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SYSTEMATIC REVIEW

REVISED Rebound effects in circular business models: A review of cases and mitigation strategies

[version 2; peer review: 4 approved, 4 approved with reservations]

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Abstract

Circular business models are typically designed with the intent to meet customer demands, while resolving environmental issues related to resource usage, product lifetimes and waste reduction. Yet, rebound effects might hinder their positive impacts. Through a systematic literature review of 76 articles, the rebound effects of different circular business model archetypes and suggestions for their mitigation were investigated. The resulting overview unveils the direct, indirect and economy-wide rebound effects of different circular business model archetypes. This is coupled with rebound mitigation suggestions from literature from a business and policy perspective. The findings also revealed an apparent lack of quantitative research on mitigation strategies. The results can be used by researchers to guide research efforts, and by practitioners who want to find ways to mitigate the rebound effects of their circular business models. Future research should focus on creating standardized assessment methods for rebounds and their mitigation strategies.

Keywords

Circular Economy, Circular Business Models, Rebound Effects, Circular Economy Rebounds, Environmental Impact, Business Model Experimentation.

This article is included in the European Research Council (ERC) gateway.

Open Peer Review

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REVISED **Amendments from Version 1**

This article has been updated to incorporate reflections from new and previously unpublished sources that have conducted research on rebound effects. The introduction and overall structure of the paper have been revised to improve coherence and flow. The Methods section has been rewritten to provide greater clarity and transparency. In addition, the Discussion section has also been refined to enhance clarity and strengthen the central message.

Any further responses from the reviewers can be found at the end of the article

1. Background

Circular business models (CBMs) aim to maximize value by slowing, closing, narrowing and/or regenerating material flows to extend resource use and minimize waste (Konietzko *et al.*, 2020). The implementation of CBMs often involve a number of business model patterns and archetypes, both upstream and downstream (Pieroni *et al.*, 2020; Rosa *et al.*, 2019; Salvador *et al.*, 2023). While companies experiment with new circular business models to test their desirability, feasibility, and viability, their performance in terms of circularity and sustainability is rarely tested (Bocken *et al.*, 2021a, b). Companies usually rely on rules of thumb to forecast impact (i.e., heuristics related to circular/sustainable design such as guidelines and policies), which can be inaccurate (Das *et al.*, 2022; Pigosso, 2024). Past research has found that negative side effects of circular business models can potentially be prevented during the design and experimentation phase so understanding these is essential (Das *et al.*, 2023).

Despite the high potential of circular business models to reduce environmental impact (Fidan *et al.*, 2021; Kaddoura *et al.*, 2019), rebound effects (REs) are increasingly recognized as a major challenge (Andrew & Pigosso, 2024; Brockway *et al.*, 2021; Zink & Geyer, 2017). Rebound effects are a form of systemic consequence that can offset, or even increase the overall environmental impact (Zink & Geyer, 2017). While rebound effects can be both positive and negative (Font Vivanco *et al.*, 2022; Zerbino, 2022), the focus of this paper is mainly on negative effects. Prominent examples include increases in consumption as a result of increased efficiency and lower prices (Chitnis *et al.*, 2013), or increased wear and tear on shared products (Ackermann & Tunn, 2024). These effects arise from changes across business model elements, such as manufacturing and design choices (upstream), consumer behaviour (downstream), and logistics (both upstream and downstream) (Sarasini *et al.*, 2024). Circular business models are by necessity specific to their context and Pieroni et al. (2020) have divided them into seven "archetypal clusters", meant to reflect the different ways in which circular business models seek to achieve circularity. This points to the importance of analysing rebound effects as they relate to specific circular business model archetypes.

The impact of rebound effects of circular businesses is not fully understood and common forms of measurement like life-cycle assessment (LCA) often fail to account for the impact of rebounds, casting doubt into the true environmental performance of circular strategies (Lowe *et al.*, 2024). Recent research on sustainable actions has shown that rebound effects can undermine potential environmental impact reductions by as much as 50% (Brockway *et al.*, 2021). In the context of mitigating rebound effects, the design of circular business models is an important area of focus as early-stage decisions shape future sustainability performance and limit opportunities for later design adjustments (Millet *et al.*, 2007). Business model innovation is increasingly seen as essential to sustainability (Bocken & Snihur, 2020), allowing companies to refine models that align with sustainability goals. Failure to assess business model impacts early on increases the risk of unintended consequences and business model lock-in. Managerial decisions in the early design phase can have a big impact on the sustainability performance of a product (McAloone & Bey, 2009). Pigosso (2024) argues that rebound effects are not yet integrated into the business model design phase and should be proactively addressed by embedding awareness and mitigation strategies from the outset. This aligns with research on product-service systems (PSSs), which highlights how business model design can strongly influence product care (Ackermann & Tunn, 2024; Müller & Remke, 2025) and sustainability performance (Siderius & Poldner, 2021; Tukker, 2015), indicating the importance of business model design in managing rebound effects.

The concept of rebound effects dates back to 19 th century literature on energy efficiency, where it was observed that efficiency gains often led to increased energy consumption (Jevons, 1866). The "circular rebound effect" specifically was first described by Zink & Geyer (2017) as operating through two primary mechanisms: insufficient substitution and price effects. Insufficient substitution occurs when secondary goods (e.g., recycled or remanufactured products) fail to fully replace goods made from virgin materials. (Zink & Geyer, 2017). Price effects arise when circular products, being more efficient and cost-effective, lead to monetary savings that are reinvested into additional consumption—potentially more resource-intensive than before (Zink & Geyer, 2017).

More recent research has identified several further mechanisms through which rebounds can occur and provided a more detailed causal understanding of how rebound effects work (Castro *et al*., 2022; Guzzo *et al*., 2024; Lange *et al*., 2021). This ranges from economic to behavioral and social practice mechanisms, at both the consumer and producer sides; directly, indirectly, through changes in demand and use intensity on different levels of the economy (on the level of the individual firm, the sector, economy wide or global), and at different points in time (at implementation, in response to implementation or at the point of attempting to mitigate rebounds) (Aguiar *et al*., 2026; Andrew *et al*., 2026; Ferrante *et al*., 2026; Van Der Loo & Pigosso, 2024). This study uses the term rebound effects (or simply rebounds) instead of circular rebound effects, as many rebound mechanisms apply to circularity as well. An example would be in the classic case of fuel-efficient cars leading to users driving them for longer distances (Pardi, 2021). Or, in the case of PSS, it has been found that rented items tend to be treated less carefully since consumers feel less attached and bear no long-term responsibility, leading to higher replacement rates (Ackermann & Tunn, 2024; Schaefers *et al*., 2016). This illustrates a link between business model design and rebound effects (McKay *et al*., 2025). The shift in ownership and responsibilities in a PSS from the consumer to the producer, which enables renting, is implicated as the cause of careless use, indicating a strong link between business model design and rebound effects. (Ackermann & Tunn, 2024). The risk of rebound effects of circular businesses is thus that they end up *increasing* overall consumption, rather than reducing it.

While research on identifying and classifying rebound effects is expanding (Lowe *et al*., 2024; Metic & Pigosso, 2022), practical approaches for identifying and mitigating them during business experimentation remain limited. Studies suggest rebounds can be mitigated through business and policy interventions (Lowe *et al*., 2024). Some rebounds, such as indirect or system-level effects like re-spending savings from efficiency on other goods and services, may be beyond a single business's control. However, direct rebounds can be influenced more easily, for example, by providing consumer information or incentive schemes (Ackermann & Tunn, 2024). Addressing these risks helps businesses meet environmental targets and comply with greenwashing regulations (Ioannou *et al*., 2022; Robertson *et al*., 2023). Proactively tackling manageable rebound effects can also provide a competitive advantage, demonstrating commitment to sustainability goals (Schaltegger *et al*., 2012). Meanwhile, indirect and economy-wide rebounds are more effectively addressed through policy (Lowe *et al*., 2024; Zerbino, 2022). For policymakers, mitigating circular rebound effects ensures that circular economy policies fulfill their goals of reducing waste, conserving resources, and lowering carbon emissions (Guzzo *et al*., 2025; Zink & Geyer, 2017).

Recent reviews by Lowe *et al.* (2024) and Zerbino (2022) developed methods to manage circular rebound effects, offering general guidelines but highlighting the lack of specific, actionable strategies for circular business models. Das *et al.* (2023) also attempted to classify rebounds across circular strategies through the Circular Rebound Tool, and a set of behavioral design strategies for preventing rebound effects have been consolidated (McKay & Pigosso, 2025). These studies emphasize the need for a more systematic analysis of rebound effects in circular business models and potential mitigation strategies. While past literature reviews exist, only two articles connect rebound effects to specific circular business model archetypes or explore mitigation through business model design. In their review of case studies Baczyk *et al.* (2024) seek to clarify the role of *consumer behaviour* in shaping the effects of circular business model archetypes once implemented. They also give some suggestions for how rebound effects can perhaps be avoided, although these recommendations take the form of guiding principles and policy recommendations. Another recent contribution to rebound effect mitigation research is Mueller & Remke (2025). Focusing on mitigation through business model design, the authors developed the Circular Systems Sandbox, a business model design tool based on systems and life cycle thinking. The tool helps designers develop circular products and services and to understand the consequences their design choices may have on the environmental impact of their product or service. Although Circular Systems Sandbox connects business model choices to rebound effects, the focus is on the process of business model design, rather than archetype specific rebound effects and how one could mitigate them in practice.

Clarifying the link between specific rebound effects and circular business model archetypes, as well as specific strategies for how to mitigate these rebound effects is an important first step toward integrating rebound mitigation into circular business model innovation, as empirical measurement is often impractical in early design phases. Thus, this paper aims to identify empirically measured rebound effects in circular business models and potential mitigation strategies, addressing the following research questions:

- RQ1: What are the potential rebound effects of different circular business model archetypes?
- RQ2: What strategies have been identified that could mitigate these circular rebound effects?

Section 2 describes the method employed for data collection and analysis. Section 3 showcases the results. Section 4 and Section 5 present the discussion and conclusions of the study.

2. Method

A systematic literature review (Bryman & Bell, 2011) was conducted to address the research questions, give an overview over the state of the art as well as a direction for future research. This method was chosen to allow a detailed investigation of rebound effects and their mitigation in the context of circular business model archetypes or business model design. This section outlines the systematic review process, including data collection, evaluation, and analysis. Figure 1 illustrates the literature search process and paper selection at each stage. The initial data collection, analysis and coding was conducted by the first author. The studies selected for review and their subsequent coding were periodically independently checked by the other authors for accuracy.

2.1. Data collection

Relevant research articles were searched for in Scopus and Web of Science until September 2024 by following the search protocol described in Table 1. The literature search was conducted through two slightly different search strings, which were investigated in conjunction. The first search string included terms that were specific to rebound effects of circular business, while the second search string had a wider focus on rebound effects of business models, while focusing on environmental impact. The primary reason for including two search strings was that while circular business models is a relatively new term, concepts that are included within the term now have existed much longer, such as efficiency and concepts within sustainability, of which circular business models can be said to be subset (Pieroni et al., 2019, 2020). Further, it was initially found that a focus on just circular and sustainable business models might be too narrow to capture all research available on their related rebound effects. However, broadening the synonyms to include the terms "business model*" and "business*" in S-2 captured too many irrelevant studies, and so this search string was further focused to specifically include environmental impacts. The two search strings were thus used in an attempt to include all articles that might have covered the occurrence of rebound effects in the circular economy before the terms such as circular/circular business started becoming more widely used in academic studies.

The initial search returned 1801 articles, which after excluding duplicates and articles of non-relevant research areas was reduced to 1091 articles. The titles and abstracts were then scanned for relevance regarding the two research questions (see Table 2):

- RQ1: The primary inclusion criterion was the clear empirical measurement and identification of rebound effects of circular business models. Articles that simply identified rebound effects but did not show empirical measurement were discarded as they were deemed as not providing enough evidence or explanation for further analysis. This resulted in a total of 74 articles. After a full read, 40 articles were excluded, while 10 new articles were discovered through cross-reference snowballing (Geissdoerfer *et al*., 2018). This involved scanning the reference lists of initially identified articles for relevant publications that met the filtering criteria. The process continued with snowballed articles until no new relevant publications emerged, resulting in 44 articles.

- RQ2: The inclusion criterion was the identification of strategies for mitigating rebound effects that would be relevant in a business context. This resulted in an initial set of 74 articles. After a full read, 48 articles were excluded and another 6 added through similar cross-reference snowballing as mentioned earlier for RQ1, resulting in a total of 32 articles.

The complete list of articles reviewed can be found in Appendix A.

2.2. Data evaluation & analysis

The set of articles selected for RQ1 were coded in Excel for qualitative characteristics (see Table 3), to address the nature of rebound effects as highly dependent on the contextual elements, and the boundaries of empirical measurement.

The rebound effects identified in the sample were categorized following two lenses, one connected to the circular business model and another to rebound effects.

First, the seven circular business model archetypal clusters defined by Pieroni *et al.* (2020) were used for coding the identified rebound effects in the literature: (1) Dematerialised or efficiency, (2) Collaborative consumption, (3) Product-service systems, (4) Long life, (5) Next life, (6) Circular sourcing, and (7) Circular production & distribution. Although alternative classifications have been proposed (for e.g.: Ellen MacArthur Foundation, 2015; Geissdoerfer *et al*., 2020;

Rosa *et al*., 2019; Salvador *et al*., 2023), the Pieroni *et al*. (2020) classification was used because it was found to be the most suitable for our analysis as it most clearly delineates both upstream and downstream circular strategies. In addition, it is based on a wide literature and practice. The upstream/downstream categorization was found to be useful as rebound effects tend to occur due to manufacturing and design choices (upstream), consumer behavior (downstream), and logistics (both upstream & downstream) (Sarasini *et al*., 2024). Whenever articles reported rebound effects for multiple business model archetypes (for e.g., in a multi-scenario case analysis), the results were split into separate rows corresponding to each circular business model archetype classification.

Second, a widespread categorization of the identified rebound effects into direct, indirect and economy-wide effects (Greening *et al*., 2000; Sorrell & Dimitropoulos, 2008) was employed. Direct rebounds refer to an immediate increase in consumer demand of the same product/service due to a new circular business model (Zink & Geyer, 2017). Indirect rebounds refer to increases in demand for other goods and services as a result of a new circular business model intervention (Zink & Geyer, 2017). And economy-wide rebounds refer to longer-term effects that a new circular business model might have on the market, consumer preferences, societal institutions, regulations, etc. that lead to overall increase in consumption (Castro *et al*., 2022; Zink & Geyer, 2017). In some cases, it was observed that some articles identified other self-defeating systemic responses that played against the purpose of the circular economy action but were not necessarily rebound effects as per our definition (for e.g., Amasawa *et al*., 2023; Koide *et al*., 2023). At times these were mis-identified in the articles as rebound effects. These were instead classified as unintended consequences and were disregarded from the main analysis.

The qualitative characteristics of the articles selected for RQ2 were similarly coded in Excel based on Table 3, and their descriptive statistical features were tabulated for graphical presentation (Figure 2– Figure 4) using Excel. The suggestions for mitigation were then classified into mitigation strategies for business and policy, and further subdivided into 'measures to reduce consumption', 'measures to reduce impact of consumption' (once the rebound effect occurs), and 'other measures'. These codes for the rebound effects and mitigation suggestions were then synthesized into broader categories for each business model archetype. This is presented in Table 4 in the Results section. To maximize the traceability of the data the mitigation strategy descriptions have been kept as close to the source as possible, irrespective of their actual potential for the actual mitigation of rebound effects. The complete list of articles reviewed and the corresponding qualitative codes for rebound effects and mitigation strategies identified can be seen in Appendix A and C.

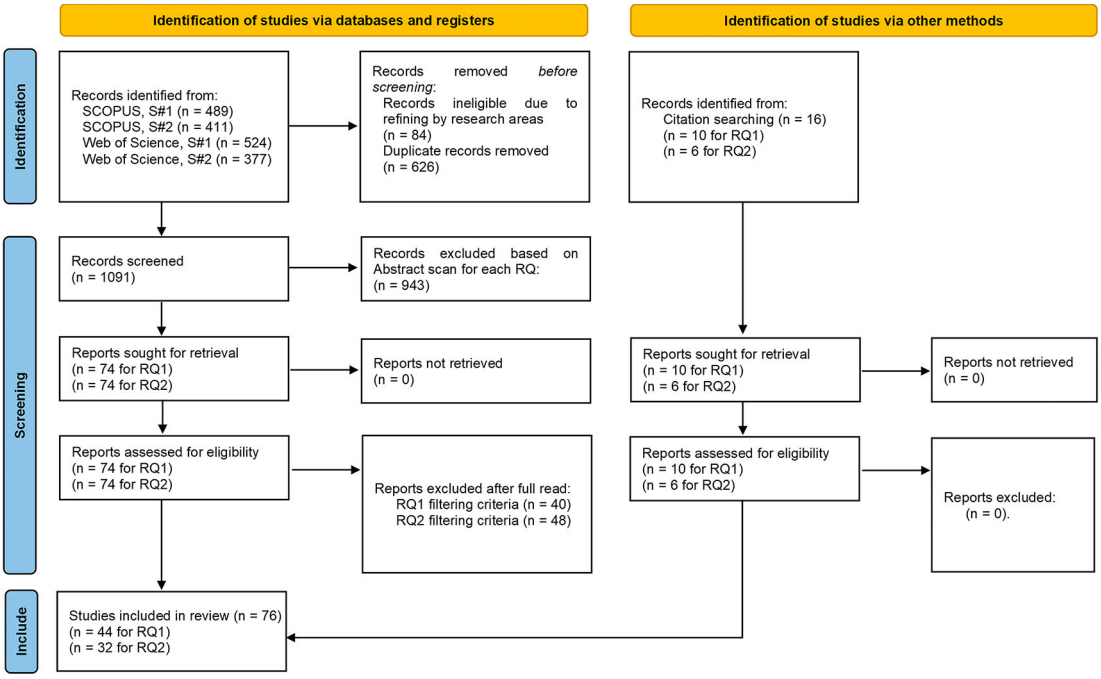

Figure 1. PRISMA flow diagram. (S-1 & S-2 refer to search strings #1 & #2 respectively).

Table 1. The search protocol followed for the data collection process.

Research Protocol	Description
Search string #1	("circular economy" OR "circular*" OR "circular business*" OR "sustainable business*") AND ("rebound effect*" OR "rebound*" OR "unintended consequence*" OR "backfire effect*" OR "take-back effect*" OR "spillover effect*" OR "indirect effect*" OR "secondary effect*")
Search string #2	("circular economy" OR "circular*" OR "circular business model*" OR "sustainab*" OR "business model*" OR "business*") AND ("rebound effect*" OR "rebound*" OR "unintended consequence*" OR "backfire effect*" OR "take-back effect*" OR "spillover effect*" OR "indirect effect*" OR "secondary effect*") AND ("environment* impact*")
Refined by Research Areas	Engineering, Environmental Sciences, Ecology, Science Technology, Business Economics, Materials Science, Energy Fuels, Public Environmental Occupational Health, Biodiversity Conservation, Behavioral Sciences, Social Issues, Psychology, Automation Control Systems, Public Administration, Transportation, Communication, Education Educational Research, Telecommunications, History, Philosophy of Science, International Relations, Philosophy, Urban Studies
Scan of	Title, Abstract, Keywords

Table 2. Filtering criteria for articles selected for review for both research questions.

Filtering criteria for RQ1	Filtering criteria for RQ2
• Study needs to be about rebound effects of circular business models • Study needs to have empirical measurement and identification of rebound effects. For e.g. through regression analysis, scenario-based analysis, attributional/consequential LCAs, system dynamics modeling, etc.	• Suggestions for mitigation strategies for rebound effects of circular business models. • Empirical measurement was not a requirement since rebound effect magnitude quantification was deemed not necessary to devise mitigation strategies, which can be based on qualitative analyses.

3. Results: Overview of rebound effects of circular business archetypes, and associated mitigation strategies

In the following section the results of the literature review are presented and discussed. First the descriptive characteristics of the papers in the study sample are presented. Second, the primary finding of this study, a classification of commonly measured rebound effects of the seven circular business model archetypal clusters, along with potential mitigation strategies is presented. Then, in the following subsections, the specific findings for each one of the seven circular business model archetypal clusters are discussed.

3.1. Descriptive characteristics of the articles in the study sample

The descriptive statistical features of the reviewed studies are illustrated in Figure 2– Figure 4. The regions and sectors of study are presented separately for the two different samples, to reflect that the two different search strings used different inclusion and exclusion criteria. As shown in Figure 2 North America and EU countries were the most frequently studied regions. The "Global" category describes papers where data was not specific to one single region, e.g. from a global market. The "Unspecified" category encompasses papers that conducted literature reviews, or that were not empirical in nature, e.g. conceptual papers. This primarily included papers in the rebounds mitigation sample, as mentioned in Table 2. In the rebound sample the most common sector was mobility, followed by fashion and electrical appliances (Figure 3). As can be seen in Figure 3, sectors were less clearly defined in the mitigation sample, which included some literature reviews and conceptual papers, with 10 studies not specifying a specific sector. Furthermore, many studies in the mitigation sample were not specific to a given sector (10). In Figure 3, the "Multiple" category refers to a study where data was drawn from many different sectors and the "Sharing Economy" category refers to a study that did not study a sector, but surveyed the sharing economy behaviours of students. The category "General" includes studies that either studied the economy as a whole or studied consumer behaviour itself, rather than any specific sector. Figure 4 shows the year of publication for papers in both samples. The majority of the papers included in this review were published in the 2020's, with the oldest included papers published in 2003.

3.2. Rebound effects of circular business archetypes and associated potential mitigation strategies

The key findings from the systematic literature review are summarized in Table 4. The findings show the potential rebound effects of the seven circular business archetypal clusters identified in the literature, together with potential

Table 3. Coding categories for analyzing final articles.

	Code categories	Definition
1.	Country	Geographical focus of the research study. (e.g., Germany, European Union, OECD countries, USA and Canada, etc.)
2.	Sector	The industry sector(s) the study focuses on. (e.g., mobility, built environment, electrical appliances, etc.)
3.	Data sample size	The size of the data sample used for the empirical research. (e.g., number of case studies, number of study participants, etc.
4.	Data collection & analysis methodology	The type of data collection and analysis methods that were used by the study. (e.g., consequential LCA, system dynamics modeling, regression analysis, etc.)
5.	Circular business model archetypal cluster	The circular business model archetype that is studied by the research article (based on the classification by Pieroni *et al*. (2020)).
6.	Rebound effects' magnitude	The magnitude of the rebound effects empirically calculated and reported by the study.
7.	Type of rebound effect	The category the identified rebound falls into (direct, indirect or economy-wide) in order to determine the potential zone of influence of business and policy.
8.	Rebound mitigation suggestions	Potential rebound mitigation suggestions (e.g., increasing consumer attachment to rental/sharing products, and gamification of usage data to reduce consumption)

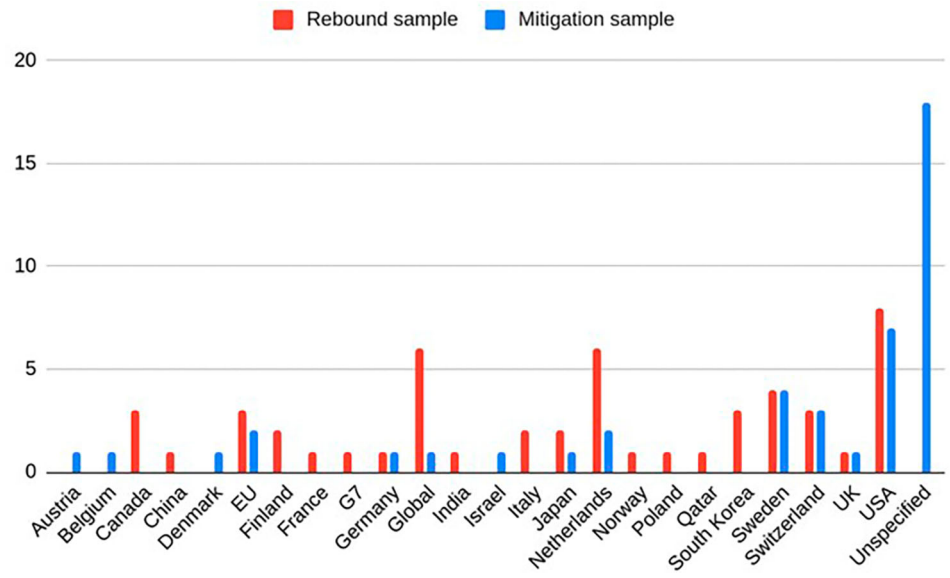

Figure 2. Geographical regions of case studies in rebound and mitigation samples (Global = nonspecific, Unspecified = reviews/conceptual).

business and policy mitigation strategies. The extended version of the Table with detailed references can be seen in Appendix B in the Supplementary Information associated with this study. In total, the archetypal clusters with the highest concentration of rebound effects were Circular Production & Distribution (23), followed by Next Life (13) and Collaborative Consumption (12). This might possibly be due to the fact that some of these business model innovations (such as material efficiency, recycling, remanufacturing, etc.) have existed for longer in the business sphere than, for example, sufficiency related strategies. Out of all 76 articles, only 11 lacked mitigation suggestions. However, the effect of these mitigation strategies was often not empirically tested, which limits the understanding of their effectiveness.

The rebound effects and corresponding mitigation suggestions of each of the seven clusters of circular business model archetypes are further explained next with examples.

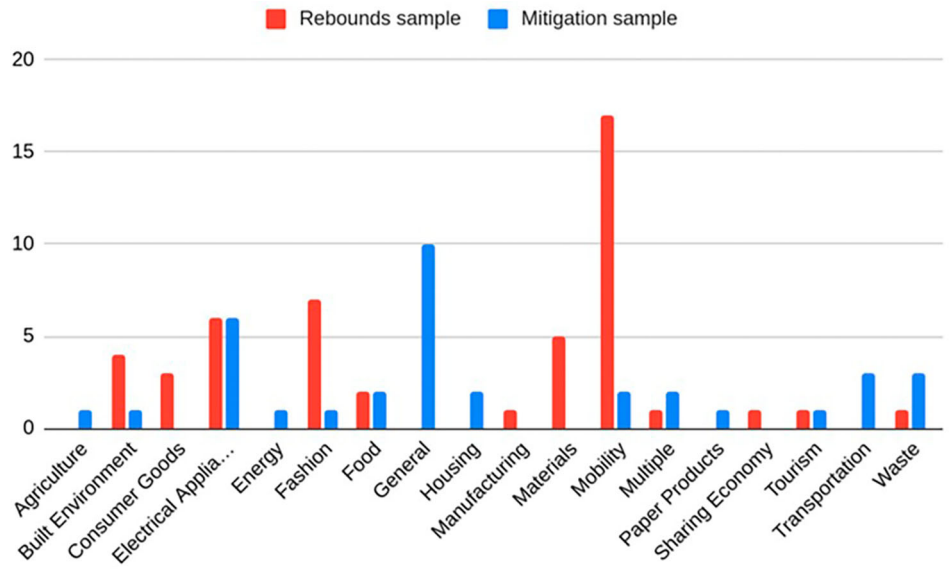

Figure 3. Sectors in rebound and mitigation samples.

3.3. Dematerialisation or efficiency

The circular business model archetype cluster of 'Dematerialised or efficiency' aims to reduce demand for physical products by replacing physical infrastructure with digital infrastructure that stimulates reduced consumption (Pieroni *et al.*, 2020). Research indicated that these strategies were vulnerable to indirect rebound effects, such as price effects, where more efficient services enable increased consumption, either of the primary good or of a secondary good (Ottelin *et al.*, 2017). For example, one study by Walzberg *et al.* (2020) found that energy usage in a smart home - that saved energy through automated temperature regulation - actually used more heating, reducing the amount of energy saved.

Studies suggested that sufficiency strategies that reduce overall consumption could be used more strongly to mitigate these rebounds, alongside even greater efficiency improvements that would lessen the environmental burden of increased use (Ottelin *et al.*, 2017). Others have suggested using 'carbon labeling', which would give consumers more accurate information about the true cost of consumption (Yakobovitch & Grinstein, 2016), or informing consumers about the true environmental footprint of consumption to avoid overconsumption (MacCutcheon *et al.*, 2020). For policy mitigation

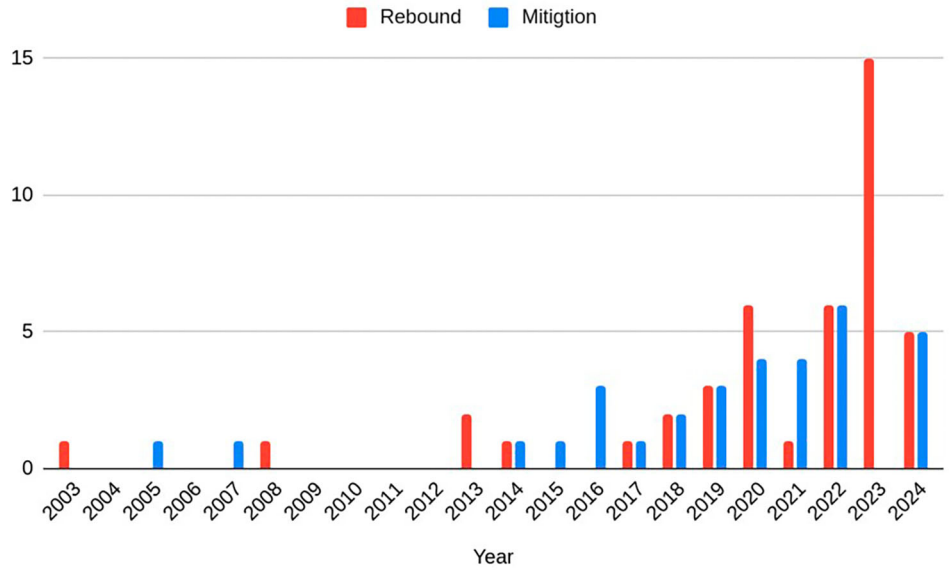

Figure 4. The publication years of the rebound and mitigation papers within the study sample.

strategies, some researchers suggested incentivizing decreased consumption (Sorrell *et al*., 2020), using taxes to increase the cost of energy while simultaneously decreasing the cost of labor, to promote labor intensive industries (Santarius *et al*., 2023), and utilizing urban planning to reduce travel time (Ottelin *et al*., 2017).

3.4. Collaborative consumption

Business models of the 'Collaborative consumption' archetype cluster aim to reduce consumption through the sharing of resources between users, either for free or for a fee (Pieroni *et al*., 2020). Examples include car sharing or carpooling (Realini *et al*., 2021), or the sharing of food waste or leftover food (Meshulam *et al*., 2023).

Several studies indicated that sharing schemes are prone to direct, indirect and economy-wide rebound effects. An example of a direct rebound is increased consumption due to increased convenience or time saved through sharing of resources (Medina-Tapia & Robusté, 2018; Warmington-Lundström & Laurenti, 2020). One study found evidence of moral licensing and imperfect substitution, meaning that the very act of collaborative consumption encouraged more consumption, while some products also proved to be poor replacements for other products and simply added additional consumption (Ribera Jemio *et al*., 2024).

Meanwhile the indirect rebounds were often found in the form of price effects, where the savings made from utilizing a sharing platform freed up money that could be used on other goods and services that may have a higher environmental impact (Meshulam *et al*., 2023; Vélez, 2023; Warmington-Lundström & Laurenti, 2020). One clear example is described by Warmington-Lundström & Laurenti (2020), where people who utilized a boat sharing scheme often spent more money on things like car travel and air travel. On a larger scale, some research has found that cost savings of sharing schemes could cause demand to increase (Medina-Tapia & Robusté, 2018), while the shift away from one mode of transport to another might cause non-operational emissions to increase, as some vehicles would not be fully utilized (Amatuni *et al*., 2020).

Mitigation proposals suggested in the literature mainly focused on improving consumer awareness of price effects (Warmington-Lundström & Laurenti, 2020) and of shifting consumption to goods and services with a lower material footprint (Vélez, 2023). Alongside these recommendations, measures to increase product attachment, employment of sufficiency strategies to reduce consumption (Junnila *et al*., 2018) and reducing unnecessary consumption alongside improving the effectiveness of the goods and services has also been proposed (Harris *et al*., 2021). In terms of policy interventions, it was suggested that urban planning that incentivizes public transport and reduces travel time, alongside restrictions on private transport and policies that support peer-to-peer sharing, could help mitigate rebound effects (Medina-Tapia & Robusté, 2018). Furthermore, it was suggested that policy could help steer consumption towards goods with a lower footprint and help create mechanisms that support the adoption of new and more sustainable technology (Vélez, 2023).

3.5. Product-service systems

The archetype cluster of "product-service systems" serves as an umbrella term for combinations of products and services such as product-as-a- service, rental, hire, leasing, p-per-use and functional sales (Pieroni *et al*., 2020; Tukker, 2004), that aim to reduce consumption by offering products as services.

A common direct rebound that was found in the research on PSS has been careless consumption (Tunn & Ackermann, 2020), the tendency to be careless with objects that one does not own. Research has also indicated that if consumers expect good-as-new products, or if consumers are encouraged to use products more, then consumption might increase in a PSS (Tunn & Ackermann, 2020). Research has also indicated a risk that as consumers are encouraged to consume more, in order to increase profits, higher stocks would need to be maintained to manage spikes in consumption which leads to increased environmental impact (Metic *et al*., 2024). Similar to collaborative consumption, research indicated that indirect rebound could occur if consumers save money from engaging in a PSS and then spend that money on other goods and services (Vélez, 2023).

To decrease the effect of careless consumption, it has been suggested that products should be designed for care (Tunn & Ackermann, 2020) and to increase the consumers attachment to the goods (Junge, 2021). It has also been suggested that careless use should be penalized (Tunn & Ackermann, 2020). If the price of the goods could also be controlled, that could mitigate price effects (Kjaer *et al*., 2019; Laurenti *et al*., 2016). Other suggestions involved incentivising/promoting a change in the lifestyle of consumers towards less resource intensive products and services (for e.g., by making less impactful consumption more desirable or convenient or nudging towards more careful consumption) (Vélez, 2023). Additional strategies included monitoring or forecasting the effects of the business model using LCA (Abdoli *et al*., 2019; Alfarisi *et al*. 2023; Koide *et al*., 2022) or to be more efficient in value creation and use more recycled input materials

Table 4. List of circular business model archetypes, their identified rebound effects and corresponding mitigation solutions.

Circular Business Model Archetype Clusters	Rebound Effect Cases	Rebound Mitigation Suggestions	
		Business	**Policy**
Dematerialisation or Efficiency *(E.g., Dematerialised services, Demand reduction services, Encourage sufficiency)*	**Direct:** None reported **Indirect:** - Increased consumption of other goods and services as a result of reduced usage of a given product/ service - Savings re-spent on high impact goods and services **Economy-wide:** None reported	**Measures to reduce consumption:** - Measures to reduce product/service use - Transparency regarding the true environmental footprint of a product or service (e.g., carbon labelling that emphasizes ecological damage of consumption) **Measures to reduce impact of consumption:** - Promote more energy efficient products/services - Pursue regenerative strategies, such as maintaining the health of ecosystems through restoration and remediation, aiming to make a positive environmental impact **Other measures:** - Account for the rebound effect in the impact measurement calculations	**Measures to reduce consumption:** - Urban planning that reduces consumption (e.g., reduce travel to essential services and product) - Incentivize consumers to consistently reduce their consumption on multiple fronts - Increase the cost of energy through taxes **Measures to reduce impact of consumption:** - Decrease cost of labour to promote labour intensive industries **Other measures:** None reported
Collaborative Consumption *(E.g., Sharing economy, Co-access, Co-ownership)*	**Direct:** - Increased consumption and product use due to reduced cost and increased convenience **Indirect:** - Increase in car passengers, due to ride sharing - Efficiency causing more consumption of other goods and services **Economy-wide:** - Increase in non-operational emissions when consumers switch to another mode of transport - A demand increase in car use would encourage urban sprawl	**Measures to reduce consumption:** - Increase opportunities for consumers to feel attached to their shared products - Trial non-economic mechanisms like symbolic rewards, information provision and nudging to reduce rebound effects - Educate consumers about the rebound effects and about the impact of their behavior on the environment **Measures to reduce impact of consumption:** - Shift consumption towards less resource intensive products and services **Other measures:** - Conduct holistic assessment of the impacts to account for rebound effects	**Measures to reduce consumption:** - Better urban planning to incentivize shared products - Policies to increase peer-to-peer sharing - Restrictions on private ownership - Incentivise efforts to change lifestyles of consumers - Reduce consumption of high-emission goods **Measures to reduce impact of consumption:** - Incentivise low-emission technology **Other measures:** None reported

Table 4. *Continued*

Circular Business Model Archetype Clusters	Rebound Effect Cases	Rebound Mitigation Suggestions	
		Business	**Policy**
Product-Service Systems *(E.g., Product-as-a- service, Rental, Hire, Leasing, Pay-per-use, functional sales)*	**Direct:** - Higher replacement rate caused by: ▶ Decrease in product care ▶ Higher consumer expectations regarding the state of the product ▶ Encouragement to use product more - Higher/relevant stock need to meet potential consumer demand) - Greater emotional attachment to second hand clothes means clothes ae discarded less frequently (positive rebound) -Introduction of more fuel-efficient cars results in an increase in travel demand	**Measures to reduce consumption:** - Make efforts to change the lifestyles of consumers towards less impactful consumption - Make users more attached to a product (adapt appearance to user, create product personality) - Use rewards and fines - Design products that feel expensive **Measures to reduce impact of consumption:** - Prevent careless consumption - Inform consumers about the importance of product care - Make timely maintenance easy to access for the consumer - Make the consequence of product care visible to the consumer - Facilitate product care by designing products with automated care functions - Use norms, ratings and other social mechanisms to foster product care - Integrate multiple CE strategies within a business model - Eco-efficient value creation (i.e. do more, with less) - Increased focus on producing from end-of-life input materials - Design to reduce the need for care, and making products more robust to different usage patterns. **Other measures:** - Price control: encourage consumers to pay more for resource efficient solution, so less disposable income is leftover - Conduct LCAs that simulate the effect of the product on system outside of the product system - User and stakeholder involvement in PSS innovation -Design a product that learns the users habits	**Measures to reduce consumption:** - Incentivise reduced consumption of high-emissions goods - Introduce emission trading rules - Energy and carbon tax to reduce the magnitude of rebound effects - Cap and trade schemes that place an upper limit on environmental stress **Measures to reduce impact of consumption:** - Incentivise low emission technology **Other measures:** None reported
	Indirect: - Savings spent on higher impact goods and services		
	Economy-wide: None reported		

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Table 4. *Continued*

Circular Business Model Archetype Clusters	Rebound Effect Cases	Rebound Mitigation Suggestions	
		Business	**Policy**
Long Life *(E.g., Long life products, Products with life extension services, Reduce, Repair, Modular design, Refill, Upgrading)*	**Direct:** - Repair services may increase sales and consumption **Indirect:** None reported **Economy-wide:** None reported	**Measures to reduce consumption:** None reported **Measures to reduce impact of consumption:** None reported **Other measures** - Introduction of a repairability index for products that can indicate a product's durability	**Measures to reduce consumption:** None reported **Measures to reduce impact of consumption:** None reported **Other measures** - Introduction of a repairability index for products that can indicate a product's durability
Next Life *(E.g., Direct reuse, Next life sales, Product transformation, Refurbish, Remanufacture, Incentivised return & reuse, Recycling, Waste Management)*	**Direct:** - Second hand markets could intensify consumption: ▶ By reducing the moral burden of consumption ▶ By allowing frequent buyers of new clothes to easily discard clothes ▶ Decrease intensity of use, as items are resold before their end-of-life - Recycling can increase consumption through moral licensing - Increased consumption from imperfect substitution of primary products - Increased global demand of materials that causes increased energy use **Indirect:** - Savings may be spent on high impact goods and services - Second hand clothing	**Measures to reduce consumption:** - Use green design to discourage buying spares - Improve social perception of used or recycled products to displace new products in the market - Only encourage product displacement when the circular system makes this convenient **Measures to reduce impact of consumption:** - Raise awareness about the limitations of recycling, while nudging towards recycling - Facilitate repairs - Work with consumers and policy makers to implement recycle and recovery systems - Design products to allow for consumer upcycling, such as modular products **Other measures**: - Incentivize consumers to spend their money on sustainable goods and services - Evaluate rebound effects relative to the value chain, and solely in terms of emission - Rebound effects should be managed as an operation and supply chain risk - Consider resource specific factors when managing rebound effects	**Measures to reduce consumption:** - Carbon tax - Incentivize consumers to spend their saved money on more sustainable goods and services - Policy to enable battery reuse and support widespread adoption of battery reuse - Discourage primary material consumption, e.g., by reducing the size of garbage bins - Charge unit-based landfill fees **Measures to reduce impact of consumption:** - Work with businesses and consumers to create recycle and recovery systems - Recycled content mandates or taxes on primary consumption **Other measures:** - Implement conservation policies that will protect natural resources

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Table 4. *Continued*

Circular Business Model Archetype Clusters	Rebound Effect Cases	Rebound Mitigation Suggestions	
		Business	**Policy**
	markets fail to substitute primary products and increase consumption - Efficiency gains result in increased consumption		
	Economy-wide: - Low price of secondhand clothes incentivize increased fashion consumption - Symbiotic rebound; e.g. circular strategies compete for inputs		
Circular Sourcing *(E.g., Source circular supplies, Industrial Symbiosis, Renewable energy, Using bio-materials)*	**Direct:** - A short supply chain increases sales and consumption	**Measures to reduce consumption:** None reported **Measures to reduce impact of consumption:** - Systemic approach to design to better enable recycling - Pursue regenerative business models **Other measures:** - Maximize the localization of the CE network, and work exclusively with renewable energy - Competitors should collaborate to develop circular infrastructure	**Measures to reduce consumption:** - Implement restrictions on the use of specific products such as fossil-based cars **Measures to reduce impact of consumption:** None reported **Other measures:** None reported
	Indirect: - Industrial agglomeration that allows waste minimization creates increased pollution from secondary and tertiary sources		
	Economy-wide: None reported		

Table 4. *Continued*

Circular Business Model Archetype Clusters	Rebound Effect Cases	Rebound Mitigation Suggestions	
		Business	**Policy**
Circular Production & Distribution *(E.g., Take-back & reprocessing used products, Cleaner production, Eco-efficiency, Energy efficiency, On demand production)*	**Direct:** - Higher efficiency of electrical appliances leads to increased consumption - EV adoption may lead to higher automobile travel demand, due to the positive perception of EVs - Lower cost of Plug-in hybrids result in increased demand - More fuel-efficient cars lead them being driven farther - Convenience and comfort of autonomous vehicles increases travel demand - Car pools may make driving more attractive relative to other modes of transport and increase congestion - More efficient tourism infrastructure leads to increased demand of energy, services & delayed stimulation of regional economic growth - Increased energy efficiency and use of renewable energy led to increased resource use	**Measures to reduce consumption:** - Prevent excessive consumption through sufficiency strategies **Measures to reduce impact of consumption:** - Use additional profit for sustainable innovation - Improve reuse and waste reduction - Ensure that sustainable alternatives are qualitative substitutes **Other measures** - All stakeholders should be encouraged to be part of CE - Managers should develop time-bound tactics to carry out and monitor CE effectively - Market secondary goods the same way primary goods are marketed - Give employees sufficient information, safe working conditions and the right to participation to safeguard working conditions - Use education to overcome stigmas towards secondary goods - Target satiable demand or make efforts to ensure that secondary goods production doesn't have a big impact on overall prices	**Measures to reduce consumption:** - Efficiency gains can be compensated for with quotas or rationing - Savings from efficiency improvements can be spent in a manner that reduces rebound effects (for e.g. by reducing government debt) - Price control measures **Measures to reduce impact of consumption:** - Create mechanisms for the adoption of more sustainable technologies, when they are ready **Other measures** - Policy incentives that reward investment in mitigation strategies
	Indirect: - Energy efficiency improvements and renewable energy use leading to		

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Table 4. *Continued*

Circular Business Model Archetype Clusters	Rebound Effect Cases	Rebound Mitigation Suggestions	
		Business	**Policy**
	increased production and company growth - Full battery electric cars and fuel cell electric cars have a higher capital cost, reducing overall consumption (positive rebound)		
	Economy-wide: - Efficiency gains result in increased economy-wide resource consumption - Insufficient substitution of primary products by circular products, leading to increased consumption - Re-investing effect: increases in profit are re-invested in production factors		

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Table 4. *Continued*

Circular Business Model Archetype Clusters	Rebound Effect Cases	Rebound Mitigation Suggestions	
		Business	**Policy**
General *(Studies not specifically related to any particular circular business model archetype)*	**N/A**	**Measures to reduce consumption:** - Inform and nudge consumer: ▶ Education and raising awareness ▶ Labeling and green labeling ▶ Smart metering and feedback to user ▶ Use default options to guide choice ▶ Guide behaviour through social context **Measures to reduce impact of consumption:** None reported **Other measures:** - Reduce labour productivity to compensate for resource productivity increase	**Measures to reduce consumption:** - Use taxes: ▶ Fuel taxes, carbon taxes or taxes on non-renewable resources, mining taxes and mining royalties ▶ Decrease taxes on labour and renewable resources - Increasing reclamation costs and exploration costs of mining - Include scrap prices on major futures exchanges - Incentives to direct consumption and expenditure **Measures to reduce impact of consumption:** - Fuel efficiency improvements, cap-and trade schemes - Lower the material footprint of all goods and services, e.g. by phasing out environmentally harmful activity **Other measures:** None reported

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(Alfarisi *et al*. 2023). Furthermore, policy could incentivize low emission technology as well as reduced consumption of high emission goods, making price effects less pronounced (Vélez, 2023). Other authors have suggested improving emission trading rules and incentivizing public transport in the mobility sector (Abdoli *et al*. 2019), or the implementation of energy or carbon taxes, along with cap and trade schemes to reduce the magnitude of rebound effects and limit environmental damage (Alfarisi *et al*., 2023).

3.6. Long life

The archetype cluster "long life" refers to business models focused on extended product lifetimes for the same user often facilitated by design for attachment or timeless design, durability, and high levels of warranties and service, coupled with a premium pricing model (Bocken *et al*., 2016). Despite relatively fewer empirical studies for this archetype, Beulque *et al*. (2023) found that offering repair subscription services can cause more sales, and a higher purchase frequency, resulting in a direct rebound effect. In the case of modular devices, one concern has been the possibility of over provisioning of modules that could lead to increased consumption (Proske & Jaeger-Erben, 2019).

In order to mitigate rebound effects of "long life" business models, studies proposed that a repairability and durability index could be introduced to support consumer decision making by making the repairability and durability of a product known, thus supporting sufficiency and reducing consumption by steering consumption towards more durable and repairable products (Beulque *et al*., 2023).

3.7. Next life

The circular business model archetype cluster "next life" refers to business models that help extend the lifetime of products and to slow resource loops. While long life aims to extend product life time for a single user, next life aims to extend the material or product lifetime beyond the single user. This can be facilitated by strategies such as design for dis- and reassembly, upgradability, maintenance and repair, as well as product take-back models and second hand platforms (Bocken *et al*., 2016; Bocken & Short, 2020).

Studies have indicated that second hand markets could *increase* consumption, as consumers simply consume more (André & Björklund, 2023; Carrasco Campos, 2022), as the reduced price makes increased consumption possible, and the lower quality increases the need for additional consumption (André, 2024). Some studies have found that recycling can provide moral licensing to incentivize additional consumption, since consumers can view the recycled alternatives as more eco-friendly and thus end up using more of the products, increasing overall consumption related impacts (Catlin & Wang, 2013; Maier *et al*., 2023). As with many other archetypes, next life strategies were found to be prone to price effects (André, 2024; Makov & Font Vivanco, 2018; Wiprächtiger *et al*., 2022). It is also important to note the limit of recycling strategies. Recycle, remanufacturing and reuse strategies have been found to lead to imperfect substitution (Makov & Font Vivanco, 2018; Safarzynska *et al*., 2023; Sourabh *et al*., 2024). Furthermore, on an economy-wide scale, next life strategies may be prone to what Figge & Thorpe (2019) calls a symbiotic rebound, where choosing one CE strategy may move us away from another (perhaps more resource effective) strategy. This involves shifting to biocentric and biomimetic design, identifying environmental degradation and taking steps to revert it in the design and development phase in order to create nature-positive business models (de Souza *et al*., 2019).

As for mitigation, researchers have pointed to the need to raise awareness about the real effects of recycling and its limitations, as well as to promote behavior change amongst consumers to stop overconsumption (Catlin & Wang, 2013; Makov & Font Vivanco, 2018). Other suggestions were to improve the social perception of secondhand goods and to facilitate repairs, to improve substitutability (Makov & Font Vivanco, 2018). For policy, researchers have suggested measures such as a carbon tax, steering consumption (Carrasco Campos, 2022) and supporting recycling through cooperation with the private sector and consumers (Dzombak *et al*., 2019).

3.8. Circular sourcing

The archetype cluster "circular sourcing" refers to upstream business model strategies like industrial symbiosis or closed-loop production that aim to create value through use of recycled materials, byproducts, and waste as inputs in their new products or services (Pieroni *et al*., 2020).

Research has indicated that circular sourcing could be prone to direct rebound effects, such as industrial agglomeration *increasing* local pollution (Fons *et al*., 2003). Meanwhile a shorter supply chain means more efficiency, which in turn can cause consumption to increase as prices go down (Vegter *et al*., 2023). Other authors have found that the perception of Electric Vehicles (EVs) as a 'green' alternative could lead to increased driving, as opposed to using more efficient modes of transportation (e.g. public transportation) (Kosmidis *et al*., 2023). As for indirect rebound effects, Fons *et al*. (2003),

suggested that strategies such as waste minimization risked leading to greater local pollution as the required waste management systems would incentivize geographical business concentration, which in turn attracts other business.

Limited direct mitigation suggestions were found in the literature connected with circular sourcing. However some authors suggested that such rebound effects where gains can be lost due to increased consumption can be counteracted by implementing regenerative strategies (de Souza *et al*., 2019).

3.9. Circular production and distribution

The archetype cluster "circular production and distribution" refers to upstream business model strategies that can, for example, involve producing goods and services on demand to reduce overconsumption, reducing waste and pollution by using cleaner energy/employing efficiency strategies, or closing the material loop through take back schemes or other forms of reprocessing of goods (Pieroni *et al*., 2020).

In the case of strategies that aim to increase efficiency or reduce consumption, some studies found that these strategies can result in direct or indirect rebounds. For example, Konash & Nasr (2022) describe a direct rebound in a case study of a medium sized complex parts manufacturing company from New York, USA. They found that the company's circular efficiency measures, such as equipment upgrades, energy and water use monitoring, optimizing operating schedules, recycling water and materials, reducing waste, performance improvement programs, actually led to increased resource use in the short term and a clear backfire effect. Energy consumption did however decrease over the long term but with direct and indirect rebound effects. Skelton *et al*. (2020) also pointed to this risk of increased consumption on a greater scale if efficiency resulted in reduced material input prices. In a similar vein, van Laarhoven (2023) suggested that if increased profit due to efficiency gains was reinvested in production factors, this could lead to increased consumption.

There were many suggestions for mitigation in the literature. Most prominent perhaps were suggestions to raise awareness among consumers (Kagawa *et al*., 2013; Shinde *et al*., 2022), and attempt to steer spending away from goods and services with a greater material footprint (Kawajiri *et al*., 2015; Throne-Holst *et al*., 2007). Alongside these suggestions were suggestions for the adoption of renewable energy and cleaner technology (Onat *et al*., 2023). At a policy level, it has been suggested that prices be controlled, and to support the adoption of newer, more sustainable technologies (Guzzo *et al*., 2023; Lifset *et al*., 2024). Additionally, in the specific case of electric vehicle (EV) adoption, Kosmidis *et al*. (2023) have suggested that restricting the use of cars could mitigate the effect of consumers choosing EV's ahead of public transport alternatives.

3.10. General mitigation suggestions

Some mitigation suggestions were identified that were not related to any specific circular business model archetypal cluster, but instead were suggested as mitigation of rebound effects in circular business in general. These suggestions were perceived as relevant and are included in a final row in Table 4. One example of such a mitigation strategy was raising consumer awareness in various ways, through education, labeling or using technology to provide feedback to the consumer, to make them more aware of their consumption (Lowe *et al*., 2024; Ottelin *et al*., 2020; Polizzi di Sorrentino *et al*., 2016). Walnum *et al*. (2014) suggested that rebound effects could be mitigated if efficiency improvements were used for something other than reduced prices or increased production, such as reduced working hours.

For policy, the general suggestions for mitigation were primarily to use various tax incentives to manage rebound effects (Lowe *et al*., 2024; Ottelin *et al*., 2020; Walnum *et al*., 2014). The primary purpose of the suggested taxes was to increase the cost of environmentally harmful consumption, such as taxing non-renewable resources (Ottelin *et al*., 2020), carbon or mining (Lowe *et al*., 2024), although Ottelin *et al*. (2020) also suggested decreasing taxes on labor and renewable resources in order to favor renewable resources and business sectors that are labor intensive as opposed to material intense.

4. Discussion

In this section the primary findings of the systematic literature review of rebound effects on the seven circular business model archetypal clusters, and their potential mitigation strategies are discussed, followed by advice for practitioners and the limitations of the study.

4.1. Rebound effects of circular business models

The main finding of this study is that although rebound effects significantly impact circular economy strategies, there is little structured knowledge to guide practitioners in implementing circular business models. The sample of 44 empirical studies showed rebound effects in every circular business model archetype, suggesting they may be an inherent aspect of circular models. These effects arise through a variety of mechanisms when attempting to slow, close, or narrow resource

loops which include price effects, careless consumption, substitution effects, cross-rebound effects (Font Vivanco *et al.* 2022), as well as consumer perception of products and their environmental impact and moral licensing. The findings revealed significant overlap in rebound effects across circular business model archetype clusters, particularly regarding efficiency gains and cost reductions leading to increased consumption. This is expected, as efficiency drives circularity (Blomsma *et al*., 2019; Zink & Geyer, 2017), though each business model achieves it differently. Some rebound effects are model-specific, such as careless consumption undermining product-service systems (Junge, 2021; Tunn & Ackermann, 2020), moral licensing encouraging consumption in next-life models (André & Björklund, 2023; Carrasco Campos, 2022; Ciechelska *et al*., 2023) and modal shifts in collaborative vehicle consumption (Amatuni *et al*., 2020; Realini *et al*., 2021). The results highlight the complexity of rebound effects, particularly their interaction with consumer behavior.

With regard to RQ2 the aim of this study was to provide insights into rebound effects of specific circular business models and the possible ways to mitigate them, that could be useful for future research as well as practitioners. Many mitigation strategies focus on influencing consumer actions through laws, incentives, nudging, price controls, or information campaigns (Carrasco Campos, 2022; Kjaer *et al*., 2019; Laurenti *et al*., 2016; Sorrell *et al*., 2020). It is clear from these examples that circular businesses need consumer participation to transition from linear to circular consumption. However, there was little discussion on rebound effects linked to producer-producer business model relationships. And, while many rebound mitigation strategies were suggested, they were rarely empirically tested to assess their effectiveness and thus their actual effects remain theoretical. Indeed, only 32 of 45 papers linked mitigation strategies to specific rebound effects. Additionally, some suggested strategies were overly general and could unintentionally reinforce rebound mechanisms, increasing environmental impact. For example, improving fuel efficiency to reduce environmental impact (Onat *et al*., 2023) may be counterproductive, as efficiency gains often trigger rebound effects. This uncertainty highlights the need for further quantitative empirical research to determine which mitigation strategies are effective, under what conditions, and how different circular strategies can be combined to minimize rebound risks.

Additionally, the literature sometimes used "rebound effects" more broadly to describe unintended consequences of circular business models. While rebound effects typically refer to negative outcomes linked to market dynamics and consumer behavior, unintended consequences encompass broader, unforeseen impacts of implementing such models. Business decision-makers may not consciously distinguish between induced impacts, unintended consequences, and rebound effects. In at least 13 papers from the initial sample, this distinction was unclear. We argue that "rebound effects" should specifically refer to systemic or behavioral responses triggered by adopting a circular business model, that are not essential elements that are part of its implementation (Kjaer *et al*., 2018). This is important since without a clear understanding of how rebound effects arise or how they differ from unintended consequences, measurement and mitigation efforts may fall short (Friedrichsmeier & Matthies, 2015; Guzzo *et al*., 2024).

Further, this paper aims to provide insights into rebound effects in specific circular business models and potential mitigation strategies useful for research and practice. Organizing rebound effects by circular business model archetypes, assuming they are shaped by the model implemented, offers clearer information on risks and mitigation strategies applicable to specific businesses. Similarly, categorizing rebound effects as direct, indirect, or economy-wide helps assess how innovations impact different economic levels and interact. Identifying the system in which a rebound effect occurs may better enable practitioners and policymakers to influence environmental impacts. Additionally, the systematic overview can help determine which rebound effects and mitigation strategies fall within the zone of influence of practitioners, hopefully further aiding them in developing strategies to avoid or mitigate rebound effects. Finally, such an overview may offer valuable guidance in early business model design, where companies often rely on "rules of thumb" rather than detailed assessments to estimate environmental impacts (Das *et al*., 2022; Das *et al*., 2023).

Past systematic reviews of circular economy rebounds indicate limited awareness of the topic in practice (Lowe *et al*., 2024; Zerbino, 2022). In their review of rebound estimation methods Lowe *et al.* (2024) found that beyond tax and pricing policies, discussions on mitigating rebounds are scarce, especially in a circular economy context. They emphasized the need for ex-ante planning and measurement in business experimentation. Meanwhile, Baczyk *et al.* (2024) explored the rebound effects with a focus on consumer behaviour, suggesting how rebound effects from consumer behaviour might be mitigated, however the suggestions are general guiding principles of mitigation, rather than strategies designed to fit specific scenarios. Indeed, past mitigation strategies have been general, vague, and more difficult to convert into practice (Zerbino, 2022), which also applies to many mitigation strategies in this review. Further research is needed to refine mitigation strategies, but categorizing them into business- and policy-focused approaches could help practitioners identify what falls within their influence. This would guide context-specific actions and integrate awareness of rebound effects into business model design. This is especially important as Das *et al.* (2022) found that small and medium-sized

business practitioners lack structured knowledge to support low-impact design decisions. Findings also suggest that coordinating business and government efforts could strengthen mitigation by aligning strategies for greater impact.

Lastly, past research calls for treating rebound effects as a risk to be managed in circular strategies (Zerbino, 2022). Meanwhile, extensive studies have explored the circular economy's role in enhancing social sustainability and addressing the needs of disadvantaged communities (Mies & Gold, 2021; Schröder *et al*., 2019). For example, some suggested mitigation strategies, e.g. price controls, suggest addressing rebound effects by making consumption more expensive. However, while raising prices may reduce consumption, it places disproportionate responsibility on lower-income groups, potentially exacerbating inequality (Mies & Gold, 2021; Schröder *et al*., 2019). Such approaches may also backfire if people simply switch to cheaper, more environmentally harmful products, and could fuel class-based resentment toward circular solutions perceived as accessible only to the wealthy. In some cases, accepting low rebound effects may be necessary (Font Vivanco *et al*., 2022). For instance, poorer households requiring thermal retrofits to escape energy poverty would generate significant energy rebounds but are essential for a dignified life (Bouzarovski *et al*., 2017). Findings from this research can help inform practitioners and policymakers about rebound risks while considering social benefits. However, concerns about rebound effects should not deter circular strategies, and unavoidable rebounds should be weighed against their potential social impact.

4.2. Contributions to research, practice and policy

Although previous reviews of circular rebound effects have been conducted (e.g., Brockway *et al*., 2021; Font Vivanco *et al*., 2022; Lowe *et al*., 2024; Metic & Pigosso, 2022; Sorrell *et al*., 2020; Warmington-Lundström & Laurenti, 2020; Zerbino, 2022), this is the first to examine them in the context of circular business model archetypes. Business models significantly influence material flows and energy use (Bocken *et al*., 2016; Halme *et al*., 2007), making it crucial for researchers and practitioners to understand the underlying rebound effects, to maximize the benefits of circular business models. One of the main contributions of this review is systematically summarizing current research on circular business models and rebound effects, serving as a foundation for future studies. The second major contribution is consolidating rebound mitigation strategies suggested by literature. Most of these suggestions are yet to be empirically tested. Mapping these suggestions to specific business model archetypes, provides a starting point for further research on their effectiveness. The findings highlight knowledge gaps and existing conclusions, guiding future investigations and informing businesses and policymakers on best practices to optimize circular model benefits.

The findings of this research can be useful to decision-makers navigating the transition to circular business models, specifically to addressing uncertainties around sustainability gains being offset by rebound effects. The systematic overview presented by this study can also support policymakers in implementing circular economy policies while considering associated risks, especially economy-wide rebound effects. For practitioners the results provide suggestions for mitigation strategies that can be trialed and refined. Innovators can use these insights to identify and address potential rebound effects early in business model design, reducing risk—especially in light of potential new regulations. Designers can also consult the overview during the early ideation phase of business model design (Bocken & Snihur, 2020) to assess and mitigate rebound effects. Further, in the experimentation phase, the systematic overview can continue to be a reference for identifying rebound effects and refining mitigation strategies as business model performance is evaluated and adjusted.

4.3. Limitations and future research

This study had some limitations. First, there are limitations pertaining to the chosen method. The literature search was carried out in only two databases, this might have led to search results being more limited than they otherwise might have been. Additionally, although the title, abstract and full text scans were carried out systematically, there is a chance for inadvertent omissions of relevant data, due to human error. It is also worth noting that the search was carried out in late 2024 and for that reason it does not encompass all the more recent contributions to the field. Further, most of the business case study examples found in the literature were from Europe or North American, limiting generalizability of results. As noted by Baczyk *et al.* (2024), consumer behavior is often specific to a certain place and culture and it's therefore important to always encourage the development of circular strategies that are tailored to the context within which the business is embedded.

Second, the non-identification of rebound effects in a given archetype does not mean they do not exist. Some circular business models are more prevalent and researched than others, for example, the 'Circular Production & Distribution' and 'Next Life' archetypes had more research studies compared to other archetypes. More research should be directed towards understanding rebound effects in the less well researched circular business archetypes. Additionally, the findings must be considered within the boundaries set by the primary studies from which the rebound effects and mitigation strategies were extracted. For example, a study on rebound effects of production of remanufactured marble did not

account for the savings from avoiding virgin raw material extraction (Zerbino, 2022). The researchers note this limitation as "the capacity to preserve mountains from anthropogenic activity cannot be easily translated into saved emissions" (Zerbino, 2022, p.9). So, while some activities might appear to generate rebound effects, they might have long-term positive societal or natural restorative or regenerative effects, that are hard to quantify, within impact measurement boundaries.

Third, while several mitigation strategies were identified, many were broad suggestions rather than actionable steps (for e.g., in the case of PSS, price controls and steering consumers towards less impactful consumption or measuring impacts of change). While others referred to initiatives that themselves can also lead to rebound effects (e.g., suggesting to improve the social perception of secondhand goods, practice that itself is connected to several rebound effects). Further, some of the suggested policy-oriented strategies, such as urban planning, fuel or carbon tax and restrictions on fossil fuel transportation are not specific to the circular economy, and could lead to additional rebound effects if not carefully planned and implemented. Moreover, most strategies were not empirically tested, meaning their actual effectiveness remains uncertain. This study, therefore, relies on mitigation strategies as reported by authors, highlighting the need for future research to identify credible, context-specific strategies and quantitatively assess their effectiveness.

Overall, while understanding rebound effects and mitigation strategies might be complex due to their context-specific nature within circular business models, more research is needed to experiment with these strategies through modeling, scenario analysis, and real-world testing. Accumulated knowledge could lead to standardized procedures for measuring and mitigating rebound effects by design while accounting for environmental impact variations. Institutional analyses considering norms, values, culture, and legislation (Scott, 2013) could also be beneficial. In spite of this lack of knowledge on how to most effectively mitigate rebound effects, there are some early signs of companies looking to gain insight into how rebound effects can potentially occur in their new business model offerings: such as the outdoor-goods manufacturer VAUDE, conducting a LCA study to evaluate the environmental impact of different scenarios before adopting a PSS business model (Friedrich, 2023).

5. Conclusion

While research on circular rebound effects has grown, there has been a lack of organized knowledge on mitigating these effects within business models. This study aimed to investigate (1) the potential rebound effects of circular business model archetypes and (2) identified strategies for their mitigation through a systematic literature review. It provides a structured overview mapping rebound effects across seven circular business model archetypal clusters, and suggestions for ways to potentially mitigate them. The study highlights where empirical research has focused on direct, indirect, and economy-wide rebound effects and where future research opportunities exist. It also provides policymakers and practitioners with a systematic overview of risks associated with circular business models and potential mitigation strategies. However, while mitigation strategies have been suggested, they remain largely untested, and their effectiveness is uncertain.

The results indicate the need for more research to attribute rebound effects to specific circular business model choices, standardise methods to analyze the behavior and magnitude of these rebound effects, and develop mitigation strategies. Additional research could also refine the key findings of this paper (Table 4) into a practical tool or process that could enhance their usability.

Finally, while mitigating rebounds is crucial, their occurrence must be weighed against the broader societal benefits of circular business models. Given the limited research on effective mitigation strategies, practitioners must carefully evaluate the impact of circular business models to ensure they achieve their intended sustainability goals. Identifying and addressing rebound effects is challenging but essential, and requires more research efforts.

Ethics and consent

Ethical approval and consent were not required.

Data availability statement

Underlying data

All data underlying the results are available as part of the article and no additional source data are required. A review protocol was not registered prior to the start of the review.

Extended data

Data sample records: Rebound effects in circular business models: A review of cases and mitigation strategies. Zenodo. https://doi.org/10.5281/zenodo.16985825 (Das, 2025).

The project contains the following data:

- List of papers selected for review
- List of circular business model archetypes, and identified rebound effects & mitigation strategies with detailed references
- Coding of rebound effects and potential mitigation strategies of circular business model archetypes
- PRISMA checklist

Reporting guidelines
PRISMA checklist for 'Rebound effects in circular business models: A review of cases and mitigation strategies.' Zenodo. https://doi.org/10.5281/zenodo.19700219 (Das, 2026).

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

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Version 2

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Changhee Kim
Xi'an Jiaotong-Liverpool University, Suzhou, China

Thank you for the opportunity to review the revised manuscript, *"Rebound effects in circular business models: A review of cases and mitigation strategies."*

The authors have made commendable efforts to address the initial feedback, particularly by expanding the discussion of practical implications and attempting to clarify key concepts. However, despite these additions, some structural inconsistencies, methodological ambiguities, and logical gaps remain unresolved.

Further clarification and correction are therefore needed before the manuscript can be fully approved. That said, I genuinely enjoyed reading the article, and I would like to thank the authors once again for their valuable contribution to the circular business model discipline.

Comment #1:
On page 8, the authors suggest that the higher concentration of rebound effects observed in the Circular Production & Distribution, Next Life, and Collaborative Consumption archetypes is *"possibly be due to the fact that some of these business model innovations (such as material efficiency, recycling, remanufacturing, etc.) have existed for longer in the business sphere".* However, this explanation is not empirically tested or supported anywhere in the manuscript. Figure 4 presents publication years only for the full sample, without disaggregation by archetype, so no data is provided that directly substantiates this interpretation.

Moreover, at least one equally plausible competing explanation is not considered. These archetypes may attract more rebound studies not because they have existed for longer, but because their rebound mechanisms are more visible and more amenable to empirical measurement (e.g. demand increases or consumption changes driven by price effects). Presenting only a single post-hoc interpretation, without acknowledging alternative explanations or providing the data needed to assess it, may give readers a stronger impression than the results actually justify.

Therefore, the authors should either: (a) provide disaggregated data (e.g. publication years by archetype) to support their interpretation, or (b) reframe the explanation as one of several competing hypotheses and present it as a potential direction for future research rather than an explanatory conclusion.

Comment #2:
The manuscript reports a total of 76 papers as the review sample, composed of two separate subsamples: 44 papers selected for RQ1 and 32 papers selected for RQ2. The PRISMA diagram in Figure 1 also sums these precisely to 76 (44 + 32 = 76), which suggests that there is no overlap between the two subsamples. However, the main text does not explicitly confirm whether the two samples are mutually exclusive, and given that both samples were derived from the same initial pool of 74 papers using the same search terms, no explanation is provided for how this complete separation was achieved.

This ambiguity is important for two reasons. First, it is analytically plausible and quite common for studies that empirically measure rebound effects (RQ1) to also propose mitigation strategies (RQ2), since empirical work often leads to policy or practical implications. If a substantial number of papers appear in both samples, it becomes difficult to regard the two research questions as being addressed by independent sets of evidence, and the total sample size of 76 may give an exaggerated impression of the diversity of the actual evidence base.

Second, the statement on page 8 that *"out of all 76 articles, only 11 lacked mitigation suggestions"* assumes that all 76 papers form a single integrated unit of analysis, which is only valid if any overlap between the two subsamples has been clearly confirmed. At present, this assumption remains unverified. (= If only 11 papers lacked mitigation suggestions, it logically follows that 65 papers (76-11) actually contained mitigation content?)

Therefore, the authors should clarify whether there is any overlap between the RQ1 and RQ2 samples. If overlap exists, its extent should be specified, along with an explanation of how it was handled in the analysis design. If the two samples are indeed mutually exclusive, a brief methodological explanation of how such separation was possible from the same initial literature pool should be provided.

Comment #3:
On page 20, the authors argue that a systematic overview *"can help determine which rebound effects and mitigation strategies fall within the zone of influence of practitioners".* The revised manuscript expands the discussion of practical implications in Sections 4.1 and 4.2 in response to earlier reviewer feedback, and these improvements are acknowledged. However, the issue raised here is different from the question of whether the practical implications are sufficiently detailed. It concerns a structural gap in the paper's underlying analytical logic, which remains unresolved in the revised version.

Table 4 distinguishes between mitigation strategies at the Business and Policy levels, which can be seen as a partial step toward clarifying the 'zone of influence'. However, the paper does not clearly explain the logic linking the three rebound types — direct, indirect, and economy-wide — to the business/policy distinction. The sentence added in Section 4.1 notes that *"categorizing rebound effects as direct, indirect, or economy-wide helps assess how innovations impact different economic levels and interact"*, but this describes the usefulness of the typology rather than the logic for mapping

rebound types to the 'zone of influence'.

For example, the paper does not explain why economy-wide rebound effects primarily require policy responses, or how practitioners should determine whether a particular indirect rebound falls within their organization's 'zone of influence'. The same gap appears in Section 4.2, where practitioners are advised to "*identify and address potential rebound effects early in business model design",* yet no guidance is provided on how the direct/indirect/economy-wide classification should inform that identification process in practice.

If the authors want the 'zone of influence' framing to function as a substantive analytical contribution rather than a rhetorical device, they need to explain explicitly how rebound types connect to the 'zone of influence'. Even a simple matrix or a short, structured paragraph showing how direct, indirect, and economy-wide rebounds correspond to business and policy domains, and why, would strengthen the argument considerably. Without such clarification, the concept remains more of an assertion than an analytical contribution, and the practical guidance offered to decision makers remains not concrete enough.

Comment #4:
The Introduction explicitly state that *"the focus of this paper is mainly on negative effects*". In their response to a previous reviewer's question about positive rebound effects, the authors also clarified that positive rebounds can be socially beneficial and, in some cases, acceptable.

However, this philosophical acknowledgement does not resolve the methodological inconsistency that remains in the published manuscript. Table 4 includes two entries explicitly labelled as positive rebound effects. Under Product Service Systems, it lists *"greater emotional attachment to second-hand clothes means clothes are discarded less frequently (positive rebound)",* and under Circular Production & Distribution, it lists *"full battery electric cars and fuel cell electric cars have a higher capital cost, reducing overall consumption (positive rebound)".* These two items are not discussed in the corresponding results section, nor are they examined analytically in the discussion. More importantly, the methods section does not specify whether positive rebound cases were included or excluded from the systematic analysis, nor does it explain why these two particular cases were retained despite the paper's stated focus on negative impacts.

This creates a methodological transparency issue that is separate from the philosophical question of whether positive rebounds matter. The inclusion criteria for RQ1 (p. 5) define the scope as the empirical measurement and identification of rebound effects, but they do not indicate how positive rebound cases should be handled. If positive rebounds are considered within scope, the methods section should state this explicitly and explain the selection criteria. If they are out of scope but retained for contextual purposes, this decision should be clearly noted in the methods or results section rather than left implicit. As currently presented, the two positive rebound entries in Table 4 exist in a methodological grey area, neither fully included within the paper's declared scope nor formally excluded.

Comment #5:
Section 2.2 does not provide any information about the safeguards used to ensure the reliability of the qualitative coding. The manuscript does not mention whether multiple researchers coded the materials independently, what steps were taken to minimise subjective interpretation bias, or whether any formal measures of inter-coder reliability (e.g. Cohen's Kappa or percentage

agreement) were assessed. The authors should therefore explain how coding disagreements were handled within the research team, outline the procedures used during the coding process, and provide empirical evidence that supports the reliability of the coding.

Comment #6:
On page 20, second paragraph, the sentence reads, *"Indeed, only 32 of 45 papers linked mitigation strategies to specific rebound effects."* But the methods section (p. 5) states that the mitigation sample consists of 32 papers, not 45. Since the manuscript never explains what the denominator of 45 refers to, it is unclear whether this number represents a combined sample, some other subset, or simply a counting error. This inconsistency needs to be clarified.

Are the rationale for, and objectives of, the Systematic Review clearly stated?
Yes

Are sufficient details of the methods and analysis provided to allow replication by others?
Partly

Is the statistical analysis and its interpretation appropriate?
Yes

Are the conclusions drawn adequately supported by the results presented in the review?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: circular business models, green human resource management

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 10 June 2026

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Mariantonietta Ferrante
Politecnico di Bari, Bari, Italy

I appreciate the careful revision and the way my comments were taken into account. I have no further remarks.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Circular economy, Circular manufacturing, Rebound effects

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 08 June 2026

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Koen Dittrich
Erasmus University, Rotterdam, South Holland, The Netherlands

1. Contribution and Originality
The manuscript addresses a highly relevant and increasingly important issue within circular economy scholarship: the persistence and management of rebound effects in circular business models (CBMs). Its principal contribution lies in systematically organizing empirically identified rebound effects according to specific circular business model archetypes. This constitutes a meaningful advancement over prior reviews, which have generally treated rebound effects at the level of the circular economy broadly, without explicitly linking them to business model configurations.
The manuscript's attempt to bridge sustainability transitions literature, rebound economics, and business model innovation is commendable. In particular, the archetype-based classification offers a potentially useful analytical structure for both researchers and practitioners. By mapping specific rebound mechanisms to archetypes such as Product-Service Systems, Next Life models, and Collaborative Consumption, the paper provides an accessible synthesis that could help organizations anticipate rebound vulnerabilities during business model design.
The practical orientation of the manuscript also enhances its relevance. The emphasis on ex-ante mitigation during business experimentation reflects an important gap in the literature, especially given that many sustainability assessments occur only after implementation. The manuscript appropriately recognizes that design-stage decisions shape long-term environmental outcomes and lock-in effects.
However, while the contribution is original in structure, it is somewhat limited in analytical ambition. The paper primarily organizes existing knowledge rather than developing a novel explanatory theory of why specific business model archetypes generate particular rebound dynamics. In this sense, the manuscript contributes more strongly as a synthesis and classification exercise than as a theoretical advancement. A stronger conceptual contribution would emerge if the paper moved beyond categorization toward mechanism-based theorization of rebound generation across different circular configurations.
Additionally, the novelty claim should be articulated more carefully. While the manuscript may indeed be among the first to systematically classify rebounds by CBM archetypes, related streams of work in industrial ecology, sufficiency research, and sustainable consumption studies have explored adjacent relationships between circular strategies and systemic behavioral responses. Positioning the paper more precisely within these debates would strengthen the originality claim.

Overall, the contribution is substantial and potentially publishable, but its theoretical significance would benefit from deeper analytical synthesis and stronger articulation of the mechanisms connecting circular business model design and rebound emergence.

2. Theoretical Framing

The manuscript demonstrates extensive familiarity with the rebound effect literature and effectively situates itself within current circular economy and sustainability transition debates. The literature review is broad, interdisciplinary, and generally up to date. The authors successfully integrate literature from industrial ecology, product-service systems, sustainable business models, consumer behavior, and circular economy research into a coherent narrative framework.

One notable strength is the manuscript's recognition that rebound effects are systemic phenomena rather than isolated behavioral anomalies. The discussion appropriately emphasizes that circular strategies can unintentionally increase environmental impact through mechanisms such as efficiency gains, cost reductions, imperfect substitution, moral licensing, and induced demand. This systems-oriented framing aligns well with contemporary rebound scholarship.

The decision to use the Pieroni et al. archetypal framework is also defensible. The authors justify the selection on the basis that the framework differentiates upstream and downstream circular strategies more clearly than competing typologies. This rationale is methodologically sound and enhances analytical consistency across the review.

Nevertheless, the theoretical framing remains conceptually underdeveloped in several important respects.

The most significant issue concerns conceptual ambiguity surrounding the definition of rebound effects themselves. Throughout the manuscript, the boundaries between rebound effects, unintended consequences, spillover effects, induced demand, moral licensing, substitution failures, and broader systemic externalities remain unclear. While the authors acknowledge this problem in the Discussion section, the ambiguity is not resolved analytically.

This conceptual instability weakens the rigor of the synthesis because several phenomena categorized as rebound effects may not satisfy stricter definitions commonly used in rebound economics literature. Some examples represent classical rebound mechanisms tied to efficiency gains and price elasticity, while others reflect broader behavioral or institutional responses not directly reducible to rebound dynamics. The review therefore risks conceptual overextension.

The manuscript would benefit substantially from a more formal conceptual architecture introduced early in the paper. Specifically, the authors should explicitly distinguish:

- direct rebound effects,
- indirect rebound effects,
- economy-wide rebound effects,
- behavioral spillovers,
- moral licensing,
- induced consumption,
- substitution failures,
- and unintended consequences.

At present, these categories overlap too heavily, creating analytical imprecision.

Another limitation is the relative absence of deeper theoretical mechanism-building. The manuscript catalogs numerous rebound phenomena but does not sufficiently explain why certain archetypes appear particularly vulnerable to specific rebound mechanisms. For instance, Product-Service Systems are repeatedly associated with careless consumption and intensified usage, yet

the paper stops short of theorizing the structural features of ownership transfer, incentive realignment, or psychological detachment that generate these outcomes. Similarly, the review identifies efficiency-induced demand increases across multiple archetypes but does not develop a broader explanatory model connecting circular efficiency logics to consumption expansion.
The manuscript also engages only minimally with critical perspectives on circular economy discourse. There is limited engagement with degrowth literature, sufficiency theory, political economy critiques of green growth, or deeper debates surrounding Jevons paradox. Incorporating these perspectives would substantially enrich the theoretical framing and position the paper more centrally within broader sustainability transition debates.
In summary, the theoretical framing is broad and competent but remains primarily descriptive rather than analytically generative. Greater conceptual precision and deeper mechanism-based theorization would significantly improve the manuscript's scholarly rigor.

3. Research Questions
The research questions are clearly stated and logically aligned with the structure of the review. The first question—concerning the potential rebound effects of different circular business model archetypes—is particularly strong and appropriately scoped for a systematic review approach. It provides a clear organizing principle for the empirical synthesis.
The second research question, concerning mitigation strategies, is also relevant and practically important. However, its formulation is somewhat limited because it encourages descriptive cataloguing rather than analytical evaluation. By asking merely "what strategies have been identified," the paper implicitly treats all proposed mitigation strategies as epistemically equivalent, regardless of evidentiary strength.
This becomes problematic later in the manuscript, where empirically observed rebound effects are juxtaposed with largely untested mitigation proposals. The asymmetry between empirical rigor on the rebound side and speculative suggestion on the mitigation side weakens the coherence of the review.
A stronger formulation of the second research question might have emphasized:

- mechanisms of mitigation,
- contextual effectiveness,
- empirical validation,
- or conditions under which mitigation strategies succeed or fail.

Such reframing would have pushed the analysis toward a more evaluative synthesis rather than a broad inventory of suggestions.
Nonetheless, the research questions are generally coherent and appropriate for the study's objectives.

4. Methodological Rigor
The methodological section demonstrates several strengths. The authors provide a reasonably transparent overview of the search process, including search strings, databases, screening stages, snowballing procedures, and coding categories. The use of a PRISMA-style flow diagram improves transparency and aligns the review with accepted systematic review conventions.
The coding framework is also relatively comprehensive. Including dimensions such as sector, geographical scope, methodology, rebound type, archetype classification, and mitigation strategies creates a robust descriptive dataset capable of supporting meaningful synthesis.
However, despite these strengths, the methodological rigor remains one of the manuscript's most significant weaknesses.

The paper labels itself a “systematic literature review,” yet methodologically it operates closer to a semi-systematic or structured qualitative synthesis. Several elements commonly expected in rigorous systematic reviews are either absent or insufficiently operationalized.
Most notably, the manuscript does not report any formal inter-coder reliability assessment. Although the authors mention that coding was periodically checked by co-authors, there is no reporting of:

- Cohen’s kappa,
- Krippendorff’s alpha,
- percentage agreement,
- or reconciliation procedures.

Given the interpretive complexity involved in classifying rebound mechanisms and assigning archetypes, this omission significantly weakens the reliability of the coding process.
The inclusion and exclusion criteria also remain under-specified. The requirement that studies demonstrate “clear empirical measurement” is insufficiently operationalized. It is unclear:

- what qualifies as empirical evidence,
- whether simulation studies are treated equivalently to observational studies,
- how scenario analyses were evaluated,
- or how conceptual extrapolations were excluded.

This ambiguity raises concerns about consistency in article selection.
Additionally, the search strategy itself presents recall and precision concerns. The search strings are extremely broad, particularly the inclusion of terms such as “business*,” “indirect effect*,” and “secondary effect*.” Such breadth likely generated substantial irrelevant noise and may have increased subjectivity during screening.
The review also lacks a formal quality appraisal framework for included studies. No attempt is made to distinguish stronger empirical evidence from weaker or more speculative studies. As a result, highly heterogeneous evidence types—including conceptual papers, LCAs, simulation models, surveys, and case studies—are synthesized without methodological weighting. This undermines the robustness of the conclusions.
Finally, there is an important epistemological asymmetry between RQ1 and RQ2. While rebound effects are restricted to empirically measured phenomena, mitigation strategies are often drawn from conceptual or normative recommendations without empirical validation. This asymmetry should be acknowledged more explicitly and analytically addressed.
Overall, while the methodology is transparent and systematic in spirit, it falls short of the rigor typically expected from high-quality systematic reviews in peer-reviewed journals.

5. Data Analysis and Synthesis
The manuscript’s synthesis work is ambitious and clearly represents a substantial effort. The archetype-based organization of rebound effects and mitigation strategies is intuitive, accessible, and potentially useful for future scholarship and practical application. Table 4, in particular, serves as the manuscript’s central integrative contribution.
The categorization of rebound effects into direct, indirect, and economy-wide forms also adds analytical structure and helps clarify the different scales at which rebound mechanisms operate. However, the synthesis remains largely descriptive rather than analytical. Much of the Results section consists of:

- cataloguing examples,
- summarizing findings,

- and aggregating mitigation proposals.

The manuscript rarely moves toward higher-order analytical interpretation. For example, while recurring patterns are observable across archetypes—especially efficiency-induced demand growth and price-mediated consumption expansion—the paper does not sufficiently theorize these recurring dynamics.
Similarly, there is little comparative analysis between archetypes. Why are Product-Service Systems especially vulnerable to careless consumption? Why do Next Life strategies repeatedly produce moral licensing effects? Why do efficiency-oriented archetypes generate economy-wide rebounds more frequently? These questions are implied but not systematically analyzed.
Another important weakness concerns evidentiary weighting. All findings appear to be treated equally regardless of methodological robustness. A single case study and a large-scale quantitative assessment receive comparable narrative emphasis. Without quality differentiation, the synthesis risks overstating the certainty and generalizability of some findings.
Table 4 exemplifies both the strengths and weaknesses of the manuscript. It is impressive in scope and likely to attract attention from readers and practitioners. At the same time, it conflates:

- empirically demonstrated rebound effects,
- speculative mitigation ideas,
- conceptual recommendations,
- and normative policy suggestions.

Some mitigation proposals appear weakly substantiated or conceptually vague. Examples such as “design products that feel expensive” or “use rewards and fines” require stronger theoretical grounding and contextual explanation.
The manuscript would benefit from:

- distinguishing empirically validated mitigation strategies from speculative proposals,
- clustering mechanisms more systematically,
- and explicitly discussing evidence strength.

As it stands, the synthesis is highly informative but analytically underdeveloped.

6. Use of Sources and Citations
The manuscript demonstrates broad engagement with relevant literature and includes a substantial number of contemporary references. The citation base spans multiple disciplines and reflects awareness of recent developments in circular economy and rebound effect scholarship. The integration of industrial ecology, business model innovation, sustainability transitions, and behavioral research is particularly commendable. The manuscript also incorporates several recent publications from 2024–2026, suggesting strong engagement with emerging debates.
However, the literature integration occasionally becomes overly accumulative. Many sections follow a repetitive structure in which individual studies are sequentially summarized without sufficient synthesis or comparison. As a result, citation density sometimes substitutes for analytical depth.
The manuscript would benefit from more explicit engagement with:

- contradictions between studies,
- methodological differences,
- contextual dependencies,
- and competing interpretations.

Additionally, several foundational rebound economics scholars receive relatively limited treatment compared to more recent circular economy literature. Greater engagement with classical rebound scholarship would strengthen theoretical grounding and historical continuity.
Despite these limitations, the literature review remains one of the stronger aspects of the manuscript overall.

7. Discussion Section
The Discussion section effectively reiterates the practical significance of rebound effects in circular business models and appropriately emphasizes the complexity of sustainability transitions. The recognition that rebound effects may be inherent to circular economy strategies is an important and intellectually honest conclusion.
The manuscript also deserves credit for acknowledging social justice implications. The discussion surrounding carbon taxes, price controls, and the disproportionate burden placed on lower-income groups introduces a valuable ethical dimension often absent in circular economy research. Similarly, the acknowledgment that some rebound effects may be socially acceptable—or even desirable—in contexts such as alleviating energy poverty demonstrates commendable nuance.
Nevertheless, the Discussion section remains relatively limited in theoretical ambition. Much of the section restates empirical observations rather than elevating them into broader conceptual insights.
The paper would benefit substantially from:

- a clearer conceptual model,
- stronger mechanism theorization,
- or a framework linking archetype characteristics to rebound susceptibility.

For example, the authors could potentially develop propositions concerning:

- ownership structures,
- pricing mechanisms,
- perceived abundance,
- substitutability,
- or user attachment as drivers of rebound vulnerability.

Without such theoretical elevation, the Discussion remains primarily reflective rather than generative.

8. Writing Quality
The manuscript is generally well written and structurally coherent. The organization follows a logical progression from background to methodology, results, discussion, and conclusion. The writing is accessible despite the conceptual complexity of the topic.
However, the manuscript would benefit from significant stylistic tightening. Several sections are repetitive, particularly around:

- efficiency gains,
- consumer awareness,
- price effects,
- and overconsumption.

The paper could likely be reduced by approximately 15–20% without loss of substantive content. There are also occasional grammatical and formatting inconsistencies, including typographical errors, inconsistent capitalization, awkward sentence constructions, and uneven table formatting.

While these are not severe, they collectively reduce perceived polish and professionalism.
Table 4, although highly valuable, is extremely dense and difficult to navigate. It may need restructuring, visual simplification, or partial relocation to supplementary materials.
Overall, the writing quality is solid but would benefit from careful editorial refinement.

9. Overall Evaluation
Overall, the manuscript is ambitious, timely, and potentially impactful. Its greatest strength lies in its systematic organization of rebound effects and mitigation strategies across circular business model archetypes. The paper fills a meaningful gap in the literature and demonstrates broad interdisciplinary engagement.
However, the manuscript currently functions more effectively as a structured mapping review than as a deeply analytical systematic review. The central weaknesses concern conceptual ambiguity, methodological limitations, insufficient evidentiary differentiation, and limited mechanism-based theorization.
The paper has strong potential, but realizing that potential will require substantial revision focused on:

- conceptual clarification,
- analytical deepening,
- methodological strengthening,
- and theoretical integration.

In its current form, I would give the manuscript a “major revisions” decision before being ready for indexing on an academic open science platform.

Are the rationale for, and objectives of, the Systematic Review clearly stated?
Yes

Are sufficient details of the methods and analysis provided to allow replication by others?
Yes

Is the statistical analysis and its interpretation appropriate?
Partly

Are the conclusions drawn adequately supported by the results presented in the review?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: circular economy, sustainable business models, closed-loop supply chains

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 08 June 2026

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Vivian S.C Tunn
Utrecht University, Utrecht, The Netherlands

First of all, I would like to thank you for the thorough, thoughtful revision and the clear explanations of the changes in the response to reviewers. The manuscript has significantly improved through the revision. Thank you for this interesting and well-written contribution.

From my side, the manuscript is approved and ready for indexing

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 03 June 2026

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Christian Koldewey
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Dear Authors,

Thank you for the thorough revision of your manuscript. Although the search string itself was not further optimized, its current form has now been sufficiently justified and explained.

In our view, the manuscript has reached a very good state. We therefore fully support its approval.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Circular Business Models, Circular Product Design

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 02 June 2026

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Joël Ntsondé
ISTEC Business School, Paris, France

Thank you for thoroughly addressing my questions and for taking my comments into account. I have no further remarks.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Circular business models, sustainable & responsable innovation, transition studies

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 02 June 2026

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Konstantin Remke
[1] ESCP Business School, Paris, France
[2] Strategy & Entrepreneurship, Ecole de Management de Normandie, Clichy, Paris, Normandy, France

Summary and General Remarks
Thank you for the opportunity to review the revised manuscript "Rebound effects in circular business models: A review of cases and mitigation strategies."

The manuscript reviews extant literature on circular economy rebound effects, identifies direct and indirect effects across different circular business model archetypes, and extracts mitigation strategies documented in the literature. The topic is timely and the overall research design remains appropriate for the study's objectives.

Compared to the previous submission, the authors have made a number of notable improvements. Most importantly, they have removed the design science framing from the

manuscript (a claim that was previously difficult to substantiate given the study's methodological nature) and have integrated Mueller & Remke (2025), which had been a significant omission in the first round. These revisions are appreciated. However, several concerns from the first round remain inadequately addressed, and new concerns have emerged from this revision. The most pressing of these relates to the methodological rigor of the literature review, the underdeveloped discussion section, and the overall weakness of the manuscript's stated contributions. These issues must be addressed before the manuscript can be considered for publication.

Major Comments

1. Methodological Grounding of the Literature Review
The authors rely on Bryman and Bell (2011) as the methodological foundation for their systematic literature review. While this is a widely cited reference, it is a non-peer-reviewed textbook that addresses a broad range of business research methods and does not constitute an appropriate methodological anchor for a systematic literature review. The authors are strongly encouraged to instead draw from Tranfield et al. (2003), which provides a well-established and domain-appropriate protocol for systematic literature reviews in management and organization research, or alternatively from Post et al. (2020), which offers a more recent methodological framework suited to this type of study. Grounding the review methodology in one of these references would substantially improve the credibility and rigor of the study design.

2. Transparency of the Search Strategy and Temporal Scope
The rationale for limiting the search to articles indexed on Web of Science and Scopus until September 2024 is not adequately explained. While both databases are appropriate choices, the authors should articulate why September 2024 was selected as the cutoff and whether this decision was theoretically or practically motivated. Moreover, the article and journal selection procedures remain insufficiently described. This is a critical issue: without clear inclusion and exclusion criteria (including how journals were evaluated for relevance and quality) the credibility of the resulting sample, and by extension the study's findings, is weakened. The previous review raised concern that many reviewed papers appear in lower-tier journals; this issue has not yet been addressed. The authors should describe their journal selection criteria explicitly and, where appropriate, consider whether quality thresholds (e.g., journal rankings or citation indices) were applied. The authors should also clarify what is meant by "articles of non-relevant research areas" as an exclusion criterion and provide at least one illustrative example to guide the reader.

3. Insufficient Explanation of the Article Screening Funnel
The drop from 1,091 articles to 74, and subsequently to 32 articles included in the final sample, represents a significant reduction that is not adequately explained. The screening process and the criteria applied at each stage should be described transparently and in sufficient detail to allow the reader to assess the plausibility of the selection decisions. Additionally, the authors are encouraged to restate the research questions (RQs) within the method section itself. In their current form, the review steps are described without a clear and explicit connection to the RQs, which makes it difficult for the reader to evaluate whether the review procedure is aligned with the study's stated objectives.

4. Structural Issue in Section 3
Section 3.2, "Rebound effects of circular business archetypes and associated potential mitigation strategies," currently functions as the overarching header for Sections 3.3 through 3.10. This

creates a structural inconsistency, as Sections 3.3–3.10 are positioned as parallel to 3.2 rather than as subsections of it. The appropriate correction is to restructure Sections 3.3–3.10 as Sections 3.2.1–3.2.8, positioned as subordinate to the overarching Section 3.2. Additionally, Section 3 should be renamed from "Results" to "Findings," as the term "Results" is conventionally reserved for quantitative studies, while "Findings" is more appropriate for qualitative and review-based research of this nature.

5. Characterization of the Circular Systems Sandbox
The authors' characterization of the Circular Systems Sandbox (Mueller & Remke, 2025) as not archetype-specific is somewhat misleading. While it is accurate that the tool focuses on the process of business model design rather than on archetype-specific rebound effects, it nonetheless explicitly connects business model choices (including references to the circular business model archetypes outlined by Pieroni et al. (2020)) to rebound effects, and its efficacy was tested in a field experiment. The manuscript's current framing risks misrepresenting this artifact's scope and empirical grounding. The authors should revise the characterization accordingly to more accurately reflect what the tool does and does not address.

6. Discussion Quality and Contribution Clarity
This remains the most critical concern with the manuscript. The discussion section continues to function largely as a repetition of the findings rather than as a space for theoretical synthesis and contribution. The authors should restructure the discussion to clearly distinguish between: (a) what the study found, (b) how the findings advance or extend extant theoretical conversations on circular economy rebound effects and circular business model design, and (c) what the practical implications are for managers and policymakers. The theoretical contribution described in Section 4.2 is a step in the right direction, but it remains underdeveloped and does not yet connect convincingly with the broader literature on circular economy rebound mitigation. In the current form, the manuscript's contributions do not justify the scope of the review. The authors should take care to clearly articulate what the study adds to the conversation that was not already known, and substantiate these claims with specific reference to the study's findings.

Minor Comments
- In the introduction, circular business model literature consistently frames these models in terms of slowing, narrowing, or closing resource loops (Bocken et al., 2016). Within this framework, regeneration is more appropriately categorized under the closing of resource loops rather than as a separate category. This framing should be corrected in the introduction to align with established terminology in the field.
- The manuscript contains recurring grammatical errors, most commonly missing commas in complex sentences. For example: "Past research has found that negative side effects of circular business models can potentially be prevented during the design and experimentation phase so understanding these is essential (Das et al., 2023)" — a comma is required before "so." A thorough proofreading pass is recommended prior to resubmission.

I hope these comments help the authors to further improve the manuscript.

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Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Circular economy, circular business model innovation, circular economy rebound mitigation, circular systems design, design science research

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 13 May 2026

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Teresa Paiva
BRIDGES - Biotechnology Research, Innovation and Design for Health Products, Instituto Politecnico da Guarda, Guarda, Guarda District, Portugal

This manuscript addresses an increasingly relevant topic within circular economy and sustainability research by systematically reviewing rebound effects associated with circular business model archetypes and the mitigation strategies proposed in the literature. The paper offers a valuable synthesis of empirical and conceptual research, helping bridge the gap between circular business model innovation and rebound effect mitigation.

The manuscript is timely, relevant, and generally well structured. Its principal contribution lies in organising rebound effects according to specific circular business model archetypes and consolidating mitigation strategies from both business and policy perspectives. The topic is highly pertinent for researchers, practitioners, and policymakers engaged in circular economy transitions.

The introduction successfully contextualises the growing relevance of rebound effects in circular economy research and establishes the importance of understanding unintended consequences within circular business model innovation. The manuscript effectively highlights the tension between sustainability intentions and actual environmental outcomes.

The discussion of circular business model archetypes and rebound mechanisms is generally relevant and well-connected to recent literature. The integration of the work of Pieroni et al. (2020), Zink & Geyer (2017), and more recent rebound-effect scholarship strengthens the study's positioning.

However, several aspects could be improved:

- The theoretical discussion of rebound effects remains somewhat descriptive and could benefit from deeper conceptual clarification regarding: direct, indirect, economy-wide, and systemic rebound effects.
- Although the revised manuscript introduces a clearer definition of rebound effects, the distinction between rebound effects, unintended consequences, and broader systemic externalities still requires greater analytical precision.
- The introduction would benefit from a more detailed explanation of the seven circular business model archetypes earlier in the paper, as they become central to the analytical framework.
- The manuscript relies heavily on literature connected to the authors' prior work. While understandable given their expertise in the field, broader engagement with adjacent sustainability transition and consumption literature would strengthen the theoretical positioning.
- The contribution relative to previous reviews, particularly Baczyk et al. (2024), should continue to be clarified carefully to avoid overstating novelty.

Overall, the introduction is strong and relevant, but the conceptual framing would benefit from greater theoretical depth and sharper distinctions between key concepts.

The systematic review methodology is generally appropriate and clearly aligned with the study objectives. The use of Scopus and Web of Science, combined with structured search strings and coding procedures, provides a solid basis for the review.

The inclusion of coding categories such as sector, rebound magnitude, business model archetype, and mitigation strategies is particularly useful and contributes to the paper's analytical structure.

Nevertheless, several methodological aspects require clarification:

1. The manuscript would benefit from a more explicit explanation of: inclusion and exclusion criteria, screening decisions, and how disagreements between authors were resolved.
2. Greater detail on coding consistency and validation procedures would strengthen confidence in the analytical reliability.
3. Although the search strategy is transparent, relying on only two databases may have constrained the comprehensiveness of the review, as acknowledged by the authors.
4. The manuscript would benefit from additional explanation regarding how mitigation strategies were synthesised and categorised into business- versus policy-oriented approaches.
5. The distinction between empirical evidence and conceptual propositions should be more consistently maintained throughout the analysis.

Overall, the methodology is appropriate and reasonably transparent, though further detail would improve reproducibility and analytical rigour.

Circular business model archetypes clearly organise the results and provide a useful overview of the rebound mechanisms associated with each category.
The categorisation of rebound effects into direct, indirect, and economy-wide is analytically valuable and facilitates interpretation.

The discussion of mitigation strategies is also relevant and practically useful, especially for

practitioners engaged in circular business model experimentation.
However, some improvements are recommended:

- Several sections remain highly descriptive and would benefit from deeper comparative synthesis across archetypes.
- Some archetypes, particularly "long life" and "next life," appear conceptually overlapping and should be more clearly differentiated.
- More concrete examples summarising how specific rebound effects emerge within particular business models would improve readability.
- The manuscript would benefit from a synthesis table explicitly linking archetypes, rebound mechanisms, mitigation strategies, and evidence strength.
- Greater differentiation between empirically observed mitigation strategies and speculative recommendations would improve interpretive clarity.

The results section is comprehensive and informative, but could be more analytically integrated.

The discussion appropriately emphasises that rebound effects may be an inherent feature of circular business models and highlights the importance of integrating awareness of rebound effects into business model design.

The manuscript also makes an important contribution by discussing the limitations of current mitigation approaches and the risks of generalised policy interventions.

Particularly valuable is the recognition that mitigation strategies may themselves trigger additional rebounds, and that social justice implications must be considered when designing restrictive consumption policies.

Nevertheless, the discussion could be strengthened further by:

- providing more critical reflection on the tension between sufficiency-oriented approaches and market-based growth logics;
- engaging more explicitly with sustainability transitions and socio-technical systems perspectives;
- discussing the practical feasibility of implementing proposed mitigation strategies in different regulatory and market contexts;
- and clarifying how practitioners can operationalise the findings during business model experimentation.

The discussion is thoughtful and relevant, but deeper critical engagement would strengthen the paper's theoretical contribution.

The conclusion is coherent, balanced, and adequately supported by the findings. The manuscript appropriately avoids overstating the effectiveness of mitigation strategies and clearly acknowledges the lack of empirical validation.

The limitations section is transparent and well-developed, particularly regarding database limitations, contextual specificity, and uncertainty about mitigation effectiveness.

However, additional limitations could be acknowledged, including:

- publication bias toward well-established circular business models,
- the predominance of European and North American case studies,

- and the limited integration of Global South perspectives.

The conclusion could also provide a stronger forward-looking research agenda regarding:

- standardised rebound assessment methods,
- integration into business model experimentation,
- and policy evaluation frameworks.

To sum up, there are some recommendations for improvement:

1. Strengthen conceptual distinctions between rebound effects, unintended consequences, and systemic externalities.
2. Provide clearer definitions and differentiation of circular business model archetypes.
3. Expand the theoretical framing beyond descriptive literature synthesis.
4. Clarify coding reliability and article selection procedures.
5. Improve analytical synthesis across archetypes rather than presenting findings mainly descriptively.
6. Differentiate more clearly between empirically tested and speculative mitigation strategies.
7. Add synthesis tables connecting archetypes, rebound effects, and mitigation strategies.
8. Expand discussion of socio-technical and sustainability transition perspectives.
9. Further clarify the manuscript's novelty relative to prior reviews.
10. Include a stronger discussion of contextual and geographical limitations.

Are the rationale for, and objectives of, the Systematic Review clearly stated?

Yes

Are sufficient details of the methods and analysis provided to allow replication by others?

Partly

Is the statistical analysis and its interpretation appropriate?

Yes

Are the conclusions drawn adequately supported by the results presented in the review?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: green marketing and circular economy marketing; innovation management and entrepreneurship

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Version 1

Reviewer Report 10 November 2025

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Joël Ntsondé
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Based on a systematic literature review of 76 articles, the objective of the paper is to connect the literature on rebound effects in circular business models (CBMs) with that on circular business model archetypes and design strategies aimed at limiting these effects—whether direct, indirect, or economy-wide.
I thank the editors for inviting me to review this paper and the authors for undertaking research on such a fundamental topic.
The paper is very interesting, clear, and important for advancing the literature on circular business models and the issue of rebound effects.
The literature review and methodology are well structured and rigorous.
The literature gap is clearly identified, as is the paper's potential contribution.
My main comments concern the Results and Discussion sections, where certain points would benefit from further clarification or elaboration.
I hope these comments will help the authors deepen their research and advance the literature on rebound effects, a crucial topic for the ecological transition.

Methodology
Figures 2 and 3: It would be useful to discuss potential biases related to the geographical and sectoral distribution of the selected articles, in order to assess their possible impact on the results.
The category "unspecified" seems to include literature reviews or conceptual papers, whereas the main selection criterion for the articles is the empirical identification of rebound effects. This point is not entirely clear: it would be useful to specify how these papers were considered in the analysis.

Results
The classification presented in Table 4 deserves to be revisited:

- The "measures to reduce impact of consumption" do not all seem relevant for discussing strategies to reduce rebound effects, as they do not directly act on economic behavior. It would be preferable to rename them, for instance, "rebound compensation strategies."
- In the "Other measures" category, some measures should be better justified by explaining how they actually reduce rebound effects (see detailed comments below).
- Rebound effects are particularly evident for "Next life" business models, probably because they are more widespread and better documented.
  For other archetypes, the effects and associated strategies are less explicit and could be described in more detail.

Discussion
The discussion provides a good synthesis of the results and contributions to the literature. However, rather than merely summarizing the findings, it would be useful to adopt a more critical analysis of the relevance of the proposed mitigation strategies.
The paper rightly notes that some studies adopt an overly broad understanding of rebound effects, but it would be valuable to go further by discussing the validity and feasibility of the identified mitigation strategies.
Some measures mainly target high-income consumers (e.g., *"Design products that feel expensive"*, *"Price control: encourage consumers to pay more for resource-efficient solutions"*). These strategies raise issues of social equity and could even reinforce perceptions of injustice. It would be interesting to build on the already cited works (*Mies & Gold, 2021; Schröder et al., 2019*) to deepen this discussion.

Detailed Comments
Page 9
- *"Conduct holistic assessment of the impacts to account for rebound effects"*: Can assessment measures really be considered reduction strategies? This seems debatable.

Page 10
- *"Make efforts to change the lifestyles of consumers towards less impactful consumption"*: please specify how this can be implemented.
- *"Use rewards and fines"*: elaborate (what mechanisms, which responsible actors?).
- *"Prevent careless consumption"* and *"Inform consumers about the importance of product care"*: how can these levers be concretely activated?
- *"Integrate multiple CE strategies within a business model"*: why would this help reduce rebound effects?
- *"Eco-efficient value creation"*: should be further detailed.
- *"Design to reduce the need for care"*: wording is unclear.
- *"Introduction of a repairability index for products that can indicate a product's durability"*: what is the link with rebound effects?
- *"Introduce emission trading rules"* and *"Cap and trade schemes that place an upper limit on environmental stress"*: clarify what these refer to and at what level of action they apply (corporate, public policy, etc.).

Page 12
- *"Prevent excessive consumption through sufficiency strategies"*: please specify (what concrete strategies?).

Are the rationale for, and objectives of, the Systematic Review clearly stated?
Yes

Are sufficient details of the methods and analysis provided to allow replication by others?
Yes

Is the statistical analysis and its interpretation appropriate?
Partly

Are the conclusions drawn adequately supported by the results presented in the review?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Circular business models, sustainable & responsable innovation, transition studies

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 22 Apr 2026

Ankita Das

Dear Reviewers, Thank you for taking the time to review our article and provide your valuable feedback. We believe they have greatly improved the quality of the article. Please see our detailed responses below.

Kind regards,
The Authors

Comment 5.1: Based on a systematic literature review of 76 articles, the objective of the paper is to connect the literature on rebound effects in circular business models (CBMs) with that on circular business model archetypes and design strategies aimed at limiting these effects—whether direct, indirect, or economy-wide. I thank the editors for inviting me to review this paper and the authors for undertaking research on such a fundamental topic. The paper is very interesting, clear, and important for advancing the literature on circular business models and the issue of rebound effects. The literature review and methodology are well structured and rigorous. The literature gap is clearly identified, as is the paper's potential contribution. My main comments concern the Results and Discussion sections, where certain points would benefit from further clarification or elaboration. I hope these comments will help the authors deepen their research and advance the literature on rebound effects, a crucial topic for the ecological transition. Methodology Figures 2 and 3: It would be useful to discuss potential biases related to the geographical and sectoral distribution of the selected articles, in order to assess their possible impact on the results. The category "unspecified" seems to include literature reviews or conceptual papers, whereas the main selection criterion for the articles is the empirical identification of rebound effects. This point is not entirely clear: it would be useful to specify how these papers were considered in the analysis.

Response 5.1: Thank you for taking the time to review our article, and for your helpful comments. We made the following addition to the limitations section: "It's worth noting that most of the business case study examples found in the literature were from Europe or North American, limiting generalisability of results. As noted by Baczyk et al. (2024), consumer behaviour is often specific to a certain place and culture and it's therefore important to always encourage the development of circular strategies that are tailored to the context within which the business is embedded." Regarding the unspecified category, these publications were only part of the mitigation sample. For this sample the inclusion

criteria was that the publications discussed or researched circular rebound effect mitigation strategies. Since research on mitigation strategies is scarce it seemed less important that these were strictly empirical and more important to include as many sources as possible (as mentioned in Table 2). Therefore publications that lacked empirical identification of rebound effects were not excluded from this sample. We have added the following sentence in Section 3.1 to clarify this further: "The "Unspecified" category encompasses papers that conducted literature reviews, or that were not empirical in nature, e.g. conceptual papers. This primarily included papers in the rebounds mitigation sample, as mentioned in Table 2. "

Comment 5.2: Results The classification presented in Table 4 deserves to be revisited:

- The "measures to reduce impact of consumption" do not all seem relevant for discussing strategies to reduce rebound effects, as they do not directly act on economic behavior. It would be preferable to rename them, for instance, "rebound compensation strategies."
- In the "Other measures" category, some measures should be better justified by explaining how they actually reduce rebound effects (see detailed comments below).
- Rebound effects are particularly evident for "Next life" business models, probably because they are more widespread and better documented.
  For other archetypes, the effects and associated strategies are less explicit and could be described in more detail.

Response 5.2: Thank you for your suggestions. Regarding point 1, these are measures that do not address rebound effects directly, but rather minimise the impact of the rebound once it happens. We have made the following clarification in Section 2.2: "The suggestions for mitigation were then classified into mitigation strategies for business and policy, and further subdivided into 'measures to reduce consumption', 'measures to reduce impact of consumption' (once the rebound effect occurs), and 'other measures'. " Regarding point 2, we simply report the mitigation suggestions suggested by articles in our sample. We discuss this in detail in replies to the detailed comments below. Regarding point 3, thank you for this observation. We made the following addition to future research in order to highlight this issue: "Second, the non-identification of rebound effects in a given archetype does not mean they do not exist. Some circular business models are more prevalent and researched than others, for example, the 'Circular Production & Distribution' and 'Next Life' archetypes had more research studies compared to other archetypes. More research should be directed towards understanding rebound effects in the less well researched circular business archetypes."

Comment 5.3: Discussion The discussion provides a good synthesis of the results and contributions to the literature. However, rather than merely summarizing the findings, it would be useful to adopt a more critical analysis of the relevance of the proposed mitigation strategies. The paper rightly notes that some studies adopt an overly broad understanding of rebound effects, but it would be valuable to go further by discussing the validity and feasibility of the identified mitigation strategies.

Response 5.3: Thank you for your comments! Perhaps you are right. Critical analysis is important, of course, however it doesn't necessarily have a lot to contribute here. The main finding with regard to mitigation strategies is that it is unknown which strategies (or

combination of strategies) would actually work. Given that we have a problem without a clear solution, we would argue that all ideas are welcome, at least until further research indicates what may or may not work. Even if we do initiate a discussion, our analysis does not conclusively reveal whether the strategies will be effective in real cases (as mentioned in the Limitations), hence making it harder to clearly argue for and against any of these mitigation strategies. Having said that, we do discuss the value of the mitigation strategies in the second paragraph of the discussion and have made a minor clarification in response to feedback from another reviewer: "With regard to RQ2 the aim of this study was to provide insights into rebound effects of specific circular business models and the possible ways to mitigate them, that could be useful for future research as well as practitioners. Many mitigation strategies focus on influencing consumer actions through laws, incentives, nudging, price controls, or information campaigns (Carrasco Campos, 2022; Kjaer et al., 2019; Laurenti et al., 2016; Sorrell et al., 2020). It is clear from these examples that circular businesses need consumer participation to transition from linear to circular consumption. However, there was little discussion on rebound effects linked to producer-producer business model relationships. And, while many rebound mitigation strategies were suggested, they were rarely empirically tested to assess their effectiveness and thus their actual effects remain theoretical. Indeed, only 32 of 45 papers linked mitigation strategies to specific rebound effects."

Comment 5.4: Some measures mainly target high-income consumers (e.g., "Design products that feel expensive", "Price control: encourage consumers to pay more for resource-efficient solutions"). These strategies raise issues of social equity and could even reinforce perceptions of injustice. It would be interesting to build on the already cited works (Mies & Gold, 2021; Schröder et al., 2019) to deepen this discussion.

Response 5.4: Thank you for this suggestion. We have now made the following additions to the discussion: "Lastly, past research calls for treating rebound effects as a risk to be managed in circular strategies (Zerbino, 2022). Meanwhile, extensive studies have explored the circular economy's role in enhancing social sustainability and addressing the needs of disadvantaged communities (Mies & Gold, 2021; Schröder et al., 2019). For example, some suggested mitigation strategies, e.g. price controls, suggest addressing rebound effects by making consumption more expensive. However, while raising prices may reduce consumption, it places disproportionate responsibility on lower-income groups, potentially exacerbating inequality (Mies & Gold, 2021; Schröder et al., 2019). Such approaches may also backfire if people simply switch to cheaper, more environmentally harmful products, and could fuel class-based resentment toward circular solutions perceived as accessible only to the wealthy. "

Comment 5.5: Detailed Comments Page 9

1. "Conduct holistic assessment of the impacts to account for rebound effects": Can assessment measures really be considered reduction strategies? This seems debatable.

Page 10

1. "Make efforts to change the lifestyles of consumers towards less impactful consumption": please specify how this can be implemented.
2. "Use rewards and fines": elaborate (what mechanisms, which responsible actors?).

3. "Prevent careless consumption" and "Inform consumers about the importance of product care": how can these levers be concretely activated?
4. "Integrate multiple CE strategies within a business model": why would this help reduce rebound effects?
5. "Eco-efficient value creation": should be further detailed.
6. "Design to reduce the need for care": wording is unclear.
7. "Introduction of a repairability index for products that can indicate a product's durability": what is the link with rebound effects?
8. "Introduce emission trading rules" and "Cap and trade schemes that place an upper limit on environmental stress": clarify what these refer to and at what level of action they apply (corporate, public policy, etc.).

Page 12

1. "Prevent excessive consumption through sufficiency strategies": please specify (what concrete strategies?).

Response 5.5: Thank you for these detailed comments. We would like to start by mentioning that we simply report the mitigation strategies suggested by the articles in our literature review sample, as mentioned at the end of Section 2.2: "To maximize the traceability of the data the mitigation strategy descriptions have been kept as close to the source as possible, irrespective of their actual potential for the actual mitigation of rebound effects. The complete list of articles reviewed and the corresponding qualitative codes for rebound effects and mitigation strategies identified can be seen in Appendix A and C." There are of course limitations related to this approach, and we reflect on this in detail in the Limitations section.

1. We would argue that it's an essential part of managing rebound effects, since current practices rarely measure impacts of rebound effects, as one cannot reduce rebound effects if one does not assess the effects of the circular strategies one has implemented. In other words, it would be a management strategy, aimed at creating a feedback loop that supports and encourages the reduction and mitigation of rebound effects. However, as mentioned above, we are mainly reporting on the mitigation strategies suggested by articles in the sample.
2. The quoted suggestion is not elaborated upon in more detail in the literature that we have sampled and a more specific strategy proposal is as a result not possible. However, the essence of these strategies is encouraging sufficiency and to make less impactful consumption (i.e. consumption of goods and services with less environmental impact) more desirable and convenient. Although mentioned in the third paragraph of section 3.5 we have made the following elaboration:

"Other suggestions involved incentivising/promoting a change in the lifestyle of consumers towards less resource intensive products and services (for e.g., by making less impactful consumption more desirable or convenient or nudging towards more careful consumption) (Vélez, 2023). Additional strategies included monitoring or forecasting the effects of the business model using LCA (Abdoli et al., 2019; Alfarisi et al. 2023; Koide et al., 2022) or to be more efficient in value creation and use more recycled input materials (Alfarisi et al. 2023)."

1. The responsible actor is specified in the table, where this particular strategy is listed as a strategy for businesses. Real-world examples already exist; for instance, the Dutch car-sharing company Greenwheels issues fines when a shared vehicle is returned in poor or dirty condition. We do not include this example in Table 4 since it

is not part of our literature review sample, and our reporting follows the approach described in Section 2.2, where we keep mitigation strategies as close to the source material as possible. However, we do discuss it briefly in the second paragraph of Section 3.5.

2. The most commonly suggested methods are through nudging and incentives, i.e. reminders and encouraging better product care, as well as product care information that is easily digestible, or rewards for product care and fines for failure to perform adequate product care. This has been elaborated on in the third paragraph of Section 3.5.
3. This is reported as it appears in the reviewed articles, following our approach of keeping mitigation strategies close to their source. The literature argues that combining strategies—such as reuse, repair, refurbishment, and efficiency—may help counterbalance rebound effects that could arise if only one strategy is used (e.g., efficiency gains triggering price-related rebounds). An example would be the introduction of sufficiency strategies to counteract the increased consumption that tends to occur when a product becomes more efficient. E.g. if your more efficient electric car - that you can afford to drive further - is actively encouraging you to utilise public transport, walk or travel by bicycle instead of driving. However, as mentioned previously, the reviewed studies do not provide empirical evidence on how this integration reduces rebounds, and we therefore highlight in the Limitations section that such strategies remain high-level and untested.
4. We have now changed this to: “Eco-efficient value creation (i.e. do more, with less)”
5. We have made the following addition: “Design to reduce the need for care, and making products more robust to different usage patterns”
6. A repairability index would allow consumers to more easily choose products that are more repair-friendly and have a longer lifespan. That way, the material flow of the product would be slowed. This was suggested by Beulque et al. (2023) in our sample to counter the short term increase in sales that resulted from repair services offering discounts and vouchers when products were not repairable. Regarding the true effectiveness of this mitigation strategy, please see the explanation above related to reporting of the mitigation strategies.
7. The level of action is specified in the table as policy, i.e. these are a matter of public policy.

Competing Interests: No competing interests were disclosed.

Reviewer Report 10 November 2025

https://doi.org/10.21956/openreseurope.23046.r62331

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Vivian S.C Tunn
[1] Utrecht University, Utrecht, The Netherlands
[2] Utrecht University, Utrecht, The Netherlands

This is a relevant and well written review of rebound effects in circular business models and related mitigation strategies. The paper provides a useful overview of rebound effects and mitigation strategies that have been identified and proposed in literature so far. The method is clearly described and the appendixes present more details on the literature review as well as the full list of reviewed articles. The article can be further improved, currently a definition of rebound effects is missing in the background section and a similar review with slightly different scope has been published in 2024 which means the contribution of this article should be rephrased. I provide more details on these points and additional comments below.

Detailed comments:

1. In the introduction on p.4 (and also in the discussion) the authors state that “no systematic overview connects rebound effects to specific circular business model archetypes”, however, *Baczyk et al. (2024) Consumer behavior in circular business models: Unveiling conservation and rebound effects*, map which rebound mechanisms occur in different circular business models based on cases in literature they reviewed (see p.290).
2. On p.6 the authors state that others have misidentified unintended consequences as rebound effects. I suggest the authors add a definition of rebound effects and delineate rebound effects from unintended consequences to clarify their understanding of the concepts. Also regarding the definition of rebound effects, on p.17 the following is stated: “while some activities might appear to generate rebound effects, they might have long-term positive societal or natural restorative or regenerative effects”. In my understanding, even a circular business model with rebound effects can still be net positive unless the rebound effect is so large that it is a backfire. Reading the manuscript I wondered whether in the authors’ understanding rebound effects have to relate to emissions or if could also relate to other environmental or even social effects?
3. Great that the differences in samples between the two search strings are illustrated.
4. Large parts of the last paragraph of section 3.5. (p.14) are not clearly linked to PSS but general strategies to reduce rebound effects/ emissions.
5. Some of the business model archetypes should be more clearly defined and delineated. The business model archetypes “long life” and “next life” seem to overlap as both aim for extended product lifetimes and modular design seem implementations applicable to both. Please clarify the differences (is it about extended lifetime for the same user (long life) versus extended lifetime for different users (next life)?). Furthermore, on p.15 recycling is mentioned “Some studies have found that recycling can provide moral licensing to incentivize additional consumption”, clarify how this relates to the “next life” business model archetype.
6. On p.15 “circular efficiency measures” are mentioned that caused rebound effects, I suggest the authors specify which “circular efficiency measures” were implemented in the case study.
7. On p.16 it is stated that “past systematic reviews indicate limited awareness of rebounds”, specify which type of systematic reviews you are referring to (reviews of circular business models of business model innovation or something else?).

Minor comments:

- On p.7 the following sentences are either redundant or the reference to the mitigation sample is missing in the second sentence. “In the rebound sample the most common sector was mobility, followed by fashion and electrical appliances (Figure 3). The most studied sectors in the sample were mobility (19 studies) and electrical appliances (12).”
- The terms rebounds and rebound effects are used, are these synonymous or slightly different?
- Supplementary material, in Appendix C, I noticed that reference it should refer to Tunn & Ackermann 2020 instead of Ackermann & Tunn 2024.
- The terms business model strategy innovation and business model innovation are used, are these synonymous or slightly different?
- The following sentence on p.8 doesn’t flow quite right. “For example, one study by Walzberg et al. (2020) found that energy usage in a smart home that saved energy through automated temperature regulation, actually used more heating, reducing the amount of energy saved.” Consider removing “energy usage in” or rephrasing.
- One of the business model archetypes is inconsistently labeled. Once as “Detmaterialised or efficiency” as by Pieroni et al. (2020) and other times as “Detmaterialised or sufficiency”.

References

1. Bączyk M, Tunn V, Worrell E, Corona B: Consumer behavior in circular business models: Unveiling conservation and rebound effects. *Sustainable Production and Consumption*. 2024; **52**: 283-298 Publisher Full Text

Are the rationale for, and objectives of, the Systematic Review clearly stated?

Yes

Are sufficient details of the methods and analysis provided to allow replication by others?

Yes

Is the statistical analysis and its interpretation appropriate?

Yes

Are the conclusions drawn adequately supported by the results presented in the review?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Circular business models and rebound effects

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 22 Apr 2026

Ankita Das

Dear Reviewers, Thank you for taking the time to review our article and provide your valuable feedback. We believe they have greatly improved the quality of the article. Please see our detailed responses below.
Kind regards,
The Authors

Comment 4.1: This is a relevant and well written review of rebound effects in circular business models and related mitigation strategies. The paper provides a useful overview of rebound effects and mitigation strategies that have been identified and proposed in literature so far. The method is clearly described and the appendixes present more details on the literature review as well as the full list of reviewed articles. The article can be further improved, currently a definition of rebound effects is missing in the background section and a similar review with slightly different scope has been published in 2024 which means the contribution of this article should be rephrased. I provide more details on these points and additional comments below. Detailed comments:

1. In the introduction on p.4 (and also in the discussion) the authors state that "no systematic overview connects rebound effects to specific circular business model archetypes", however, Baczyk et al. (2024) Consumer behavior in circular business models: Unveiling conservation and rebound effects, map which rebound mechanisms occur in different circular business models based on cases in literature they reviewed (see p.290).

Response 4.1: Thank you for your comments! In line with your suggestion, and that of other reviewers, we now provide a clear definition of rebound effects at the start of the second paragraph of the introduction: "Despite the high potential of circular business models to reduce environmental impact (Fidan et al., 2021; Kaddoura et al., 2019), rebound effects (REs) are increasingly recognized as a major challenge (Andrew & Pigosso, 2024; Brockway et al., 2021; Zink & Geyer, 2017). Rebound effects are a form of negative systemic consequence that can offset or even increase the overall environmental impact (Zink & Geyer, 2017). While rebound effects can be both positive and negative (Font Vivanco et al., 2022; Zerbino, 2022), the focus of this paper is mainly on negative effects. Prominent examples include increases in consumption as a result of increased efficiency and lower prices (Chitnis et al., 2013), or increased wear and tear on shared products (Ackermann & Tunn, 2024). These effects arise from changes across business model elements, such as manufacturing and design choices (upstream), consumer behavior (downstream), and logistics (both upstream and downstream) (Sarasini et al., 2024)." Furthermore, we have made the following changes to acknowledge the contribution of Baczyk et al. (2024): "Recent reviews by Lowe et al. (2024) and Zerbino (2022) developed methods to manage circular rebound effects, offering general guidelines but highlighting the lack of specific, actionable strategies for circular business models. Das et al. (2023) also attempted to classify rebounds across circular strategies through the Circular Rebound Tool, and a set of behavioral design strategies for preventing rebound effects have been consolidated (McKay & Pigosso, 2025). These studies emphasize the need for a more systematic analysis of rebound effects in circular business models and potential mitigation strategies. While past literature reviews exist, onlytwo articles connect rebound effects to specific circular business model archetypes or explore mitigation through business model design. In their review of case studies Baczyk et al. (2024) seek to clarify the role of consumer behaviour in shaping the effects of circular business model archetypes once implemented. They also give some

suggestions for how rebound effects can perhaps be avoided, although these recommendations take the form of guiding principles and policy recommendations. Another recent contribution to rebound effect mitigation research is Mueller & Remke (2025). Focusing on mitigation through business model design, the authors developed the Circular Systems Sandbox, a business model design tool based on systems and life cycle thinking. The tool helps designers develop circular products and services and to understand the consequences their design choices may have on the environmental impact of their product or service. Although Circular Systems Sandbox connects business model choices to rebound effects, the focus is on the process of business model design, rather than archetype specific rebound effects and how one could mitigate them in practice. Clarifying the link between specific rebound effects and circular business model archetypes, as well as specific strategies for how to mitigate these rebound effects is an important first step toward integrating rebound mitigation into circular business model innovation, as empirical measurement is often impractical in early design phases."

Comment 4.2:

1. On p.6 the authors state that others have misidentified unintended consequences as rebound effects. I suggest the authors add a definition of rebound effects and delineate rebound effects from unintended consequences to clarify their understanding of the concepts. Also regarding the definition of rebound effects, on p.17 the following is stated: "while some activities might appear to generate rebound effects, they might have long-term positive societal or natural restorative or regenerative effects". In my understanding, even a circular business model with rebound effects can still be net positive unless the rebound effect is so large that it is a backfire. Reading the manuscript I wondered whether in the authors' understanding rebound effects have to relate to emissions or if could also relate to other environmental or even social effects?

Response 4.2: Thank you for your comment! Although rebound effects are differentiated from unintended consequences in the discussion: "Additionally, the literature sometimes used "rebound effects" more broadly to describe unintended consequences of circular business models. While rebound effects typically refer to negative outcomes linked to market dynamics and consumer behavior, unintended consequences encompass broader, unforeseen impacts of implementing such models. Business decision-makers may not consciously distinguish between induced impacts, unintended consequences, and rebound effects. In at least 13 papers from the initial sample, this distinction was unclear. We argue that "rebound effects" should specifically refer to systemic or behavioral responses triggered by adopting a circular business model, that are not essential elements that are part of its implementation (Kjaer et al., 2018)." We agree that it would be appropriate to properly define rebound effects in the introduction. We have therefore made the following changes to the second paragraph of the introduction: "Despite the high potential of circular business models to reduce environmental impact (Fidan et al., 2021; Kaddoura et al., 2019), rebound effects (REs) are increasingly recognized as a major challenge that can offset or even increase overall environmental impact (Andrew & Pigosso, 2024; Brockway et al., 2021 ; Zink & Geyer, 2017). Rebound effects are a form of systemic consequence that can offset or even increase the overall environmental impact (Zink & Geyer, 2017). While rebound effects can be both positive and negative (Font Vivanco et al., 2022; Zerbino, 2022), the focus of this paper is mainly on negative effects. Prominent examples include increases in

consumption as a result of increased efficiency and lower prices (Chitnis et al., 2013), or increased wear and tear on shared products (Ackermann & Tunn, 2024). These effects arise from changes across business model elements, such as manufacturing and design choices (upstream), consumer behavior (downstream), and logistics (both upstream and downstream) (Sarasini et al., 2024)." You are quite correct that a circular business model with rebound effects can still be a net positive - indeed there are several studies that show net positive effects in spite of rebound effects. Research has shown that the circular economy has played a role in enhancing social sustainability (Font Vivanco et al., 2022). We therefore argue that it could at times be important to see beyond measures such as CO2-emissions, and perhaps even accept some rebound effects as part of achieving or maintaining socially sustainable gains. One concrete example is poorer households receiving thermal retrofits (Font Vivanco et al., 2022). This would produce rebound effects, but is also incredibly important to help end energy poverty and provide people with dignified living.

Comment 4.3:

1. Great that the differences in samples between the two search strings are illustrated.
2. Large parts of the last paragraph of section 3.5. (p.14) are not clearly linked to PSS but general strategies to reduce rebound effects/ emissions.

Response 4.3: Thank you for your comment! Although these might seem like general suggestions, they were in fact either specifically proposed as strategies to counter rebound effects on PSS or were proposed in papers that examined the size of rebound effects in PSS. In other words, they are in the right paragraph. We have made further reference to this in our limitations, where we comment on the many of the proposed mitigation strategies being very general: "Third, while several mitigation strategies were identified, many were broad suggestions rather than actionable steps (for e.g., in the case of PSS, price controls and steering consumers towards less impactful consumption or measuring impacts of change). "

Comment 4.4:

1. Some of the business model archetypes should be more clearly defined and delineated. The business model archetypes "long life" and "next life" seem to overlap as both aim for extended product lifetimes and modular design seem implementations applicable to both. Please clarify the differences (is it about extended lifetime for the same user (long life) versus extended lifetime for different users (next life)?). Furthermore, on p.15 recycling is mentioned "Some studies have found that recycling can provide moral licensing to incentivize additional consumption", clarify how this relates to the "next life" business model archetype.

Response 4.4: Thank you for your comment! There can indeed appear to be some overlap between these two circular business model archetypes. Long life refers to strategies that extend the life of a product and retain their value, so as to avoid premature disposal, which would represent a waste. Next life, meanwhile, refers to strategies that seek to capture value at the end of the use phase, and these strategies include recycling, reusing or repurposing products, such as through second hand sales. We have made the following changes in Sections 3.6 and 3.7 in order to provide examples of business model strategies associated with each archetypal cluster: "The archetype cluster "long life" refers to business

models focused on extended product lifetimes for the same user often facilitated by design for attachment or timeless design, durability, and high levels of warranties and service, coupled with a premium pricing model " "The circular business model archetype cluster "next life" refers to business models that help extend the lifetime of products and to slow resource loops. While long life aims to extend product lif time for a single user, next life aims to extend the material or product lifetime beyond the single user. This can be facilitated by strategies such as design for dis-and reassembly, upgradability, maintenance and repair, as well as product take-back models and second hand platforms " "Some studies have found that recycling can provide moral licensing to incentivize additional consumption, since consumers can view the recycled alternatives as more eco-friendly and thus end up using more of the products, increasing overall consumption related impacts."

Comment 4.5:

1. On p.15 "circular efficiency measures" are mentioned that caused rebound effects, I suggest the authors specify which "circular efficiency measures" were implemented in the case study.
2. On p.16 it is stated that "past systematic reviews indicate limited awareness of rebounds", specify which type of systematic reviews you are referring to (reviews of circular business models of business model innovation or something else?).

Response 4.5: Thank you for your comments! The circular efficiency measures that pertained to the study by Konash & Nasr (2022) have been specified as per your suggestion: "In the case of strategies that aim to increase efficiency or reduce consumption, some studies found that these strategies can result in direct or indirect rebounds. For example, Konash & Nasr (2022) describe a direct rebound in a case study of a medium sized complex parts manufacturing company from New York, USA. They found that the company's circular efficiency measures, such as equipment upgrades, energy and water use monitoring, optimizing operating schedules, recycling water and materials, reducing waste, performance improvement programs, actually led to increased resource use in the short term and a clear backfire effect." Thank you for this comment! We have made the following changes in line with your comment: "Past systematic reviews of circular economy rebounds indicate limited awareness of the topic in practice (Lowe et al., 2024; Zerbino, 2022). In their review of rebound estimation methods Lowe et al. (2024) found that beyond tax and pricing policies, discussions on mitigating rebounds are scarce, especially in a circular economy context."

Comment 4.6: Minor comments:

- On p.7 the following sentences are either redundant or the reference to the mitigation sample is missing in the second sentence. "In the rebound sample the most common sector was mobility, followed by fashion and electrical appliances (Figure 3). The most studied sectors in the sample were mobility (19 studies) and electrical appliances (12)."

Response 4.6: Thank you for noticing this error. We have rectified this error by removing the second sentence now.

Comment 4.7:

- The terms rebounds and rebound effects are used, are these synonymous or slightly different?

- Supplementary material, in Appendix C, I noticed that reference it should refer to Tunn & Ackermann 2020 instead of Ackermann & Tunn 2024.
- The terms business model strategy innovation and business model innovation are used, are these synonymous or slightly different?

Response 4.7: Thank you for your comments!

1. Yes, these are synonymous. We have clarified this in the 4th paragraph of the introduction:

" The study uses the term rebound effects (or simply rebounds) instead of circular rebound effects, as many rebound mechanisms apply to circularity as well. "

1. Thank you, we have corrected the reference!
2. Yes these terms are synonymous, we have now standardised them to 'business model innovation'

Comment 4.8:

- The following sentence on p.8 doesn't flow quite right. "For example, one study by Walzberg et al. (2020) found that energy usage in a smart home that saved energy through automated temperature regulation, actually used more heating, reducing the amount of energy saved." Consider removing "energy usage in" or rephrasing.
- One of the business model archetypes is inconsistently labeled. Once as "Detmaterialised or efficiency" as by Pieroni et al. (2020) and other times as "Detmaterialised or sufficiency".

Response 4.8: Thank you for your comments! 1. Yes, it is quite long, containing more than one dependent clause. We have made the following changes in the hope that it will flow better: "For example, one study by Walzberg et al. (2020) found that energy usage in a smart home - that saved energy through automated temperature regulation - actually used more heating, reducing the amount of energy saved." 2. Thank you for noticing this error. This inconsistency has been corrected now.

Competing Interests: No competing interests were disclosed.

Reviewer Report 08 November 2025

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Dear authors,
Thank you for the opportunity to review your interesting paper.

The article addresses a highly relevant issue: rebound effects in circular business models and strategies for mitigating them. This topic is important both scientifically and practically, as rebound effects often diminish the positive environmental contribution of the circular economy. However, they have not been systematically investigated yet. The authors provide a valuable synthesis of existing empirical studies and offer an initial structured link between circular business model archetypes and rebound mechanisms.
Overall, the article is well organized and transparent, with a sound and well-documented methodological approach. Nonetheless, some areas would benefit from clarification and refinement, as outlined below.

Introduction
The introduction is clearly written, and the research questions are well developed. The research gap is convincingly justified, and the linkage to existing work is strong. The authors cite their prior works extensively; however, since Pigosso and Bocken are leading scholars in the field, this appears justified, however the focus should remain on seminal and relevant contributions. Vague statements like “Similarly, Pigosso (2024) called for advancing design science to incorporate rebound effects into business model design.” should be reduced or specified.
Furthermore, while the elaborations on rebound effects are comprehensive and interesting, a clear definition of this central concept for the paper is missing. The paper would greatly benefit from an explicit definition to establish conceptual clarity for the remainder of the paper.

Method
The research method is described in detailed and with transparency. However, the section begins by blending the *state of the art* and the *justification for the chosen method*. For clarity, the delineation to Lowe et al. and Zerbino should be made in the introduction and the method chapter should explain why a systematic literature review is suitable to answer the research question.
There are two main issues concerning the search strategy:
First, the search strings themselves contain inconsistencies. In Search String 1, the terms “sustainable business”, “circular business*”, and “circular*” are linked with OR. “circular*” already includes “circular business*”, making the expression partly redundant, while “sustainable business” makes the query overly broad because it captures much non-circular literature. *Search String 2* introduces slightly different terms (“circular business model*” instead of “circular business*”) and (“sustainab*” instead of “sustainable business”) without justification. The rationale behind these changes is unclear and should be clarified.
Second, the connection between the search strings and the research questions could be improved. *Research Question 2* focuses on strategies to mitigate rebound effects, while *Search String 2* mainly targets environmental impacts. Thus, its logic does not fully match the intent of the

second question. Either the research question or the string should be refined for consistency. While the inclusion of multiple synonyms for “rebound effects” is commendable and ensures comprehensiveness, the search strings would benefit from greater conceptual coherence and clearer alignment with the stated research question. In general, the authors should reflect and argue on their ambitions regarding comprehensiveness and precision.
The inclusion criteria are otherwise sound, and the use of archetypal clusters (Pieroni et al., 2020) and the distinction between direct, indirect, and economy-wide rebound effects are clearly explained. A minor issue concerns the cut-off date (September 2024); more recent publications may already exist.

Results
The results section is comprehensive and clearly structured, providing a detailed overview of the analyzed studies and their categorization according to circular business model archetypes. The descriptive characteristics of the reviewed studies are well presented and transparent. The authors identify gaps (e.g., geographic concentration, methodological limitations), and these are sufficiently described.
The results for each archetype are presented clearly, and the accompanying tables effectively support the textual discussion. However, several of the proposed mitigation strategies, such as “urban planning to reduce travel time” are general sustainability policies rather than rebound-specific measures. A clearer distinction between genuinely circular and generic interventions would improve precision.
Regarding the “Product-service systems” archetype, the definition provided in the paper (“combinations of products and services such as rental and lease”) is too narrow and does not fully reflect Tukker’s (2004) conceptualization. Tukker distinguishes eight PSS types. Beyond rental and leasing, PSS also includes models such as product-related services, consultancy (e.g., for the most efficient use) and functional result-oriented services, which differ in ownership, risk, and sustainability potential. The results of the SLR mainly address rebound effects in use-oriented models (e.g., renting, leasing, pay-per-use). The authors should either expand their definition of PSS accordingly and include relevant rebound effects or clarify why rebound effects were only observed for this subgroup and possibly re-examine the data for other PSS types.

Discussion
The discussion is generally well-developed. It would profit from a stronger interpretative stance on the results (e.g., by suggesting categories of mitigation strategies) to be less repetitive and descriptive. The numbering in 4.1 should be removed and a stronger focus on answering the RQs explicitly should be given. In the section on limitations (4.3), the authors might explicitly mention review-specific constraints, such as reliance on only two databases and the potential for omission during title or full-text screening.

Conclusion
The conclusion provides a clear and concise summary of the study’s main insights and contributions. It highlights the relevance of linking circular business model archetypes with rebound mechanisms and offers valuable guidance for future research and practice. Overall, it closes the paper effectively and leaves the reader with a coherent understanding of the study’s contribution.

Minor issues
There are a few minor issues throughout the paper, such as typographical errors and inconsistent

spacing. Careful proofreading is recommended.

Overall assessment
The paper is a valuable and thorough contribution to the growing literature on circular business models and rebound effects. Its main strengths lie in its systematic approach, clarity, and relevance. The main areas for improvement concern methodological precision (alignment of research questions and search strings), refinement of the archetype discussion, and a clearer distinction between rebound-specific and general sustainability measures.
Hopefully, these comments will help you further strengthen this already solid and insightful paper.

Are the rationale for, and objectives of, the Systematic Review clearly stated?
Yes

Are sufficient details of the methods and analysis provided to allow replication by others?
Partly

Is the statistical analysis and its interpretation appropriate?
Yes

Are the conclusions drawn adequately supported by the results presented in the review?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Circular Business Models, Circular Product Design

We confirm that we have read this submission and believe that we have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however we have significant reservations, as outlined above.

Author Response 22 Apr 2026

Ankita Das

Dear Reviewers, Thank you for taking the time to review our article and provide your valuable feedback. We believe they have greatly improved the quality of the article. Please see our detailed responses below.

Kind regards,
The Authors

Comment 3.1: Dear authors, Thank you for the opportunity to review your interesting paper. The article addresses a highly relevant issue: rebound effects in circular business models and strategies for mitigating them. This topic is important both scientifically and practically, as rebound effects often diminish the positive environmental contribution of the circular economy. However, they have not been systematically investigated yet. The authors provide a valuable synthesis of existing empirical studies and offer an initial structured link

between circular business model archetypes and rebound mechanisms. Overall, the article is well organized and transparent, with a sound and well-documented methodological approach. Nonetheless, some areas would benefit from clarification and refinement, as outlined below. Introduction The introduction is clearly written, and the research questions are well developed. The research gap is convincingly justified, and the linkage to existing work is strong. The authors cite their prior works extensively; however, since Pigosso and Bocken are leading scholars in the field, this appears justified, however the focus should remain on seminal and relevant contributions. Vague statements like “Similarly, Pigosso (2024) called for advancing design science to incorporate rebound effects into business model design.” should be reduced or specified. Furthermore, while the elaborations on rebound effects are comprehensive and interesting, a clear definition of this central concept for the paper is missing. The paper would greatly benefit from an explicit definition to establish conceptual clarity for the remainder of the paper.

Response 3.1: Thank you for taking the time to review our paper and provide your insightful comments! We have made the following changes to the Introduction to reduce vague statements: “Despite the high potential of circular business models to reduce environmental impact (Fidan et al., 2021; Kaddoura et al., 2019), rebound effects (REs) are increasingly recognized as a major challenge (Andrew & Pigosso, 2024; Brockway et al., 2021; Zink & Geyer, 2017). Rebound effects are a form of negative systemic consequence that can offset or even increase the overall environmental impact (Zink & Geyer, 2017). While rebound effects can be both positive and negative (Font Vivanco et al., 2022; Zerbino, 2022), the focus of this paper is mainly on negative effects. Prominent examples include increases in consumption as a result of increased efficiency and lower prices (Chitnis et al., 2013), or increased wear and tear on shared products (Ackermann & Tunn, 2024). These effects arise from changes across business model elements, such as manufacturing and design choices (upstream), consumer behavior (downstream), and logistics (both upstream and downstream) (Sarasini et al., 2024).”

Comment 3.2: Method The research method is described in detailed and with transparency. However, the section begins by blending the state of the art and the justification for the chosen method. For clarity, the delineation to Lowe et al. and Zerbino should be made in the introduction and the method chapter should explain why a systematic literature review is suitable to answer the research question.

Response 3.2: Thank you for your comment. We have made the following change to the start of section 2: “A systematic literature review (Bryman & Bell, 2011) was conducted to address the research questions, give an overview over the state of the art as well as a direction for future research. This method was chosen to allow a detailed investigation of rebound effects and their mitigation in the context of circular business model archetypes or business model design.”

Comment 3.3: There are two main issues concerning the search strategy: First, the search strings themselves contain inconsistencies. In Search String 1, the terms “sustainable business”, “circular business*”, and “circular*” are linked with OR. “circular*” already includes “circular business*”, making the expression partly redundant, while “sustainable business” makes the query overly broad because it captures much non-circular literature.

Search String 2 introduces slightly different terms (“circular business model*” instead of “circular business*”) and (“sustainab*” instead of “sustainable business”) without justification. The rationale behind these changes is unclear and should be clarified. Second, the connection between the search strings and the research questions could be improved. Research Question 2 focuses on strategies to mitigate rebound effects, while Search String 2 mainly targets environmental impacts. Thus, its logic does not fully match the intent of the second question. Either the research question or the string should be refined for consistency. While the inclusion of multiple synonyms for “rebound effects” is commendable and ensures comprehensiveness, the search strings would benefit from greater conceptual coherence and clearer alignment with the stated research question. In general, the authors should reflect and argue on their ambitions regarding comprehensiveness and precision. The inclusion criteria are otherwise sound, and the use of archetypal clusters (Pieroni et al., 2020) and the distinction between direct, indirect, and economy-wide rebound effects are clearly explained. A minor issue concerns the cut-off date (September 2024); more recent publications may already exist.

Response 3.3: Thank you for your comment! The reason for using overlapping and broad search terms was to ensure we sufficiently captured relevant literature on the topic. Although both search strings are numbered S-1 and S-2 are not meant to correspond to R1 and R2 respectively. Rather S-1 and S-2 were used as complementary searches to ensure a comprehensive search of the topic. Subsequently the title and abstract scans were used to identify papers that could answer R1 and/or R2. With the title and abstract scan including 1091 papers it's fair to say that the search prioritised comprehensiveness rather than precision. We realise the previous framing might have been misleading, and have added the following changes to Section 2.1 to clarify this further: “The primary reason for including two search strings was that while circular business models is a relatively new term, concepts that are included within the term now have existed much longer, such as efficiency and concepts within sustainability, of which circular business models can be said to be subset (Pieroni et al., 2019, 2020). Further, it was initially found that a focus on just circular and sustainable business models might be too narrow to capture all research available on their related rebound effects. However, broadening the synonyms to include the terms “business model*” and “business*” in S-2 captured too many irrelevant studies, and so this search string was further focused to specifically include environmental impacts.” We have also added the following sentence to the first paragraph of the limitations: “It is also worth noting that the search was carried out in late 2024 and for that reason it does not encompass all the more recent contributions to the field.”

Comment 3.4: Results The results section is comprehensive and clearly structured, providing a detailed overview of the analyzed studies and their categorization according to circular business model archetypes. The descriptive characteristics of the reviewed studies are well presented and transparent. The authors identify gaps (e.g., geographic concentration, methodological limitations), and these are sufficiently described. The results for each archetype are presented clearly, and the accompanying tables effectively support the textual discussion. However, several of the proposed mitigation strategies, such as “urban planning to reduce travel time” are general sustainability policies rather than rebound-specific measures. A clearer distinction between genuinely circular and generic interventions would improve precision.

Response 3.4: Thank you for your encouraging comment. We agree that some of the suggested mitigation strategies that we found in the literature are quite general and not always specific to circular business models or their rebound effects. In section 4.3 of the discussion this is mentioned as a limitation of the present study, but we have made the following additions in line with your reflections: "Third, while several mitigation strategies were identified, many were broad suggestions rather than actionable steps (for e.g., in the case of PSS, price controls and steering consumers towards less impactful consumption or measuring impacts of change). While others referred to initiatives that themselves can also lead to rebound effects (e.g., suggesting to improve the social perception of secondhand goods, practice that itself is connected to several rebound effects). Further, some of the suggested policy-oriented strategies, such as urban planning, fuel or carbon tax and restrictions on fossil fuel transportation are not specific to the circular economy, and could lead to additional rebound effects if not carefully planned and implemented. Moreover, most strategies were not empirically tested, meaning their actual effectiveness remains uncertain. This study, therefore, relies on mitigation strategies as reported by authors, highlighting the need for future research to identify credible, context-specific strategies and quantitatively assess their effectiveness."

Comment 3.5: Regarding the "Product-service systems" archetype, the definition provided in the paper ("combinations of products and services such as rental and lease") is too narrow and does not fully reflect Tukker's (2004) conceptualization. Tukker distinguishes eight PSS types. Beyond rental and leasing, PSS also includes models such as product-related services, consultancy (e.g., for the most efficient use) and functional result-oriented services, which differ in ownership, risk, and sustainability potential. The results of the SLR mainly address rebound effects in use-oriented models (e.g., renting, leasing, pay-per-use). The authors should either expand their definition of PSS accordingly and include relevant rebound effects or clarify why rebound effects were only observed for this subgroup and possibly re-examine the data for other PSS types.

Response 3.5: Thank you for your suggestion. You are correct in your summation of PSS according to Tukker (2004), however, and that the initial description in Section 3.5 was too brief. We base our definition upon the categorisation defined by Pieroni et al. (2020), hence the slightly narrower focus on what PSS models are. We did provide a broader definition in Table 4 "(Product-Service Systems (E.g., Product-as-a- service, Rental, Hire, Leasing, Pay-per-use, functional sales)" previously, but for clarity we have added this definition in Section 3.5: "The archetype cluster of "product-service systems" serves as an umbrella term for combinations of products and services such as product-as-a- service, rental, hire, leasing, pay-per-use and functional sales (Pieroni et al., 2020; Tukker, 2004), that aim to reduce consumption by offering products as services."

Comment 3.6: Discussion The discussion is generally well-developed. It would profit from a stronger interpretative stance on the results (e.g., by suggesting categories of mitigation strategies) to be less repetitive and descriptive. The numbering in 4.1 should be removed and a stronger focus on answering the RQs explicitly should be given. In the section on limitations (4.3), the authors might explicitly mention review-specific constraints, such as

reliance on only two databases and the potential for omission during title or full-text screening.

Response 3.6: Thank you for your comments and insights! We have made changes to section 4.1 to make the links to the research questions clearer, and removed the numbering. Regarding the suggestions for changes to the limitations section, we have added the following sentences to clarify the limitations of the method better: "This study had some limitations. First, there are limitations pertaining to the chosen method. The literature search was carried out in only two databases, this might have led to search results being more limited than they otherwise might have been. Additionally, although the title, abstract and full text scans were carried out systematically, there is a chance for inadvertent omissions of relevant data, due to human error."

Comment 3.7: Conclusion The conclusion provides a clear and concise summary of the study's main insights and contributions. It highlights the relevance of linking circular business model archetypes with rebound mechanisms and offers valuable guidance for future research and practice. Overall, it closes the paper effectively and leaves the reader with a coherent understanding of the study's contribution. Minor issues There are a few minor issues throughout the paper, such as typographical errors and inconsistent spacing. Careful proofreading is recommended. Overall assessment The paper is a valuable and thorough contribution to the growing literature on circular business models and rebound effects. Its main strengths lie in its systematic approach, clarity, and relevance. The main areas for improvement concern methodological precision (alignment of research questions and search strings), refinement of the archetype discussion, and a clearer distinction between rebound-specific and general sustainability measures. Hopefully, these comments will help you further strengthen this already solid and insightful paper.

Response 3.7: Thank you for all your kind words and for your insightful comments! We have carried out diligent proofreading as suggested.

Competing Interests: No competing interests were disclosed.

Reviewer Report 06 November 2025

https://doi.org/10.21956/openreseurope.23046.r62330

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Mariantonietta Ferrante
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The topic of this paper is highly relevant and makes a significant contribution to the field of

research. The study's focus on the relationship between circular business models and rebound effects is particularly compelling. The authors conduct a systematic literature review and provide a comprehensive summary of rebound effects, organized across seven different circular business model archetypes. The paper also clearly explains how rebound effects can manifest within these circular business model archetypes, along with the associated strategies for mitigation. The inclusion of tables throughout the paper significantly aids in clarifying the work and enhancing its readability.
The background section is well-written and effectively sets the stage for the study, outlining the rationale behind the research. The objective of the paper is clearly defined and logically structured.
One point for improvement would be to ensure consistency in the use of acronyms throughout the paper. I suggest reviewing the document to confirm that all acronyms are introduced and defined at their first occurrence.
The methodology section is well-structured and presented in a clear, coherent manner. Figure 1 is particularly useful in illustrating the research methodology, and the tables presenting the search protocol and criteria used to select relevant documents are a helpful addition.
The authors present their results effectively, and the results section is generally well-written and easy to follow. However, Table 4 is quite lengthy and may hinder the paper's readability. It could be split into smaller tables, perhaps one for each archetype, with the content condensed to improve clarity.
The discussion section is clear, and the authors provide useful comparisons with other works in the field. However, the use of lists in this section may be somewhat distracting and could be streamlined for better readability. While the contributions are well outlined, they could be made more specific by linking the circular business model archetypes directly to the rebound effects and offering more practical insights on how these effects could be mitigated.
The conclusion provides a suitable summary of the paper's key findings and contributions. However, the section discussing limitations and future developments would be better placed at the end of the conclusion for better structural flow.

Are the rationale for, and objectives of, the Systematic Review clearly stated?

Yes

Are sufficient details of the methods and analysis provided to allow replication by others?

Yes

Is the statistical analysis and its interpretation appropriate?

Yes

Are the conclusions drawn adequately supported by the results presented in the review?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Circular economy, Circular manufacturing, Rebound effects

I confirm that I have read this submission and believe that I have an appropriate level of

expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 22 Apr 2026

Ankita Das

Dear Reviewers, Thank you for taking the time to review our article and provide your valuable feedback. We believe they have greatly improved the quality of the article. Please see our detailed responses below. Kind regards,

The Authors --

Comment 2.1: The topic of this paper is highly relevant and makes a significant contribution to the field of research. The study's focus on the relationship between circular business models and rebound effects is particularly compelling. The authors conduct a systematic literature review and provide a comprehensive summary of rebound effects, organized across seven different circular business model archetypes. The paper also clearly explains how rebound effects can manifest within these circular business model archetypes, along with the associated strategies for mitigation. The inclusion of tables throughout the paper significantly aids in clarifying the work and enhancing its readability. The background section is well-written and effectively sets the stage for the study, outlining the rationale behind the research. The objective of the paper is clearly defined and logically structured. One point for improvement would be to ensure consistency in the use of acronyms throughout the paper. I suggest reviewing the document to confirm that all acronyms are introduced and defined at their first occurrence.

Response 2.1: Thank you for taking the time to review our paper, and for the positive review. We have reviewed the paper in line with your suggestion and added acronyms where necessary.

Comment 2.2: The methodology section is well-structured and presented in a clear, coherent manner. Figure 1 is particularly useful in illustrating the research methodology, and the tables presenting the search protocol and criteria used to select relevant documents are a helpful addition. The authors present their results effectively, and the results section is generally well-written and easy to follow. However, Table 4 is quite lengthy and may hinder the paper's readability. It could be split into smaller tables, perhaps one for each archetype, with the content condensed to improve clarity.

Response 2.2: Thank you for your kind comment! You’re quite right that Table 4 is very large and contains a fair amount of detail. At the same time, this table allows us to summarize information that will be difficult to contain in the main text, and the information in the table has already been condensed to a bare minimum. Meanwhile, we have also had requests from reviewers to add more detail to the results section, rather than further condense the information that’s presented. We have found it challenging to balance the different suggestions that have been made for the results section. As for splitting the table into several tables, we tried this, but have been concerned that that will make the article difficult to navigate, given the amount of size any of these 7 tables would need to occupy

(most of a page). We did not find that this improves readability. Given the diverse opinions on this topic we have chosen to keep the table as is.

Comment 2.3: The discussion section is clear, and the authors provide useful comparisons with other works in the field. However, the use of lists in this section may be somewhat distracting and could be streamlined for better readability. While the contributions are well outlined, they could be made more specific by linking the circular business model archetypes directly to the rebound effects and offering more practical insights on how these effects could be mitigated.

Response 2.3: Thank you for your comment! It may however be difficult to offer further practical insight into how specific rebound effects can be mitigated, since one of the main findings of the review is that the suggested mitigation strategies that were found have yet to be properly tested and evaluated. We reflect on this further in the fifth paragraph of Section 4.1 and in the limitations section in 4.3. In this sense, the practical insight is that while there are many suggestions about mitigating rebound effects, it is yet unknown if these ideas can be translated into successful rebound effect mitigation.

Comment 2.4: The conclusion provides a suitable summary of the paper's key findings and contributions. However, the section discussing limitations and future developments would be better placed at the end of the conclusion for better structural flow.

Response 2.4: Thank you for this suggestion! We have however elected to keep the conclusion shorter, without subsections to enable clearer readability of the findings for non-academic readers who benefit from this research.

Competing Interests: No competing interests were disclosed.

Reviewer Report 28 October 2025

https://doi.org/10.21956/openreseurope.23046.r62332

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Summary and General Remarks:

Thank you for giving me the opportunity to review the manuscript "Rebound effects in circular business models: A review of cases and mitigation strategies" to be published in ORE. The manuscript reviews the extant literature on circular economy rebound effects and idenfies direct and indirect effects for different business model archetypes. Additionally, the manuscript extracts circular economy rebound effect mitigation strategies that have been described by extant literature.

The manuscript offers an important, novel, and interesting account of circular economy rebound effects and mitigation strategies. The manuscript's research design works well with the outset of the study, and the findings yield interesting insights.

While the manuscript topic-wise seems promising, in the following I would like to point to some avenues for improvement:

Introduction:

- In the first paragraph, the authors describe which conversation they join. However, at this point they are mainly engaged in citing their own articles. While some of these articles may certainly relate and are central to the conversation at hand, others do not really relate (e.g., business model experimentation; Bocken et al., 2021b). Although the first paragraph appears to mainly serve the explanation of circular business models, referring specifically to the experimentation aspect feels forced. In contrast, a more specific explanation of what circular business model (archetypes) are would have been useful. Despite later being central to the method, the circular business model archetypes categorization by Pieroni et al. (2020) is not even mentioned in the introduction.

- In the second paragraph, the authors then open up on the conversation around rebound effects and the challenges they pose for circular business models. However, the authors overlook articles important for providing the full picture of the conversation and that are well aligned with the argument that "business model design can strongly influence product care and sustainability performance" when referring to PSS, to finally mitigate circular economy rebound effects (e.g., Mueller & Remke, 2025 - ref 2; Siderius & Poldner, 2021 - ref 1).

- In the third paragraph, the description of circular economy rebound remains a bit shallow given the fact that the manuscript does not include a theoretical background section. Instead of just mentioning more recent studies in one sentence, these could have been described in more detail to provide the full picture of how the circular economy rebound effect concept evolved.

- In the fourth and fifth paragraphs, the authors describe circular economy rebound effect mitigation strategies and highlight articles that approached these. Furthermore, the authors argue that more design science is needed for advancing circular economy rebound effect mitigation literature such as the Circular Economy Rebound Tool by Das et al. (2023). They conclude that "no systematic overview connects rebound effects to specific business model archetypes or explores mitigation through business model designs". It is very surprising that the authors are not mentioning or referring to the article by Mueller and Remke (2025) (or alternatively Remke & Mueller, 2024 - ref 3) (throughout their entire manuscript), which does exactly what the authors describe as being a gap in extant literature (apart from conducting a systematic literature review). The article applies design science to develop and even test a tool that

is targeted at circular economy rebound mitigation through linking circular product design, PSS design, business model design (and explicitly archetypes), and circular ecosystem design. Thus, a part of the underlying research gap of the manuscript to be reviewed here, has basically already been filled. At least, the authors should have been aware of at least one of the two publications. Thus, the contribution "this is a critical first step toward integrating rebound mitigation into design science" is not an actual contribution.

- The abstract and introductions would benefit from including more detailed findings from the literature review. Just referring to "the findings revealed an apparent lack of quantitative research on mitigation strategies" is too narrow.

Method:

- It remains a bit unclear what a literature review has to do with design science (as initially claimed to be part of the contribution in the introduction). This could have been better argued in the first paragraph of the method section. Maybe the reason for this is a different understanding of what is meant by design science in your manuscript. Thus, this concept would need further clarification. To check upon established research on what design science is, you may refer to for example Dimov et al. (2023) - ref 4.

- While using the Pieroni et al. (2020) circular business model archetypes is fair, this again may be understood as being self-promotional. Why did the authors not use a different classification? The argument that Pieroni et al. would be the "most comprehensive classification" is a bit shallow. Please provide a more sophisticated argument on this.

- The authors do not explain the journal selection criteria. This is problematic because it influences the quality of the reviewed literature sample. Upon checking the reviewed articles, the reviewed papers are mainly published in lower-tier journals. This is undermining the overall quality and contributions of the manuscript.

Results:

- The results could have been a bit more detailed. For some circular business model categories, the authors only provide one example for why it may cause circular economy rebound effects. As this is the most insightful part of the manuscript, it should be more elaborated. The same applies for the mitigation strategies, which could be explained in greater detail (for now one sentence on average).

Discussion:

- The discussion should follow a clearer structure of theoretical contributions and practical implications. In the current version (especially the first part of the discussion), it is difficult to follow for the reader as the argumentation is not optimally interwoven with the manuscript's findings.

- The articles cited at the very beginning of the introduction (e.g., business model experimentation) are not really mentioned further in the discussion, confirming the impressions mentioned for the introduction section.

- The theoretical contributions do not yet connect well with the actual conversation on circular economy rebound mitigation. However, I feel that there could be a decent contribution to the conversation upon optimized argumentation and connection with extant literature on that topic.

- In the introduction, the authors are claiming to making a contribution to design science in the context of circular economy rebound mitigation. However, this claim is not picked up in the discussion.

- The practical implications could be described in greater detail.

Conclusion:

- The conclusion is overly repetitive and can be condensed to the essence of the final paragraph.

Minor Comments:
- There are some writing and punctuation errors.

- The authors continuously provide "roadmaps" at the beginning of each section. This could be avoided by a clearer flow of argumentation as it takes up a lot of space.

References
1. Siderius T, Poldner K: Reconsidering the Circular Economy Rebound effect: Propositions from a case study of the Dutch Circular Textile Valley. *Journal of Cleaner Production*. 2021; **293**. Publisher Full Text
2. Müller H, Remke K: Circular Systems Sandbox: A process tool for circular systems design and rebound effect reduction. *Journal of Business Venturing Design*. 2025; **4**. Publisher Full Text
3. Remke K, Müller H: Overcoming Rebound Effects: A Process Blueprint for Circular Systems Design. **14621**: 33-47 Publisher Full Text
4. Dimov D, Maula M, Romme A: Crafting and Assessing Design Science Research for Entrepreneurship. *Entrepreneurship Theory and Practice*. 2023; **47** (5): 1543-1567 Publisher Full Text

Are the rationale for, and objectives of, the Systematic Review clearly stated?
Yes

Are sufficient details of the methods and analysis provided to allow replication by others?
Partly

Is the statistical analysis and its interpretation appropriate?
Partly

Are the conclusions drawn adequately supported by the results presented in the review?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Circular economy, circular business model innovation, circular economy

rebound mitigation, circular systems design, design science research

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 22 Apr 2026

Ankita Das

Dear Reviewers, Thank you for taking the time to review our article and provide your valuable feedback. We believe they have greatly improved the quality of the article.

Please see our detailed responses below. Kind regards,

The Authors --
Comment 1.1 Summary and General Remarks:

Thank you for giving me the opportunity to review the manuscript "Rebound effects in circular business models: A review of cases and mitigation strategies" to be published in ORE. The manuscript reviews the extant literature on circular economy rebound effects and idenfies direct and indirect effects for different business model archetypes. Additionally, the manuscript extracts circular economy rebound effect mitigation strategies that have been described by extant literature. The manuscript offers an important, novel, and interesting account of circular economy rebound effects and mitigation strategies. The manuscript's research design works well with the outset of the study, and the findings yield interesting insights. While the manuscript topic-wise seems promising, in the following I would like to point to some avenues for improvement:
Introduction: - In the first paragraph, the authors describe which conversation they join. However, at this point they are mainly engaged in citing their own articles. While some of these articles may certainly relate and are central to the conversation at hand, others do not really relate (e.g., business model experimentation; Bocken et al., 2021b). Although the first paragraph appears to mainly serve the explanation of circular business models, referring specifically to the experimentation aspect feels forced. In contrast, a more specific explanation of what circular business model (archetypes) are would have been useful. Despite later being central to the method, the circular business model archetypes categorization by Pieroni et al. (2020) is not even mentioned in the introduction.

Response 1.1: Thank you for your kind words and for your comment! We added the Pieroni et al. (2020) paper now earlier on in the paper, although our original intention was to introduce it later. Business model experimentation was an important starting point for our research as we noticed that rebound effects can be mitigated through good design (see also Das, A., Konietzko, J., Bocken, N., & Dijk, M. (2023). The Circular Rebound Tool: A tool to move companies towards more sustainable circular business models. Resources, conservation & recycling advances, 20, 200185). Hence, we kept this focus/ rationale in the introduction but improved the opening paragraph based on your suggestions. As a result of this comment, we have made the following changes in line with this comment: “Circular

business models (CBMs) aim to maximize value by slowing, closing, narrowing and/or regenerating material flows to extend resource use and minimize waste (Konietzko et al., 2020). The implementation of CBMs often involve a number of business model patterns and archetypes, both upstream and downstream (Pieroni et al., 2020; Rosa et al., 2019; Salvador et al., 2023). While companies experiment with new circular business models to test their desirability, feasibility, and viability, their performance in terms of circularity and sustainability is rarely tested (Bocken et al., 2021a, b). Companies usually rely on rules of thumb to forecast impact (i.e., heuristics related to circular/sustainable design such as guidelines and policies), which can be inaccurate (Das et al., 2022). Negative side effects of circular business models can potentially be prevented during the design and experimentation phase so understanding these is essential (Das et al., 2023; Pigosso, 2024). Past research has found that negative side effects of circular business models can potentially be prevented during the design and experimentation phase so understanding these is essential (Das et al., 2023).”

Comment 1.2: - In the second paragraph, the authors then open up on the conversation around rebound effects and the challenges they pose for circular business models. However, the authors overlook articles important for providing the full picture of the conversation and that are well aligned with the argument that "business model design can strongly influence product care and sustainability performance" when referring to PSS, to finally mitigate circular economy rebound effects (e.g., Mueller & Remke, 2025 - ref 2; Siderius & Poldner, 2021 - ref 1). - In the third paragraph, the description of circular economy rebound remains a bit shallow given the fact that the manuscript does not include a theoretical background section. Instead of just mentioning more recent studies in one sentence, these could have been described in more detail to provide the full picture of how the circular economy rebound effect concept evolved.

Response 1.2: Thank you for your comment! We have made the following changes to the second paragraph: “ Managerial decisions in the early design phase can have a big impact on the sustainability performance of a product (McAloone & Bey, 2009). Pigosso (2024) argues that rebound effects are not yet integrated into the business model design phase and should be proactively addressed by embedding awareness and mitigation strategies from the outset. This aligns with research on product-service systems, which highlights how business model design can strongly influence product care (Ackermann & Tunn, 2024; Müller& Remke, 2025) and sustainability performance (Siderius & Poldner, 2021; Tukker, 2015), indicating the importance of business model design in managing rebound effects.” We also made the following changes to the fourth (previously third) paragraph, in line with your comments: “More recent research has identified several further mechanisms through which rebounds can occur and provided a more detailed causal understanding of how rebound effects work (Castro et al., 2022; Guzzo et al., 2024; Lange et al., 2021). This ranges from economic to behavioral and social practice mechanisms, at both the consumer and producer sides; directly, indirectly, through changes in demand and use intensity on different levels of the economy (on the level of the individual firm, the sector, economy wide or global), and at different points in time (at implementation, in response to implementation or at the point of attempting to mitigate rebounds) (Aguiar et al., 2026; Andrew et al., 2026; Ferrante et al., 2026; Van Der Loo & Pigosso, 2024). This study uses the term rebound effects (or simply rebounds) instead of circular rebound effects, as many rebound

mechanisms apply to circularity as well. An example would be in the classic case of fuel-efficient cars leading to users driving them for longer distances (Pardi, 2021). Or, in the case of PSS, it has been found that rented items tend to be treated less carefully since consumers feel less attached and bear no long-term responsibility, leading to higher replacement rates (Ackermann & Tunn, 2024; Schaefers et al., 2016). This illustrates a link between business model design and rebound effects (McKay et al., 2025).”

Comment 1.3: - In the fourth and fifth paragraphs, the authors describe circular economy rebound effect mitigation strategies and highlight articles that approached these. Furthermore, the authors argue that more design science is needed for advancing circular economy rebound effect mitigation literature such as the Circular Economy Rebound Tool by Das et al. (2023). They conclude that "no systematic overview connects rebound effects to specific business model archetypes or explores mitigation through business model designs". It is very surprising that the authors are not mentioning or referring to the article by Mueller and Remke (2025) (or alternatively Remke & Mueller, 2024 - ref 3) (throughout their entire manuscript), which does exactly what the authors describe as being a gap in extant literature (apart from conducting a systematic literature review). The article applies design science to develop and even test a tool that is targeted at circular economy rebound mitigation through linking circular product design, PSS design, business model design (and explicitly archetypes), and circular ecosystem design. Thus, a part of the underlying research gap of the manuscript to be reviewed here, has basically already been filled. At least, the authors should have been aware of at least one of the two publications. Thus, the contribution "this is a critical first step toward integrating rebound mitigation into design science" is not an actual contribution. - The abstract and introductions would benefit from including more detailed findings from the literature review. Just referring to "the findings revealed an apparent lack of quantitative research on mitigation strategies" is too narrow.

Response 1.3: Thank you for your comments. We have made the added the following changes to the Introduction: “While past literature reviews exist, only two articles connect rebound effects to specific circular business model archetypes or explore mitigation through business model design. In their review of case studies Baczyk et al. (2024) seek to clarify the role of consumer behaviour in shaping the effects of circular business model archetypes once implemented. They also give some suggestions for how rebound effects can perhaps be avoided, although these recommendations take the form of guiding principles and policy recommendations. Another recent contribution to rebound effect mitigation research is Mueller & Remke (2025). Focusing on mitigation through business model design, the authors developed the Circular Systems Sandbox, a business model design tool based on systems and life cycle thinking. The tool helps designers develop circular products and services and to understand the consequences their design choices may have on the environmental impact of their product or service. Although Circular Systems Sandbox connects business model choices to rebound effects, the focus is on the process of business model design, rather than archetype specific rebound effects and how one could mitigate them in practice. Clarifying the link between specific rebound effects and circular business model archetypes, as well as specific strategies for how to mitigate these rebound effects is an important first step toward integrating rebound mitigation into circular business model innovation, as empirical measurement is often impractical in early design phases. Thus, this paper aims to identify empirically measured rebound effects in

circular business models and potential mitigation strategies, addressing the following research questions:" As pertains to the lack of quantitative research on mitigation strategies, this refers to the result of our systematic overview. As elaborated in the discussion, while some papers did quantitatively investigate the size of rebound effects, no papers were found that actually provided a quantitative measurement of the effect of rebound mitigation strategies that had been implemented. To clarify this we have made the following changes to the discussion: "And, while many rebound mitigation strategies were suggested, they were rarely empirically tested to assess their effectiveness and thus their actual effects remain theoretical. Indeed, only 32 of 45 papers linked mitigation strategies to specific rebound effects. Additionally, some suggested strategies were overly general and could unintentionally reinforce rebound mechanisms, increasing environmental impact."

Comment 1.4: Method: - It remains a bit unclear what a literature review has to do with design science (as initially claimed to be part of the contribution in the introduction). This could have been better argued in the first paragraph of the method section. Maybe the reason for this is a different understanding of what is meant by design science in your manuscript. Thus, this concept would need further clarification. To check upon established research on what design science is, you may refer to for example Dimov et al. (2023) - ref 4. - While using the Pieroni et al. (2020) circular business model archetypes is fair, this again may be understood as being self-promotional. Why did the authors not use a different classification? The argument that Pieroni et al. would be the "most comprehensive classification" is a bit shallow. Please provide a more sophisticated argument on this. - The authors do not explain the journal selection criteria. This is problematic because it influences the quality of the reviewed literature sample. Upon checking the reviewed articles, the reviewed papers are mainly published in lower-tier journals. This is undermining the overall quality and contributions of the manuscript.

Response 1.4: Thank you for your comment. We have now removed references to design science research to make the contributions more streamlined. Regarding your point about the Pieroni et al. (2020) paper, it was the first author of the present paper (not a co-author of the Pieroni et al 2020 work) who selected this paper initially. The main reason for this was the upstream/ downstream categorization. We removed any 'promotional-sounding' text and focused on the categorization instead. It should be noted that this list of archetypes is based on an extensive consolidation and analysis of 180+ CEBM cases, and is well-cited, thus having a strong empirical base for the work. So this was an additional reason for seeing this as a valid approach. Regarding the journal selection criteria: we recognise that circular business model literature is widespread and interdisciplinary so we deliberately chose to keep the sample broad to capture the widest possible sample of studies (including upcoming and early stage research) that empirically and quantitatively measure rebound effects, since at the time of conducting the initial systematic literature review there were no other studies published that had conducted such a meta-analysis.

Comment 1.5: Results: - The results could have been a bit more detailed. For some circular business model categories, the authors only provide one example for why it may cause circular economy rebound effects. As this is the most insightful part of the manuscript, it should be more elaborated. The same applies for the mitigation strategies, which could be explained in greater detail (for now one sentence on average).

Response 1.5: Thank you for this comment. The rebound effects and mitigation strategies reported in the table are entirely based on the results of the systematic literature review, and the results quantified and reported by the articles in the sample. Hence, some circular business model categories have less rebound effects reported compared to others. We have chosen to stick strictly to only the results reported by the articles in our sample. One of our challenges was to find ways to present as much detail as possible, whilst still making the results very readable. We therefore chose to collect a full account of the results in table 4 and to provide narrative summary in the text.

Comment 1.6: Discussion: - The discussion should follow a clearer structure of theoretical contributions and practical implications. In the current version (especially the first part of the discussion), it is difficult to follow for the reader as the argumentation is not optimally interwoven with the manuscript's findings. - The theoretical contributions do not yet connect well with the actual conversation on circular economy rebound mitigation. However, I feel that there could be a decent contribution to the conversation upon optimized argumentation and connection with extant literature on that topic.

Response 1.6: Thank you for your comment. A more detailed discussion of the contributions of the study to research, practice and policy has already been included in Section 4.2, and the Discussion section has now undergone significant revision in line with the comments received from the peer review.

Comment 1.7: - The articles cited at the very beginning of the introduction (e.g., business model experimentation) are not really mentioned further in the discussion, confirming the impressions mentioned for the introduction section. - In the introduction, the authors are claiming to making a contribution to design science in the context of circular economy rebound mitigation. However, this claim is not picked up in the discussion. - The practical implications could be described in greater detail.

Response 1.7: Thank you for your comments! You're quite correct that Linder & Williander, 2017,Bocken et al., 2021a and Bocken et al., 2021b are not cited in the discussion. That said, the link with business model experimentation is firmly made in the third and fourth paragraphs of section 4.1, with relevant citations, as well as in the second paragraph of section 4.2: "Further, this paper aims to provide insights into rebound effects in specific circular business models and potential mitigation strategies useful for research and practice. Organizing rebound effects by circular business model archetypes, assuming they are shaped by the model implemented, offers clearer information on risks and mitigation strategies applicable to specific businesses. Similarly, categorizing rebound effects as direct, indirect, or economy-wide helps assess how innovations impact different economic levels and interact. Identifying the system in which a rebound effect occurs may better enable practitioners and policymakers to influence environmental impacts. Additionally, the systematic overview can help determine which rebound effects and mitigation strategies fall within zone of influence. Finally, such an overview may offer valuable guidance in early business model design, where companies often rely on "rules of thumb" rather than detailed assessments to estimate environmental impacts (Das et al., 2022; Das et al., 2023

).” And in section 4.2, where the implication of our systematic overview for practitioners is discussed in terms of the different phases of business model experimentation: “For practitioners the results provide suggestions for mitigation strategies that can be trialed and refined. Innovators can use these insights to identify and address potential rebound effects early in business model design, reducing risk—especially in light of potential new regulations. Designers can also consult the overview during the early ideation phase of business model design (Bocken & Snihur, 2020) to assess and mitigate rebound effects. Further, in the experimentation phase, the systematic overview can continue to be a reference for identifying rebound effects and refining mitigation strategies as business model performance is evaluated and adjusted.” We have now also removed references to design science research in the Introduction to make our contributions more streamlined. Although the discussion of the practical implications in section 4.1 can benefit from some further detail, we are wary of repetition, given that the practical implications are discussed in detail in section 4.2. That said, in service of readability and to make the discussion of the practical implications more salient, have made the following changes to the third paragraph of section 4.1: “Additionally, the systematic overview can help determine which rebound effects and mitigation strategies fall within the zone of influence of practitioners, hopefully further aiding them in developing strategies to avoid or mitigate rebound effects. Finally, such an overview may offer valuable guidance in early business model design, where companies often rely on “rules of thumb” rather than detailed assessments to estimate environmental impacts (Das et al., 2022; Das et al., 2023).”

Comment 1.8: Conclusion: - The conclusion is overly repetitive and can be condensed to the essence of the final paragraph. Minor Comments: - There are some writing and punctuation errors. - The authors continuously provide "roadmaps" at the beginning of each section. This could be avoided by a clearer flow of argumentation as it takes up a lot of space.

Response 1.8: Thank you for your comment! We have made the following changes to the conclusion to make it more concise: “While research on circular rebound effects has grown, there has been a lack of organized knowledge on mitigating these effects within business models. This study aimed to investigate (1) the potential rebound effects of circular business model archetypes and (2) identified strategies for their mitigation through a systematic literature review. It provides a structured overview mapping rebound effects across seven circular business model archetypal clusters, and suggestions for ways to potentially mitigate them. These findings help bridge a critical gap in circular economy and business model innovation literature, offering academics and practitioners a structured way to consider the true net environmental impact of new circular product and business model ideas, and preventing rebound effects that could undermine their benefits. The study highlights where empirical research has focused on direct, indirect, and economy-wide rebound effects and where future research opportunities exist. It also provides policymakers and practitioners with a systematic overview of risks associated with circular business models and potential mitigation strategies. However, while mitigation strategies have been suggested, they remain largely untested, and their effectiveness is uncertain. The results indicate the need for more research to attribute rebound effects to specific circular business model choices, standardise methods to analyze the behavior and magnitude of these rebound effects, and develop mitigation strategies. Additional research

could also refine the key findings of this paper (Table 4) into a practical tool or process that could enhance their usability. Finally, while mitigating rebounds is crucial, their occurrence must be weighed against the broader societal benefits of circular business models." Thank you for your comment regarding the punctuation errors, we have now read through the document and made the necessary changes. Further regarding the comment on the 'roadmaps', while we appreciate the suggestion, we provided these in order to improve readability, and make the paper more accessible to readers outside of academia, such as business leaders and innovators, who constitute an important audience for this research. Thus, after careful consideration we have chosen to leave them as is.

Competing Interests: No competing interests were disclosed.