Extended Abstract
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The rebound mechanisms identification tool: finding rebound effects in circular economy business models

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Introduction

The pervasive occurrence of rebound effects (RE) jeopardises the potential sustainability benefits of circular economy (CE) (Castro *et al.*, 2022; Metic and Pigosso, 2022; Zink and Geyer, 2017). RE are driven by economic and behavioural mechanisms that offset the potential sustainability gains of interventions (Guzzo *et al.*, 2024; Lange *et al.*, 2021).

Despite the evidence that rebound mechanisms are a critical path to addressing RE (Colmenares *et al.*, 2020; Guzzo *et al.*, 2024; Lange *et al.*, 2021; Metic and Pigosso, 2022), several challenges hinder the identification of rebound mechanisms in the early phases of circular economy business models (CEBM) innovation.

Designers struggle to anticipate potential RE emerging from CEBM interventions, as higher-level effects are hard to identify (Guzzo *et al.*, 2023). While tools for identifying RE in CE are emerging (Ackermann and Tunn, 2024; Das *et al.*, 2023; Metic *et al.*, 2024; Schultz *et al.*, 2024; Zerbino, 2022), they still fail to build the causal thread between the CE action and the rebound mechanisms, which would better explain RE and enable addressing them.

Building upon efforts into 'cracking the RE code' that conceptually associated the dynamics between CEBM patterns and rebound mechanisms (Guzzo and Pigosso, 2024a), this work aims to develop a rebound mechanisms identification tool to assist designers in systematically identifying potential rebound mechanisms emerging from CEBM. In this paper, we describe the steps for using the tool and demonstrate its use in one case (i.e., Bundles, a washing machine as a service solution). Directions for further development are also discussed.

Method

This research employed three steps for the conceptualisation and demonstration of the rebound mechanisms identification tool:

Step 1: The tool was developed by operationalising the knowledge about CEBM patterns, the actors potentially performing those patterns, and the stimulation of consumption factors to anticipate the activation of potential rebound mechanisms based on previous work (Guzzo and Pigosso, 2024a). It was implemented in Excel as a step-by-step process to assist designers in systematically revealing the interplay between CEBM patterns and rebound mechanisms.

Step 2: Document analysis (Yin, 2009) of a CEBM case was employed to demonstrate the use of the tool. The analysis of the CEBM patterns followed a strict content analysis of available descriptions for the case (Bundles, n.d.; Ellen Macarthur Foundation, 2021; Grassi and Zimmer, 2021), and comprised critical analyses of the stimulation of consumption factors activating rebound mechanisms.

Step 3: To test the usefulness of the tool, the results were compared with a previous case study aiming at RE identification of the Bundles case using a similar but more time-consuming method, carried out manually (Guzzo and Pigosso, 2024b).

Results

The rebound mechanisms identification tool

The application of the rebound mechanisms identification tool (Guzzo and Pigosso, 2025), which is implemented in Excel and intended for use in a workshop setting to analyse an existing CEBM or a CEBM concept, involves three main steps:

1. Analyse the BM
   a. Identify the relevant CEBM patterns based on a set of 24 BM patterns representing alternative configuration options (Pieroni et al., 2021).
   b. Determine the relevant actors considering business-to-business (B2B) and business-to-consumer (B2C) setups for the CEBM.

2. Determine the consumption factors (i.e., factors that lead to consumption and production activities) potentially stimulated by the selected CEBM patterns.

3. Review the scenarios for consumption factors stimulation to determine candidate rebound mechanisms activated within the CEBM, following the 26 underlying economic and behavioural rebound mechanisms (Guzzo *et al.*, 2024).

Case study: Bundles

The analysis of the case resulted in the selection of 10 CEBM patterns (step 1a), with the definition of the key actors (step 1b): Bundles (service provider), household consumers (renters), washing machine, and Miele (machine manufacturer)

Subsequently, out of the analysis of 38 instances of consumption factor stimulation suggested (step 2), 21 instances remained – 7 within the service provider (e.g., new revenues from the product as a service contract), 13 within household consumers (e.g., decreased costs to own a product by replacing products less frequently due to life care services), and one within product manufacturer (i.e., decreased costs from using circular supplies). Most factors are economic/financial (16), while some relate to consumer choices (5).

Finally, step 3 led to identifying economic/financial rebound mechanisms within the company (e.g., output, re-investment, and factor substitution mechanisms—8 instances) and the individuals (e.g., income, re-spending, and substitution mechanisms—7 instances). Three instances of motivational consumption and substitution mechanisms are also related to consumer choices (individuals).

Several of the consumption factors stimulation instances match the existing case study (e.g., reduced investment cost from consumers, decreased costs from more efficient use, and moral hazard from no ownership and no charges for repair), showing a consistent case analysis in a significantly shorter timeframe.

Nevertheless, the tool did not help identify rebound mechanisms linked to released time for household chores—previously identified. It limited the consideration of nuances that could constrain consumption factors, potentially leading to secondary benefits. Finally, the tool only indicates rebound mechanisms whose dynamics have been previously mapped.

Final remarks

By enabling the visualisation of the causal chains from the CEBM to RE via the stimulation of consumption factors and activation of rebound mechanisms, this research demonstrated the potential to enable the anticipation and prevention of potential RE.

The tool accelerated the identification of instances of consumption factor stimulation consistent with the previous case study, leading to the recognition of relevant rebound mechanisms for further consideration. The structured and stepwise approach shows promise to aid in identifying RE in CEBM cases.

Future research should expand the risk analysis of identified rebound mechanisms. Also, there is room to further integrate socio-behavioural mechanisms, secondary benefits, leverage points, and interventions beyond CEBM. The tool and its supporting conceptual frameworks ought to be examined as boundary objects for engaging with designers in structured and less structured applications, thereby facilitating the understanding of its strengths and limitations while ensuring its ability to assist non-specialists in recognising RE in CEBM.

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