opportunities in recycling and repair, and fostering long-term cost savings. However, challenges such as higher initial investments and the need for stronger regulatory support are also discussed. The linear model's weaknesses, including its reliance on finite resources and its contribution to pollution and environmental degradation, further highlight the need for its transformation. This article concludes that transitioning from a linear to a circular economy is crucial for achieving sustainability. By adopting circular principles, businesses can not only minimize their ecological footprints but also enhance economic growth, improve competitiveness, and align with the growing consumer demand for environmentally responsible practices.

Keywords: *linear economy; circular economy; product life cycle; sustainability; environmental impact*

Content

Introduction

Currently, the world faces serious environmental and economic problems that are a consequence of the traditional linear economic model. This model, also known as the "take-make-dispose" approach, focuses on maximizing production and consumption while ignoring the negative impacts on natural resources and the environment (Ellen MacArthur Foundation, 2013)[1]. With the growing number of inhabitants and consumers worldwide, it is evident that such an approach is no longer sustainable (Murray et al., 2017)[2]. On the other hand, the circular economy offers an alternative model that emphasizes closing material loops, efficient resource use, and waste reduction (Geissdoerfer et al., 2017)[3]. In order to better understand the advantages and limitations of these two models, a SWOT analysis was conducted to assess their respective strengths, weaknesses, opportunities, and threats (Hill et al., 2014)[4]. The aim of this article is to compare linear and circular economies, with a particular focus on their impacts on the product life cycle. The article will discuss the individual stages of the product life cycle in both economic models and their environmental and economic consequences (Bocken et al., 2014)[5].

Materials and methods

The analysis of the impact of linear and circular economies on the product life cycle employed a literature review and comparative analysis method. Sources were obtained from scholarly articles, reports, books, and research studies that address sustainability issues, environmental impacts, and innovations in recycling and waste valorization. Specific criteria included publications from the last ten years to ensure the currency and relevance of the information.

In addition to the literature review, a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis was conducted for both the linear and circular economy models (Gürel & Tat, 2017)[6]. This analysis aimed to assess the internal and external factors that influence the performance and sustainability of both models. The SWOT analysis was based on key performance indicators such as resource efficiency, environmental impact, and economic viability. Quantitative data on waste, emissions, and resource efficiency in both models were utilized for the analysis, as well as the qualitative aspects derived from the literature.

To support the SWOT evaluation, a weighted scoring approach was used to compare individual factors within each model. Each factor was assigned a performance score (ranging from 1 to 5) based on its impact as described in the literature, and a relative weight (0 to 1) indicating its significance. These scores were derived from repeated findings in peer-reviewed research and informed author judgment. While the values are not based on primary empirical research or expert surveys, they reflect synthesized trends and common conclusions found in the literature (e.g., Geissdoerfer et al., 2017; Haas et al., 2019; Bocken et al., 2016)[3, 5, 7]. This semi-quantitative method was chosen to create a clear and structured comparison framework. However, the approach carries a degree of subjectivity, and future studies may improve its robustness by applying empirical validation or expert-based methods.

A comparative analysis was also applied to systematically evaluate both models across selected sustainability and economic indicators. This comparison involved the structured examination of qualitative and semi-quantitative aspects, including life cycle phases, environmental impacts, and strategic potential. The aim was to clarify the differences and identify the areas where circular approaches offer improvements over linear ones.

The aim of this analysis is to identify the main differences between linear and circular economies and to understand how each model affects the various stages of the product life cycle. Quantitative data on waste, emissions, and resource efficiency in both models were also utilized for the analysis.

Product life cycle in linear and circular economy

The product life cycle (PLC) is a critical concept in understanding the environmental and economic impacts of product manufacturing and consumption. Traditionally, the linear economy has dominated, where products follow a “take-make-dispose” approach, resulting in high resource consumption, waste, and environmental degradation. In contrast, the circular economy presents a sustainable alternative by emphasizing the reuse, repair, and recycling of materials, creating a closed-loop system that minimizes waste and optimizes resource use. This section will explore the differences between these two models, focusing on their respective impacts throughout the various stages of the product life cycle, and evaluate how each model contributes to or mitigates environmental and economic challenges (Geissdoerfer et al., 2017)[3].

Linear Economy

In a linear economy, a product has a limited life cycle characterized by a "take-make-dispose" model. This model progresses through four fundamental phases: raw material extraction, production, consumption, and disposal (Bocken et al., 2016)[5]. Following the phases of production, distribution, and consumption, the product is disposed of, often through landfilling or incineration. This approach results in excessive resource waste and high environmental costs, as it generates significant amounts of waste that can be challenging to recycle. This linear progression is illustrated in Figure 1.

During the raw material extraction phase, resources are extracted with minimal regard for environmental consequences, contributing to land degradation and resource depletion (Lehner et al., 2019)[8]. According to a report by the European Environment Agency (2020)[9], over 2 billion tons of waste are generated globally each year, with the majority stemming from linear economic practices. In the production phase, raw materials are transformed into finished products; however, this process often overlooks the principles of resource efficiency. For example, in the automotive industry, it is estimated that the production of a single vehicle generates an average of 20 tons of waste (Geissdoerfer et al., 2017)[3].

Consumption focuses on short-term needs and a preference for disposable products, which leads to significant waste and pollution problems (Murray et al., 2017)[2]. The linear model promotes a culture of consumption that emphasizes quantity over quality, ultimately resulting in unsustainable practices that not only deplete natural resources but also exacerbate environmental issues. The lack of incentives for recycling and reusing materials further entrenches this wasteful cycle, highlighting the urgent need for a transition to more sustainable economic models that prioritize the circular economy.

Figure 1: The phases of the product life cycle in a linear economy

This model's reliance on finite resources and its consequent environmental impact underscore the necessity for a systemic shift toward sustainable practices that prioritize resource conservation, waste reduction, and long-term ecological balance.

Circular Economy

In contrast, the circular economy aims to transform traditional linear processes into a closed-loop system. This model focuses on the design of products that are durable, repairable, and recyclable (Bocken et al., 2016)[5]. The life cycle phases in a circular economy encompass design for longevity, recycling, repair, and the reuse of materials (Wright et al., 2016)[10]. This approach has the potential to reduce environmental burdens as fewer resources are depleted and less waste is produced. Moel of circular economy is illustrated in Figure 2.

The circular economy emphasizes the efficient use of existing resources through strategies such as reuse and recycling. Many companies are striving to harness renewable energy sources and innovative technologies that minimize waste production (Haas et al., 2019)[7]. By integrating sustainability into their operations, businesses can not only comply with regulatory demands but also cater to the growing consumer preference for eco-friendly products.

Figure 2: Phases of the product life cycle in a circular economy

In the final phase, recovery and recycling, the circular economy focuses on collecting and processing materials to regenerate resources. This contributes to reducing ecological footprints and fosters innovation and sustainability through the creation of new business models (Korhonen et al., 2018)[11]. For instance, companies can implement take-back programs that encourage consumers to return used products, which can then be refurbished or recycled into new items. This practice not only helps conserve natural resources but also promotes a circular economy mindset among consumers.

Moreover, the circular economy fosters collaboration among various stakeholders, including manufacturers, consumers, and policymakers. By working together, these groups can create a supportive environment for sustainable practices, encouraging investment in circular solutions and reducing regulatory barriers.

In summary, the circular economy represents a paradigm shift that not only addresses the limitations of the linear model but also presents opportunities for sustainable growth and innovation. By prioritizing resource efficiency and waste reduction, the circular economy paves the way for a more sustainable future that benefits both the environment and the economy.

Environmental and economic aspects

In analyzing the impacts of linear and circular economic models, it is crucial to consider both environmental and economic factors. The environmental consequences of production and consumption practices are significant, with both models contributing to and mitigating ecological degradation in different ways. Similarly, the economic implications extend beyond short-term profit and immediate costs, influencing long-term sustainability, resource efficiency, and innovation. This section will explore both the environmental and economic aspects of each model, highlighting the benefits and challenges of transitioning to more sustainable practices (Tukker, 2015)[12].

Environmental Aspects

The environmental impact of economic models is perhaps the most urgent issue facing societies today. Linear economies often contribute to resource depletion, pollution, and ecosystem degradation, whereas circular economies offer solutions that focus on sustainability, waste reduction, and efficient resource use. This section will explore the significant environmental challenges posed by linear models and the potential for circular economies to alleviate these pressures (Bocken et al., 2016)[5].

Linear Economy and Environmental Impact

The linear model of production and consumption has a significant negative impact on the environment. The continuous extraction of raw materials leads to deforestation, loss of biodiversity, and greenhouse gas emissions (Lehner et al., 2019)[8]. For instance, mining activities can devastate ecosystems, while industrial agriculture contributes to soil degradation and water scarcity. Additionally, the production of waste, particularly non-recyclable materials, contributes to pollution of soil, water, and air (Ellen MacArthur Foundation, 2013)[1]. Landfills emit methane, a potent greenhouse gas, and contaminated water runoff from these sites can severely affect surrounding communities and wildlife. This model's focus on short-term gains and high consumption rates disregards the long-term sustainability of the planet's resources.

Circular Economy and Its Environmental Benefits

Transitioning to a circular economy can significantly reduce environmental burdens. Recycling materials, extending product lifespans, and effectively utilizing resources lead to reductions in emissions and energy consumption (Haas et al., 2019)[7]. For example, recycling aluminum saves up to 95% of the energy required to produce new aluminum from raw materials. This approach also alleviates pressure on natural ecosystems by minimizing the need for the extraction of new resources. Moreover, initiatives like urban mining, where materials from old products are recovered, can contribute to sustainability goals while reducing dependence on virgin resources. The circular economy not only promotes environmental sustainability but also fosters a culture of responsibility and stewardship towards natural resources.

Economic Aspects

Economically, both the linear and circular economy models present distinct advantages and challenges. The linear economy, with its emphasis on efficiency and cost-cutting in the short term, contrasts with the long-term financial benefits that can be realized by embracing circular practices. This section will examine the economic implications of both systems, including their impact on resource efficiency, innovation, and job creation (Geissdoerfer et al., 2017)[3].

Economic Efficiency of the Linear Economy

In the short term, the linear model may be more advantageous for certain sectors as it minimizes costs associated with research and development for new solutions aimed at reusing materials (Bocken et al., 2016)[5]. This model allows businesses to operate at lower immediate costs, potentially increasing profit margins. However, this approach does not account for external costs in the long term, such as environmental damages that can become significant financial burdens for society (Murray et al., 2017)[2]. These hidden costs may manifest in the form of increased healthcare expenses due to pollution-related illnesses, loss of ecosystem services, and government expenditures on waste management.

Economic Benefits of the Circular Economy

The circular economy can provide long-term economic advantages. It reduces costs associated with raw materials, supports innovation, and creates new jobs in recycling and repair industries (Wright et al., 2016)[10]. For instance, businesses that implement circular principles often find opportunities to develop new markets for refurbished goods. Despite higher initial investments required for developing sustainable products and processes, long-term savings and environmental benefits can contribute to economic stability and competitiveness (Haas et al., 2019)[7]. Furthermore, the circular economy can enhance brand reputation, attracting consumers who are increasingly concerned about sustainability, thus driving sales and fostering loyalty.

Comparison of the Impacts of Both Economic Models

When comparing the impacts of linear and circular economies, it is evident that the circular model offers a more sustainable approach to production and consumption. The linear economy, while historically prevalent, fails to facilitate the efficient use of resources and contributes to ecological issues that are becoming increasingly urgent. This traditional model, often characterized by a "take-make-dispose" mentality, promotes overconsumption and waste generation, leading to significant environmental degradation.

For instance, the extraction of raw materials in the linear model often results in habitat destruction and increased carbon emissions. Furthermore, the lack of emphasis on recycling and resource recovery means that valuable materials are frequently discarded, contributing to the depletion of natural resources and escalating landfill problems (Ellen MacArthur Foundation, 2013)[1]. This cycle of consumption and disposal not only harms the environment but also poses long-term economic risks, as resource scarcity can drive up costs and destabilize markets (Murray et al., 2017)[2].

In contrast, the circular economy represents an innovative paradigm that takes into account the entire life cycle of products. It emphasizes reducing waste and conserving resources by promoting practices such as recycling, reusing, and refurbishing materials. This approach fosters a closed-loop system where products are designed for durability and end-of-life disassembly, allowing for materials to be reclaimed and reintegrated into the production process (Bocken et al., 2016)[5]. As a result, the circular economy not only mitigates environmental impacts but also enhances resource efficiency and economic resilience.

Moreover, transitioning to a circular economy can lead to new economic opportunities. By adopting circular principles, companies can innovate their business models, reduce dependency on finite resources, and engage consumers in sustainable practices. This shift not only benefits the environment but can also enhance brand loyalty and attract a growing market segment that prioritizes sustainability (Wright et al., 2016)[10].

Ultimately, the comparative analysis highlights that while the linear economy may provide short-term economic gains, it is the circular economy that offers a viable pathway towards long-term sustainability, environmental protection, and economic stability. Adopting circular practices is crucial in addressing the pressing challenges of resource depletion and environmental degradation that our society faces today.

SWOT Analysis of Linear and Circular Economies

To further illustrate the differences between the linear and circular economic models, a SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) has been conducted. This analysis provides a structured overview of the internal and external factors influencing each model, highlighting their respective advantages, limitations, potential opportunities, and challenges (Kotler & Keller, 2016)[13].

SWOT Analysis of the Linear Economy

The linear economy, characterized by the "take-make-dispose" approach, has been the dominant model for decades. Its strengths include straightforward implementation and low initial costs, but it faces significant challenges related to sustainability.

The SWOT analysis of the linear economy (Table 1) highlights its foundational characteristics, practical strengths, and substantial challenges. The linear model, based on the "take-make-dispose" paradigm, has long been the dominant economic framework across numerous industries due to its simplicity, low initial investments, and clearly defined processes. It benefits from established supply chains, fast time-to-market, and short-term profitability, making it attractive especially in traditional production systems.

Table 1: SWOT analysis of the linear economy

Strengths	**Weakness**
Simple and well-established processes.	High dependence on non-renewable resources.
Low initial investments in infrastructure.	Excessive waste generation and environmental pollution.
Existing supply chain and market mechanisms.	External costs of environmental degradation.
Fast time-to-market and adaptability in production.	Short product lifecycles with minimal reuse or recycling.
Clear cost structures and pricing models.	Limited incentives for innovation in sustainability.
Opportunities	**Threats**
Implementation of policies to reduce environmental impacts.	Rising raw material costs due to resource depletion.
Technological advancements for resource efficiency.	Consumer pressure for sustainable alternatives.
Collaboration on waste reduction initiatives.	Environmental risks leading to economic instability.
Potential to integrate partial circular strategies (e.g. reuse).	Stricter environmental regulations and carbon pricing.
Shift in investor interest towards sustainable transformation.	Competitive disadvantage compared to circular-oriented businesses.

However, the model's long-term viability is increasingly under scrutiny due to its unsustainable use of finite resources, extensive waste generation, and associated environmental degradation. Despite some opportunities for improvement through policy support and technological innovation, the model is exposed to growing threats such as resource scarcity, regulatory pressure, and consumer demand for sustainability. The following analysis outlines five key strengths, weaknesses, opportunities, and threats that characterize the linear economy and affect its future potential.

The linear economy's strengths lie in its straightforward and widely established processes. It does not require complex systems for material recovery or waste management, making it cost-effective in the short term. Companies operating within this model benefit from mature and efficient supply chains, as well as low initial investments in infrastructure. Moreover, the model enables fast time-to-market, supporting quick adaptation to market demands and maintaining competitive agility. Clear cost structures and predictable pricing models further enhance its attractiveness, particularly for industries focused on short-term profitability and operational simplicity. These strengths explain the long-standing dominance of the linear economy in traditional industrial sectors. (Sariatli, 2017)[14].

The weaknesses of the linear economy are primarily rooted in its unsustainable use of resources. It relies heavily on non-renewable natural resources, which contributes to their depletion and environmental degradation. The "take-make-dispose" approach generates excessive waste and pollution, overlooking opportunities for material reuse or recycling. As a result, the model not only causes environmental harm but also externalizes these costs, often leading to long-term economic burdens such as escalating waste management expenses and the loss of biodiversity. Additionally, the linear economy's short product lifecycles and lack of innovation in sustainable practices hinder progress toward resource efficiency. The absence of incentives for integrating circular principles or reducing environmental impact further compounds the model's inherent inefficiencies (Sharma et al., 2021)[15].

Despite its challenges, the linear economy presents several opportunities for reform and adaptation. Governments and industries have the potential to implement policies aimed at mitigating environmental impacts, such as enhancing waste management systems, adopting stricter regulations on resource extraction, and promoting sustainable practices across sectors. Emerging technologies, particularly in the fields of resource efficiency and waste reduction, offer the chance to improve the sustainability of the linear model. Innovations such as resource-efficient production processes and cleaner technologies could help

reduce material consumption and pollution. Additionally, there are opportunities for collaboration within industries to reduce waste and improve recycling efforts, even within the confines of existing linear systems. As consumer demand for more sustainable products rises, industries can explore new ways to integrate eco-friendly strategies, creating a path for gradual transformation (Marino et al., 2016)[16].

The linear economy faces substantial threats, particularly as global awareness of environmental issues continues to grow. Resource scarcity, driven by the continued depletion of natural resources, is leading to increased raw material costs, which can destabilize supply chains and cause economic uncertainty. Additionally, consumer demand is shifting rapidly toward more sustainable products and practices, putting pressure on businesses to adapt to these evolving expectations. Legislative and regulatory changes, such as the introduction of carbon taxes, waste reduction mandates, and stricter environmental regulations, are creating additional challenges for industries still reliant on the linear model.

Furthermore, the linear economy is increasingly vulnerable to economic instability caused by environmental crises, such as climate change, biodiversity loss, and the negative effects of pollution. These threats highlight the urgent need for industries to embrace more sustainable practices or face the risk of obsolescence (Sillanpää & Ncibi, 2019)[17].

The SWOT analysis of the linear economy underscores its reliance on simplicity and short-term profitability, which have contributed to its dominance over time. However, it also reveals significant limitations, particularly in terms of sustainability and resource efficiency. Although there are opportunities for incremental improvements—such as policy reforms, technological advancements, and industry collaborations—the model's dependence on finite resources, environmental impacts, and growing pressures from consumers and regulations make it vulnerable. The threats posed by resource scarcity, environmental degradation, and shifting market demands emphasize the need for a transition to more sustainable models. Transitioning to the circular economy is increasingly seen as critical for mitigating these risks and ensuring long-term economic and environmental stability.

SWOT Analysis of the Circular Economy

The circular economy represents a paradigm shift, offering solutions to many of the linear economy's challenges. While it holds promise for long-term sustainability, its implementation requires overcoming several hurdles.

Table 2: SWOT analysis of the circular economy

Strengths	**Weakness**
Reduction in waste and environmental impact.	Higher initial costs for transition.
Efficient use of resources and extended product lifecycles.	Complexity of implementation across industries.
Encourages innovation and new business models.	Dependence on the availability of recyclable materials.
Reduced dependence on finite resources.	Consumer reluctance to change behaviors.
Creation of new job opportunities.	Insufficient data and tracking mechanisms.
Opportunities	**Threats**
Development of innovative technologies, e.g., urban mining.	Resistance to change from traditional industries.
Increased consumer demand for sustainable products.	Inadequate recycling infrastructure.
Emergence of new markets for refurbished and recycled goods.	Lack of international coordination.
Government incentives and regulations promoting sustainability.	Market volatility and economic instability.
Expansion of collaboration across sectors.	Competition from linear economy models.

The SWOT analysis of the circular economy highlights its innovative framework, environmental benefits, and implementation challenges. Unlike the traditional linear model, the circular economy is based on resource efficiency, reuse, and waste minimization. It aims to create closed-loop systems that reduce environmental impact while stimulating sustainable economic growth. Although the circular model offers considerable advantages in terms of sustainability and innovation, its adoption is often limited by systemic complexity, infrastructure limitations, and the need for coordinated policy support.

The circular economy is based on resource efficiency, waste reduction, and sustainability, offering several key strengths. One of the primary advantages is the reduction of waste and environmental impact, as products are designed for reuse, recycling, and refurbishment. This model contributes to a more sustainable use of resources. The circular economy also promotes the efficient use of materials, extending product lifecycles and reducing the need for raw material extraction. Moreover, the circular economy fosters innovation, creating new business opportunities and driving the development of innovative technologies such as closed-loop recycling and urban mining. It encourages the creation of new business models that can help build a more resilient and sustainable economy. Additionally, the circular economy aligns well with increasing consumer demand for sustainable products, enhancing market growth and improving brand reputation for companies that embrace circular practices. The model also supports a sustainable economic framework that reduces reliance on finite resources and minimizes external environmental costs. By preserving natural capital and creating closed-loop systems, it helps industries become more economically resilient (Kirchherr et al., 2017)[18].

The transition to a circular economy requires significant initial investment, which can be a financial barrier. Implementation is complex and demands coordination across various sectors, requiring adaptation of existing processes. The circular model also depends on the availability of recyclable materials, which can limit its effectiveness in some industries. Furthermore, the lack of standardization in circular practices hinders widespread adoption, and limited consumer awareness and reluctance to embrace circular products can further restrict market growth (Corvellec et al., 2022)[19].

Despite the challenges, the circular economy offers substantial opportunities for innovation and growth. Governments and industries have the potential to implement policies that promote sustainability, such as incentivizing businesses to adopt circular models, improving waste management systems, and fostering cross-sector collaboration. Technological advancements, especially in urban mining and closed-loop recycling, present opportunities to recover valuable materials from waste, reducing dependence on virgin resources. Innovations in product design, repairability, and recyclability can also contribute to longer product lifecycles and more efficient resource use. Additionally, the growing consumer demand for sustainable products creates a market incentive for businesses to adopt circular practices. As environmental awareness increases, industries have an opportunity to tap into new markets for refurbished, recycled, and upcycled goods. Collaboration between governments, industries, and consumers can drive the development of new business models such as product-as-a-service or take-back schemes, further promoting sustainability and waste reduction (Sariatli, 2017)[14].

The transition to a circular economy faces several threats. Resistance from industries entrenched in linear production models is a major challenge, as companies may be hesitant to invest in new technologies or modify existing processes. Inadequate recycling infrastructure remains a significant barrier, with many regions lacking proper facilities to effectively process and recycle materials. Furthermore, the lack of international coordination and harmonized regulations can complicate the global adoption of circular economy principles. Differences in policies, standards, and practices across regions create obstacles for businesses seeking to implement circular models worldwide. Market fragmentation could also disrupt alignment between sectors, leading to inefficiencies and slow progress. Lastly, insufficient political and financial support from governments could delay the transition to a circular economy. Without robust policies, incentives, and investments to support circular initiatives, the model may struggle to gain the necessary traction for widespread adoption (Geisendorf & Pietrulla, 2018)[20].

The SWOT analysis demonstrates that the circular economy has strong potential to reduce environmental impacts and promote sustainable growth. While there are challenges such as high initial costs, systemic complexity, and infrastructure gaps, the model offers a promising alternative to the linear

economy. As technology advances and consumer demand for sustainability grows, the circular economy is poised to play a critical role in addressing global environmental and economic challenges.

Comparative Evaluation of Strengths in Linear and Circular Economic Models

Understanding the strengths of both linear and circular economic models is essential for assessing their practical relevance and potential for sustainable development. While the linear economy is characterized by simplicity and established infrastructure, the circular economy emphasizes resource efficiency and long-term sustainability. This section provides a comparative overview of the key strengths of each model, including their performance and significance, evaluated through a weighted scoring system.

Table 3: Strengths of the Linear Economy

Strengths	**Performance (1 – 5)**	**Weight (0 – 1)**	**Calculated Value**	**Max Value**
Simple and well-established processes	5	0.25	1.25	1.25
Low initial investments in infrastructure	4	0.20	0.80	1.00
Existing supply chain and market mechanisms	4	0.20	0.80	1.00
Fast time-to-market and adaptability in production	4	0.20	0.80	1.00
Clear cost structures and pricing models	3	0.15	0.45	0.75
Total		**1.00**	**4.10**	**5.00**

The strengths of the linear economy, as shown in Table 3, highlight its operational efficiency, particularly in terms of simplicity, established infrastructure, and quick adaptability. These factors contribute to the model's high performance in a variety of industries where rapid production and low initial investment are crucial. However, the linear economy lacks a sustainability orientation, which limits its capacity to address long-term environmental challenges. The total calculated value of 4.10 out of 5.00 reflects these strengths but also underscores the inherent trade-off between operational efficiency and environmental sustainability.

Table 4: Strengths of the Circular Economy

Strengths	**Performance (1 – 5)**	**Weight (0 – 1)**	**Calculated Value**	**Max Value**
Reduction in waste and environmental impact	5	0.25	1.25	1.25
Efficient use of resources and extended product lifecycles	5	0.25	1.25	1.25
Encourages innovation and new business models	4	0.20	0.80	1.00
Reduced dependence on finite resources	4	0.15	0.60	0.75
Creation of new job opportunities	3	0.15	0.45	0.75
Total		**1.00**	**4.35**	**5.00**

In contrast, the circular economy's strengths, outlined in Table 4, emphasize sustainability through waste reduction, resource efficiency, and long product lifecycles. The model's ability to innovate and foster new business models like product-as-a-service is also a critical advantage, driving new market opportunities. With a total calculated value of 4.35, the circular economy demonstrates a strong potential

to address environmental and economic challenges that are becoming increasingly important in today's global context. Although the creation of new job opportunities in circular industries is a notable benefit, the model's performance in this area is slightly less significant compared to its environmental and resource-focused strengths.

While both economic models offer valuable strengths, the linear economy excels in operational efficiency, established supply chains, and low upfront costs, making it suitable for rapid production cycles. However, the circular economy presents a more sustainable alternative, with higher potential for environmental impact reduction, resource efficiency, and long-term resilience. As industries and governments increasingly prioritize sustainability, the circular model's strengths are likely to gain more importance in shaping future economic strategies.

Weaknesses of the Linear and Circular Economies

The linear and circular economic models each have their own set of weaknesses that must be considered when evaluating their long-term viability and potential for sustainable development.

Table 5: Weaknesses of the Linear Economy

Weakness	**Performance (1 – 5)**	**Weight (0 – 1)**	**Calculated Value**	**Max Value**
High dependence on non-renewable resources	5	0.25	1.25	1.25
Excessive waste generation and environmental pollution	5	0.25	1.25	1.25
External costs of environmental degradation	4	0.20	0.80	1.00
Short product lifecycles with minimal reuse or recycling	4	0.15	0.60	0.75
Limited incentives for innovation in sustainability	3	0.15	0.45	0.75
Total		**1.00**	**4.15**	**5.00**

Table 5 evaluates the weaknesses of the linear economy, highlighting significant issues such as high dependence on non-renewable resources and excessive waste generation, both scoring the highest performance rating of 5. These factors contribute to environmental degradation. The external costs of environmental harm, short product lifecycles, and limited incentives for sustainability innovation further underscore the limitations of the linear model. With a total calculated value of 4.15, these weaknesses reveal the need for more sustainable practices, which the circular economy model aims to address.

Table 6: Weaknesses of the Cirkular Economy

Weakness	**Performance (1 – 5)**	**Weight (0 – 1)**	**Calculated Value**	**Max Value**
Higher initial costs for transition	4	0.25	1.00	1.25
Complexity of implementation across industries	4	0.20	0.80	1.00
Dependence on the availability of recyclable materials	3	0.20	0.60	1.00
Consumer reluctance to change behaviors	4	0.15	0.60	0.75
Insufficient data and tracking mechanisms	3	0.20	0.60	1.00
Total		**1.00**	**3.60**	**5.00**

The table above outlines the weaknesses of the circular economy (Table 6), highlighting key challenges such as higher initial costs, complexity of implementation, and reliance on recyclable materials. The highest-scoring weaknesses are the initial transition costs and implementation complexity, both rated 4, reflecting their significant impact. Consumer reluctance and insufficient data tracking mechanisms also pose barriers, scoring 4 and 3, respectively. The total calculated value of 3.60 out of a maximum of 5.00 indicates that while the circular economy offers strong potential, these challenges must be addressed for broader adoption.

In summary, both the linear and circular economies present weaknesses that impact their effectiveness in achieving sustainability goals. The linear economy's weaknesses are primarily environmental, resulting from resource depletion and waste generation. Meanwhile, the circular economy faces challenges related to implementation complexity, initial costs, and consumer adoption. Addressing these weaknesses is crucial for transitioning toward a more sustainable, circular model while mitigating the negative effects of the linear approach.

Opportunities of the Linear and Circular Economies

The opportunities associated with both the linear and circular economy models are essential for shaping future sustainability efforts. While the linear economy remains grounded in traditional business models, it still presents significant areas where transformation can occur, particularly through policy changes, technological advancements, and evolving market dynamics. In contrast, the circular economy offers a more profound, systemic shift that prioritizes sustainability, innovation, and resource efficiency, promoting long-term environmental and economic benefits.

It's important to note that in the tables provided, the probability of success for each opportunity does not necessarily need to sum to 1. Each opportunity is assessed independently, reflecting its individual likelihood of success without the constraint of a total probability. This approach allows for a more nuanced evaluation of each opportunity, considering factors that may vary across different contexts and scenarios.

Table 7: Opportunities of the Linear Economy

Opportunities	**Appeal (1 – 5)**	**Probability of Success (0 – 1)**	**Calculated Value**	**Max Value**
Implementation of policies to reduce environmental impacts	5	0.60	3.00	5
Technological advancements for resource efficiency	5	0.50	2.50	5
Collaboration on waste reduction initiatives	4	0.30	1.20	4
Potential to integrate partial circular strategies (e.g. reuse)	4	0.40	1.60	4
Shift in investor interest towards sustainable transformation	3	0.70	2.10	3
Total			**10,4**	**21**

Table 7 summarizes the key opportunities within the linear economy model. Notable opportunities include the implementation of environmental policies and technological advancements, both demonstrating high appeal and a strong probability of success. Investor interest in sustainable transformation stands out, with a high probability (0.70), suggesting increasing external pressure for change. The potential to integrate circular principles, like reuse, implies that hybrid strategies may improve the sustainability of linear systems. With a total calculated value of 10.4 out of 21, these opportunities show that, despite its constraints, the linear economy can still foster positive change when bolstered by innovation and policy.

Table 8: Opportunities of the Circular Economy

Opportunities	Appeal (1 – 5)	Probability of Success (0 – 1)	Calculated Value	Max Value
Development of innovative technologies, e.g., urban mining	5	0.70	3.50	5
Increased consumer demand for sustainable products	4	0.60	2.40	4
Emergence of new markets for refurbished and recycled goods	4	0.50	2.00	4
Government incentives and regulations promoting sustainability	5	0.60	3.00	5
Expansion of collaboration across sectors	4	0.40	1.60	4
Total			**12.50**	**22**

Table 8 highlights key opportunities associated with the circular economy model. Significant prospects include the development of innovative technologies such as urban mining and strong government support through incentives and regulations, both of which have high appeal (5) and considerable probabilities of success. The growing consumer interest in sustainable products and the rise of new markets for refurbished and recycled goods emphasize the circular economy's potential. With a total calculated value of 12.50 out of a maximum 22, this model shows considerable promise, particularly in technology, policy, and shifting market demands.

The comparison of opportunities in the linear and circular economies reveals that both models offer potential for positive transformation, albeit in different ways. The linear economy's opportunities primarily focus on incremental improvements and hybrid strategies, while the circular economy offers a more transformative, sustainability-driven approach. Despite the foundational differences, both models highlight the importance of innovation, policy, and market dynamics in creating a sustainable future. While the circular economy shows greater potential for systemic change, the linear economy still holds opportunities for improvement and positive impact.

Threats of the Linear and Circular Economies

This table (Table 9) outlines the key threats associated with the linear economy model. The most significant risks include rising raw material costs, driven by resource depletion, and consumer pressure for sustainable alternatives, both of which are considered highly probable and impactful. Environmental risks, such as those leading to economic instability, also pose substantial challenges, as do stricter environmental regulations and carbon pricing, which increase operational costs for linear businesses.

Table 9: Threats of the Linear Economy

Threat	Appeal (1 – 5)	Probability of Success (0 – 1)	Calculated Value	Max Value
Rising raw material costs due to resource depletion	4	0.70	2.80	4
Consumer pressure for sustainable alternatives	5	0.80	4.00	5
Environmental risks leading to economic instability	4	0.60	2.40	4
Stricter environmental regulations and carbon pricing	5	0.75	3.75	5
Competitive disadvantage compared to circular-oriented businesses	4	0.65	2.60	4
Total			**15.55**	**24**

Additionally, the competitive disadvantage of linear-oriented businesses, compared to circular models, is another critical concern that could hinder long-term success. With a total calculated value of 15.55 out of 24, this highlights the considerable threats facing the linear economy, with a particular emphasis on sustainability challenges and market pressures driving a shift towards more circular and sustainable business models. These risks call for strategic adaptation and innovation to mitigate negative impacts and transition toward more resilient and sustainable practices.

Table 10: Threats of the Circular Economy

Threats	Appeal (1 – 5)	Probability of Success (0 – 1)	Calculated Value	Max Value
Resistance to change from traditional industries	4	0.40	1.60	4
Inadequate recycling infrastructure	3	0.30	0.90	3
Lack of international coordination	3	0.20	0.60	3
Market volatility and economic instability	4	0.50	2.00	4
Competition from linear economy models	2	0.30	0.60	2
Total			**5.70**	**16**

Table 10 highlights the key threats associated with the circular economy model. Resistance to change from traditional industries is considered a notable threat, with a relatively high probability of occurrence, as industries may be hesitant to adopt circular principles due to established business practices. The inadequate recycling infrastructure poses another challenge, reducing the potential for effective material recovery and reuse. Similarly, a lack of international coordination can hinder the widespread adoption of circular strategies, particularly in global supply chains. Market volatility and economic instability also represent significant risks, as fluctuations in the market can undermine investment in sustainable practices. Lastly, competition from linear economy models remains a concern, particularly in sectors that have yet to embrace circular models fully. With a total calculated value of 5.70 out of 16, this illustrates that while there are significant threats to the circular economy, the overall calculated value remains lower than that of the linear economy. This suggests that despite the challenges, the circular economy model still holds substantial potential for long-term sustainability, but overcoming these threats will require coordinated efforts, infrastructure development, and systemic changes in industry practices.

Final SWOT Matrix of the Linear Economy

The results of the SWOT analysis of the linear economy indicate that weaknesses slightly outweigh strengths ($\sum S - \sum W = 4.10 - 4.15 = -0.05$), suggesting challenges in its current form, particularly in terms of environmental impact and sustainability. Externally, threats significantly outweigh opportunities ($\sum O - \sum T = 10.4 - 15.55 = -5.15$), highlighting the growing pressure from regulatory changes, resource depletion, and the market's shift toward more sustainable practices (Figure 3). The need for internal transformation toward sustainability and adaptation to external pressures is evident.

$$\sum S - \sum W = 4.10 - 4.15 = -0.05 \rightarrow$$ Weaknesses outweigh strengths slightly

$$\sum O - \sum T = 10.4 - 15.55 = -5.15 \rightarrow$$ Threats slightly outweigh opportunities

Figure 3: SWOT Score Calculation for the Linear Economy

Based on the quantitatively evaluated SWOT analysis, the calculated coordinate for the linear economy is (−0.05, −5.15), which we have illustrated in the strategic SWOT matrix (Figure 4). This coordinate falls within the fourth quadrant, specifically in the area of the retreat strategy.The retreat

strategy indicates that weaknesses (W) and threats (T) significantly outweigh strengths (S) and opportunities (O). In the case of the linear economic model, this suggests that the approach is environmentally and economically unsustainable in the long term. Dominant negative factors, such as high waste generation, excessive use of natural resources, and environmental burden, outweigh potential benefits such as implementation simplicity or low initial costs. From a strategic decision-making perspective, this points to the need for a gradual abandonment or radical transformation of the linear model toward more sustainable forms of economic activity, such as the circular economy. Implementing a circular economy model could help reduce environmental impacts while creating new economic opportunities.

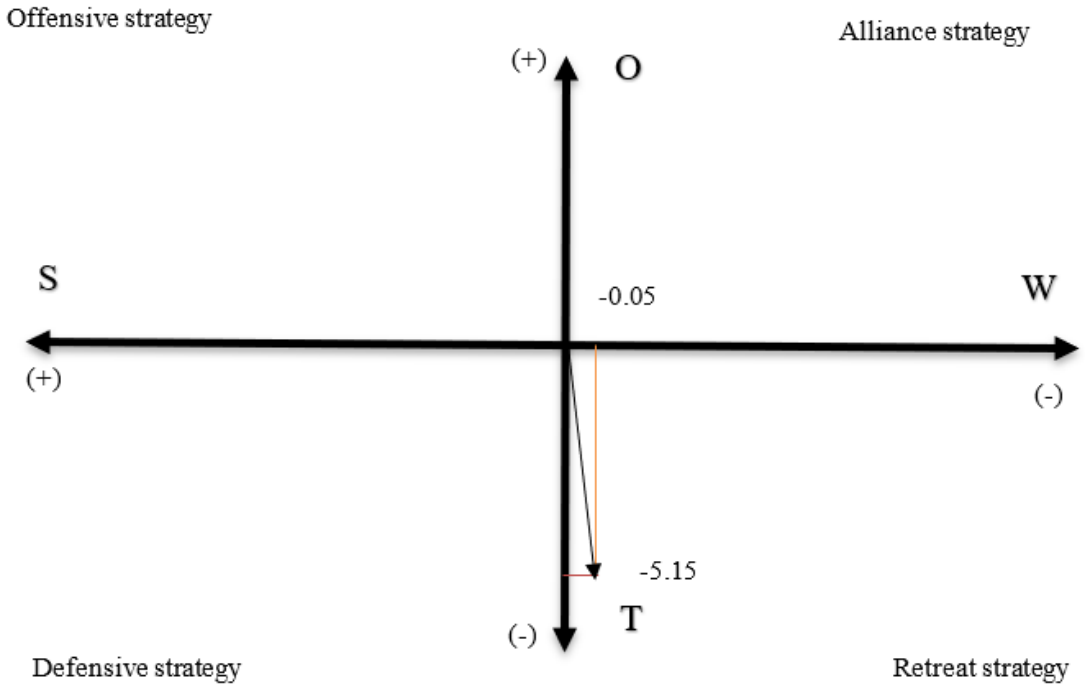

Figure 4: SWOT Score Calculation for the Linear Economy

The results of the SWOT analysis of the circular economy (Figure 5) show that strengths outweigh weaknesses (∑S – ∑W = 4.35 – 3.60 = +0.75), indicating that the circular economy offers significant advantages in resource efficiency, innovation, and long-term sustainability. Externally, opportunities significantly outweigh threats (∑O – ∑T = 12.50 – 5.70 = +6.80), suggesting a favorable environment for the growth of circular economy models, driven by increasing consumer demand for sustainable products, government incentives, and technological developments. This shift presents a promising future for industries embracing the circular economy.

$$\sum S - \sum W = 4.35 - 3.60 = +0.75 \longrightarrow \text{Strengths outweigh weaknesses}$$
$$\sum O - \sum T = 12.50 - 5.70 = +6.80 \longrightarrow \text{Opportunities significantly outweigh threats}$$

Figure 5: SWOT Score Calculation for the Circular Economy

Based on the quantitatively evaluated SWOT analysis, the calculated coordinate for the circular economy model is (+0.75, +6.80), which we have graphically represented in the strategic SWOT matrix (Figure 6). The position of the point in the first quadrant clearly indicates the area of the offensive strategy. An offensive strategy suggests that, in the case of the circular economy, strengths (S) and opportunities (O) significantly outweigh weaknesses and threats. This result confirms the potential of this economic model as a sustainable alternative to the traditional linear economy (Figure 6). Key strengths

include more efficient resource use, reduced waste generation, support for innovation, and a positive impact on the environment. At the same time, the circular economy is supported by legislation and environmental trends, creating favorable opportunities for its development.

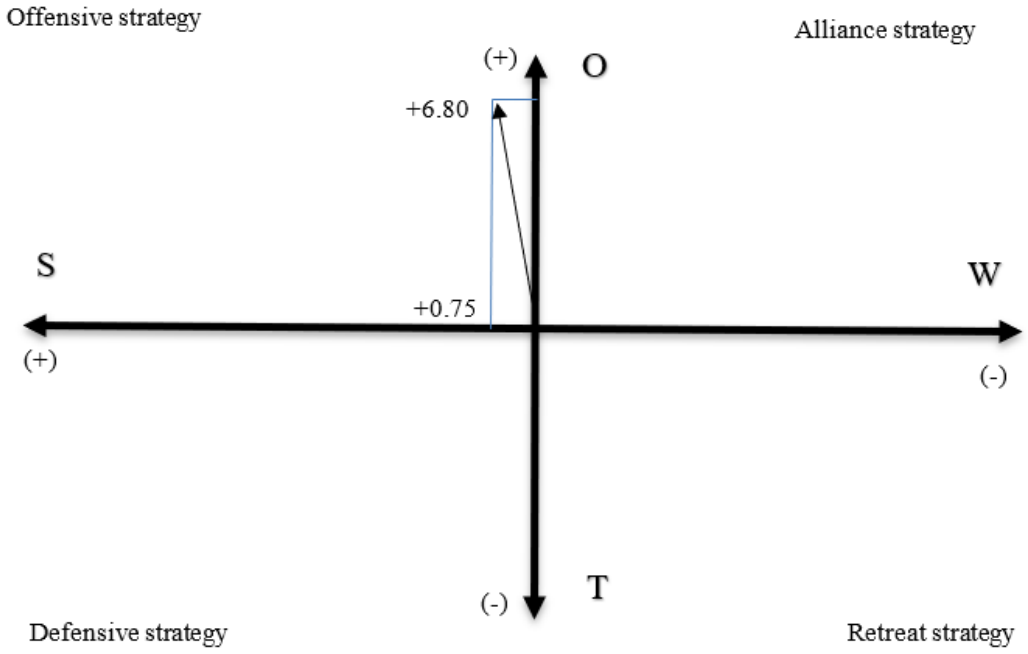

Figure 6: Graphical representation of the strategy for the Circular Economy

The analysis result suggests that organizations and companies implementing the principles of the circular economy should actively develop this strategy and support its wider adoption, thereby gaining a competitive advantage and positively contributing to sustainable development.

Conclusions

The transition from a linear to a circular economy is essential for achieving sustainability and protecting the environment. Based on the results of our analysis, including a detailed SWOT evaluation, it is clear that the linear model, with its inherent focus on resource depletion, waste generation, and inefficiency, is no longer a viable path for long-term economic and environmental health. The circular economy provides a comprehensive framework to address critical environmental issues, such as resource depletion, waste generation, and the exhaustion of natural ecosystems. By prioritizing the reuse and recycling of materials, this model seeks to minimize ecological footprints and foster a more sustainable relationship between economic growth and environmental stewardship.

Our SWOT analysis revealed key strengths of the circular economy, such as its potential for reducing waste, lowering costs in the long run, and creating new job opportunities in the recycling and repair sectors. However, challenges include the higher initial investment required and the need for stronger legislative support and business commitment. Conversely, the linear economy's weaknesses—resource depletion, pollution, and lack of long-term sustainability—highlight the necessity for its transformation. Notably, the linear model's short-term economic benefits often obscure its long-term environmental and economic costs.

Investment in innovation and legislative support are crucial for the successful implementation of the circular model. This includes funding for research and development of sustainable technologies, as well as policies that encourage businesses to adopt circular practices. Specific recommendations for transitioning toward a circular economy include:

Encouraging government subsidies and incentives for companies that embrace circular principles, particularly in industries with high material consumption, such as manufacturing and construction.

Promoting consumer awareness campaigns to increase demand for circular products and services.

Fostering collaboration between industries, governments, and academia to drive forward-thinking solutions to the challenges posed by waste and resource inefficiency.

Without such transformation, we face serious ecological, economic, and social challenges that demand collective efforts from all stakeholders involved, including governments, businesses, and consumers.

The circular economy not only reduces environmental impacts but also promotes economic growth and enhances the competitiveness of businesses. By implementing circular principles, companies can reduce costs associated with raw material procurement, minimize waste, and create new revenue streams through recycling and reuse. Additionally, this shift towards sustainable practices can enhance brand loyalty among consumers who are increasingly prioritizing environmental responsibility in their purchasing decisions.

Based on our SWOT analysis and the identified strengths, weaknesses, opportunities, and threats for both the linear and circular economic models, it is imperative that governments, businesses, and individuals commit to adopting more sustainable practices and models. Such a commitment will ensure a better future for our planet and future generations. By embracing the principles of the circular economy, we can work towards a resilient economic system that aligns with the ecological limits of our planet, fostering a harmonious coexistence between humanity and nature.

Acknowledgements

This article was funded by the project Univnet 0201/0082/19.

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Porovnání lineární a cirkulární ekonomiky a jejich vlivu na životní cyklus produktu

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Souhrn

Tento článek analyzuje rozdíly mezi lineární a cirkulární ekonomikou a zaměřuje se na jejich dopad na životní cyklus produktu. Zkoumá, jak každý z těchto ekonomických modelů ovlivňuje environmentální a ekonomické aspekty cyklu produktu, s důrazem na fáze výroby, použití a likvidace. Lineární ekonomika, založená na tradičním modelu „vezmi-vyrob-zniči", často vede k vyčerpání zdrojů a poškozování životního prostředí s omezenými možnostmi opětovného využití a recyklace materiálů. Naproti tomu cirkulární ekonomika upřednostňuje efektivní využívání zdrojů, snižování odpadu a opětovné použití materiálů s cílem uzavřít materiálové cyklus a podporovat udržitelnost v celém životním cyklu produktu. Článek porovnává výhody a nevýhody obou modelů a hodnotí jejich dopady na ochranu životního prostředí a ekonomickou udržitelnost. Prostřednictvím SWOT analýzy studie identifikuje silné stránky cirkulární ekonomiky, jako je její potenciál pro snižování odpadu, vytváření nových pracovních příležitostí v oblasti recyklace a oprav a podporu dlouhodobých úspor nákladů. Diskutuje se však také o výzvách, jako jsou vyšší počáteční investice a potřeba silnější regulační podpory. Slabé stránky lineárního modelu, včetně jeho závislosti na omezených zdrojích a jeho příspěvku ke znečištění a degradaci životního prostředí, dále zdůrazňují potřebu jeho transformace. Tento článek dochází k závěru, že přechod z lineární na cirkulární ekonomiku je klíčový pro dosažení udržitelnosti. Přijetím cirkulárních principů mohou podniky nejen minimalizovat svou ekologickou stopu, ale také podpořit hospodářský růst, zlepšit konkurenceschopnost a přizpůsobit se rostoucí poptávce spotřebitelů po environmentálně odpovědných postupech.

Klíčová slova: *lineární ekonomika; cirkulární ekonomika; životní cyklus produktu; udržitelnost; dopad na životní prostředí*