

Advancing the Circular Economy: A Framework to Address the Challenges of Adopting Reusable Packaging in US Industries

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Abstract

This study examines the adoption of reusable transit packaging in US aerospace, machinery, and automotive industries, focusing on current perceptions, barriers to adoption, and potential mechanisms for implementing their broader use. Employing a combination of a survey, semi-structured interviews, and a literature review, the research explores and analyzes industry perceptions and existing approaches regarding reusable packaging. A significant finding is the consensus among respondents on the critical role of packaging choices in meeting their organizations' sustainability goals. The study identifies barriers across the chosen industries, such as the lack of mandatory policies, perceived complexity, insufficient capacity, and cost concerns. Interestingly, companies with existing reusable packaging systems are more inclined to expand their use, implying the effectiveness of internal motivation and the need for external stimuli to drive organizations to use reusable packaging to achieve wider adoption. Finally, the article proposes a framework of facilitating mechanisms, including policy interventions and industry-led initiatives to address these barriers. The research offers a strategic roadmap for enhancing the legislative and operational environment to support reusable packaging by ranking these mechanisms based on business impact and feasibility of implementation.

Keywords: reusable packaging, sustainable packaging, sustainable supply chain management, packaging waste reduction, legislative support for sustainability, regulatory framework.

1. Introduction

With increasing global concern and attention regarding the causes and implications of global warming, organizations are under growing pressure from multiple external and internal stakeholders to reduce their organizational carbon footprint and improve their environmental performance. This pressure and the importance of reducing supply chain costs lead many organizations to integrate sustainable practices into their supply chain management.

An organization's selection of industrial packaging significantly impacts both the effectiveness and sustainability of business-to-business (B2B) supply chains. Indeed, environmental and cost implications extending throughout the supply chain [1]. Over the past decade, volumes of transport packaging material have increased exponentially as a result of globalization, and this increase in packaging waste has historically been countered by encouraging the use of recycling. However, in the circular economy's hierarchy, shifting from material recycling to product reuse retains greater value [2] and reduces waste. Furthermore, under certain conditions [3], reusing packaging presents a significant opportunity to maintain material and product functionality and achieve substantial cost savings [4, 5]. Companies from many industries, including automotive, aerospace, and machinery, have started to adopt reusable packaging systems, and according to the Reusable Packaging Association, the \$100 billion market of reusable transit packaging is expected to increase steadily over the coming years [6].

Policies and legislation are crucial in promoting supplier responsibility, changing customer behavior, and facilitating the development and adoption of new technologies, thereby improving the economic viability of switching to reusable packaging [7]. Equally, there needs to be more focus on incentivizing companies along the value chain to collaborate efficiently and adopt a standardized system [3]. Reusable packaging systems are still gaining momentum in the US and currently are not fully examined in the context of manufacturing and heavy industries. This research, therefore, aims to evaluate the impact of existing and potential policies and regulations concerning tertiary (transit) reusable packaging in the US aerospace, automotive, and machinery industries.

This paper's contribution is to research the under-explored topic of the implementation of reusable packaging within our defined industries to provide up-to-date insights into the B2B sector's reusable packaging landscape, drawing from the perspectives of industry practitioners. Additionally, the paper highlights overarching issues and barriers essential for strategic policy formulation and top-tier decision-making. Beyond identification, the research also introduces a highly practical framework for the execution of suggested mechanisms to address the main barriers, ensuring targeted intervention. This policy-based framework enables practitioners to effectively advocate for legislative support in order to implement or expand reusable packaging systems. We consider the strategic realm of policy interventions, focusing our intention to address high-level, systemic barriers rather than delving into the operational intricacies. Furthermore, policymakers can utilize this framework to gain insights into the tangible

obstacles encountered by businesses, which must be addressed to foster sustainable ecosystems. In the paper, the following research questions have been formulated and addressed:

- **Research Question 1 (RQ1):** What is the existing landscape of reusable packaging in the American aerospace, automotive, and machinery sectors, and how do industry professionals perceive its benefits, confront its challenges, and envision its future role?
- **Research Question 2 (RQ2):** What intra-industry mechanisms can organizations collaborate with in order to facilitate the adoption of reusable packaging systems?
- **Research Question 3 (RQ3):** What governmental policies would further promote the development of reusable packaging infrastructure?
- **Research Question 4 (RQ4):** In what order should these mechanisms be advocated for / prioritized in order to mitigate the key barriers affecting both participating and non-participating organizations?

The rest of this study is organized as follows. In section 2, the research methodology is introduced. Section 3 provides research background to identify existing challenges and lists current European and US policies and regulations concerning incentives for adopting reusable packaging systems. Next, Section 4 presents the obtained results. Section 5 introduces the framework. Section 6 discusses the research findings. Finally, Section 7 elaborates on limitations and lists opportunities for future research.

2. Materials and Methods

This study employed semi-structured interviews and a survey of industry professionals to gather insights into companies' current implementation of reusable packaging systems and the associated barriers and opportunities they perceive. This approach was chosen for its practical applicability, as directly engaging with practitioners offers an invaluable perspective on real-world challenges and solutions. Furthermore, the research aimed to achieve methodological triangulation by cross-verifying insights to present a more comprehensive and multi-dimensional understanding of the subject. This methodology aligns with Mangan's [8] approach, which showed that quantitative and qualitative methodologies can provide more profound insights than using a single method alone. Such triangulation enhances the empirical support for the theory under investigation, leveraging the strengths and compensating for the limitations of various methodologies.

In the first part, research background, the recent related works were examined to establish the current state, identify research opportunities, and provide an overview of various impactful barriers that can potentially be lifted with effective green policies and industry action. In the literature review, the articles were obtained from two major citation databases, SCOPUS and World of Science. Specific criteria were to eliminate the research's inclusion and exclusion bias

and achieve the data's heterogeneity [9]. Namely, only articles with complete attributes, such as authors, title, year, journal name, and abstract, were considered. Also, only scientific papers focused on sustainable packaging in supply chain management studies concerning environmental, economic, and social aspect assessment were used to complete the research background. Also, official government reports and publications have been used in this study.

The second part of the study involved a descriptive analysis of survey results from 55 sustainability and supply chain professionals in the aerospace, machinery, and automotive industries in the US. The survey, with 11 questions, focused on reusable packaging adoption and sustainability practices. Respondents, evenly distributed across the industries, were selected from 100 professionals, yielding a 55% response rate. The study used the one-sided Wilcoxon Signed-Rank Test in R for data analysis, suitable for non-normally distributed responses, to compare the median response against a neutral value of 5.5. This comprehensive analysis aimed to identify trends, challenges, and opportunities in reusable packaging, enhancing understanding and validating previous data. It sought to provide insights for managing risks, advocating for legislation, and implementing reusable packaging systems [10]. The respondents were guaranteed anonymity.

Four semi-structured, in-depth interviews with sustainability and supply chain professionals from leading American companies were conducted in the final part of the research. We targeted professionals with relevant positions and expertise in sustainability, supply chain management, or related fields, as they possessed the knowledge and insights crucial to our research objectives. The decision to employ the interview method in a semi-structured format was made as it facilitates discovering and exploring individual participants' opinions, diverse experiences, insights, and perceptions. While we had a predefined set of central questions or topics, we could adjust and pose additional questions or seek more comprehensive responses based on the interviewees' input. The core questions posed in the semi-structured interviews were identical to those found in the survey questionnaire provided in Appendix A. The interviews were conducted by identifying a pool of professionals with specific experience in the industries of interest, composing an in-depth interview scenario, scheduling and conducting the interviews, and analyzing the qualitative data. The interviewees were informed about the purposes of the research, provided with a list of questions before the interviews, and guaranteed anonymity. The following professionals have been interviewed: (A) a sustainability compliance advisor from a Fortune 500 company working in the US machinery industry; (B) a supply chain sustainability professional in the automotive industry; (C) a sustainability consultant for the automotive industry; (D) a supply chain team lead working on reusable packaging implementation in the aerospace industry, stated below as Interviewee A, Interviewee B, Interviewee C and Interviewee D. The interviewees elaborated on their organizations' experience in implementing reusable packaging systems. All interviewees are from companies that have already implemented or had extensive experience working with reusable packaging. Figure 1 represents the research methodology. These interviews, conducted July 2023, sought to

identify the real-world priorities, challenges, and insights regarding reusable packaging systems in their industries and to understand the importance of and the current regulatory role in encouraging the adoption of reusable packaging.

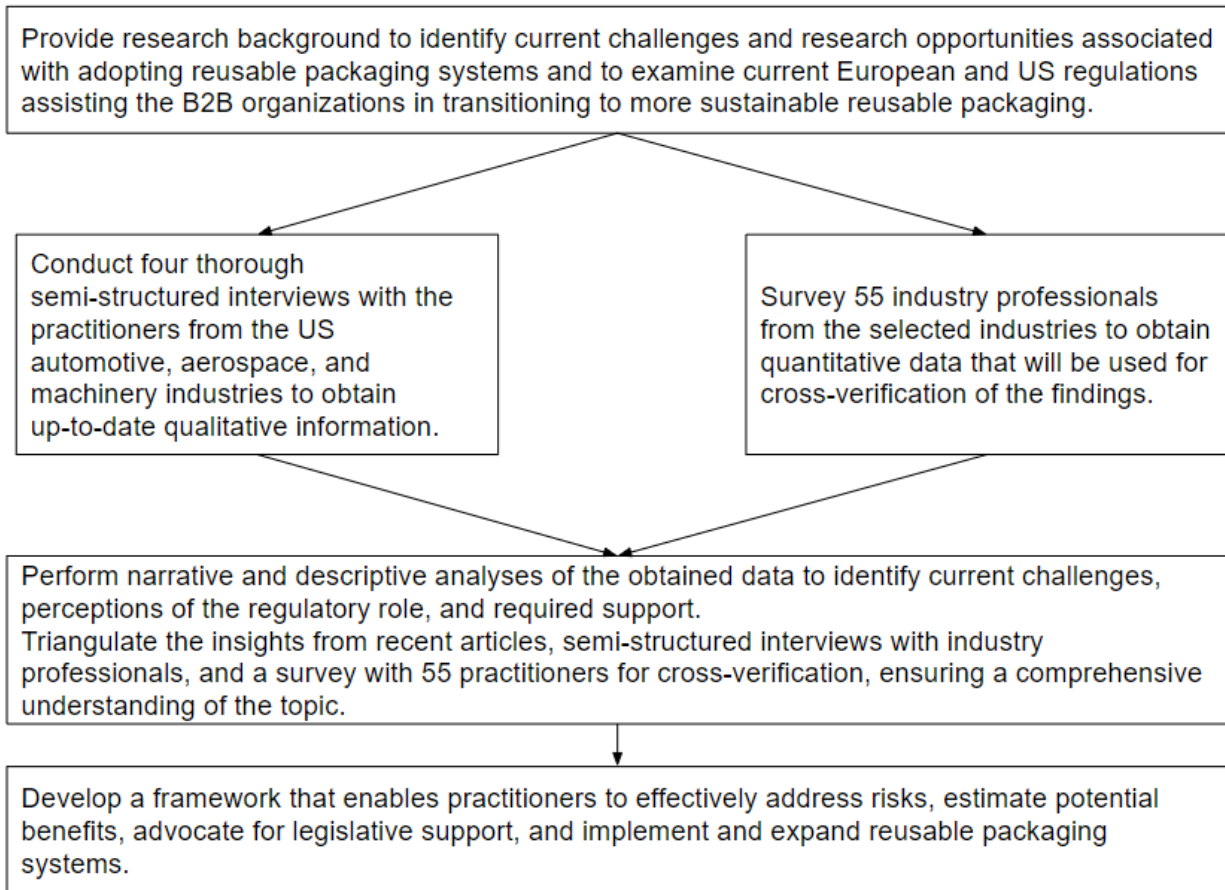


Figure 1. Research methodology.

After discussing the methodology employed in the research, it is essential to acknowledge and address the limitations inherent in our research approach. These limitations are comprehensively examined in the 'Limitations and Future Work' section.

3. Research background

In this section, we provide the definition of tertiary packaging, discuss existing challenges associated with implementing reusable packaging that could be mitigated with effective green policies and industry action, and review current American and European regulations that aim to assist B2B organizations in adopting reusable packaging.

Pålsson [11] defines tertiary or transit packaging as that used in shipping, storage, and bulk handling. Reusable transit packaging includes plastic pallets, crates, totes, boxes, tanks, drums, barrels, and dunnage. There are numerous examples of successful design and implementation of reusable transit packaging systems in various industries. Coelho *et al.* [5] argue that in B2B markets, many industries use pallets, crates, dunnage, drums, and intermediate bulk containers, where standardization allows for automation and cost reductions. However, there are particular challenges regarding the implementation of reusable packaging systems.

The significant capital investment required to establish reusable packaging and high disposal costs is often major organizational barriers. The upfront investments required to utilize the system are elevated by the cost of containers or the payment of a deposit for reusable packaging. Also, the risks of loss and damage lead to additional investments and operating expenses [12, 13].

Another concern is that companies sometimes cannot quantify the economic and environmental effects of industrial packaging and do not see value in adopting a reusable packaging system. That can be due to a company's culture, a lack of organizational motivation, or insufficient human resources. Adopting a systems perspective that considers the interplay between packaging and supply chain operations across the whole supply chain is crucial to ensure sustainability. Neglecting this perspective could lead to suboptimal outcomes and decreased sustainability performance within the supply chains, as highlighted by Garcia-Arca *et al.* [4].

In Europe, packaging and packaging waste has been legislated through a number of directives, including the Packaging and Packaging Waste Directive (1994), the Waste Framework Directive (2004), and the Single Use Plastics Directive (2019). The Waste Framework Directive introduced Extended Producer Responsibility (EPR), and the Packaging Waste Directive requires producers to pay for collecting, recycling, and safely disposing of packaging. Over the last 30 years, almost every European member state has introduced EPR for packaging based on specific national legislation [16].

From a B2B reusable packaging perspective, the proposed revision of the Packaging and Packaging Waste Directive of 2022 includes firm targets for waste reduction, reuse targets for specific sectors, and harmonized product rules. For transport packaging, the revised legislation proposes a target of 30% reusable packaging by 2030 and 90% reusable packaging by 2040 [17]. Together with greater standardization, these targets will stimulate a seismic shift towards reusable packaging in B2B supply chains in Europe and will likely have a stimulating effect on US policymaking.

In the United States, solid waste is legislated across all tiers of government, including the federal, state, and local levels. The Resource Conservation and Recovery Act (RCRA), a federal law enacted in 1976, creates the framework for properly managing hazardous and

non-hazardous waste, intending to reduce the amount of generated waste, protect human health and the environment, and save natural resources. Material reuse is the most preferred solution according to the solid waste management hierarchy [18]. However, the RCRA focuses more on recycling than preventing packaging waste generation.

The Environment Protection Agency (EPA) delegates a significant portion of waste regulation to state and local authorities. Forty-eight states have been granted authorization by the EPA to enforce the RCRA. This authorization mandates that state regulations must meet the federal-level requirements as a minimum standard and can also be more stringent. Since the RCRA is not strongly focused on supporting the adoption of reusable packaging, we should consider other available mechanisms.

Extended producer responsibility (EPR) is a legislative mechanism that shifts the responsibility for end-of-life of products and waste management from authorities to producers and incentivizes the latter to invest in reusing, repairing, and recycling. This mechanism should motivate producers to design their products sustainably, creating products that would eventually decrease waste, negative environmental impact, and end-of-life costs.

In the US, Maine, Oregon, Colorado, California, Washington, and New Jersey have enacted EPR as of 2023. However, in these states, the legislation prioritizes recyclability rather than reusable packaging as a means to minimize the volume of packaging waste.

Fundamentally, no existing legislation in the US promotes the adoption of reusable packaging despite this resource management strategy being higher up the waste management hierarchy than recycling. This research seeks to address this gap and enable practitioners to advocate for policies that would effectively address the challenges that are currently preventing them from implementing and expanding reusable packaging systems.

4. Results

In this chapter, we review and cross-validate the results of the semi-structured interviews and the survey with sustainability and supply chain managers from the examined US industries.

4.1 Current uptake of reusable packaging systems

As seen in Figure 2, on average, 66% of the respondents surveyed stated that their organizations have already adopted reusable packaging systems.

Interviewees A, B, and D stated that their organizations had implemented some reusable packaging systems. Interviewee C stated that reusable packaging was now commonly used in the automotive industry.

Does your company currently use reusable packaging systems?

● Yes ● No ● Not sure

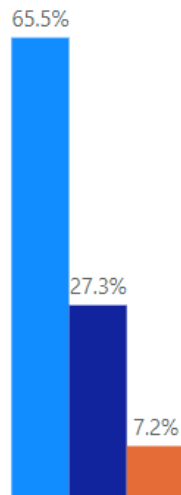


Figure 2. Responses to the question "Does your company currently use reusable packaging systems?" n=55.

Questions regarding the use and benefits of reusable packaging were only asked to respondents who had answered that their organization currently uses reusable packaging. Any respondents answering "No" or "Not Sure" were excluded from these questions.

4.2 Perceived benefits of adopting reusable packaging

As demonstrated in Figure 6, the respondents indicated that a reduced environmental footprint (69%) and cost-savings (61%) were the two most significant benefits across a wide range of experienced improvements. This supports the previous conclusions that we made based on our literature review that highlighted the positive correlation between sustainability advantages and economic advantages.

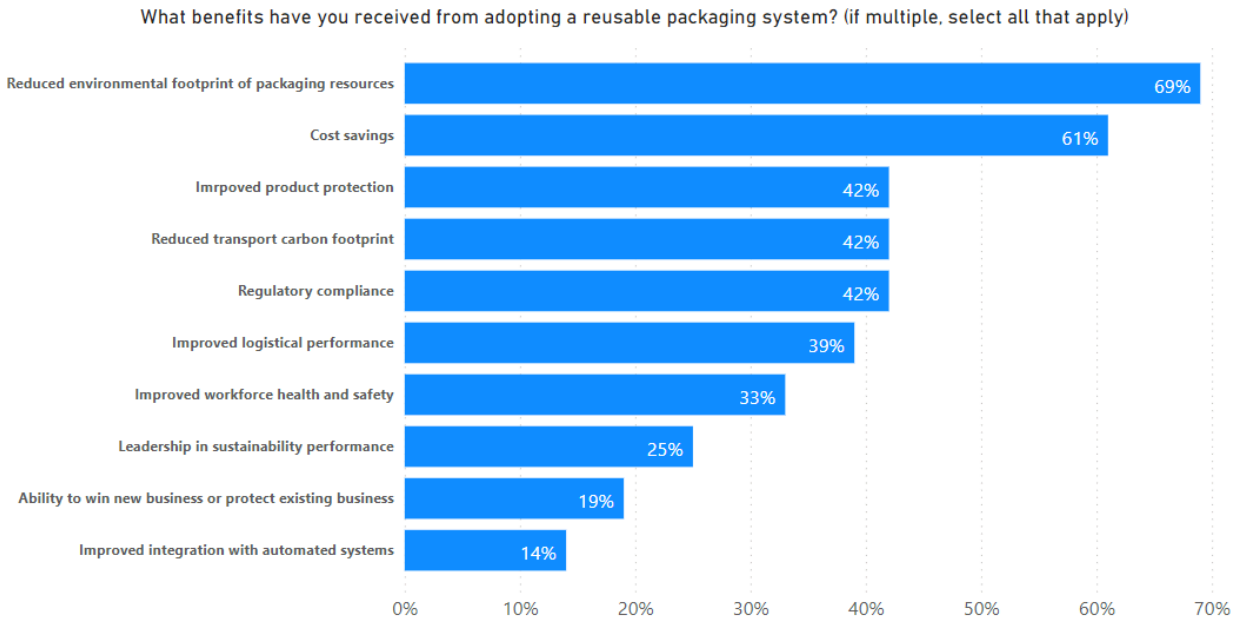


Figure 6. Chart showing the benefits that respondents perceived as a result of implementing reusable packaging. n=55.

Interviewee B further supported this conclusion, stating that their organization wanted to increase the use of returnable packaging, predominantly because expendable packaging is expensive. They stated that this was particularly the case for larger parts, such as fascias (bumper covers), where expendable boxes are costly, and they believe that a possibility for a switch to returnables exists.

Interviewee C stated that as organizations continue to push through with their ESG goals, they see the benefits of returnables, but they also see more bottom-line economic value as a result of implementing these systems because of the use of broader metrics and long-term thinking, predominantly product carbon footprinting, and life cycle analysis (LCA).

42% of respondents also stated that regulatory compliance, improved product protection, and reduced transport carbon footprint were benefits that reusable packaging had conferred, further supported by interviewee D, who believed a reduced environmental footprint to be the main benefit, along with improved employee safety and better parts protection.

4.3 Factors influencing the sustainability of packaging materials

This question was asked to all survey respondents. As can be inferred from Figure 7, for the analyzed industries, economic drivers (47%), customer demand (42%), and logistical ease (36%) were the three most important perceived factors. Government regulation (35%) was also commonly perceived to be an important factor influencing the choice and sustainability of industrial packaging. These results confirm previous studies from our research background findings, discussed in Chapter 3.

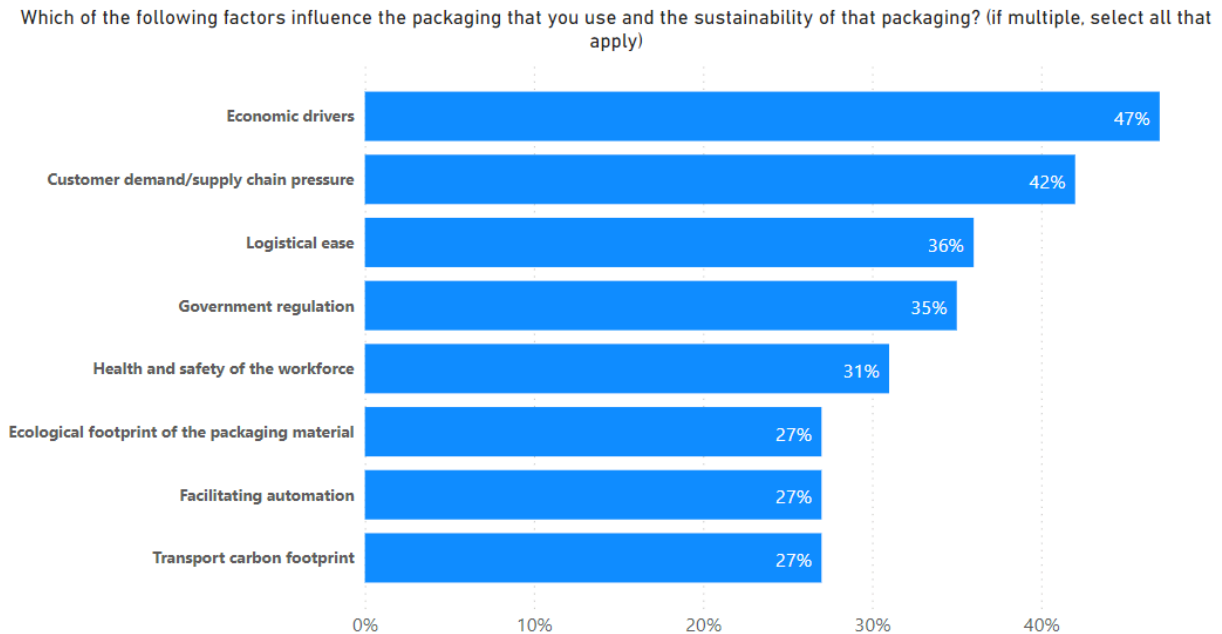


Figure 7. Chart showing the factors that respondents felt influenced the packaging material used and the sustainability of that packaging. n=55.

4.4 The importance of packaging choice for reducing an organization's ecological impact

Figure 8 demonstrates that respondents from all three industries perceive that packaging material choice plays a significant role in their organization's ecological impact, with 69% of respondents giving it a score of over 7.

Interviewee B supported this view, stating that their organization had specific sustainability targets relating to packaging and that using returnable packaging was an important

consideration. Interviewee A stated that their organization considered the sustainability of packaging materials under broader targets of reducing waste and efficiency of operations.. Interviewee C said that packaging designers within the automotive industry are trying to solve the problem of the large volumes and varieties of waste materials disposed of and are considering how to make them more reusable.

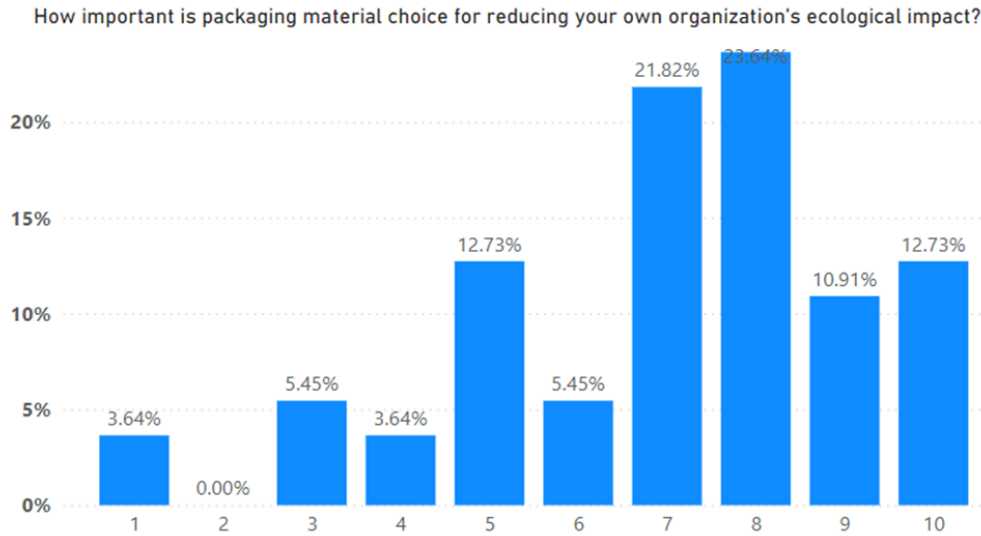


Figure 8. Chart showing the perceived importance of packaging choice for reducing the respondents' organizations' ecological impact, broken down by industry type. A score of 1 denoted that they strongly disagreed with the statement, and a score of 10 denoted that they strongly agreed.

It can, therefore, be concluded that reusable packaging is an essential consideration for B2B organizations to achieve their sustainability goals.

4.5 Barriers to the utilization of reusable packaging

We filtered the answers to the question of barriers by those respondents who stated that their organizations had implemented reusable packaging systems and those who had not.

As shown in Figure 9, the two most significant barriers for those organizations that have not yet implemented reusable packaging are that leadership does not see sufficient value (47%) and the lack of mandatory status for such industrial packaging (47%). This finding is supported by our literature review, including Coelho *et al.* [5], which highlighted the importance of leadership in adopting innovative technologies and approaches. It can also be concluded that some companies prefer to react to changes in environmental legislation and limit their sustainability efforts to those that ensure compliance with current environmental requirements.

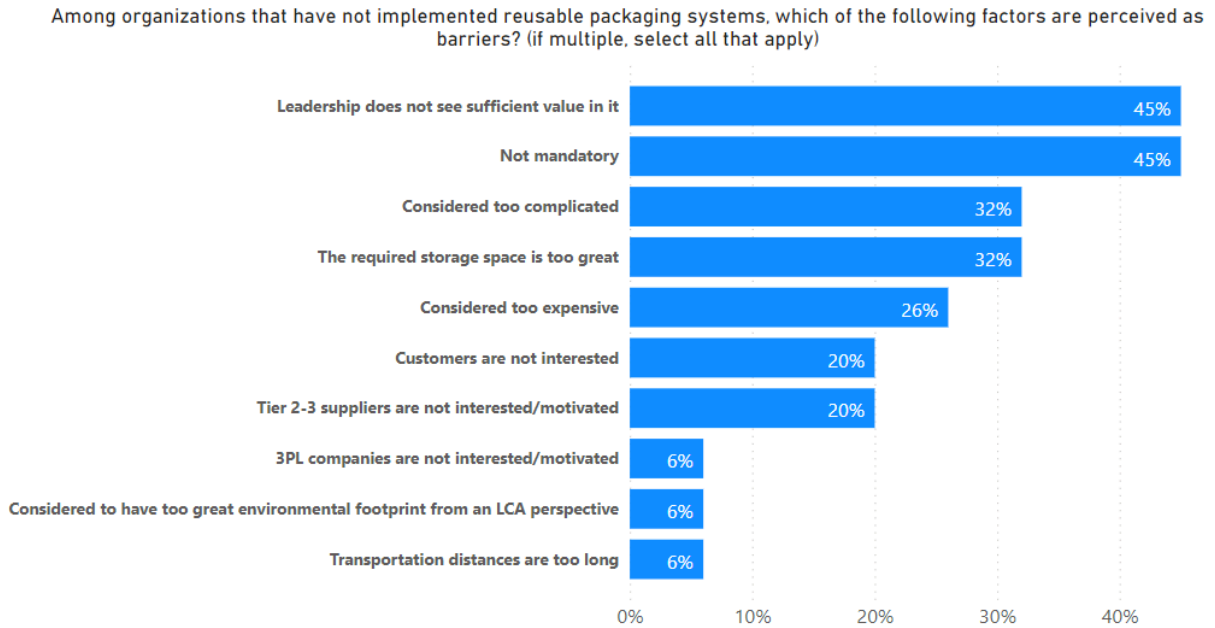


Figure 9. Chart showing the perceived barriers to the use of reusable packaging systems for those organizations that **have not** currently implemented such systems. n=15.

In contrast, as seen in Figure 10, managers in the pioneering organizations admitted that high capital costs (50%) and the voluntary legislative status of the initiative (42%) were the two barriers that most hindered the further adoption of reusable packaging.

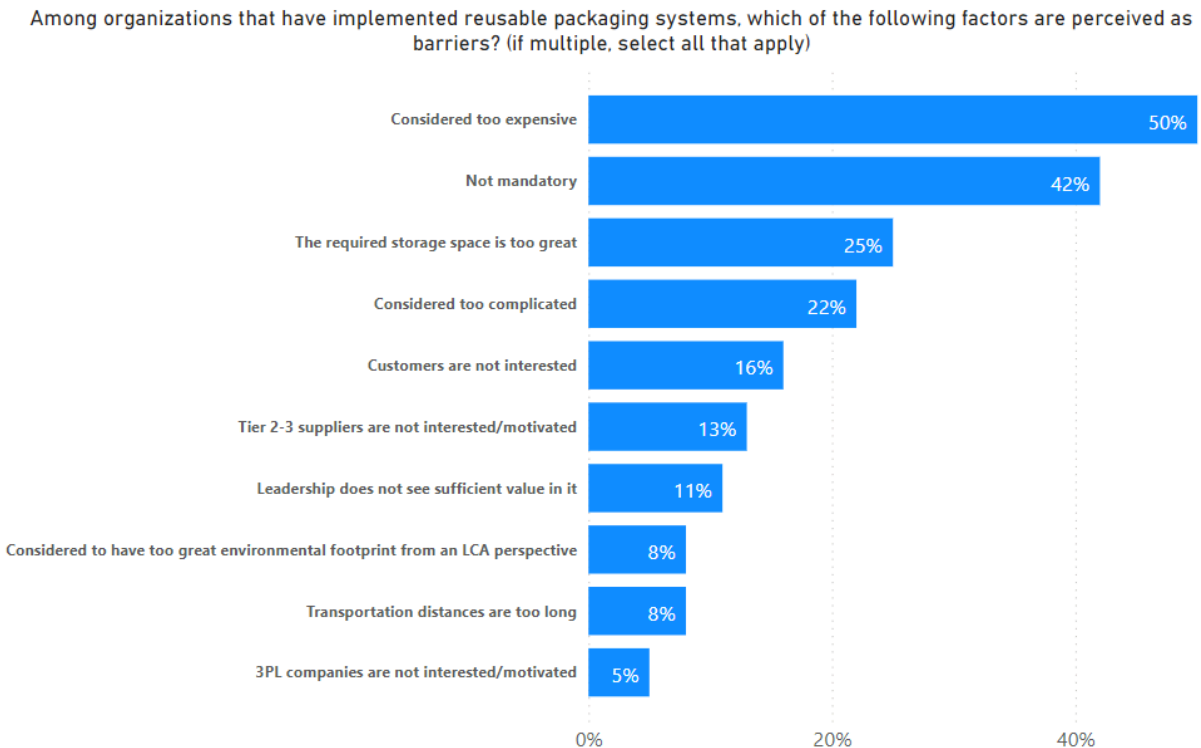


Figure 10. Chart showing the perceived barriers to the use of reusable packaging systems for those organizations that **have** implemented such systems. n=36.

Interviewee A believes mandatory policies for returnable packaging would level the investment field, eliminating competitive advantage gained from not investing, thereby addressing the high initial cost barrier. Interviewee B highlighted that high capital costs hinder early adopters, citing issues with tracking returnable packaging and maintaining sufficient stock due to damage and loss. Interviewee C emphasized cost as a primary concern, noting the challenge of justifying reusable packaging without including intangible factors like carbon impact, unless a company has stringent ESG goals. Interviewee D identified the main logistical challenges as tracking containers throughout the supply chain and efficiently storing them to avoid supplier storage fees.

4.6 The government mechanisms to prioritize

As represented in Figure 12, when respondents were asked to choose the single government mechanism they felt should be prioritized to stimulate a reusable packaging ecosystem, indirect financial support was the most commonly supported measure, favored by over a quarter of respondents (27%).

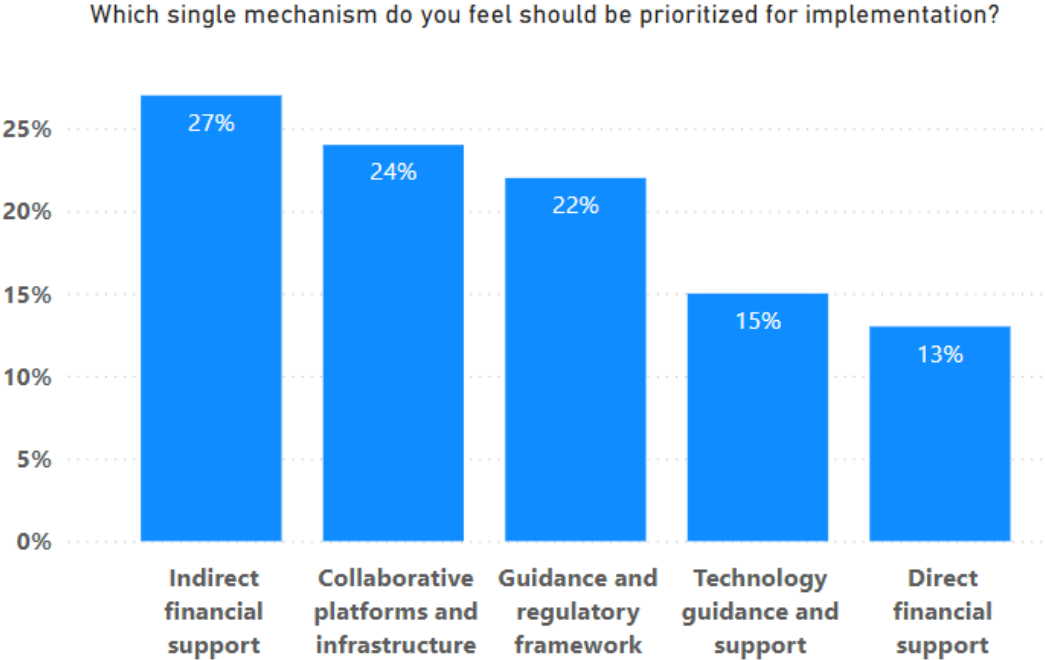


Figure 12. Chart showing the single government mechanism respondents felt should be prioritized to aid the implementation of reusable packaging in their sector. n=55.

Interviewee D emphasized prioritizing collaborative platforms and infrastructure in government policies.

Interviewee C believed monetary incentives or penalties would significantly impact, effective in cohesive industries with influential trade associations but challenging in disparate sectors. They noted private sector interest in financial gains and legal compliance in case of penalties, though implementation might be tough in anti-government contexts. Interviewee C also saw value in government-assisted trade associations for developing regulatory frameworks, citing benefits for both parties in convening necessary stakeholders for efficient policy development. They felt context was crucial in choosing the right approach among five potential mechanisms.

Interviewee B shared their company's participation in a cross-industry platform for sustainability in storage and transportation, highlighting the benefits of sharing non-competitive best practices. This was echoed by Interviewee C, who noted similar initiatives for sustainable packaging in the automotive industry.

While there are specific differences between the examined industries because of dissimilarities in the products' life cycles, volumes, regulations, supply bases, etc., there are also numerous resemblances. Our research suggests that there are sufficient shared barriers, influencing factors, and incentivizing mechanisms across the three industries.

4.7 The role of standardization of transport packaging formats

As seen in Figure 14, respondents from all three industries highlight the importance of standardizing packaging formats to assist in adopting reusable packaging. The mean is 7.3. From the Wilcoxon Signed-Rank Test results, respondents perceive the standardization of transit packaging as favorable for incorporating a reusable packaging system. The central response notably surpasses the neutral benchmark of 5.5, with a median estimate close to 8 ($p < 0.001$, Wilcoxon's signed rank test, $n=55$). The analysis demonstrated that we are 95% confident that the true median of the population is at least 7.5.

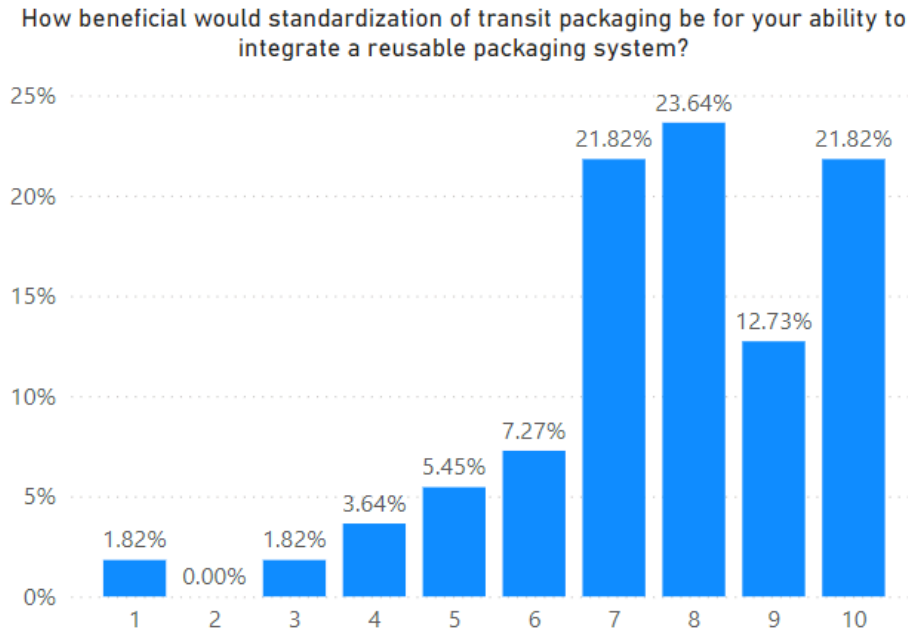


Figure 14. Chart showing how beneficial respondents felt standardization of tertiary packaging material formats would be to their ability to integrate reusable packaging systems. A score of 1 denoted that the respondents felt standardization would have no beneficial impact, and a score of 10 denoted that they felt it would have a significant beneficial impact. $p < 0.001$, Wilcoxon Signed-Rank Test, $n = 55$.

Interviewee A viewed standardization as beneficial, noting that shifting to a new reusable packaging design entails investment and risk. They believed standardization would facilitate decision-making and prevent organizations from hesitating over packaging choices.

Interviewee B also supported standardization, citing the current use of various materials and dimensions in packaging. They argued that standardization would lessen the loss of unique packaging and reduce capital costs.

Interviewee C stressed the importance of considering materials and ease of disassembly in standardization to ensure ecological benefits in the lifecycle of returnable packaging.

4.8 The potential influence of industry standards

Figure 15 validates the insights obtained through the interviews that overarching industry standards are a vital mechanism for stimulating the creation of reusable packaging infrastructure. The mean score is 8.24. Based on the Wilcoxon Signed-Rank Test results, the

respondents view industry standards as highly advantageous for implementing reusable packaging in their sector. The primary response surpasses the neutral reference point of 5.5, with the median and mean values both approximating 8 ($p < 0.001$, Wilcoxon's signed rank test, $n = 55$). The study indicates with 95% confidence that the actual median of the entire group is 8 or higher.

How beneficial do you think that industry standards can be in adopting reusable packaging within your sector?

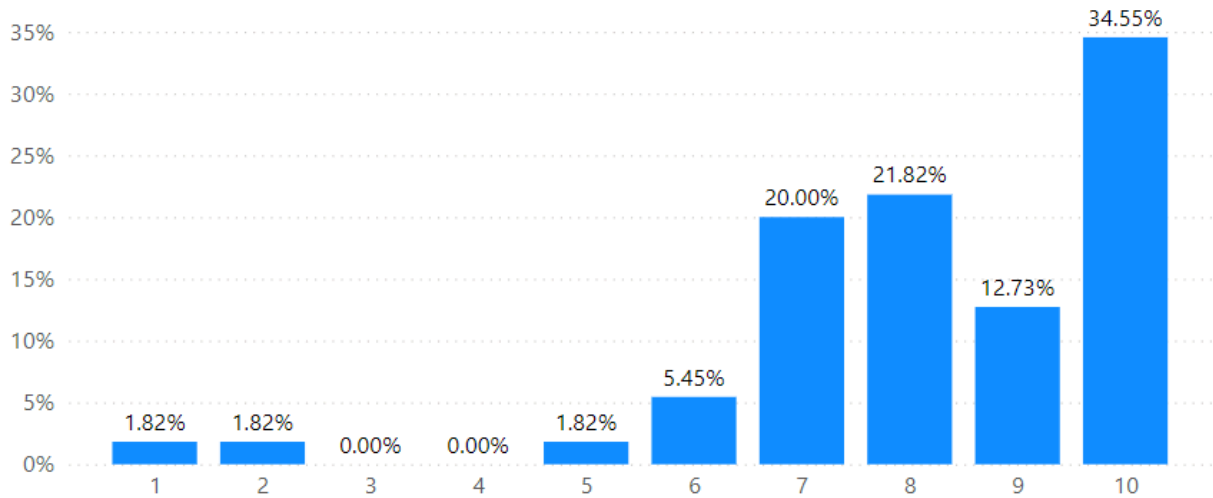


Figure 15. Chart showing respondents' perceptions of how beneficial industry standards could be in adopting reusable packaging within their sector. A score of 1 denoted that the respondents felt that industry standards would have no beneficial impact, and a score of 10 denoted that the respondents felt industry standards would have a significant beneficial impact. $p < 0.001$, Wilcoxon Signed-Rank Test, $n = 55$.

Interviewee A felt that switching to regulatory requirements related to sustainability and specifically returnable packaging will spur changes in behavior that are more market-driven. They stated that their organization would be encouraged to use a returnable packaging option that was more expensive if that choice didn't make them less competitive compared to others in the market.

Interviewee C advocated for collaboration, supported by regulatory frameworks and standards, especially in the automotive sector. They cited the "Suppliers Partnership for the Environment" as an example, pursuing initially voluntary standards with widespread recognition of their value. Emphasizing the need for industry-wide agreement on mandates and standards, they highlighted the importance of providing clear governance rules to suppliers.

4.9 Customer interest in an organization's choice of packaging materials

As seen in Figure 17, most respondents (63.6%) believed that customer interest in their organization's sustainability performance extended as far as their choice of packaging materials and predicted that this interest would increase within five years (70.9%). Customer demand is, and will continue to be, a core stimulating factor for organizations to implement reusable packaging.

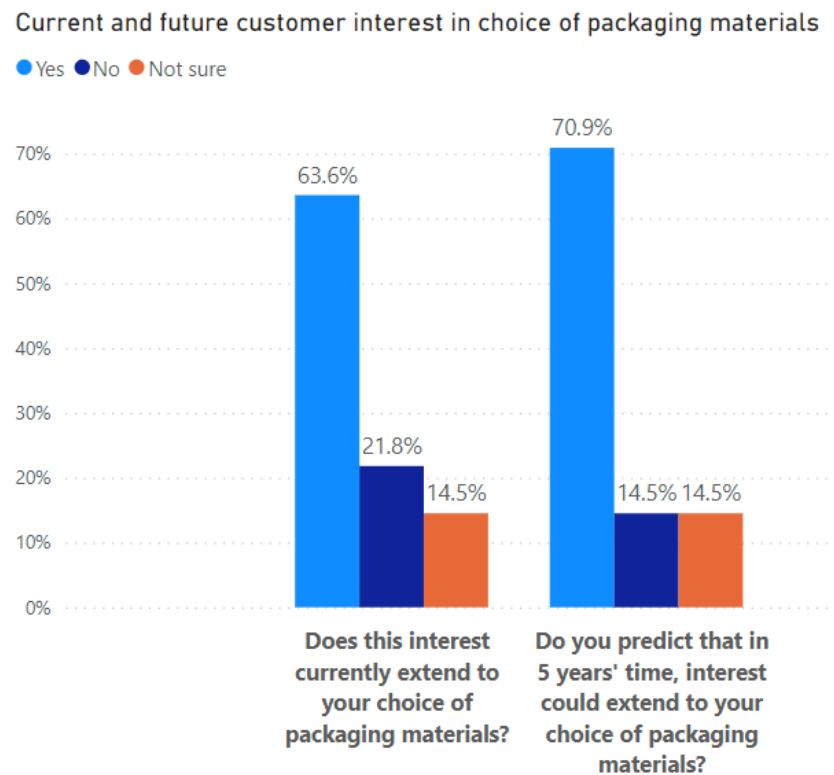


Figure 17. Chart showing respondents' perception of customer interest in their choice of packaging materials now and in five years' time. n=55.

Interviewee D found there to already be fairly high interest from their customers due to their values and interests, along with the cost savings their suppliers can pass on in their contracts.

4.10 Plans to expand the use of reusable packaging systems in the future

According to Figure 18, those respondents in organizations that already have reusable packaging systems in place are significantly stronger in their belief that their organization would extend the use of reusable packaging (75% in those that have, versus 20% in those who have not).

Does your company have plans to expand the use of reusable packaging in the future?

● Yes ● No ● Not sure

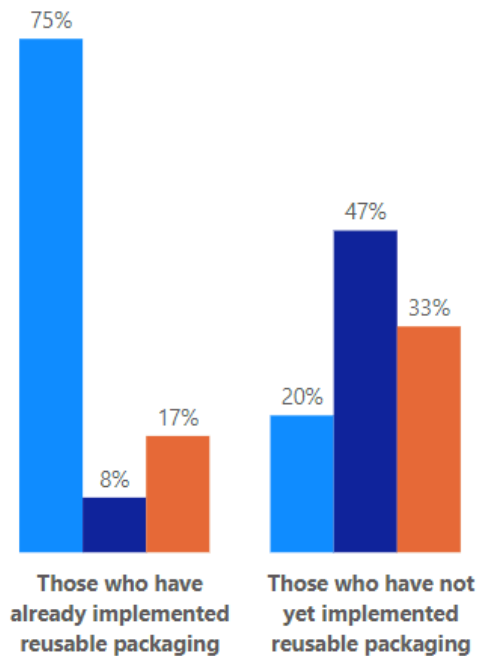


Figure 18. Chart showing respondents' belief that their organization has plans to expand reusable packaging within the next five years. (a) n=36 (b) n=15.

This highlights the need for mandatory government policies for reusable packaging adoption. While internally motivated organizations will naturally adopt these systems, others require external stimuli to conform. Research indicates that once implemented, organizations realize the benefits outweigh the costs, leading to widespread support for reusable packaging enhancing B2B supply chain sustainability.

5. Framework

In developing the framework, we took the five barriers that respondents identified as most important across participating and non-participating organizations. We matched these barriers against the policy mechanisms our data analysis showed respondents believed could be the most beneficial, supplemented by proposed innovative solutions. Some proposed mechanisms address several barriers since many operational and financial challenges are intertwined and can be tackled collectively.

The four most significant barriers for non-participating organizations were that leadership does not see sufficient value, the lack of mandatory status for reusable packaging, that it was considered too complicated, and a perceived lack of storage infrastructure. Respondents from participating organizations concurred that the lack of mandatory status and lack of storage infrastructure were principal barriers, with higher capital costs associated with establishing reusable infrastructure as the final identified barrier.

According to our data analysis, indirect financial support, collaborative platforms, and guidance and regulatory frameworks were deemed to be the most valuable broad policy mechanisms to assist organizations in developing reusable packaging ecosystems. We have prioritized these most high-potential broad mechanisms in the framework, breaking them down into specific initiatives and policies that have proven successful in other relevant studies or were suggested by the industry professionals we interviewed based on their direct experience.

We initially matched the barriers with the mechanisms that would most effectively counter them, then scored each mechanism for its predicted potential business impact (BI) at mitigating that particular barrier, where the highest score indicates a mechanism that could have the greatest positive business impact for assisting organizations in establishing reusable packaging systems. We then assigned a score for each mechanism's predicted ease of implementation (EoI), where the highest number is assigned to the mechanism that could be relatively simple to implement. The scoring methodology for BI and EoI is included in Appendix B. Mechanisms that score high in both categories fall into the high-impact/high ease of implementation zone, represented by a blue square on the chart. All scores are based on the insights that have been obtained from the literature review, survey, and series of interviews with industry professionals.

Our research and the framework were significantly enhanced by constructive feedback from William Hall, an expert with over 30 years of experience in strategic development, procurement planning, supply chain management, and business continuity in the automotive sector. Mr. Hall guides projects involving sustainability, strategic development, supply chain resilience, and risk management. Such seasoned insights are instrumental in grounding our findings in real-world applicability and expertise.

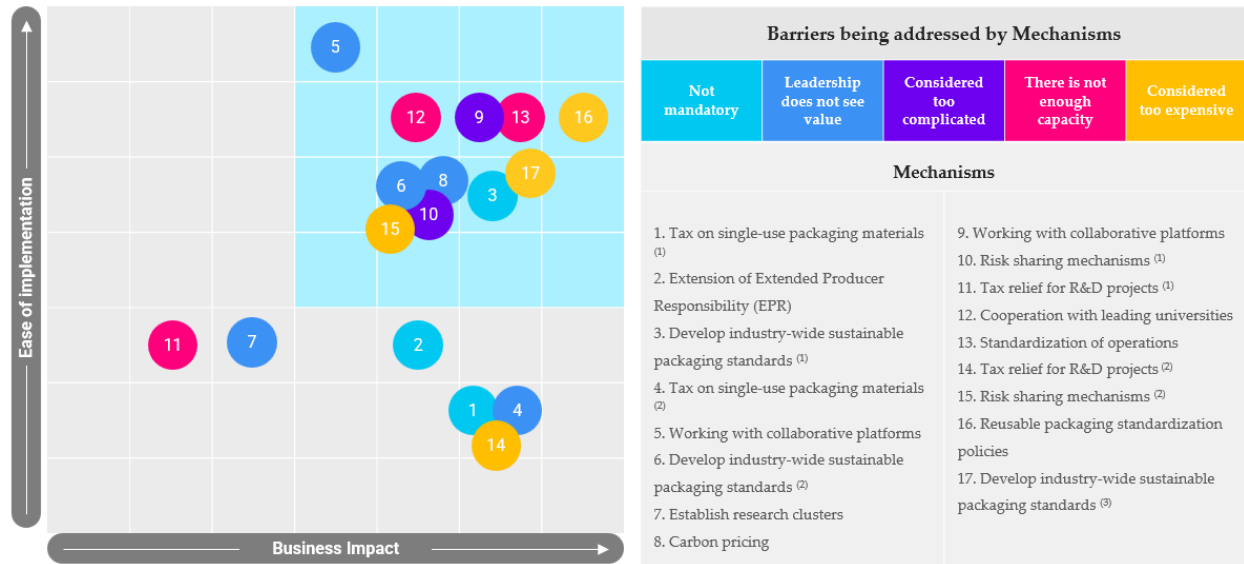


Figure 19. Mechanisms for Overcoming the Principal Barriers and Stimulating the Implementation of Reusable Packaging in the Examined Industries.

Below, we outline the mechanisms identified in the chart that can address the recognized obstacles. It is essential to understand that these methods will have the most favorable result when they are implemented collectively.

5.1 Tax on single-use packaging materials (mechanisms 1 & 4)

Barriers addressed: Lack of mandatory status, Leadership does not see value

Since the adoption of reusable packaging is not currently mandatory for B2B companies, pioneering companies risk losing their financial competitiveness in industries with razor-thin margins. For many business leaders, this lack of mandatory status causes them to not assign value to investing in reusable packaging infrastructure. Implementing mandatory taxes on single-use packaging could prompt business leaders to rethink their packaging strategies throughout their value chains. By prioritizing using returnable containers, they can sidestep financial penalties that would undermine their competitiveness.

Taxes on single-use plastic consumer products have been successfully implemented in many countries. In the UK, a 5 pence (6 cents) fee on single-use plastic carrier bags has reduced their use by over 80% [19]. Although this mechanism is very impactful, it takes work to implement and is likely to face resistance in an anti-government setting. Martinho et al. [20] highlight the tax's role in altering consumer habits, suggesting that the tax and the availability of alternatives to single-use plastic contributed to this change. In particular, the study demonstrates the tax's success in two European cities, where it led to a notable reduction in single-use plastic

consumption and an increased adoption of reusable alternatives, reflecting the tax's potential as an effective economic tool for addressing environmental issues.

5.2 Extension of Extended Producer Responsibility (EPR) scheme to stimulate funding for reusable packaging materials (mechanism 2)

Barrier addressed: Lack of mandatory status

Interviewee C found in their experience that the current system cannot independently create the plans and resources for closed-loop supply chains and that there is a need for additional funds to stimulate the formation of these systems. EPR programs have been implemented successfully for consumer packaging and could, in turn, be applied to transit packaging. These programs aim to shift the cost of managing packaging waste from taxpayers to businesses. This change intends to motivate producers to create products with less environmental impact. The focus is on designing sustainable products, initially prioritizing their recyclability and the use of recycled materials in products and packaging. Diggle et al. [22] discuss positive results, challenges, and best practices for implementing EPR incentives in various industries, including manufacturing. Moreover, Sin and Tuen [23] list international environmental policies related to waste management and discuss the promising outcomes of EPR. Miller et al. [24] suggest adjusting fees in EPR schemes per the European Single-use Plastics Directive. They propose higher fees for more polluting products, such as single-use plastics, and lower fees for less polluting ones, such as reusable items.

Copello and Simon [25] found that current EPR schemes fall short of covering the entire cost of managing single-use packaging waste, making reuse systems seem more costly due to their comprehensive internalization of expenses. They proposed the establishment of a 'Fund for Change,' financed by EPR schemes, to support reusable systems financially. This fund would help cover initial costs. They also suggested that municipalities use EPR systems to contribute to waste prevention and reuse initiatives. The authors referenced CITEO, the French Producer Responsibility Organization, which allocates a portion of its funds to achieve the 5% reusable packaging goal set by the French Circular Economy Law, as a successful example.

5.3 Development of industry-wide sustainable packaging standards (mechanisms 3, 6 & 17)

Barriers addressed: Lack of mandatory status, Leadership does not see value, Considered too expensive

By collaborating through industry trade associations, industries have the power to create mandates and frameworks even in the absence of government legislation. Initially, these standards can be voluntary, aiming to motivate and draw organizations into participation. Over time, they can transition to mandatory requirements, ensuring alignment across the entire

industry. Since standards require the action of all businesses within the industry equally, it removes some of the comparative cost of entry and reduces costs through economies of scale.

These standards can force action from business leaders in previously non-participating organizations and be applied to suppliers through procurement programs to incite action down the value stream. Interviewee C found standards to be a particularly important mechanism: "That's why it's important for the industry to come together and establish mandates and standards so that they can turn to their suppliers and say "here are your rules of governance to live by." In effect, the industry can come together and agree to make something that acts like a law, even when no law is present.

Such standards could ban single-use items, advocate for incentives for reusables, and incorporate packaging standardization specifications, which we have detailed as a standalone mechanism in 5.11.

5.4 Working with collaborative platforms (mechanisms 5 & 9)

Barriers addressed: Leadership does not see value, Considered too complicated

Stakeholders can engage with collaborative platforms such as industry trade associations to learn best practices and avoid costly, firsthand mistakes before approaching initially hesitant leaders. This can break down some of the challenges of what is a multi-faceted and challenging project, requiring experience and approval from various management levels. Numerous intra-industry associations are already in place, aiming for broader adoption of sustainable packaging through experience sharing and mutual support for organizations. For example, in the automotive sector, the Suppliers Partnership for the Environment (SP), the Automotive Industry Action Group (AIAG), and the North American Service Benchmark (NASP) aim to strengthen the automotive service industry by fostering collaboration and sharing best practices.

Interviewee C found that from their experience, "a lot of sustainability initiatives really only succeed if you do it together, and it is a win for everybody. For this to happen, everyone must agree that this is pre-competitive." If so, collaboration can drive solutions, ensuring success for all parties involved. The respondents highlighted the importance of knowledge sharing and collaboration with competitors and supplier tiers, as it is a mutually beneficial mechanism for all parties involved. Interviewee B stated that their organization participates with the NASP with a "goal to take advantage of best practice as non-competitors, so that improvements in non-competing areas of [sustainable] operations can be shared openly", and the Supplier's

Partnership for the environment brings together global automotive manufacturers and their large and small suppliers, gaining their insights and experience in an open and collaborative environment to tackle collaboratively, for example, the challenge of packaging waste to make the industry less environmentally impactful.

Interviewee C also stated that if such trade associations could get help from the government in developing a regulatory framework, this would greatly benefit both the trade association and the government since the working groups and key stakeholders are already present to facilitate the process. Ellsworth-Krebs et al. [26] stress the importance of creating an industry-wide informational environment and data sharing in overcoming barriers.

5.5 Establishment of research clusters (mechanism 7)

Barrier addressed: Leadership does not see value

Innovative solutions might emerge from outside the industry by integrating organizations' R&D teams with university participation, forming research clusters similar to the Research Triangle Park in North Carolina. Such an approach could prove effective on a national scale. However, this mechanism demands substantial investment and time before yielding initial results. Iritié [27] explains that the effectiveness of R&D cooperation and subsequent social welfare enhancements are not solely due to the presence of clusters but are significantly influenced by the clusters' networking capabilities, member diversity, and attractive environments. He points out that these clusters are more conducive to collaboration than isolated efforts and advocates for the reinforcement of such clusters through strategic public incentive policies that complement and strengthen private sector initiatives, underscoring this as a central consideration in the design of R&D subsidy policies, especially for firms within competitive clusters.

5.6 Carbon pricing (mechanism 8)

Barrier addressed: Leadership does not see value

Carbon pricing can drive investments and innovation towards cleaner, reusable alternatives by increasing the relative cost of utilizing carbon-intensive technologies. Business leaders seeking cost-effective solutions to reduce emissions may be prompted to explore reusable packaging systems to maintain their competitive edge. This mechanism is already in effect, and it is widely recognized that the price will escalate following the carbon emission targets set by the Paris Agreement. This makes implementing carbon pricing arguably simpler than introducing taxes on specific packaging materials, and interviewee C felt that it would help to trickle down the ESG-related goals to the next layers in the supply chain, with a carbon price effectively

monetizing these sustainable considerations. However, its precision is less exacting than a tax approach directly targeting single-use packaging items. Therefore, this mechanism should be implemented along with other measures. Khan and Johansson [28] echo this and conclude that carbon pricing is a crucial but not singular tool for enabling a low-carbon transition, requiring a mix of policies to address barriers and achieve rapid emission reductions without compromising other sustainability goals. The research indicates a pressing need for policy blends that balance industrial competitiveness with the drive towards net-zero carbon objectives amidst likely resistance from business interests.

5.7 Risk-sharing (mechanisms 10 & 15)

Barriers addressed: Considered too complicated, Considered too expensive

Risk-sharing mechanisms where key suppliers and customers are invited to participate in a new project to share the risk and potential future savings can tackle the perceived lack of expertise. If an organization considers it too complicated to restructure packaging infrastructure towards reusability or has insufficient human resources to manage the change, collaborating with its primary suppliers and customers can distribute the risk. As a result, the organization might be more inclined to embark on such a venture.

Organizations frequently partner with their key suppliers when developing a new model, inviting them to co-invest in the project. This joint investment allows both parties to share risks and potential future profits. A similar approach could be employed for creating returnable packaging infrastructure. Companies that feel resource-constrained for R&D investment might benefit from distributing costs and future savings with primary suppliers and customers.

5.8 Tax relief for R&D projects (mechanisms 11 & 14)

Barriers addressed: Perceived lack of storage capacity, considered too expensive

Many companies argue that they need more financial and human resources to transition to reusable packaging systems, believing such systems demand more advanced operations than their current capabilities. Offering tax relief for R&D projects dedicated to developing and managing reusable packaging can mitigate this concern. It indirectly supplies the funding needed for both materials and the labor hours essential for conceptualizing and rolling out these advanced operations.

Buyn et al. [29] argue that tax instruments boost R&D in recipient firms and precipitate a cascade effect of knowledge and technology benefits across their industry. Li et al. [30] further

assert that these incentives improve environmental performance through enhanced overall productivity and serve as a sustainable fiscal measure for promoting green enterprise development.

5.9 Cooperation with leading universities (mechanism 12)

Barrier addressed: Perceived lack of storage capacity

Collaborating with top-tier universities by facilitating summer projects and internships can be a strategic move to attract future sustainability and operations professionals. Institutions such as the Erb Institute and the Tauber Institute at the University of Michigan are good examples of how universities can cooperate with various industries to tackle real-world problems and provide high-potential talent to companies. Such partnerships can benefit from both direct and indirect financial support. Renowned universities boast significant resources, including esteemed faculty, graduate and postgraduate students, and distinguished alumni. This collective expertise is primed to invest in and devise solutions that can effectively address existing barriers.

5.10 Standardization of operations and packaging (mechanisms 13 & 16)

Barriers addressed: Perceived lack of storage capacity, considered too expensive

Currently, the variety in dimensions, materials, and durability of individually designed reusable containers leads to inefficiencies. Industry-wide standardization involving shape, volume, weight, material, and configuration can greatly improve cost efficiency and operational logistics. This should be informed by supply chain practitioner insights and lower entry barriers for new systems, easing the shift from single-use to reusable containers. Standardization's role in improving system integration and reducing waste management inefficiencies is highlighted by Mahalik [33] and Ceyhan et al. [34]. In Europe, Copello [35] pushes for harmonized, universal packaging formats to enhance efficiency and interoperability across reuse schemes. Standardization in industrial packaging is key to establishing an efficient returnable packaging ecosystem in the B2B supply chain. It enhances integration, coordination, and collaboration, optimizing storage, transportation, and handling while reducing reliance on custom solutions. Research shows benefits like more durable, collapsible, multi-use containers (Smoljan et al. [15]) and lower shipment costs (Katephap and Limnararat [31]). Applying standardization across the value stream, including suppliers, transportation, warehousing, production, consumption, and reverse logistics, streamlines container management and addresses capacity and attrition issues. This approach, as Castka [32] suggests, improves firm performance and fosters competitive adaptation to these standards.

This mechanism has been assigned the highest score because of its potential impact and the consensus among the respondents. Based on the interviews and the survey, our respondents perceive standardization as one of the most promising approaches to stimulate broader adoption of reusable packaging in their industries.

6. Discussion

We conducted a comprehensive survey and open-ended semi-structured interviews, complemented by our research into existing literature. This approach was designed to delve into how machinery, aerospace, and automotive companies view reusable packaging. Our focus was on understanding their perception of it, identifying the key barriers hindering its adoption or expansion, and exploring their ideas on strategies that could mitigate these obstacles and encourage the development of a reusable packaging infrastructure.

Our survey concluded that most respondents felt that packaging choice was important for reducing their organization's ecological footprint. Our semi-structured interviews strongly supported this sentiment, and the conclusion we drew from both studies and the literature review is that reusable packaging is essential for B2B organizations to achieve sustainability goals. While there are specific differences between the examined industries because of dissimilarities in the products' life cycles, volumes, regulations, supply bases, etc., there are also numerous resemblances. There is also a need to differentiate between B2B and B2C industries since more guidance and support currently exist for B2C sectors with regard to packaging materials. For this reason, this research considers the three industries collectively in order to come to conclusions that can be applied to other B2B industries outside of the scope of our study. Our research suggests that there are sufficient shared barriers, influencing factors, and incentivizing mechanisms across the three industries. Namely, we have identified the following core barriers in the examined B2B industries: the lack of mandatory status for reusable packaging, that leadership does not see value, that it is considered too complicated, that there is insufficient capacity, and that it is considered too expensive.

Our survey results showed that organizations that already have reusable packaging systems in place are significantly more likely to extend the use of reusable packaging (75% in those that **have** versus 20% in those who **have not**). This highlights the importance of intra-industry or government mechanisms that would make it obligatory for organizations to implement reusable packaging. Those organizations that are internally motivated to implement such systems will

continue to do so organically, but the evidence suggests that the organizations that are non-participatory to date will need an external stimulus to force them to conform and adopt such measures. Once reusable packaging systems have been implemented, our research suggests that organizations will recognize that the benefits outweigh the costs, and newly participating organizations should, in turn, become proponents of reusable packaging, ultimately improving the sustainability performance of B2B supply chains.

In this study, we identified several facilitating policy mechanisms that practitioners can advocate for through their representatives in governments and at industrial conferences to address the core barriers currently preventing the establishment and expansion of reusable packaging systems in the B2B sector. Namely, these are a tax on single-use packaging materials, extension of Extended Producer Responsibility (EPR), carbon pricing, development of industry-wide sustainable packaging standards, interaction with collaborative platforms, establishment of research clusters, tax relief for R&D projects, standardization of operations and packaging, cooperation with leading universities, and risk-sharing mechanisms.

In ranking these mechanisms in our framework based on their business impact together with their potential ease of implementation, we have created a road map that practitioners can enact to make the environment and legislation more favorable. Naturally, those facilitating mechanisms that can be actioned from within an industry or together with research institutes and universities through collaboration, knowledge sharing, and participation were judged to be easier to implement and more immediately valuable than those that would require advocating for government policy and legislation changes. As we developed the framework, it became apparent that some proposed mechanisms address several barriers simultaneously since many operational and financial challenges are intertwined. The combined benefit of enacting these mechanisms, therefore, affords a greater potential benefit for the development of reusable packaging infrastructure. Such duplicate mechanisms were establishing industry-wide packaging standards (3, 6 & 18); standardization (14 & 17); tax on single-use packaging items (1 & 4); tax relief for R&D projects (12 & 15); and risk-sharing mechanisms (11 & 16).

Industry-wide packaging standards, standardization, and risk-sharing mechanisms all fall into the high impact/high ease of implementation zone, represented by the blue square in our framework chart (Figure 19). We, therefore, conclude that these are the mechanisms where practitioners should focus their efforts first, offering the greatest potential chance to shift the landscape in favor of the establishment and proliferation of reusable packaging systems for the relatively slightest effort.

The financial support mechanisms of a tax on single-use packaging items and tax relief for R&D scored highly for potential business impact, making them important policies to advocate for

with representatives in government. However, they had comparatively low ease of implementation scores since they require legislative action, which generally takes significant time and political will to pass. However, since a tax on single-use items is more punitive and tax relief for R&D would be considered a more stimulating measure, there may be a greater likelihood of a tax relief mechanism gaining political traction.

In conclusion, this study not only investigates the complexities and commonalities of adopting reusable packaging in the examined industries but also provides a practical, actionable framework, serving as a vital tool for companies aiming to enhance both the sustainability and operational efficiency of their supply chains.

This study provides a clear pathway for practitioners in B2B industries to take in order to advocate for legislative backing and successfully implement or expand reusable packaging systems, increasing the sustainability and circularity of their supply chains.

7. Limitations and Future Work

Our research was subject to several limitations related to the study's methodology and the industries' unique features.

- Although we surveyed 55 respondents and interviewed four professionals from the chosen industries, their insights will naturally not represent the entire population.
- Many practitioners we approached to participate in our qualitative questionnaire refused to participate in the study. Thus, we need to account for the non-response bias.
- Also, in our research, we assumed that all the respondents and interviewees answered truthfully and to the best of their abilities.

One of the possible directions of future research could be replicating this methodology using a large sample and perhaps adjacent industries. Examining the trends and barriers in the chemical, electronics, and pharmaceutical industries would help understand the broader applicability and potential variations in adopting reusable packaging practices.

Finally, investigating the specific challenges of reusable packaging within this setting presents an intriguing dimension.

Author Contributions

Conceptualization, IK and LH; methodology, IK and LH; software, IK and LH; validation, IK and LH; formal analysis, IK and LH; investigation, IK and LH; resources, IK and LH; data curation, LH; writing—original draft preparation, IK and LH; writing—review and editing, IK and LH; visualization, IK; supervision, IK and LH; project administration, IK and LH; funding acquisition, IK. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Data Availability Statement

Data is available upon request from researchers who meet the eligibility criteria. Kindly contact the first author privately via email.

Conflicts of Interest

The authors declare no conflict of interest.

Appendix A. Survey and Interviews Questionnaire

1. Are any reusable packaging systems currently in place within your organization? Y/N
 - a. If yes, what benefits have you received from adopting a reusable packaging system? (rate from 1 to 10, where 1 is *no benefit* and 10 is a *considerable benefit*)
 - Cost savings
 - Regulatory compliance
 - Leadership in sustainability performance
 - Improved logistical performance
 - Reduced transport carbon footprint
 - Reduced environmental footprint of packaging resources
 - Improved integration with automated systems
 - Improved workforce health and safety
 - Improved product protection
 - Ability to win new business or protect existing business
 - b. If not, does your organization plan to implement reusable packaging within the next five years? Y/N
 - c. If you have no such plans, how do you rate the following factors as barriers? (rate each potential barrier from 1 to 10, where 1 is *strongly disagree*, and 10 is *strongly agree*.)
 - Not mandatory
 - Leadership does not see sufficient value in it
 - Considered too expensive (potential loss/damage of containers, high upfront costs)
 - Considered too complicated
 - Tier 2-3 suppliers are not interested/motivated
 - 3PL companies are not interested/motivated
 - Customers are not interested

- Considered to have too great an environmental footprint from an LCA perspective
 - Transportation distances are too long
 - The required storage space is too great
2. How important is packaging material choice for reducing your own organization's ecological impact? (considering resource consumption, fuel, and water use, as well as the carbon footprint) (1 = *of least importance*, 10= *of most importance*)
 3. How do you rate the potential importance of these governmental policy mechanisms for facilitating the creation of a packaging reuse ecosystem within your sector (rate from 1 to 10, where 1 is *not important* and 10 is *critical*):
 - Direct financial support, e.g., grants for business R&D projects
 - Indirect financial support, e.g., tax on environmentally harmful products
 - Technology guidance and support, e.g., technology transfer advisory centers
 - Collaborative platforms and infrastructure, e.g., dedicated support for new research infrastructure
 - Guidance and regulatory framework, e.g., packaging standards, minimum reusable packaging targets
 4. How important would standardization of tertiary packaging material formats be to your ability to integrate a reusable packaging system (rate from 1 to 10, where 1 is *not important* and 10 is *critical*)
 5. How do you rate the current interest/pressure from the supply chain (your customers) in your environmental performance? (rate from 1 to 10, where 1 is *low* and 10 is *high*)
 - a. Does this interest or pressure currently extend to your choice of packaging materials? Y/N
 6. How do you predict that customer interest/pressure in your environmental performance will be in 5 years' time? (rate from 1 to 10, where 1 is *low* and 10 is *high*)
 - a. Do you predict that in 5 years' time, interest/pressure could extend to your choice of packaging materials? Y/N

7. How helpful do you think that industry standards can be in adopting reusable packaging within your sector? (rate from 1 to 10, where 1 is *not helpful at all* and 10 is *critical*.)

Appendix B. The framework's scoring principles

Business Impact Scale:

This scale evaluates the potential effect of a mechanism on alleviating a specific barrier and adopting reusable packaging systems.

1. Minimal Impact: The mechanism offers a negligible change in alleviating the specific barrier.
2. Slight Impact: The mechanism provides a minor improvement in overcoming the barrier but may not drastically increase adoption rates.
3. Moderate Impact: The mechanism results in noticeable improvements in overcoming the barrier but doesn't address all the major challenges.
4. Considerable Impact: The mechanism offers clear strategies that make adoption easier and more efficient for many businesses.
5. High Impact: The mechanism successfully overcomes the barrier, significantly enhancing the potential for widespread adoption.
6. Major Impact: The mechanism transforms the approach to reusable packaging, creating a paradigm shift in its adoption.
7. Game-changing Impact: The mechanism revolutionizes the adoption of reusable packaging systems concerning this particular barrier.

Ease of Implementation Scale:

This scale evaluates the feasibility and simplicity of introducing and applying a particular mechanism in reusable packaging.

1. Extremely Challenging: The mechanism is theoretical and would require extensive resources, time, and expertise to be realized.
2. Very Challenging: The mechanism is solid in theory but would need significant adjustments or resources for real-world application.
3. Challenging: The mechanism can be integrated with some effort, facing potential hurdles in specific contexts or industries.

4. Moderate: The mechanism offers a balanced approach, with some resources needed, but its introduction is mainly feasible.
5. Somewhat Easy: The mechanism is well-supported by existing infrastructures or resources, with minor adjustments needed.
6. Easy: The mechanism aligns closely with current industry practices, making its introduction smooth and straightforward.
7. Extremely Easy: The mechanism is almost plug-and-play, requiring minimal effort or change to be adopted in the reusable packaging landscape.

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