Journal of Scientific & Industrial Research
Vol. 84, March 2025, pp. 278-286
DOI: 10.56042/jsir.v84i03.9847

Prioritizing Barriers to Circular Economy Implementation in Toy Industry using Analytical Hierarchy Process

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Received 23 March 2024; revised 13 June 2024; accepted 19 September 2024

The transition towards a circular economy has gained considerable attention as a promising strategy to mitigate environmental degradation and resource depletion. This study aims to prioritize barriers to circular economy implementation within the toy industry using the Analytical Hierarchy Process (AHP) methodology, driven by the need to identify and address obstacles hindering circular practices in a sector notable for its environmental impact and waste production. The methodology included a comprehensive literature review to identify relevant barriers, expert consultation, and AHP analysis to assign weights and ranks to each factor. The study identified and ranked factors influencing circular economy implementation based on their relative importance. Key findings highlight Lack of Collaboration (weight 0.351), Limited Market Demand (weight 0.109), and Economic Viability (weight 0.092) as primary barriers, with Lack of Infrastructure and Supply Chain Complexity also emerging as critical challenges. These findings emphasize the need for collaborative efforts, innovative solutions, and robust regulatory frameworks to overcome these barriers and promote sustainable practices in the industry. This study provides valuable insights for policymakers, industry stakeholders, and researchers to develop targeted strategies and initiatives for fostering circular economy principles in the toy industry. The novelty of this research lies in its application of the AHP methodology to systematically assess and rank barriers to circular economy implementation in a specific sector, offering a replicable framework for similar analyses in other industries.

Keywords: Analytical hierarchy process, Barriers, Circular economy, Prioritization, Sustainability

Introduction

Circular Economy (CE) Concept

The concept of a circular economy represents a fundamental shift away from the linear model of production and consumption, offering a sustainable alternative to the traditional 'take-make-waste' approach.[1,2] At its core, the circular economy promotes a regenerative approach that aims to minimize waste, optimize resource efficiency, and foster closed-loop systems. Key principles include designing products for durability, reuse, and recyclability, challenging the prevailing culture of planned obsolescence and emphasizing longevity and quality. Circular business models, such as product-as-a-service and remanufacturing, play a crucial role in realizing these principles, incentivizing manufacturers to produce durable goods and extending the lifecycle of products through refurbishment and resource recovery. Implementing circular economy principles requires collaboration and innovation across sectors, with governments providing policy support and businesses embracing circularity in their operations.[3] By adopting circular supply chains and exploring partnerships for resource sharing and closed-loop systems, companies can minimize waste and environmental impact while maximizing resource efficiency.[4] Educating consumers about sustainable choices is also essential, empowering individuals to make informed decisions that support a transition to a circular economy. The circular economy offers a holistic framework for addressing environmental challenges while driving economic prosperity, presenting a transformative pathway towards a more resilient and sustainable future.[5]

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CE Challenges for Toy Making Industry

The toy industry holds a special place in the hearts of many, synonymous with childhood joy, imagination, and wonder. Yet, beneath its enchanting facade lies a concerning reality: the industry's significant environmental footprint. Traditional linear models of toy production follow a linear trajectory from resource extraction, manufacturing, consumption, to disposal, contributing substantially to waste generation and environmental degradation. However, as global awareness of sustainability issues continues to rise, there is a growing interest in integrating CE principles into the toy sector.[6] Nevertheless, this transition is fraught with challenges.

To comprehend the significance of integrating CE principles into the toy industry, it's crucial to grasp the current linear model's shortcomings. Traditional toy production heavily relies on finite resources, leading to resource depletion and environmental harm. Moreover, the linear model perpetuates a "take-make-dispose" mind-set, where toys often end up in landfills, contributing to pollution and further resource squandering. This unsustainable approach not only damages the environment but also disregards the potential for resource efficiency and economic opportunities. Enter the CE—a paradigm shift aimed at decoupling economic growth from resource consumption by promoting the reuse, repair, and recycling of products. In the context of the toy industry, embracing CE principles entails designing toys for longevity, facilitating reuse and refurbishment, and implementing effective recycling systems. Such initiatives not only reduce environmental impact but also foster innovation, create new revenue streams, and enhance brand reputation.

However, transitioning to a CE in the toy industry is no easy feat. Several challenges impede progress, requiring careful navigation and collaboration across stakeholders. One of the primary hurdles is shifting consumer behaviour and perceptions. While there is a growing demand for sustainable products, consumers often prioritize price and novelty over environmental considerations. Educating consumers about the benefits of circular toys and altering purchasing habits is crucial for widespread adoption. Furthermore, implementing circular practices necessitates rethinking traditional business models and supply chains. Manufacturers must invest in research and development to design durable, repairable, and recyclable toys while considering cost implications and market demand. Collaboration across the value chain is essential, from suppliers to retailers, to ensure seamless integration of circular principles. Moreover, infrastructure and policy support are critical for successful implementation. Adequate waste management facilities, recycling infrastructure, and regulatory frameworks promoting circularity are essential enablers.

Another significant challenge is addressing the complexity of materials used in toy manufacturing. Many toys consist of composite materials that are difficult to separate and recycle. Designing for disassembly and utilizing eco-friendly materials are imperative steps towards overcoming this challenge. Additionally, fostering innovation in material science and investing in advanced recycling technologies can unlock new possibilities for circular toy production. Despite these challenges, the momentum towards a circular toy industry is palpable. Numerous initiatives and collaborations are underway to drive progress. Manufacturers are increasingly embracing eco-design principles, designing toys with longevity and recyclability in mind.[7]

Research Gaps

Despite the burgeoning interest in CE transitions across industries, the toy industry remains relatively underexplored in terms of its specific challenges and barriers to implementation.[8] While there exists a growing body of literature on CE transitions, studies often overlook the complexities inherent in the toy industry's supply chain and product lifecycle. Existing research tends to focus on broader sectors, leaving a gap in understanding the unique hurdles faced by toy manufacturers, retailers, and consumers in adopting circular practices. Recognizing and addressing this research gap is paramount for developing tailored strategies that can effectively overcome barriers and drive the adoption of CE principles within the toy sector.

Understanding the intricacies of the toy industry's supply chain and product lifecycle is crucial for identifying and addressing the barriers to CE implementation. Unlike many other sectors, the toy industry involves unique considerations such as safety regulations, cultural trends, and the role of play in child development. These complexities can present distinct challenges to implementing circular practices, ranging from designing durable and safe toys to managing product returns and end-of-life disposal. By conducting targeted research that delves into these specific challenges, policymakers, businesses, and stakeholders can develop strategies tailored to the unique needs of the toy industry. This approach can help unlock the full potential of CE principles, not only reducing waste and environmental impact but also fostering innovation, economic growth, and sustainable consumption patterns within the toy sector.

Research Objectives

Against this backdrop, the primary objectives of this research are twofold:

1. To identify and analyze the key barriers to implementing CE practices in the toy industry,

encompassing political, economic, social, technological, legal, and environmental dimensions.

2. To elucidate the implications of these barriers for sustainability initiatives, policy formulation, and industry practices, and to propose actionable recommendations for overcoming obstacles and accelerating progress toward a circular toy economy.

By achieving these objectives, this research aims to shed light on the multifaceted challenges impeding CE implementation in the toy industry and provide insights into strategies for fostering sustainability and resilience in the sector.

Study Motivation

The study addresses a critical need to shift towards more sustainable practices within the toy industry. The environmental impact of the toy industry is significant due to the extensive use of plastics and other non-biodegradable materials, leading to substantial waste generation. Implementing circular economy principles can drastically reduce this environmental footprint by promoting the reuse, recycling, and responsible sourcing of materials, thereby fostering environmental sustainability. Resource efficiency is another key motivation for this study. The circular economy aims to keep products, components, and materials at their highest utility and value, reducing waste and the demand for raw materials. This approach is particularly relevant for the toy industry, which often relies on single-use plastics and other resources that contribute to environmental degradation. By identifying and prioritizing barriers to circular economy implementation, the study can help the industry adopt more efficient and sustainable resource utilization practices.

Furthermore, the economic benefits of adopting a circular economy are substantial. Companies can achieve significant cost savings through improved resource efficiency, waste reduction, and the creation of new business models based on recycling and reuse. However, the transition to a circular economy is complex and faces numerous barriers, including technological, financial, and regulatory challenges. By using the Analytical Hierarchy Process to systematically identify and prioritize these barriers, the study provides a clear roadmap for industry stakeholders, facilitating the effective implementation of circular economy practices. This not only supports environmental and resource efficiency goals but also enhances the economic viability and sustainability of the toy industry.

Methodology

The methodology employed for factor identification in this study involved a multi-faceted approach. Initially, a comprehensive literature review was conducted to identify a broad range of potential criteria or factors influencing the implementation of CE practices in the toy industry. This literature review served as the foundation for understanding existing research findings, industry trends, and expert opinions on relevant factors. Subsequently, to refine and validate the list of criteria, a survey or interview process was undertaken with industry experts, including two manufacturers, two policymakers, four academicians, and one environmental advocate having more than 10 years of experience in the same field. These stakeholders were asked to provide insights into the most pertinent criteria based on their expertise and experience in the field. The responses from the survey or interviews were then analyzed to identify common themes and prioritize the criteria according to their perceived significance. Finally, a consensus-building process involving further discussions and deliberations among experts was undertaken to finalize the most significant criteria for inclusion in the study. This methodology ensured a robust and inclusive approach to factor identification, drawing upon both existing literature and expert insights to establish a comprehensive list of criteria relevant to the implementation of CE practices in the toy industry.

The AHP methodology[9] used in this study followed a systematic process to prioritize criteria for CE implementation in the toy industry (Fig. 1):

Step 1: Construct the Hierarchical Structure

The hierarchical structure was constructed to organize the criteria into a logical framework. This structure consisted of a top-level criterion representing the overall objective, with subsequent levels containing sub-criteria related to different aspects of CE implementation in the toy industry.

Step 2: Constitute Pairwise Comparison Matrices

Pairwise comparison matrices were developed to capture the relative importance of criteria at each level of the hierarchy. Experts were asked to compare each criterion against every other criterion within the same level, assigning numerical values based on their

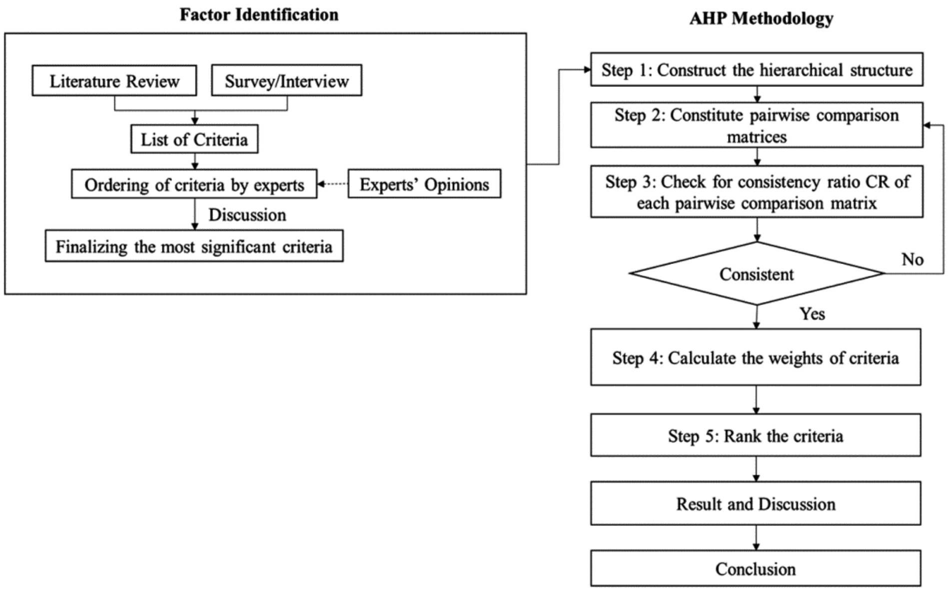

Fig. 1 — Research framework

perceived importance as shown in Table 1. The majority is taken as a basis to deal with multiple responses.

Table 1 — Linguistic measures of importance

Degree of preference	Score index (SI)
Absolutely more importance (AM)	9
Very high importance (VH)	7
High importance (HI)	5
Slightly more importance (SM)	3
Equally importance (EI)	1
Slightly lower importance (SL)	1/3
Low importance (LI)	1/5
Very low importance (VL)	1/7
Absolutely low importance (AL)	1/9

Step 3: Calculate the Weights of Criteria

Using the validated pairwise comparison matrices, the weights of criteria were calculated through the AHP algorithm using Eqs (1) & (2). These weights represented the relative importance of each criterion in achieving the overall objective of CE implementation in the toy industry.

$$GMi = \left(\prod_{i=1}^{A} x_i\right)^{\frac{1}{A}} \quad \ldots (1)$$

where, GM_i represents the geometric mean of each, x_i are the individual values of alternatives, A is the total number of factors/alternatives.

$$\text{Weight}_i = \frac{GM_i}{\sum_{i=1}^{A} GM} \quad \ldots (2)$$

Step 4: Rank the Criteria

Based on their calculated weights, the criteria were ranked in order of importance. This ranking provided valuable insights into which criteria were considered most critical for addressing barriers and facilitating the transition to a CE in the toy industry.

Step 5: Check for Consistency Ratio (CR) of Pairwise Comparison Matrix

To ensure the reliability of the pairwise comparisons, Consistency Ratios (CRs) were calculated for each matrix using Eq. (3). If the CR fell within an acceptable range (10%), indicating reasonable consistency in the judgments, the comparisons were deemed valid and proceeded to the next step.

$$CR = \frac{CI}{RI} \quad \ldots (3)$$

The Consistency Index (CI) is calculated as follows using Eq. (4):

$$CI = \frac{\lambda_{\max} - n}{n-1} \quad \ldots (4)$$

where, the maximum eigenvalue of the matrix, denoted as λ_{max}, is used in conjunction with the number of criteria (n) in the calculation. The Random Index (RI) used in Eq. (3) is determined by considering the number of criteria utilized in the research study.

By following this structured AHP methodology, the study was able to systematically prioritize criteria and provide actionable recommendations for stakeholders aiming to promote CE practices within the toy industry.

Results and Discussion

The initial phase of the study focused on comprehensive factor identification to discern the key determinants influencing the adoption of CE practices within the toy industry. Through a meticulous literature review encompassing academic publications, industry reports, and case studies, a wide range of factors such as regulatory requirements, consumer behavior, supply chain dynamics, technological capabilities, economic incentives, and environmental considerations were identified. Additionally, consultations with domain experts, stakeholders, and industry professionals provided valuable insights into nuanced factors, while workshops and brainstorming sessions facilitated collaborative identification and prioritization of factors based on relevance, impact, and feasibility. Data analysis of industry metrics, market trends, and historical data further enriched factor identification. This multifaceted approach ensured a comprehensive understanding of the factors influencing CE implementation in the toy industry, laying the groundwork for subsequent analysis and decision-making in the AHP methodology. By integrating insights from diverse sources, the study aimed to facilitate informed decision-making and strategic planning for CE initiatives, grounded in empirical evidence, stakeholder perspectives, and industry-specific dynamics. The hierarchical structure is shown in Fig. 2.

Product-related Factors (C1)

- Product Design Complexity (C_{11})[10]: Toy designs often incorporate intricate structures and multiple components, making disassembly and recycling challenging. The complexity of product design can hinder the separation of materials during the recycling process, leading to inefficiencies and increased costs.
- Material Composition (C_{12})[11]: Toys typically consist of various materials, including plastics, metals, and electronics. The combination of these materials complicates recycling efforts as different components require separate processing methods. Mixed material composition can hinder the efficient recovery and reuse of resources.
- Toxic Materials (C_{13})[12]: Some toys contain hazardous substances such as lead, phthalates, or flame retardants, posing health risks to children and environmental hazards. The presences of toxic materials poses challenges for recycling and reuse efforts, necessitating specialized handling and disposal methods to prevent contamination.

Market-related Factors (C2)

- Consumer Behaviour (C_{21})[13,14]: Consumer preferences for new toys over refurbished or recycled ones can limit the demand for sustainable products. Additionally, low awareness or interest in recycling toys may result in reduced demand for eco-friendly alternatives.
- Limited Market Demand (C_{22}): Insufficient consumer demand for recycled or refurbished toys can deter manufacturers from investing in CE initiatives. If consumers show little interest in sustainable products, manufacturers may prioritize traditional production methods to meet market demand.
- Seasonality (C_{23}): Toy demand often fluctuates throughout the year, with peak seasons such as holidays driving higher sales volumes. Seasonal demand variations can affect the feasibility of implementing circular practices, influencing production schedules, inventory management, and resource allocation.
- Brand Image and Perception (C_{24}): Consumer perceptions of toy brands' sustainability efforts can

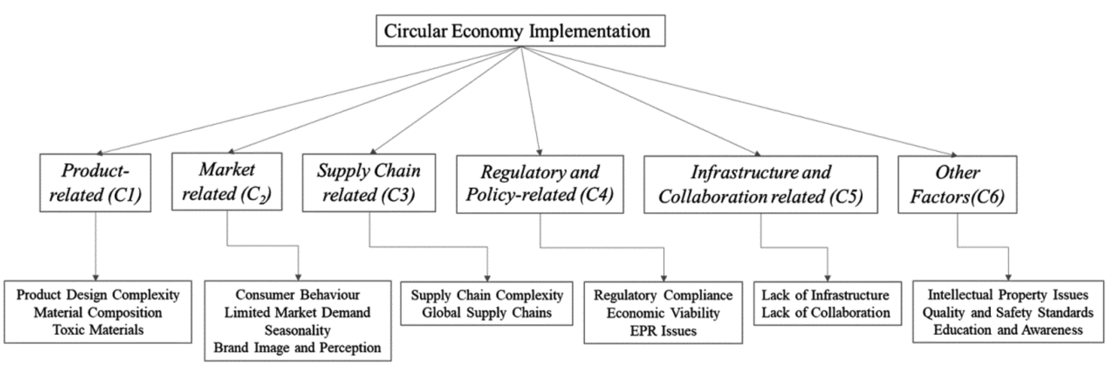

Fig. 2 — Hierarchical structure of CE implementation barriers

influence purchasing decisions. Brands perceived as environmentally responsible may attract consumers seeking eco-friendly products, while those with a negative reputation for sustainability may face challenges in the market.

Supply Chain-related Factors (C3)

- Supply Chain Complexity (C_{31})[15]: The toy industry's supply chain involves multiple stages, including sourcing raw materials, manufacturing, distribution, and retailing. Managing the complexity of these interconnected processes presents challenges in implementing circular practices, such as coordinating logistics and ensuring product traceability.
- Global Supply Chains (C_{32})[16]: Toy manufacturers often operate within global supply chains, sourcing materials and components from different regions. Managing global supply chains adds complexity to CE initiatives, requiring coordination across international borders and compliance with diverse regulations.

Regulatory and Policy-related Factors(C4)

- Regulatory Compliance (C_{41})[17]: Compliance with regulations related to product safety, environmental standards, and waste management is essential for toy manufacturers. Meeting regulatory requirements adds complexity and cost to CE implementation, as manufacturers must ensure compliance throughout the product lifecycle.
- Economic Viability (C_{42})[18]: Transitioning to circular business models may entail upfront costs, such as investments in recycling infrastructure or product redesign. Assessing the economic viability of circular initiatives is crucial for manufacturers, as they weigh the long-term benefits against the initial investment and potential returns.
- Extended Producer Responsibility (EPR) Issues (C_{43})[19]: EPR policies hold manufacturers responsible for managing products throughout their lifecycle, including end-of-life disposal. Implementing EPR programs in the toy industry can be challenging due to the diverse range of products and materials, requiring effective coordination and collaboration among stakeholders.

Infrastructure and Collaboration-related Factors (C5)

- Lack of Infrastructure (C_{51})[20]: Inadequate recycling facilities or infrastructure for sorting and processing toy materials can hinder the effective implementation of circular practices. The lack of specialized facilities and equipment limits the scalability of recycling initiatives and increases reliance on landfilling or incineration.
- Lack of Collaboration (C_{52})[21]: Successful CE implementation requires collaboration among stakeholders, including manufacturers, retailers, consumers, and recycling facilities. However, achieving collaboration can be challenging due to competing interests, lack of incentives, and communication barriers among stakeholders.

Other Factors (C6)

- Intellectual Property Issues (C_{61}): Intellectual property rights, such as patents and trademarks, may pose challenges to the reuse or refurbishment of toys. Manufacturers may face legal constraints or licensing issues when attempting to redesign or repurpose existing products.
- Quality and Safety Standards (C_{62})[22]: Maintaining high-quality and safety standards in recycled or refurbished toys is essential to ensure consumer trust and compliance with regulations. Meeting quality and safety requirements may require additional testing, certification, and quality control measures.
- Education and Awareness (C_{63}): Raising awareness and educating stakeholders about the benefits of CE practices is crucial for driving adoption. Educating consumers, stakeholders, and industry professionals about the environmental and economic advantages of CE initiatives can foster a culture of sustainability and encourage behavioural changes. Educational campaigns, workshops, and outreach programs play a vital role in increasing awareness and promoting the adoption of circular practices.

The AHP analysis delves deeply into the multifaceted landscape of sustainability within the toy industry, unveiling critical insights into the varying degrees of importance among different factors. Through a systematic classification of factors into distinct categories, the analysis offers a comprehensive overview of the key determinants shaping sustainability outcomes. Each category, ranging from product-related factors to regulatory and policy-related considerations, is assigned a class weight reflecting its overall significance in influencing sustainability practices. The pairwise comparison matrix for main and subcategories categories are given in Table 2 and Table 3. On the

Table 2 — Pairwise Comparison Matrix for main categories

	C1	C2	C3	C4	C5	C6	Weight
Product related factors (C1)	1.000	0.333	0.500	1.000	0.200	0.500	0.066
Market related factors (C2)	3.000	1.000	3.000	3.000	0.333	3.000	0.226
Supply chain related factors (C3)	2.000	0.333	1.000	0.333	0.200	1.000	0.078
Regulatory & policy related factors (C4)	1.000	0.333	3.000	1.000	0.333	3.000	0.131
Infra & collaboration related factors (C5)	5.000	3.000	5.000	3.000	1.000	5.000	0.421
Other Factors (C6)	2.000	0.333	1.000	0.333	0.200	1.000	0.078

Table 3 — Pairwise Comparison Matrix for subcategories

Product related factors (C_1)					
	C_{11}	C_{12}	C_{13}		Weight
C_{11}	1.000	3.000	5.000		0.618
C_{12}	0.333	1.000	5.000		0.297
C_{13}	0.200	0.200	1.000		0.086
Market Related factors (C_2)					
	C_{21}	C_{22}	C_{23}	C_{24}	Weight
C_{21}	1.000	0.333	0.333	1.000	0.122
C_{22}	3.000	1.000	3.000	3.000	0.480
C_{23}	3.000	0.333	1.000	3.000	0.277
C_{24}	1.000	0.333	0.333	1.000	0.122
Supply chain related factors (C_3)					
	C_{31}	C_{32}			Weight
C_{31}	1.000	1.000			0.500
C_{32}	1.000	1.000			0.500
Regulatory & Policy related factors (C_4)					
	C_{41}	C_{42}	C_{43}		Weight
C_{41}	1.000	0.200	0.333		0.097
C_{42}	5.000	1.000	5.000		0.701
C_{43}	3.000	0.200	1.000		0.202
Infra & Collaboration related factors (C_5)					
	C_{51}	C_{52}			Weight
C_{51}	1.000	0.200			0.167
C_{52}	5.000	1.000			0.833
Other factors (C_6)					
	C_{61}	C_{62}	C_{63}		Weight
C_{61}	1.000	3.000	5.000		0.618
C_{62}	0.333	1.000	5.000		0.297
C_{63}	0.200	0.200	1.000		0.086

other hand, global weights and rank of each factor in consideration is given in Table 4.

The primary sustainability concern in the toy industry is the lack of collaboration, which ranks first with a substantial global weight of 0.351. This factor underscores the critical importance of fostering cooperation among stakeholders, including manufacturers, suppliers, regulators, and consumers. Collaboration is indispensable for orchestrating collective action towards sustainability goals, including supply chain optimization, waste reduction, and innovation in sustainable practices. Overcoming siloed approaches and fostering partnerships can unlock synergies, driving transformative change across the industry.

Securing the second rank, Limited Market Demand carries significant weight with a global weight of 0.109. This factor highlights the profound impact of market dynamics on sustainability initiatives within the toy industry sector. Adapting to fluctuating market demands, understanding consumer preferences, and aligning production with market needs are essential for sustainability-driven business strategies. Industry players must stay attuned to evolving market trends and consumer expectations to remain competitive and drive demand for sustainable products and services.

Ranked third, Economic Viability holds substantial importance with a global weight of 0.092. This factor underscores the imperative of balancing sustainability objectives with economic imperatives for the long-term success and viability of toy businesses. Investments in sustainable practices must demonstrate tangible economic benefits, such as cost savings, improved efficiency, and enhanced brand reputation, to ensure widespread adoption and industry-wide transformation. Integrating sustainability into business models can create value and resilience, fostering innovation and driving competitive advantage in the marketplace.

Lack of Infrastructure secures the fourth rank with a global weight of 0.070. This factor highlights the challenges posed by inadequate infrastructure for recycling, waste management, and sustainable production processes within the toy industry. Addressing infrastructure gaps requires significant investments in facilities, technology, and logistics to support CE practices, reduce environmental impacts, and ensure compliance with regulatory requirements. Building robust infrastructure systems is essential for enabling sustainable growth and fostering a resilient industry ecosystem.

At the fifth rank, both Supply Chain Complexity and Global Supply Chains share equal importance, each with a global weight of 0.039. These factors underscore the critical need for streamlining supply chain operations and effectively managing global networks to enhance sustainability efforts. Optimizing supply chain processes, improving transparency, and

Table 4 — Global weights and Rank

Classification	Class weight	Factor	Global weight	Rank
Product related factors (C1)	0.066	Product design complexity	0.041	7
		Material composition	0.020	14
		Toxic materials	0.006	17
Market related factors (C2)	0.226	Consumer behavior	0.028	10
		Limited market demand	0.109	2
		Seasonality	0.063	5
		Brand image and perception	0.028	10
Supply chain related factors (C3)	0.078	Supply chain complexity	0.039	8
		Global supply chains	0.039	8
Regulatory & policy related factors (C4)	0.131	Regulatory compliance	0.013	15
		Economic viability	0.092	3
		Extended producer responsibility	0.026	12
Infra & collaboration related factors (C5)	0.421	Lack of infrastructure	0.070	4
		Lack of collaboration	0.351	1
Other Factors (C6)	0.078	Intellectual property issues	0.048	6
		Quality and safety standards	0.023	13
		Education and awareness	0.007	16

ensuring ethical sourcing practices are essential for reducing environmental footprint, minimizing risks, and enhancing stakeholder trust throughout the supply chain. Collaborating with suppliers and partners is crucial for developing resilient and sustainable supply chains that can meet evolving market demands and regulatory requirements.

Ranked sixth, Intellectual Property Issues carry weight with a global weight of 0.048. This factor emphasizes the need to protect intellectual property rights while fostering collaboration and innovation for sustainable solutions. Intellectual property regimes should strike a balance between providing incentives for innovation and ensuring open access to sustainable technologies and practices. Addressing intellectual property challenges can unlock opportunities for collaboration, knowledge sharing, and technology transfer, driving progress towards sustainability goals.

Product Design Complexity ranks seventh with a global weight of 0.041. While not the foremost determinant, optimizing product designs for sustainability remains pivotal for reducing environmental impact and enhancing product recyclability. Simplifying designs, reducing material use, and incorporating eco-friendly materials can extend product lifecycles, reduce resource consumption, and minimize waste generation. Integrating sustainable design principles into product development processes can create value for customers, enhance brand reputation, and drive market differentiation.

Both Seasonality and Consumer Behavior share the eighth rank, each with a global weight of 0.028. These factors underscore the importance of understanding seasonal trends and consumer preferences in driving sustainable product offerings and market strategies. Adapting to seasonal variations in demand, promoting eco-friendly products, and educating consumers about sustainable choices can influence purchasing decisions and drive demand for environmentally responsible products and services. Engaging consumers as active participants in the sustainability journey can foster a culture of responsibility and drive positive change across the industry.

Material Composition, Toxic Materials, Regulatory Compliance, Extended Producer Responsibility, Quality and Safety Standards, Education and Awareness, Brand Image and Perception, and Global Supply Chains form a cluster of factors occupying lower ranks based on their global weights. Despite their lower rankings, each factor contributes uniquely to the sustainability landscape within the toy industry. Whether it's ensuring compliance with regulations, promoting responsible production practices, raising awareness among stakeholders, or enhancing brand reputation, these factors play pivotal roles in shaping sustainability outcomes. To address these factors comprehensively, collaborative efforts, innovative solutions, and robust regulatory frameworks are essential. By overcoming existing challenges and fostering cooperation among stakeholders, the industry can drive meaningful progress towards a more sustainable future, ensuring responsible production, consumption, and disposal practices throughout the supply chain.

Conclusions

The AHP methodology has provided key insights into prioritizing barriers to implementing Circular Economy (CE) practices in the toy industry. Through structured analysis, critical barriers such as Lack of Collaboration, Limited Market Demand, Economic Viability, Supply Chain Complexity, and Lack of Infrastructure have been identified. These barriers highlight areas requiring focused efforts for effective CE adoption. The study underscores the need for collaborative efforts, innovation, and robust regulatory support to tackle these challenges and promote sustainability in the toy sector. However, the study also faces limitations, including potential bias from subjective judgments in the pairwise comparisons and a limited scope that may not capture all relevant barriers. Additionally, findings are based on current conditions, which may change with technological advancements, regulatory shifts, or evolving consumer preferences. Future research should explore the economic benefits of CE practices, quantify impacts, and investigate emerging technologies to optimize CE efforts in toy manufacturing for a more sustainable future.

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