



Adoption of reusable transit packaging in US industries: a framework for enhanced sustainability

Ivan Kudrenko¹ · Lindsey Hall²

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Abstract

This study examines the adoption of reusable transit packaging in the United States 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 · Supply chain management · Legislative support for sustainability · Regulatory framework

JEL Classification Q53 · Q58 · L62 · M11 · O32

✉ Ivan Kudrenko
ivank@umich.edu

Lindsey Hall
lindsey@green-steps.org

¹ Charleston, USA

² Topsham, UK

1 Introduction

With increasing global concern and attention regarding the causes and implications of global warming (Lash and Wellington 2007), 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 leads 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 extend throughout the supply chain (Pålsson and Hellström 2016). 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 (Kirchherr et al. 2017) and reduces waste. Furthermore, under certain conditions (Bradley and Corsini 2023), reusing packaging presents a significant opportunity to maintain material and product functionality and achieve substantial cost savings (García-Arca et al. 2017; Coelho et al. 2020). 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 (RPA 2020).

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 (Kroon and Vrijens 1995). Equally, there needs to be more focus on incentivizing companies along the value chain to collaborate efficiently and adopt a standardized system (Bradley and Corsini 2023). 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 identified 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 Sect. 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, Sect. 4 presents the obtained results. Section 5 introduces the framework. Section 6 discusses the research findings and 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 et al. (2004) 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.

We incorporated methodologies from Robert Yin and John Creswell to validate our semi-structured interview techniques, ensuring the robustness and credibility of our qualitative data collection and analysis. Following Yin's (2018) case study research design, we defined clear research questions, selected multiple cases, and employed a structured data collection and analysis approach. We maintained a case study database by systematically documenting all interview transcripts, field notes, and coding processes. This database was stored securely and organized to facilitate easy retrieval and cross-referencing. Maintaining a chain of evidence involved detailed records of data collection procedures, ensuring that each piece of evidence could be traced

back to its source. In line with Creswell's (2013) qualitative research strategies, we designed our interview protocols to elicit comprehensive and meaningful data, incorporating strategies such as triangulation, member checking, and providing detailed descriptions to enhance the credibility and transferability of our findings.

To ensure construct validity, we used multiple sources of evidence and established a chain of evidence. Internal validity was enhanced through pattern matching and explanation building, while external validity was addressed by replicating the study across multiple cases. Reliability was ensured by developing and following a detailed case study protocol and maintaining a case study database. Our interview protocols were designed to elicit rich, meaningful data by including open-ended questions encouraging detailed responses. We adjusted our questions based on interviewees' responses to explore emerging themes and insights more deeply. Rich descriptions were used to capture the context of participants' responses, providing a detailed account of their experiences and perspectives. Triangulation was conducted by comparing data from interviews and surveys and cross-referencing findings with existing literature. We also clarified researcher bias by acknowledging our perspectives and potential influences on the research. Peer debriefing was used to review and validate our analysis, ensuring the credibility and reliability of our findings.

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. The specific criteria used to search for literature included selecting international peer-reviewed research papers from highly impactful academic journals, focusing on studies published within the last ten years to ensure relevance. In the literature review, the articles were obtained from two major citation databases, Scopus and World of Science. Keywords such as "sustainable packaging," "sustainable supply chain management," "environmental impact," and "reusable packaging" were used. Specific criteria were to eliminate the research's inclusion and exclusion bias and achieve the data's heterogeneity (Meline 2006). 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. Official government reports and publications have also been used in this study. As for the government reports and publications, we focused on the United States, the United Kingdom, and the European Union. We searched for these documents through government websites, official publications databases, and international organizations' resources. Selection criteria included relevance to sustainable packaging practices, regulatory frameworks, and policies impacting supply chain management.

The second part of the study involved a descriptive analysis of survey results from 55 sustainability and supply chain professionals in the US aerospace, machinery, and automotive industries. 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. Supply chain and sustainability professionals within the sectors of machinery, automotive and aviation were identified and selected by the research platform, Centinent. An initial question asked respondents to confirm their industry, with the survey clos-

ing down for any respondent who stated they were in none of those three industries. 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 (Olsen 2004). The respondents were informed about the study purpose, procedures, voluntary participation, and 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 1. 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. In conducting the interviews, we adhered to Creswell's (2013) strategies for ensuring the credibility and transferability of qualitative data. Techniques such as triangulation, member checking, and providing rich, thick descriptions were employed to validate the interview data and enhance the study's rigor. Yin's (2018) principles for case study research were applied to maintain a chain of evidence and use pattern matching and cross-case synthesis in data analysis, thereby ensuring reliability and validity. To ensure authenticity and preserve the participants' true voices, we incorporated verbatim quotes from the interviews, following the recommendations of Saldana (2016). Saldana emphasizes the importance of using exact words of the interviewees to maintain the integrity and authenticity of the qualitative data. 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

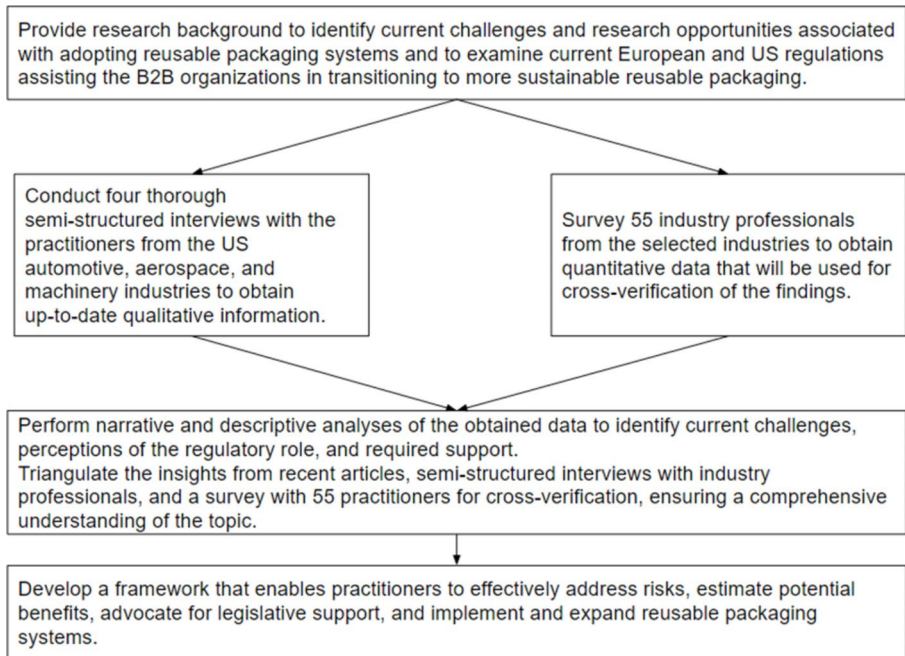


Fig. 1 Research methodology

reusable packaging systems in their industries and to understand the importance of and the current regulatory role in encouraging the adoption of reusable packaging.

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 examined in the Discussion 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 (2018) 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. (2020) 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 a major organizational barrier. 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 (Ilic et al. 2009; Mason et al. 2012).

Often companies cannot quantify the economic and environmental effects of industrial packaging and do not see value in reusable packaging. That can be due to a company's culture, insufficient organizational motivation, or scarce 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. (2017).

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 (Monier et al. 2014).

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 (Ragonnaud 2023). Together with greater standardization, these targets will stimulate a seismic shift towards reusable packaging in B2B supply chains in Europe and will stimulate 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. According to the solid waste management hierarchy, material reuse is the most preferred solution. 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 (2023) 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.

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 Fig. 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, "Reusable packaging is now commonly used in the automotive industry across several tiers of suppliers of various components, especially for fragile ones."

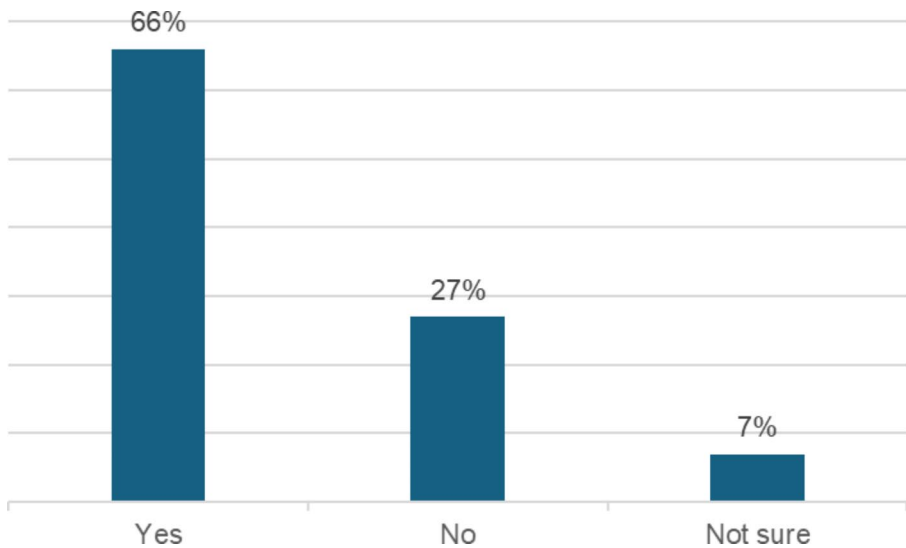


Fig. 2 Responses to the question "Does your company currently use reusable packaging systems?"
n=55

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 Fig. 3, 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.

Interviewee B further supported this conclusion, stating, "Our organization wants to increase the use of returnable packaging because expendable packaging is expensive, especially for larger parts like fascias (bumper covers) where expendable boxes are costly. We believe there is a possibility of switching to returnables." 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 is the main benefit, along with improved employee safety and better parts protection."

Integrating survey responses with Interviewee C's feedback highlights several critical benefits of adopting returnable packaging systems. Both the survey and Interviewee C emphasize the dual advantage of sustainability and economic value. For instance, Interviewee C stated, "As organizations continue to push through with their ESG goals, we see the benefits of returnables. We also see more bottom-line economic value from implementing these systems because of the use of broader metrics and long-term thinking, predominantly product carbon footprinting and life cycle analysis," which aligns with the survey results showing that 69% of respondents recognize the reduced environmental footprint as a major benefit.

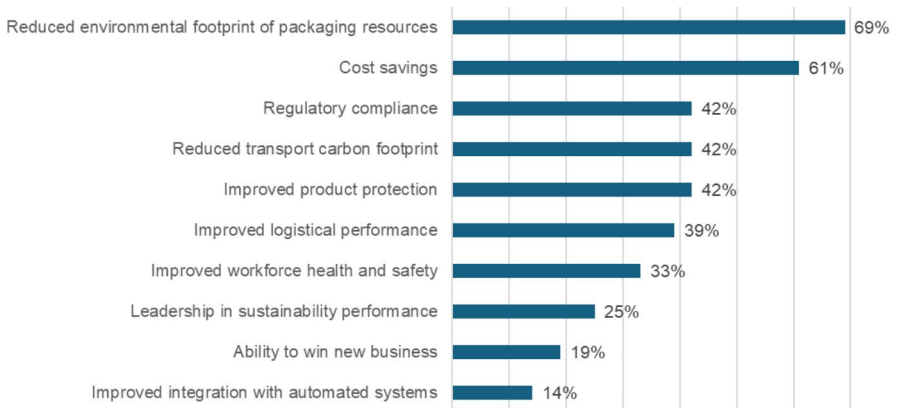


Fig. 3 Chart showing the benefits that respondents perceived as a result of implementing reusable packaging. n=55

Additionally, regulatory compliance is a significant benefit noted by 42% of survey respondents. Interviewee C's insights underscore this point by linking the economic value of returnable packaging systems to the achievement of ESG goals and compliance with environmental regulations. By merging these insights, it becomes evident that the adoption of returnable packaging systems not only supports sustainability goals but also provides tangible economic benefits, such as cost savings and enhanced regulatory compliance. This integrated perspective strengthens the argument for the widespread adoption of reusable packaging systems in various industries.

4.3 Factors influencing the sustainability of packaging materials

This question was asked to all survey respondents. As can be inferred from Fig. 4, 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.

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

Figure 5 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, "Our organization has specific sustainability targets relating to packaging, and using returnable packaging is an important consideration." Interviewee A added, "Our organization considers the sustainability of packaging materials under broader targets of reducing waste and efficiency of operations." Interviewee C said, "Packaging designers within the automotive indus-

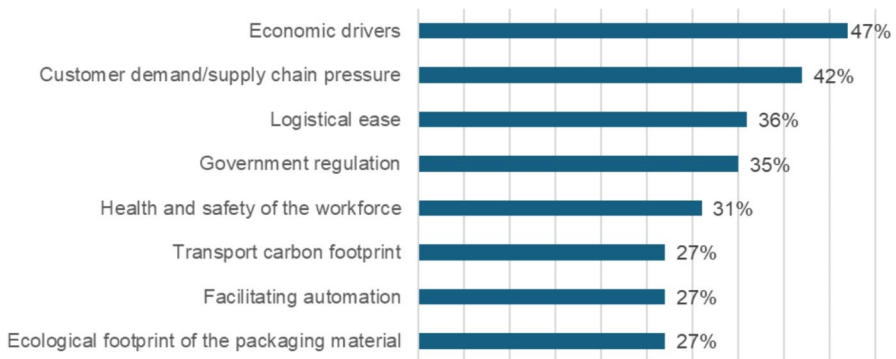


Fig. 4 Chart showing the factors that respondents felt influenced the packaging material used and the sustainability of that packaging. n=55

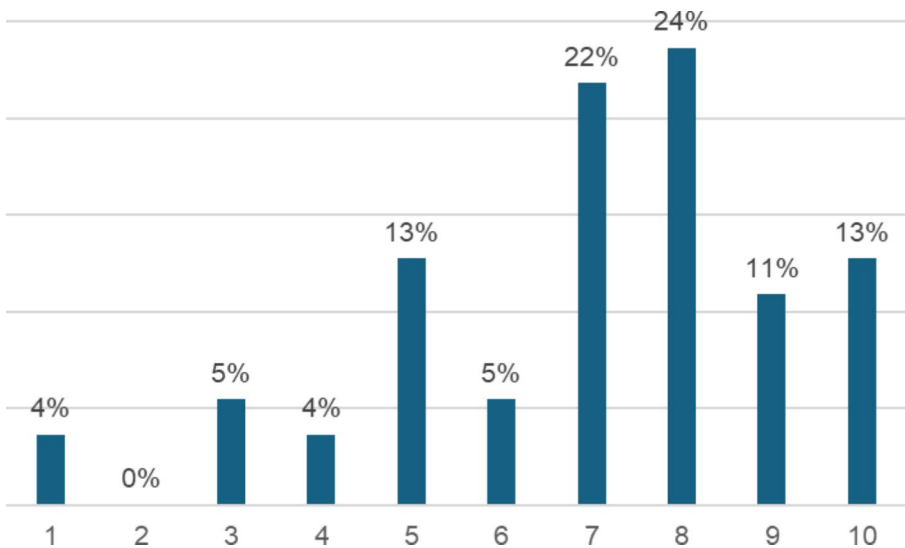


Fig. 5 Chart showing the perceived importance of packaging choice for reducing the respondents' organizations' ecological impact, broken down by industry type. A score of 1 denoted that they strongly disagreed with the statement, and a score of 10 denoted that they strongly agreed

try 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."

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 Fig. 6, 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. (2020), 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.

In contrast, as seen in Fig. 7, 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.

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, "High

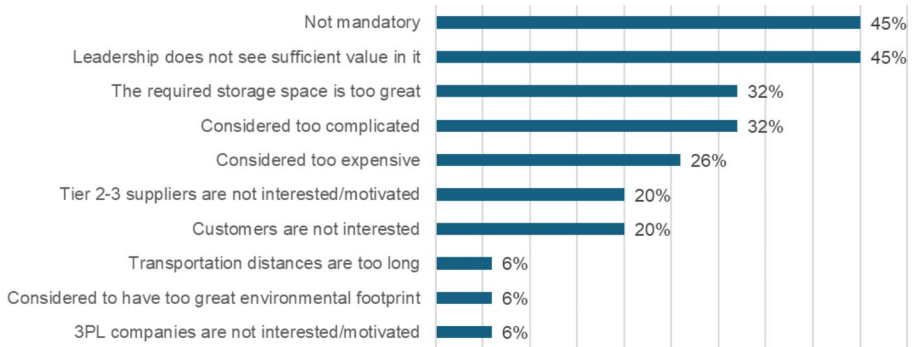


Fig. 6 Chart showing the perceived barriers to the use of reusable packaging systems for those organizations that have not currently implemented such systems. n=15

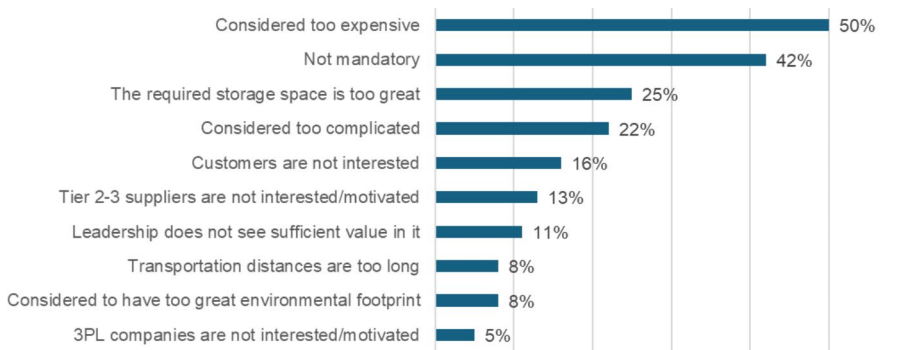


Fig. 7 Chart showing the perceived barriers to the use of reusable packaging systems for those organizations that have implemented such systems. n=36

capital costs hinder early adopters. Issues with tracking returnable packaging and maintaining sufficient stock due to damage and loss are significant challenges." Interviewee C emphasized, "Cost is a primary concern. Justifying reusable packaging without including intangible factors like carbon impact is challenging unless a company has stringent ESG goals." Interviewee D shared, "The main logistical challenges are 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 Fig. 8, 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 supported measure, favored by over a quarter of respondents (27%).

Interviewee D emphasized, "Collaborative platforms and infrastructure in government policies should be prioritized. We have positive experience in addressing other large-scale industry challenges by cooperating with our colleagues from other compa-

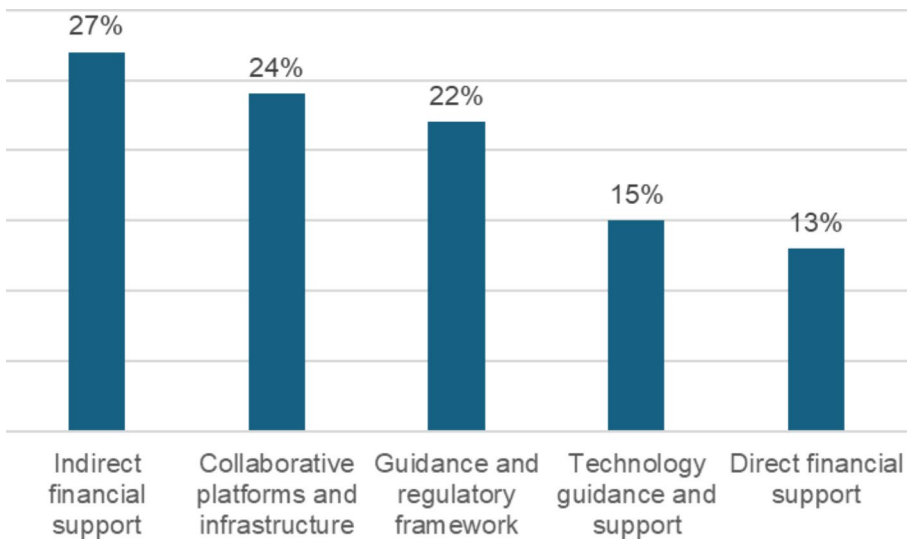


Fig. 8 Chart showing the single government mechanism respondents felt should be prioritized to aid the implementation of reusable packaging in their sector. $n=55$

nies." Interviewee C believed, "Monetary incentives or penalties would significantly impact cohesive industries with influential trade associations but be challenging in disparate sectors. Private sector interest in financial gains and legal compliance in case of penalties could drive change, though implementation might be tough in anti-government contexts." They also noted, "Government-assisted trade associations for developing regulatory frameworks are valuable. Convening necessary stakeholders for efficient policy development is crucial." Interviewee B shared, "Our company participates in a cross-industry platform for sustainability in storage and transportation, highlighting the benefits of sharing non-competitive best practices." Interviewee C noted, "Similar initiatives for sustainable packaging in the automotive industry exist."

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 Fig. 9, 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 analy-

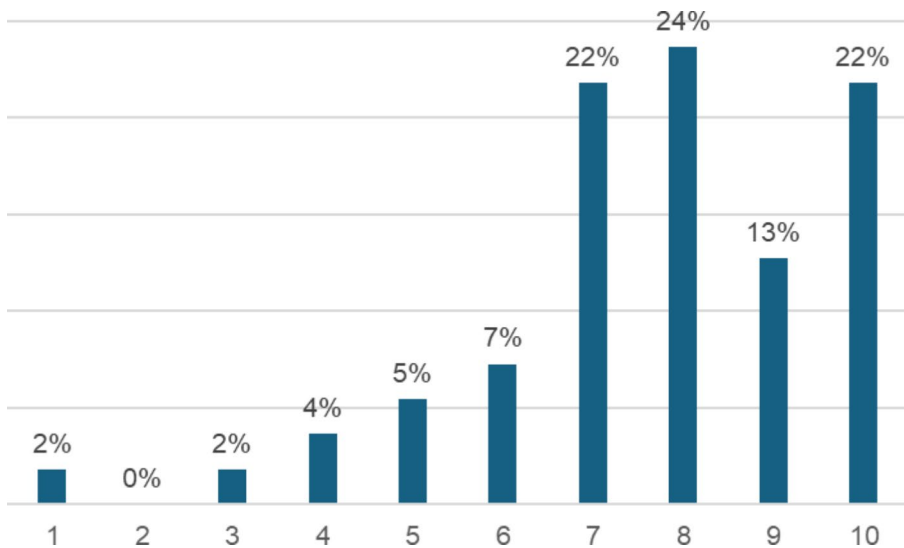


Fig. 9 Chart showing how beneficial respondents felt standardization of tertiary packaging material formats would be to their ability to integrate reusable packaging systems. A score of 1 denoted that the respondents felt standardization would have no beneficial impact, and a score of 10 denoted that they felt it would have a significant beneficial impact. $p < 0.001$, Wilcoxon Signed-Rank Test, $n = 55$

sis demonstrated that we are 95% confident that the true median of the population is at least 7.5.

Interviewee A viewed standardization as beneficial, noting, "Shifting to a new reusable packaging design entails investment and risk. Standardization would facilitate decision-making and prevent organizations from hesitating over packaging choices." Interviewee B also supported standardization, stating, "Currently, various materials and dimensions are used in packaging. Standardization would lessen the loss of unique packaging and reduce capital costs." Interviewee C stressed, "Considering materials and ease of disassembly in standardization is important to ensure ecological benefits in the lifecycle of returnable packaging."

4.8 The potential influence of industry standards

Figure 10 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.

Interviewee A felt, "Switching to regulatory requirements related to sustainability and specifically returnable packaging will spur changes in behavior that are more market-driven. Our organization would be encouraged to use a returnable packaging

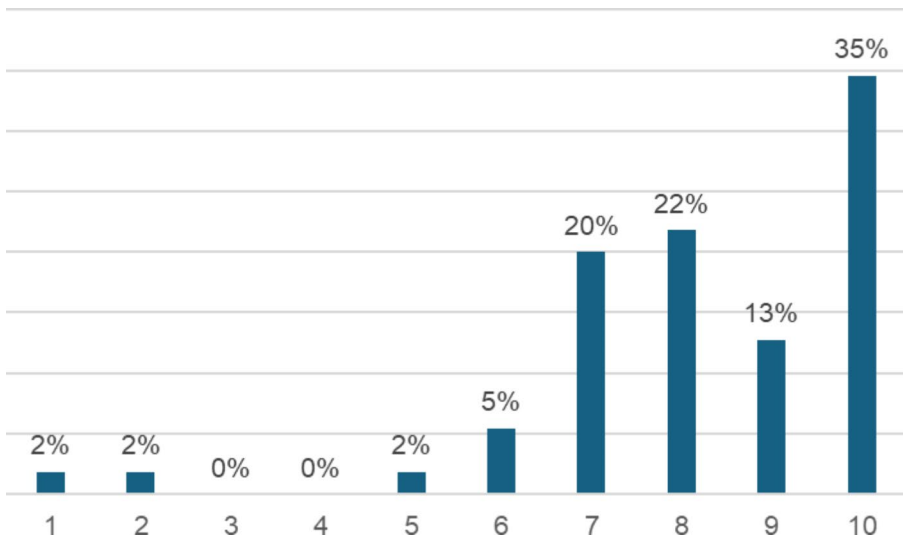


Fig. 10 Chart showing respondents' perceptions of how beneficial industry standards could be in adopting reusable packaging within their sector. A score of 1 denoted that the respondents felt that industry standards would have no beneficial impact, and a score of 10 denoted that the respondents felt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

option that was more expensive if that choice didn't make us less competitive compared to others in the market." Interviewee C advocated, "Collaboration, supported by regulatory frameworks and standards, is especially needed in the automotive sector. The 'Suppliers Partnership for the Environment' is an example, pursuing initially voluntary standards with widespread recognition of their value." They emphasized, "Industry-wide agreement on mandates and standards is important, providing clear governance rules to suppliers."

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

As seen in Fig. 11, 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.

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

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

According to Fig. 12, those respondents in organizations that already have reusable packaging systems in place are significantly stronger in their belief that their organi-

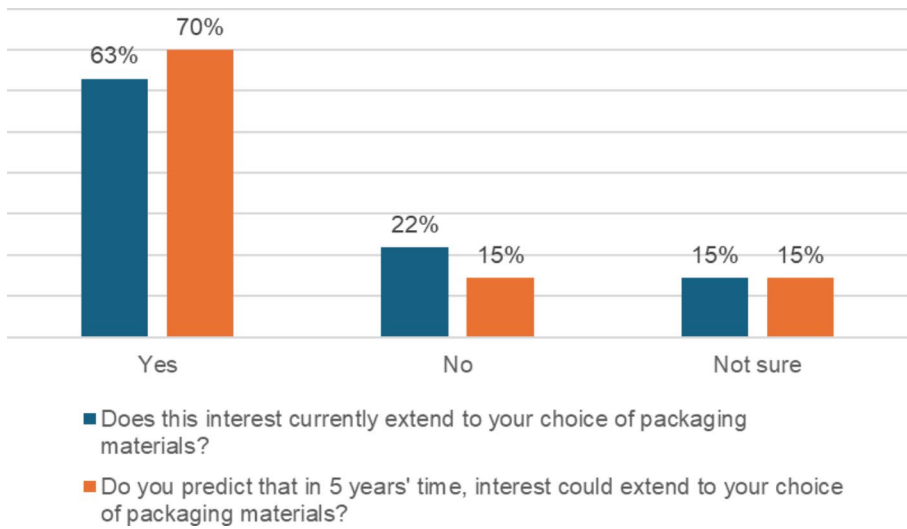


Fig. 11 Chart showing respondents' perception of customer interest in their choice of packaging materials now and in five years' time. $n=55$

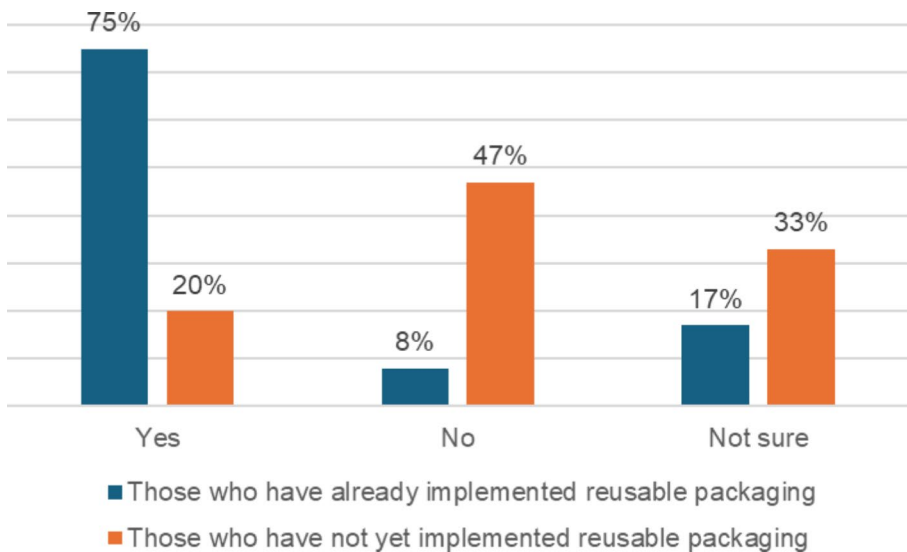


Fig. 12 Chart showing respondents' belief that their organization has plans to expand reusable packaging within the next five years. **a** $n=36$, **b** $n=15$

zation would extend the use of reusable packaging (75% in those that have, versus 20% in those who have not).

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 (Fig. 13), we identified the five most essential barriers from survey responses and semi-structured interviews across both participating and non-participating organizations. These barriers were matched with policy mechanisms that our data analysis and structured brainstorming sessions with industry experts, including William Hall (his biography is provided in Appendix 3), indicated as the most beneficial. Innovative solutions from successful case studies and literature reviews further supplemented the process. Each barrier was carefully evaluated for its relevance and impact using qualitative insights from interviews and quantitative data from surveys. This iterative process ensured the robustness and applicability of the proposed mechanisms. Some mechanisms were designed to address multiple barriers, recognizing that 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 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

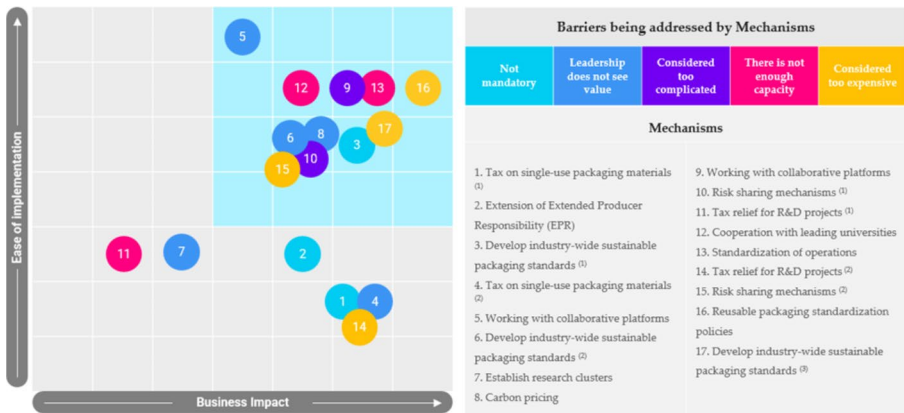


Fig. 13 Mechanisms for overcoming the principal barriers and stimulating the implementation of reusable packaging in the examined industries

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 2. 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 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 sustainability, strategic development, supply chain resilience, and risk management projects. Such seasoned insights are instrumental in grounding our findings in real-world applicability and expertise.

Below, we outline the mechanisms identified in the chart that can address the recognized obstacles. These methods will have the most favorable result when they are implemented collectively.

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

5.1.1 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% (HM treasury 2018). 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. (2017) 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. Convery et al. (2007) highlight the success of the Irish plastic bags levy, which led to

a dramatic reduction in plastic bag usage, demonstrating the potential effectiveness of taxation in altering consumer and business behaviors towards more sustainable practices.

5.2 EPR scheme to stimulate funding for reusable packaging materials (mechanism 2)

5.2.1 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. (2023) discuss positive results, challenges, and best practices for implementing EPR incentives in various industries, including manufacturing. Moreover, Sin and Tuen (2023) list international environmental policies related to waste management and discuss the promising outcomes of EPR. Miller et al. (2019) 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. Van Rossem et al. (2006) discuss how EPR schemes have spurred innovation and encouraged the development of greener products, indicating that similar schemes could effectively support the transition to reusable packaging in industrial settings.

Copello and Simon (2023) 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)

5.3.1 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. Seuring and Müller (2008) emphasize the importance of standardized practices in sustainable supply chain management, suggesting that industry-wide packaging standards can harmonize efforts and drive collective action towards sustainability.

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)

5.4.1 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. Bitzer and Glasbergen (2015) highlight the role of collaborative platforms in fostering sustainable change through business-NGO partnerships, underscoring the potential of such collaborations to drive the adoption of reusable packaging.

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. (2022) stress the importance of creating an industry-wide informational environment and data sharing in overcoming barriers.

5.5 Establishment of research clusters (mechanism 7)

5.5.1 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 (2021) 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. Cooke and Leydesdorff (2006) demonstrate how research clusters can foster regional development and innovation, indicating that establishing such clusters could support the advancement of reusable packaging technologies.

5.6 Carbon pricing (mechanism 8)

5.6.1 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 (2022) 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. Moreover, Aldy and Stavins (2012) discuss the effectiveness of carbon pricing in reducing emissions and driving investment in cleaner technologies, supporting its use as a mechanism to incentivize reusable packaging solutions.

5.7 Risk-sharing (mechanisms 10 & 15)

5.7.1 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. Smit and Trigeorgis (2004) explore risk-sharing mechanisms in strategic investments, highlighting how collaborative risk-sharing can encourage the adoption of innovative practices such as reusable packaging.

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)

5.8.1 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. The financial support mechanisms of tax relief for R&D scored highly for potential business impact, making them important policies to advocate for with representatives in government. Various financial support mechanisms could be involved, including direct subsidies for businesses investing in reusable packaging infrastructure, grants for pilot projects and research, and low-interest loans for companies transitioning to sustainable practices. Tax relief can take the form of R&D tax credits, which provide deductions or credits for expenses related to the research and development of innovative packaging solutions. For instance, Bloom et al. (2002) found that R&D tax credits significantly stimulate innovation

across industries, indicating their potential effectiveness in promoting reusable packaging technologies. Such financial support mechanisms can incentivize companies to adopt sustainable packaging solutions, thereby reducing environmental impact and fostering long-term economic benefits.

5.9 Cooperation with leading universities (mechanism 12)

5.9.1 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. Perkmann and Walsh (2007) highlight the benefits of university-industry collaborations in fostering open innovation, indicating that partnerships with leading universities could drive advancements in reusable packaging systems. 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)

5.10.1 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 (2014) and Ceyhan et al. (2020). Brunsson et al. (2012) discuss the dynamics of standardization and its impact on organizational practices, supporting the argument for standardized packaging formats to streamline operations and enhance efficiency. In Europe, Copello (2020) 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. (2020) and lower shipment costs (Katephap and Limnararat (2017)). 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 (2020) 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. The 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. Despite the similarities, it is important to acknowledge potential differences between industries that might have been overlooked. For example, the aerospace industry deals with high-value, low-volume products, which may result in different logistical and financial considerations compared to the automotive industry, which handles high-volume, lower-value components. Additionally, the machinery industry's diverse range of products can lead to varying levels of feasibility and cost-effectiveness in implementing reusable packaging systems. These industry-specific nuances might influence the perceived benefits and barriers to adopting reusable packaging differently.

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. From a managerial perspective, it is crucial for supply chain leaders to identify and leverage internal champions who can drive the adoption of reusable packaging by demonstrating early successes and creating a positive feedback loop within the organization. Also, managers should consider strategic partnerships with regulatory bodies or industry alliances to advocate for incentives or mandates that can spur broader adoption. This approach not only mitigates the initial resistance but also helps in embedding reusable packaging as a norm rather than an exception within the supply chain ecosystem. To boost the adoption of reusable packaging, organizations should set clear metrics and KPIs to assess their impact, providing solid, data-backed proof of their benefits. Investing in training and education across all levels of the company can raise awareness of the economic and environmental advantages, fostering a culture that embraces sustainable practices. Managers can also look for ways to collaborate with supply chain partners to share insights and co-create innovative solutions to common challenges. Highlighting potential cost savings, like reduced waste management expenses and lower long-term procurement costs, can make a stronger case for reusable packaging. Additionally, focusing on the positive effects on relationships with stakeholders, such as customers and investors who value sustainability, can further encourage adoption. By implementing these strategies, organizations can not only overcome initial hurdles but also position themselves as sustainability leaders within their industries.

This study contributes significantly to the academic field by providing a nuanced understanding of the barriers and facilitators of reusable packaging adoption in B2B industries. By integrating survey data with in-depth qualitative insights, we offer a comprehensive framework that bridges the gap between theoretical concepts and practical applications. This research extends the current literature by highlighting the importance of industry-specific and cross-industry considerations, thus providing a more detailed analysis than previous studies that often focus on single industries or general sustainability practices. Furthermore, the identification and ranking of policy mechanisms based on business impact and ease of implementation provide actionable insights for policymakers and industry leaders. This practical framework can guide future research to explore the efficacy of these mechanisms in various contexts, thereby fostering a more robust and adaptable understanding of sustainable packaging practices. Our findings also emphasize the need for legislative support and industry collaboration, which can inspire further academic inquiries into the role of policy in driving sustainable practices across different sectors.

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 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.

Practitioners, including supply chain managers, sustainability officers, industry trade associations, and policymakers, should focus their efforts on these mechanisms. Supply chain managers and sustainability officers can begin by conducting internal assessments to identify potential areas for implementing reusable packaging and seek collaborations with industry peers through trade associations. Industry trade associations should advocate for the adoption of these policy mechanisms at governmental and international conferences. Policymakers should consider integrating these mechanisms into national and regional sustainability agendas to create a more supportive regulatory environment. Moreover, managers should proactively engage in benchmarking and best practice sharing through such trade associations, creating an environment where lessons learned from early adopters can be rapidly shared and scaled across industries. Engaging with international bodies to establish more uniform global standards for reusable packaging could also standardize practices and reduce variability, making it easier for companies operating across borders to implement and maintain consistent reusable packaging systems.

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 (Fig. 13). 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. Supply chain managers and sustainability officers should start by aligning their strategies with these high-priority mechanisms and seek partnerships and funding opportunities to support implementation. Industry trade associations can play a crucial role by setting voluntary standards that can later become mandatory, creating a level playing field.

Policymakers should prioritize legislative support for these mechanisms, recognizing their potential to drive significant environmental and economic benefits.

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. These mechanisms can include direct subsidies, grants, and low-interest loans for companies transitioning to sustainable practices. For example, R&D tax credits can provide significant incentives for innovation in reusable packaging technologies, as demonstrated by Bloom et al. (2002). The success of Ireland's plastic bag levy, which led to a dramatic reduction in plastic bag usage (Convery et al. 2007), illustrates the potential impact of taxation on single-use items. 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.

Finally, we have identified several potential directions for the future research outlined below.

- Our research was conducted within the US context, where regulatory, economic, and cultural factors differ significantly from other regions. European countries, for example, often have stricter environmental regulations and stronger governmental support for sustainable practices, which can influence the adoption and effectiveness of reusable packaging systems. Conversely, developing countries may face challenges like limited infrastructure, different economic priorities, and weaker regulatory frameworks, which could hinder the implementation of such systems. Future research should replicate this methodology in various countries to explore these contextual differences and broaden the applicability of our findings. Specifically, examining how diverse regulatory landscapes, economic conditions, and cultural attitudes toward sustainability affect the adoption of reusable packaging can provide insights into its adaptability and scalability. This highlights the need for context-specific strategies that address local challenges such as infrastructure limitations and varying levels of governmental support.
- Expanding the scope to include adjacent B2B sectors and comparing these findings with B2C industries can offer a more comprehensive view of reusable packaging adoption. This comparative analysis could uncover unique drivers and barriers in B2C contexts, like consumer perception and demand for sustainable packaging, which are less prominent in B2B scenarios. Such insights would be valuable for tailoring industry-specific recommendations and exploring the cross-over of successful strategies between B2B and B2C markets.
- Conducting longitudinal studies on the long-term impacts of specific policy mechanisms on reusable packaging adoption is a promising area for further research. This could involve tracking the effects of tax reliefs, standardized packaging norms, or other supportive regulations over time to assess their effectiveness in driving sustainable practices. Longitudinal research would provide critical data on the durability and scalability of these policy interventions, allowing for adjustments based on observed outcomes. Additionally, these studies could examine

unintended consequences, ensuring that the most effective mechanisms are identified, promoted, and refined over time.

Appendix 1

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 lifecycle analysis (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 2

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.

Appendix 3

William Hall's brief biography

William Hall is the founder of Hall Partners LLC, a firm recognized for pioneering sustainable business practices focused on societal value creation, human rights preservation, and environmental stewardship. With a career spanning over three decades, William has been a vital contributor to the automotive sector, having held influential positions at Fiat Chrysler Automobiles and General Motors. His roles at these companies encompassed a broad range of responsibilities, including supply chain management, sustainability, purchasing, product development, sales and marketing, manufacturing, and human resources.

William earned his Master of Business Administration from Harvard Business School and a Bachelor of Science in Industrial and Operations Engineering from the University of Michigan. His academic and professional training has laid a strong foundation for his roles in strategic development, procurement planning, supply chain management, and business continuity.

Currently, William serves on several nonprofit and academic boards, offering his wealth of experience and leadership. His expertise extends to guiding projects on strategic development, stakeholder engagement, supply chain resilience, sustainability, risk management, and corporate sustainability.

His areas of specialization include Corporate Sustainability Strategy, Corporate Social Responsibility, Extended/Voluntary Producer Responsibility, and sustainability in water and forest resources. William's contributions to the automotive industry and his advocacy for sustainable practices have established him as a leading figure in both business and environmental stewardship.

Author contributions All authors contributed to the study's conception and design. Material preparation, data collection and analysis were performed by Ivan Kudrenko and Lindsey Hall. The first draft of the manuscript was written by Ivan Kudrenko and Lindsey Hall, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability The dataset containing the survey data is available at: <https://doi.org/10.17605/OSF.IO/RQH76>.

Declarations

Conflict of interest The authors have no conflict of interest to declare that are relevant to the content of this article.

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References

- Aldy JE, Stavins RN (2012) The promise and problems of pricing carbon: Theory and experience. *J Environ Dev* 21(2):152–180. <https://doi.org/10.1177/1070496512442508>
- Bitzer V, Glasbergen P (2015) Business–NGO partnerships in global value chains: part of the solution or part of the problem of sustainable change? *Curr Opin Environ Sustain* 12:35–40. <https://doi.org/10.1016/j.cosust.2014.08.012>
- Bloom N, Griffith R, Van Reenen J (2002) Do R&D tax credits work? Evidence from a panel of countries 1979–1997. *J Public Econ* 85(1):1–31. [https://doi.org/10.1016/S0047-2727\(01\)00086-X](https://doi.org/10.1016/S0047-2727(01)00086-X)
- Bradley CG, Corsini L (2023) A literature review and analytical framework of the sustainability of reusable packaging. *Sustain Prod Consum* 37:126–141. <https://doi.org/10.1016/j.spc.2023.02.009>
- Brunsson N, Rasche A, Seidl D (2012) The dynamics of standardization: Three perspectives on standards in organization studies. *Organ Stud* 33(5–6):613–632. <https://doi.org/10.1177/0170840612450120>
- Castka P (2020) The role of standards in the development and delivery of sustainable products: a research framework. *Sustainability* 12(24):10461. <https://doi.org/10.3390/su122410461>
- Ceyhan Ö, Türk M, Helvacı H, Yüksel D, Kutup N (2020) Standardization of packaging materials for various products and cost optimization in packaging. In: Durakbasa NM, Gençyılmaz MG (eds) *Proceeding of the international symposium for production research 2019*. Springer, Berlin, pp 775–790. https://doi.org/10.1007/978-3-030-31343-2_65
- Coelho PM, Corona B, Ten Klooster R, Worrell E (2020) Sustainability of reusable packaging—Current situation and trends. *Resour Conserv Recycl X* 6:100037. <https://doi.org/10.1016/j.rcrx.2020.100037>
- Convery F, McDonnell S, Ferreira S (2007) The most popular tax in Europe? Lessons from the Irish plastic bags levy. *Environ Resource Econ* 38(1):1–11. <https://doi.org/10.1007/s10640-006-9059-2>
- Cooke P, Leydesdorff L (2006) Regional development in the knowledge-based economy: the construction of advantage. *J Technol Transf* 31(1):5–15. <https://doi.org/10.1007/s10961-005-5009-3>
- Copello L, Simon J (2023). Policy recommendations for efficient and economically viable reuse packaging systems. *Policy Recommendations*. Zero Waste Europe. <https://zerowasteurope.eu/wp-content/uploads/2023/07/Policy-recommendations-for-efficient-and-economically-viable-reuse-packaging-systems.docx.pdf>
- Copello L (2020) Reducing Packaging waste: choose prevention and reuse. Policy briefing. Zero waste Europe and ReLoop. https://www.reloopplatform.org/wp-content/uploads/2020/12/zwe_reloop_policy-briefing_reducing-packaging-waste-choose-prevention-and-reuse_en-3.pdf
- Creswell JW (2013) *Qualitative inquiry and research design: choosing among five approaches*, 3rd edn. Sage Publications, New York
- Diggel A, Walker TR, Adams M (2023) Examining potential business impacts from the implementation of an extended producer responsibility program for printed paper and packaging waste in Nova Scotia. *Canada Circular Econ* 2(2):100039. <https://doi.org/10.1016/j.ccc.2023.100039>

- Ellsworth-Krebs K, Rampen C, Rogers E, Dudley L, Wishart L (2022) Circular economy infrastructure: why we need track and trace for reusable packaging. *Sustain Prod Consum* 29:249–258. <https://doi.org/10.1016/j.spc.2021.10.007>
- García-Arca J, Garrido A, Prado-Prado J (2017) “Sustainable packaging logistics”. The link between sustainability and competitiveness in supply chains. *Sustainability* 9(7):1098. <https://doi.org/10.3390/s9071098>
- HM Treasury (2018) Tackling the plastic problem Using the tax system or charges to address single-use plastic waste. https://assets.publishing.service.gov.uk/media/5aa91cbce5274a3e3603ac83/PU2154_Call_for_evidence_plastics_web.pdf
- Ilic A, Ng JWP, Bowman P, Staake T (2009) The value of RFID for RTI management. *Electron Mark* 19(2–3):125–135. <https://doi.org/10.1007/s12525-009-0011-5>
- Iritié BGJJ (2021) R&D cooperation performance inside innovation clusters. *Int J Comput Econ Econom* 11(3):222. <https://doi.org/10.1504/IJCEE.2021.116386>
- Katephap N, Limnararat S (2017) The operational, economic and environmental benefits of returnable packaging under various reverse logistics arrangements. *Int J Intell Eng Syst* 10:210–219
- Khan J, Johansson B (2022) Adoption, implementation and design of carbon pricing policy instruments. *Energ Strat Rev* 40:100801. <https://doi.org/10.1016/j.esr.2022.100801>
- Kirchherr J, Reike D, Hekkert M (2017) Conceptualizing the circular economy: an analysis of 114 definitions. *SSRN Electron J*. <https://doi.org/10.2139/ssrn.3037579>
- Kroon L, Vrijens G (1995) Returnable containers: an example of reverse logistics. *Int J Phys Distrib Logist Manag* 25(2):56–68. <https://doi.org/10.1108/09600039510083934>
- Lash J, Wellington F (2007) Competitive advantage on a warming planet. *Harv Bus Rev* 85(3):94–102
- Mahalik N (2014) Advances in packaging methods, processes and systems. *Challenges* 5(2):374–389. <https://doi.org/10.3390/challe5020374>
- Mangan J, Lalwani C, Gardner B (2004) Combining quantitative and qualitative methodologies in logistics research. *Int J Phys Distrib Logist Manag* 34(7):565–578. <https://doi.org/10.1108/09600030410552258>
- Martinho G, Balaia N, Pires A (2017) The Portuguese plastic carrier bag tax: the effects on consumers’ behavior. *Waste Manage* 61:3–12. <https://doi.org/10.1016/j.wasman.2017.01.023>
- Mason A, Shaw A, Al-Shamma’a A (2012) Peer-to-peer inventory management of returnable transport items: a design science approach. *Comput Ind* 63(3):265–274. <https://doi.org/10.1016/j.compind.2012.01.007>
- Meline T (2006) Selecting studies for systemic review: inclusion and exclusion criteria. *Contemp Issues Commun Sci Disord* 33(Spring):21–27. https://doi.org/10.1044/cicds_33_S_21
- Miller S, Bolger M, & Copello L (2019) Reusable solutions: how governments can help stop single use plastic pollution. https://rethinkplasticalliance.eu/wp-content/uploads/2019/10/bfip_rpa_reusable_solutions_report.pdf
- Monier V, Hestin M, Cave J, Laureysens I (2014) Development of Guidance on Extended Producer Responsibility (EPR). European Commission—DG Environment, BIO Intelligence Service; in collaboration with Arcadis, Ecologic, Institute for European Environmental Policy (IEEP), Umweltbundesamt (UBA). https://ec.europa.eu/environment/pdf/waste/target_review/Guidance%20on%20EPR%20-%20Final%20Report.pdf
- Olsen W (2004) Triangulation in social research: qualitative and quantitative methods can really be mixed. *Dev Sociol* 20:103–118
- Pålsson H (2018) Packaging logistics: understanding and managing the economic and environmental impacts of packaging in supply chains. Kogan Page Publishers, London
- Pålsson H, Hellström D (2016) Packaging logistics in supply chain practice—current state, trade-offs and improvement potential. *Int J Log Res Appl* 19(5):351–368. <https://doi.org/10.1080/13675567.2015.1115472>
- Perkmann M, Walsh K (2007) University–industry relationships and open innovation: towards a research agenda. *Int J Manag Rev* 9(4):259–280. <https://doi.org/10.1111/j.1468-2370.2007.00225.x>
- Ragonnaud G (2023) Briefing EU Legislation in Progress. Revision of the Packaging and Packaging Waste Directive. European Parliamentary Research Service (EPRS) Members’ Research Service. [https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/745707/EPRS_BRI\(2023\)745707_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/745707/EPRS_BRI(2023)745707_EN.pdf)
- Reusable Transport Packaging: State of the Industry Report (2020) RPA. <https://www.reusables.org/reusable-transport-packaging-state-of-the-industry-report-2020/>
- Saldana J (2016) The coding manual for qualitative researchers, 3rd edn. Sage Publications, New York
- Seuring S, Müller M (2008) From a literature review to a conceptual framework for sustainable supply chain management. *J Clean Prod* 16:1699–1710. <https://doi.org/10.1016/j.jclepro.2008.04.020>

-
- Sin LT, Tveen BS (2023). International policies of plastic use and consumption. In: *Plastics and sustainability*. Elsevier, pp 255–296 <https://doi.org/10.1016/B978-0-12-824489-0.00009-X>
- Smit HT, Trigeorgis L (2004) *Strategic investment: real options and games*. Princeton University Press, Princeton
- Smoljan B, Hajdek K, Sarkanj B, Bogunović J (2020) An analysis of performance factors evaluation of reusable/returnable packaging. *IOP Conf Series Mater Sci Eng* 916:012107. <https://doi.org/10.1088/1757-899X/916/1/012107>
- U.S. Environmental Protection Agency (2023) Sustainable materials management: non-hazardous materials and waste management hierarchy. <https://www.epa.gov/smm/sustainable-materials-management-hierarchy>
- Van Rossem C, Tojo N, Lindqvist T (2006) Extended producer responsibility: an examination of its impact on innovation and greening products. *J Ind Ecol* 10(2):61–77
- Yin RK (2018) *Case study research and applications: design and methods*, 6th edn. Sage Publications, New York

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