INTERNATIONAL DESIGN CONFERENCE – DESIGN 2024
https://doi.org/10.1017/pds.2024.130

Identifying rebound effects in product-service systems: actors, mechanisms, triggers and drivers

Daniel Guzzo ✉ and Daniela C. A. Pigosso

Technical University of Denmark, DTU Construct, Denmark

✉ dgdco@dtu.dk

Abstract

The implementation of product-service systems (PSS) is prone to the occurrence of rebound effects (RE). This research aims to systematically identify the rebound mechanisms in a PSS context. Through the case study of a use-oriented PSS offer, we showcase a structured way to address RE that led to a comprehensive mapping of 23 mechanisms. The analysis demonstrates an approach to mapping rebound triggers, drivers, and mechanisms within the actors' realms that designers can apply to ensure the potential sustainability gains of PSS offers.

Keywords: product-service systems (PSS), sustainable design, design methods

1. Introduction

The empirical evidence for Rebound Effects (RE) offsetting the potential sustainability gains of Product-Service Systems (PSS) is surging. For instance, clothing rental has led to additional consumption due to the released budget by lower purchasing costs (Johnson and Plepys, 2021). Similarly, the availability of peer-to-peer boat sharing has increased other forms of travel, such as flying (Warmington-Lundström and Laurenti, 2020). Allais and Gobert (2016) suggest that the lower commitment required by rental services can cause additional demand, as customers may try products they would not otherwise have. They also highlight a potential shift in behaviour, emphasising that moving away from ownership might lead to less careful behaviour. The systematic literature review of 103 studies performed by Koide and colleagues (2022) shows that the expected sustainability gains of PSS are not being reached and suggests that further addressing RE is critical. The potential for RE occurrence in PSS solutions and the need for addressing them has also been pointed out from the outset by the PSS community (Aurich *et al.*, 2006; Bartolomeo *et al.*, 2003; Goedkoop *et al.*, 1999; Manzini and Vezzoli, 2003; Tukker, 2004).

RE is a systemic response to an intervention that offsets their potential sustainability gains (Hertwich, 2005; Lange *et al.*, 2021). Rebound mechanisms causally explain why and how RE occurs (Guzzo *et al.*, 2024; Lange *et al.*, 2021; Metic and Pigosso, 2022), and are defined as a feedback structure that explains the occurrence of RE originating from a sustainability action (Guzzo *et al.*, 2024). The mechanisms can be decomposed into specific triggers (i.e., factors mediating changes in consumption) and drivers (i.e., factors moderating changes in consumption). If changed, the interplay of triggers and drivers will influence resource consumption and lead to RE (Font-Vivanco *et al.*, 2016; Guzzo *et al.*, 2024). RE can partially offset the potential gains or even be higher than the potential gains (i.e., backfire) depending on its magnitude (Saunders, 2008). The modes of consumption are determinants of the RE magnitude: if the consumer engages in a low-intensity service, such as violin lessons, the magnitude is low; if they re-spend on flights, it is high (Goedkoop et al., 1999). RE can also positively impact if those

responses reinforce potential sustainability gains leading to Secondary Benefits (SB) (Kjaer *et al.*, 2018, 2019; Saunders, 2008).
In this context, the prevention of RE during PSS design is fundamental to ensure that the potential sustainability gains of PSS are reached after its implementation (Barquet *et al.*, 2016). Investigating RE should, therefore, be central to the design community as the occurrence of RE poses severe risks of not reaching the expected sustainability and circularity gains (Guzzo *et al.*, 2019; Tukker, 2015). Nevertheless, identifying the ex-ante occurrence of RE is challenging: the complexity and interrelatedness of systems limit the capacity to foresee the potential RE of PSS offers (Manzini and Vezzoli, 2003). A few studies have proposed the systematic examination of RE in PSS design. For example, Kjaer et al. (2018) provided guidelines for identifying PSS's potential direct and indirect RE through Life Cycle Assessment (LCA). Furthermore, Kjaer et al. (2019) provided a tool to analyse the resource decoupling potential of PSS offers, aiming to avoid burden shifting between life cycle stages and mitigate potential RE. Alfarisi et al. (2022) provided a framework for detecting RE throughout the PSS lifecycle. Finally, Sarancic et al. (2023) used the rebound effect framework (Metic and Pigosso, 2022) to identify positive and negative hotspots in PSS offers.
Nevertheless, there is still limited research investigating the reasons for RE occurrence within a PSS context, i.e., connecting the core of the PSS offer to the structures that can explain the systemic responses that lead to RE. Therefore, this research aims to systematically identify the causal elements leading to RE in a PSS context, exploring and describing the role of actors, mechanisms, triggers and drivers in RE occurrence in the context of PSS.
Section 2 describes the research methodology employed in this research and is followed by the description of the research results (Section 3). Subsequently, insights for addressing RE in PSS design are highlighted (Section 4). Finally, the conclusions and final remarks are presented in Section 5.

2. Research methodology

This research adopts an inductive approach to answering the following research question: "How to systematically identify rebound mechanisms of PSS?". It is based upon the document analysis (Yin, 2009) of a use-oriented PSS case (research input 1) and collections of rebound triggers, drivers and mechanisms (research inputs 2 and 3, respectively). Figure 1 illustrates the three main research steps alongside the research inputs and outputs.

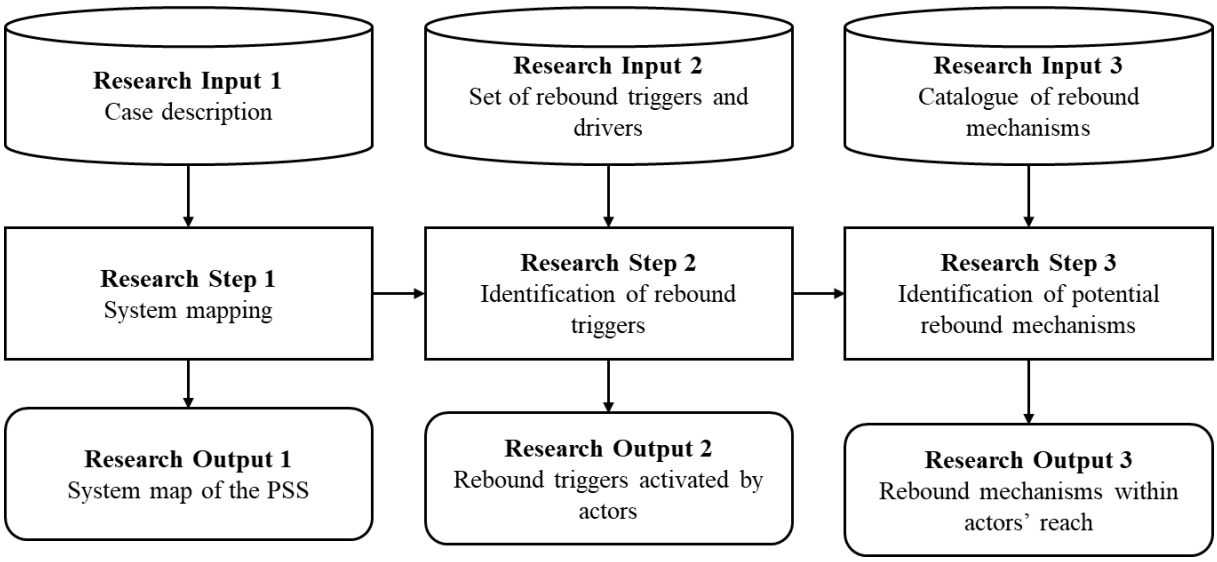

Figure 1. Main research steps, inputs and outputs

The selected use-oriented PSS case is Bundles (washing machine as a service), investigated through three main sources: Ref 1: CE Knowledge Hub case description (Grassi and Zimmer, 2021); Ref 2: Ellen

https://doi.org/10.1017/pds.2024.130 Published online by Cambridge University Press

Macarthur Foundation case description (Ellen Macarthur Foundation, 2021) and Ref 3: Bundles website (Bundles, no date). The research step 1 consisted of mapping the PSS system based on the case descriptions available, focusing on visualising the configuration of the use-oriented PSS offer, the actors, components, and interaction flows (based on Vezzoli et al. (2014)). The expected environmental and business gains were stated.
Research step 2 consisted of systematically identifying and analysing rebound triggers and drivers in the PSS offer within the realm of the identified actors. The identification was based on content analysis of the case descriptions. The analysis identified the release or additional constraining of rebound triggers and drivers obtained from the literature (Table 1).

Table 1. Research Input 2: exemplary set of triggers and drivers of rebound mechanisms

Classes of triggers and drivers	Set of exemplary triggers and drivers	Set of references
Economic/financial	Price, available income, profits	(Azevedo, 2014; van den Bergh *et al.*, 2011; Castro *et al.*, 2022; Metic and Pigosso, 2022; Sorrell *et al.*, 2020)
Consumer choices	Preferences, environmental motivation	
Company choices	Capital productivity, re-investment in innovation	
Socio-cultural	Cultural acceptance, status	
Physical constraints	Time, space	
Goods and services attributes	Substitutability, utility	

Finally, research step 3 consisted of the identification and description of potential rebound mechanisms for the case under investigation, following a five-step approach:

- Step 3.1. Identify the potential consumption modes for the actors (e.g., consumption of the same product/service/process or of a different product/service/process).
- Step 3.2. Identify the eligible rebound mechanisms by analysing the released triggers and drivers against the catalogue of mechanisms (Guzzo *et al.*, 2024). For example, if time is released, the related mechanisms should be considered.
- Step 3.3. Develop assertions of how the dynamic interplay of triggers and drivers can activate the consumption modes.
- Step 3.4. Develop assertions of how the drivers can limit those dynamics.
- Step 3.5. Elaborate on the dynamics of potential rebound mechanisms specific to the case.
- Step 3.6. Repeat 3.3, 3.4, and 3.5 for secondary benefits (SB).

The case-specific mechanisms were determined based on the dynamics emerging from the release and constraining of identified rebound triggers and drivers that feedback into decreasing the PSS offer's potential sustainability gains (i.e., RE) or increasing its sustainability gains (i.e., SB).

3. Results: rebound effects within PSS

In addition to describing the PSS system map (Section 3.1), the rebound triggers (Section 3.2) and the rebound mechanisms (Section 3.3), this section includes insights into the prevention of potential RE within PSS design (Section 3.4).

3.1. System map: washing machine as a service

Washing machine as a service involves the interplay of four main actors (A1, household; A2, PSS provider; A3, Real estate company; A4, manufacturer), with the machine as a critical component (Figure 2).

https://doi.org/10.1017/pds.2024.130 Published online by Cambridge University Press

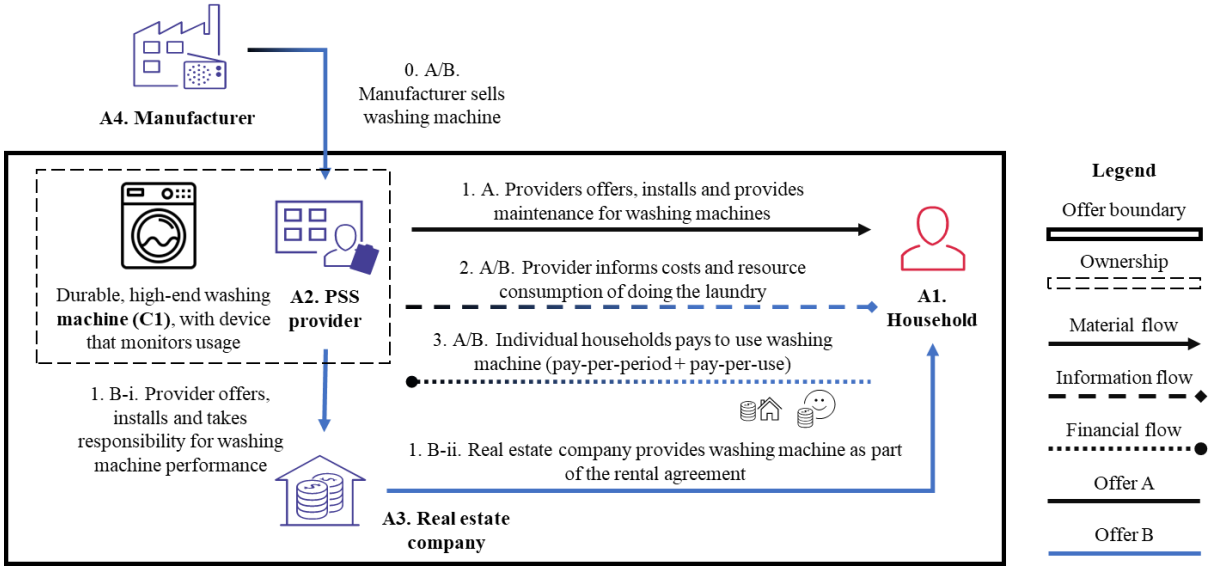

Figure 2. System map making explicit actors, components, and interaction flows

The main offer consists of pre-configured subscription packages made available directly to household customers (Offer A). In addition to offering, installing, and taking responsibility for the washing machine's performance, the PSS provider informs the costs and resource consumption of laundering through an online platform based on an IoT device installed in the machine. Individual households pay to use the washing machine in a pay-per-period and a pay-per-use format, i.e., a monthly fee and a fee for using the machine. One variation of the offer occurs via real estate companies that incorporate the washing machines as part of the rental agreement, acting as a key partner for customer acquisition and releasing the financial burden on the PSS provider (Offer B). In both offers, the manufacturer sells the washing machine to the PSS provider, which keeps its ownership the whole time.

The expected environmental sustainability gains come from the increased usage rate of durable products (Refs 1 and 3) with more efficient use of consumables and energy (Refs 1 and 2). Essentially, the full care provided by the PSS provider and the continuous provision of information connected to costs and resource consumption enabled by the monitoring systems enable those sustainability gains. From a business perspective, the PSS offer relies upon an economic win-win-win for the PSS provider, the household, and the real estate company, in addition to convenience and peace of mind for the household.

3.2. Rebound triggers and drivers activated by the involved actors

Table 2 lists the 17 rebound triggers and drivers identified from the case descriptions for each actor alongside their most likely effect on additional resource consumption.

For example, the economic and financial triggers and drivers will influence the household budget dynamics, ultimately influencing consumption. From one side, reduced investment cost (TD1), reduced use costs due to more efficient use (TD3), and the decreasing price per use (TD4) will release the consumption budget, while the increased lifetime costs when compared to purchasing (TD2) might constrain it. Meanwhile, the easiness of getting household chores done (TD5) can also influence consumption dynamics. Of the ten triggers and drivers relevant to the customer (household), four are economic/financial, five are due to consumer choices, and 1 to physical constraints.

Apart from the household, one trigger was identified for the PSS provider, the real estate company and the manufacturer. Finally, four triggers were identified within the realm of the machines, e.g., longer lifetime (TD14) and fewer functionalities (TD15) than common machines.

https://doi.org/10.1017/pds.2024.130 Published online by Cambridge University Press

Table 2. List of rebound triggers and drivers (TD) identified from the case descriptions

Actor \ component	TD class	TD description	Effect	Case ref
A1. Household	Economic/ financial (E/F)	TD1 - Reduced (investment) costs	Release	1, 2, and 3
		TD2 - Increased lifetime costs when compared to purchasing	Constrain	Assumption
		TD3 - Reduced use costs due to more efficient use	Release	1, 2, and 3
		TD4 - Decreasing price per use the more times used		
	Consumer choices	TD5 - Easiness in getting household chores done	Release	2
		TD6 - Association of cost to use	Constrain	3
		TD7 - Easiness in joining the solution (e.g., getting rid of used machines at the start of the contract)	Release	2, 3
		TD8 - Moral licensing as engaging in sustainable activity	Release	Assumption
		TD9 - No ownership and no charges for repair	Release	Assumption
	Physical constraints	TD10 - Released time for household chores	Release	2
A2. PSS Provider	E/F	TD11 - Increased revenues through new market	Release	2
A3. Real estate company	E/F	TD12 - Increased revenues through new market	Release	1
A4. Manufacturer	E/F	TD13 - Decreased business-as-usual revenues	Constrain	Assumption
C1. Machine	Goods and services attributes	TD14 - Longer lifetime	Constrain	1, 2
		TD15 - Less unnecessary functionalities	Constrain	2,
		TD16 - Monitoring of use for enhanced performance of washing	Constrain	1, 2
		TD17 - Monitoring of use for enhanced management of machine lifecycle	Constrain	2

3.3. Identified rebound mechanisms

Table 3 shows the 23 mechanisms identified across the investigated actors. In total, 11 identified rebound mechanisms relied on responses from the household (M1-12), four from the PSS provider (M13-16), two from the real estate company (M17-18) and two from the manufacturer (M19-20). Furthermore, three mechanisms are related to the responses of multiple actors: two to the PSS provider and the manufacturer (M21-22) and one to the PSS provider and the collective of households (M23). Sixteen of the identified mechanisms are instances of those available in Guzzo et al. (2024), while the six marked with an asterisk constitute additional mechanisms not yet included in the catalogue.

Fifteen of the mechanisms are prone to RE (i.e., offsets the potential sustainability gains). For example, households may wash clothes more often because of reduced costs due to more efficient use (TD3), reinforced by the decreasing price per use (TD4) – income mechanism (M2). This mechanism is counterbalanced by increased lifetime costs (TD2), monitoring of use (TD16), and the association of cost to use (TD6). Meanwhile, eight mechanisms can lead to secondary benefits (i.e., increasing the potential sustainability gains). For example, the PSS provider may use increased revenues (TD11) to make operations of the PSS solution more efficient and further expand the business model – the output mechanism (M13). This mechanism is limited by the willingness to re-invest its profits and the actual sustainability gains the offer can deliver, including RE.

https://doi.org/10.1017/pds.2024.130 Published online by Cambridge University Press

Table 3. Identified rebound mechanisms for each actor (A1. Household; A2. PSS provider; A3. Real estate company; A4. Manufacturer); RE/SB indicates if the dynamics will likely lead to a rebound effect or a secondary benefit

A	Mechanism	Dynamics >> RE/SB	Limiting dynamics
A1	M1 - Income	Spending of reduced investment costs (TD1) into subscribing to additional machines >> RE	Limited by the need for only one machine
	M2 - Income	Spending of reduced use costs due to more efficient use (TD3), reinforced by the decreasing price per use (TD4) leading to washing more >> RE	Counterbalanced by increased lifetime costs (TD2), monitoring of use (TD16), and the association of cost to use (TD6)
	M3 - Consumption time	Less time used for household chores (TD10) leading to washing more >> RE	Limited by the household need for washing. Counterbalanced by the monitoring of use (TD16)
	M4 - Motivational consumption	Easiness in joining the solution (TD7) leading to additional machines >> RE	Limited by the need for only one machine
	M5 - Motivational consumption	Easiness in getting household jobs done (TD5) leading to washing more >> RE	Same as M3
	M6 - Re-spending (with limited income)	Released investment costs (TD1) used to purchase other products and services, especially if they fail to account for the lifetime costs (TD2) >> RE	Limited by the household income. Influenced by sustainability impacts of the other products and services
	M7 - Substitution	Reduced investment costs (TD1) attracting users of laundry services or shared facilities >> RE	Limited by other factors (e.g., space and infrastructure access). Influenced by resource consumption of other services
	M8 - Motivational substitution	Facilitated access (TD5) attracting users of laundry services or shared facilities >> RE	Same as M7
	M9* - Moral licensing	Accumulation of moral points (TD8) due to sharing spent in resource-intensive products or services >> RE	Same as M7
	M10* - Less careful behaviour	Consumers take less care of the product (TD9) as they do not own it, decreasing their lifetime >> RE	Counterbalanced by monitoring of use (TD16 and TD17)
	M11* - Substitution due to consumption time	Less time used for household chores (TD10) attracts users of laundry services or shared facilities >> RE	Same as M7
	M12* - Substitution due to consumption time	Less time used for household chores (TD10) is used for other activities >> RE	Influenced by the resource consumption of the activity
A2	M13 - Output	Increased revenues (TD11) used to make operations of the PSS solution more efficient >> SB	Limited by the willingness to re-invest its profits and the offer's sustainability gains, including RE
	M14 - Re-investment	Increased revenues (TD11) re-invested in PSS solutions of other products >> SB	Same as M13
	M15 - Cost-dependent output	Increased revenues (TD11) used to make operations of the solution more efficient, which also contributes to PSS solutions of other products >> SB	Same as M13
	M16* - Less careful behaviour	Providers take less care of the product if they can't take any value from the machine >> RE	Counterbalanced by long lifetime machines (TD14) and monitoring use for enhanced lifecycle management (TD17)

https://doi.org/10.1017/pds.2024.130 Published online by Cambridge University Press

A	Mechanism	Dynamics >> RE/SB	Limiting dynamics
A3	M17 - Output	Increased revenues (TD12) encouraging the adoption of PSS solutions >> SB	Same as M13
	M18 - Re-investment	Increased revenues (TD12) used for construction of buildings >> RE	Limited by the willingness to re-invest its profits and the resource consumption of the activity
A4	M19 - Output	Decreased business-as-usual revenues (TD13) leading to the phase-out of the as-is business model >> SB	Limited by the willingness to disinvest.
	M20* - Demand adjustment initiated by effectiveness	Decreased business as usual revenues (TD13) leading to a price war >> RE	Limited by the profitability
A2 A4	M21 - Re-design	Provider influences manufacturers to decrease the functionality (TD15) to the most sustainable options >> SB	Limited by the minimum functionality possible
	M22 - Re-design	Provider influences manufacturer to increase the lifetime of products (TD14) as their revenues are connected to that (TD11) >> SB	Limited by the lifetime potential
A2 A1	M23 - Labour income (with limited labour supply)	Increased revenues (TD11) used to keep wages of the PSS provider workforce higher than average leading to additional consumption >> RE	Limited by the labour supply

The co-existence of RE and SB within each actor realm shows that the roles they can play in influencing sustainability gains are not given or static. On the one hand, actors may consume more, leading to RE. For example, households can obtain additional washing machines, wash more times, substitute other more efficient means for washing, and consume something else. The manufacturer may reinforce the business-as-usual model (i.e., based on selling machines with a lower lifetime). Finally, the real estate company may engage in building more.

On the other hand, actors can contribute to further limiting resource consumption. For example, a PSS provider making PSS offers operations more efficient and re-investing into other PSS offers. The manufacturer may decrease the functionalities while focusing on the most sustainable ones, increase machine lifetime, and, ultimately, phasing out the business-as-usual model. Finally, the real estate company may include other PSS offers in their buildings.

It is also important to notice that several mechanisms can influence the same consumption mode. For example, income (M2), consumption time (M3), and motivation through ease of getting household jobs done (M5) can simultaneously lead a household to wash more. In other words, it is the interplay between reduced use costs due to more efficient use (TD3) considering decreasing price per use (TD4), released time for household chores (TD10), and facilitation of getting household chores done (TD5) that should determine the conditions for RE. In that sense, limiting the release of those triggers and drivers is critical in mitigating these mechanisms. The PSS solution already partially deals with it by monitoring use (TD16) and associating cost to use (TD6). Nevertheless, there may be other options to do so. For example, could the solution further influence households' use of released time towards less resource-intensive behaviour?

4. Discussion: insights for addressing RE in PSS design

The release of consumption constraints has been extensively indicated as the cause of RE occurrence in PSS offers (Bartolomeo *et al.*, 2003; Kjaer *et al.*, 2018, 2019) and should be a primary concern for designers (Koide *et al.*, 2022). Also, designers should be further supported in identifying the actor's realms of influence if they aim to mitigate RE (Kjaer *et al.*, 2019). Based on the systematic analysis of the case, this section contains four insights for addressing RE in PSS design.

https://doi.org/10.1017/pds.2024.130 Published online by Cambridge University Press

First and foremost, identifying rebound mechanisms requires a deep understanding of the offer. Using the system map in this research helped make the PSS offer tangible while highlighting the actors, their interactions, and their sphere of action. Furthermore, the map helped position the triggers, drivers, and mechanisms, working as a framework to discuss the means for addressing RE. Therefore, the system map can be used to visualise the configuration of the PSS offer before diving into the investigation of rebound mechanisms.

Secondly, the rebound triggers and drivers are the critical link to systematically identify rebound mechanisms. Investigating the changes in the triggers and drivers that can offset or reinforce sustainability gains of offers was vital in determining the relevant rebound mechanisms and their dynamics. When designing a PSS, systematically identifying the rebound triggers and drivers building upon known consumption factors can pave the way to identify eligible rebound mechanisms the offer may activate.

Thirdly, addressing rebound mechanisms requires understanding how they happen. Towards the prevention of potential RE, a careful consideration of the RE dynamics (including the limiting dynamics) will help answer the reasons for constrained sustainability gains. Also, the cross-analysis between rebound mechanisms can be enabled by analysing the ones influencing similar modes of consumption or being activated by similar triggers and drivers. When designing a PSS, it is essential to systematically understand the most sensitive triggers and drivers for additional resource consumption to find ways to integrate design features that further limit those dynamics.

Lastly, RE can be addressed by design by preventing the occurrence of RE and nurturing the intensification of SB. Addressing RE means influencing actors in the right direction, i.e., away from additional consumption and towards further limiting it. When designing a PSS, it is critical to consider the dynamics of mechanisms leading to SB so that solutions can further nurture actors towards enhanced sustainability gains.

5. Conclusion and final remarks

The results demonstrated an approach for systematically identifying rebound mechanisms in a PSS context. The research procedure and results showcase a structured way to address RE in PSS design based on a careful analysis of the system configuration of a use-oriented PSS offer, the systematic identification of the further released or constrained rebound triggers and drivers, and a description of the potential mechanisms' dynamics within the realm of each actor. The analysis led to a comprehensive mapping of 23 mechanisms for the washing machine case, with a thorough description of the RE dynamics to provide actionable insight for action. Also, it clarifies the set of 17 triggers and drivers within the actors' realms that designers could aim to influence through changes in the PSS offer. The research unfolds four main insights for addressing RE in PSS design.

Overall, this research provides practitioners with an approach to systematically identify rebound mechanisms during PSS conceptual design. This capability is valuable for companies as it can enhance their odds of reaching their sustainability goals without being surprised by RE. In the face of the state-of-the-art research, this research clarifies the complex dynamics leading to RE in PSS (Manzini and Vezzoli, 2003) in a way that enables tackling RE in the design phase (Barquet et al., 2016). It revisits the meaning of rebound triggers, drivers, and mechanisms (Guzzo et al., 2024; Sarancic et al., 2023) to provide a stepwise way to identify potential RE (and SB) in PSS cases. The high quantity of plausible mechanisms identified, with a thorough description of their dynamics, indicates noticeable effectiveness of the proposed approach in identifying the causal elements leading to RE in a PSS context.

A few limitations provide plenty of space for additional research. First, this work showcases that rebound mechanisms go beyond the financial/economic responses to change. In reality, most triggers and drivers identified for households are related to consumer choice. Meanwhile, most consumer choice-related mechanisms were outside the catalogue of mechanisms used as a reference. For example, the moral licensing (M9) mechanisms are very likely as sharing has a positive connotation in consumers' minds and may lead them to spend their "moral points" on resource-intensive activities. Nevertheless, moral licensing is not yet included in the catalogue. Furthermore, the gap between the number of triggers and drivers and the number of mechanisms identified relating to consumer choice shows that there is space to extend the state-of-the-art understanding of rebound mechanisms. Future research steps should

https://doi.org/10.1017/pds.2024.130 Published online by Cambridge University Press

further explain the rebound mechanisms dynamics emerging from consumer choices so that designers can better identify them in advance.

Second, a long list of rebound mechanisms can overload design decision-making, as a list of 23 plausible mechanisms can be hard to prioritise. Meanwhile, their descriptions may hint at their likelihood and potential impact. For instance, the income mechanisms activated by actors into subscribing to additional washing machines seem low, as households do not need more than one washing machine. On the other hand, the potential impact of re-spending on other products and services due to released investment costs seems more likely and detrimental. Future research should help assess the most likely and potentially impactful rebound mechanisms to help designers prioritise mitigation.

Finally, the long list of plausible rebound mechanisms provides evidence that the business logic sustaining the PSS offer is intrinsically connected with rebound triggers and drivers and, therefore, to rebound mechanisms. Nevertheless, the possibility of suggesting generalisations about to which extent the dynamics of sustainability-oriented innovations are prone to RE is still limited as this research builds upon the document analysis of only one case. Therefore, additional research should focus on conceptually understanding in which ways PSS, circular and sustainability business models are prone to RE so that designers can be better equipped to tackle them and enhance the likelihood of unfolding the complete sustainability potential of designed solutions.

Acknowledgements

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement no. 899987.

Co-funded by the European Union (ERC, REBOUNDLESS, 101043931). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Council. Neither the European Union nor the granting authority can be held responsible for them.

References

Alfarisi, S., Mitake, Y., Tsutsui, Y., Wang, H. and Shimomura, Y. (2022), "A study of the rebound effect on the product-service system: Why should it be a top priority?", Procedia CIRP, Elsevier B.V., Vol. 109 No. March, pp. 257–262, https://dx.doi.org/10.1016/j.procir.2022.05.246.

Allais, R. and Gobert, J. (2016), "A multidisciplinary method for sustainability assessment of PSS: Challenges and developments", CIRP Journal of Manufacturing Science and Technology, CIRP, Vol. 15, pp. 56–64, https://dx.doi.org/10.1016/j.cirpj.2016.04.007.

Aurich, J.C., Fuchs, C. and Wagenknecht, C. (2006), "Life cycle oriented design of technical Product-Service Systems", Journal of Cleaner Production, Vol. 14 No. 17, pp. 1480–1494, https://dx.doi.org/10.1016/j.jclepro.2006.01.019.

Azevedo, I.M.L. (2014), "Consumer end-use energy efficiency and rebound effects", Annual Review of Environment and Resources, Vol. 39, pp. 393–418, https://dx.doi.org/10.1146/annurev-environ-021913-153558.

Barquet, A.P., Seidel, J., Seliger, G. and Kohl, H. (2016), "Sustainability Factors for PSS Business Models", Procedia CIRP, Elsevier B.V., Vol. 47, pp. 436–441, https://dx.doi.org/10.1016/j.procir.2016.03.021.

Bartolomeo, M., Dal Maso, D., De Jong, P., Eder, P., Groenewegen, P., Hopkinson, P., James, P., et al. (2003), "Eco-efficient producer services - What are they, how do they benefit customers and the environment and how likely are they to develop and be extensively utilised?", Journal of Cleaner Production, Vol. 11 No. 8 SPEC., pp. 829–837, https://dx.doi.org/10.1016/S0959-6526(02)00157-9.

van den Bergh, J.C.J.M., Truffer, B. and Kallis, G. (2011), "Environmental innovation and societal transitions: Introduction and overview", Environmental Innovation and Societal Transitions, Elsevier B.V., Vol. 1 No. 1, pp. 1–23, https://dx.doi.org/10.1016/j.eist.2011.04.010.

Bundles. (n.d.). "Bundles", available at: https://bundles.nl/ (accessed 13 November 2023).

Castro, C.G., Trevisan, A.H., Pigosso, D.A. and Mascarenhas, J. (2022), "The rebound effect of circular economy: Definitions, mechanisms and a research agenda", Journal of Cleaner Production, Elsevier Ltd, Vol. 345 No. October 2021, p. 131136, https://dx.doi.org/10.1016/j.jclepro.2022.131136.

Ellen Macarthur Foundation. (2021), "A model offering multiple benefits for multiple electronic products: Bundles", available at: https://www.ellenmacarthurfoundation.org/circular-examples/a-model-offering-multiple-benefits-for-multiple-electronic-products (accessed 13 November 2023).

Font-Vivanco, D., McDowall, W., Freire-González, J., Kemp, R. and van der Voet, E. (2016), "The foundations of the environmental rebound effect and its contribution towards a general framework", Ecological Economics, Elsevier B.V., Vol. 125, pp. 60–69, https://dx.doi.org/10.1016/j.ecolecon.2016.02.006.

Goedkoop, M.J., Van Halen, C.J.G., Te Riele, H.R.M. and Rommens, P.J.M. (1999), "Product Service systems , Ecological and Economic Basics", Report for Dutch Ministries of Environment (VROM) and Economic Affairs (EZ), Amersfoort, https://dx.doi.org/10.1111/j.1365-294X.2004.02125.x.

Grassi, C.A. and Zimmer, J. (2021), "Subscription-based, payment per use, sensors for household washing equipment", Circle Economy, available at: https://knowledge-hub.circle-economy.com/cirkular/article/3543?n=Subscription-based%2C-payment-per-use%2C-sensors-for-household-washing-equipment (accessed 13 November 2023).

Guzzo, D., Trevisan, A.H., Echeveste, M. and Costa, J.M.H. (2019), "Circular Innovation Framework: Verifying Conceptual to Practical Decisions in Sustainability-Oriented Product-Service System Cases", Sustainability, Vol. 11 No. 12, p. 3248, https://dx.doi.org/10.3390/su11123248.

Guzzo, D., Walrave, B., Videira, N., Oliveira, I.C. and Pigosso, D.C.A. (2024), "Towards a systemic view on rebound effects: Modelling the feedback loops of rebound mechanisms", Ecological Economics, Vol. 217, p. 108050, https://dx.doi.org/10.1016/j.ecolecon.2023.108050.

Hertwich, E.G. (2005), "Consumption and the rebound effect: An industrial ecology perspective", Journal of Industrial Ecology, Vol. 9 No. 1–2, pp. 85–98, https://dx.doi.org/10.1162/1088198054084635.

Johnson, E. and Plepys, A. (2021), "Product-Service Systems and Sustainability : Analysing the Environmental Impacts of Rental Clothing", Sustainability, Vol. 13 No. 2118.

Kjaer, L.L., Pigosso, D.C.A., McAloone, T.C. and Birkved, M. (2018), "Guidelines for evaluating the environmental performance of Product/Service-Systems through life cycle assessment", Journal of Cleaner Production, Elsevier Ltd, Vol. 190, pp. 666–678, https://dx.doi.org/10.1016/j.jclepro.2018.04.108.

Kjaer, L.L., Pigosso, D.C.A., Niero, M., Bech, N.M. and McAloone, T.C. (2019), "Product/Service-Systems for a Circular Economy: The Route to Decoupling Economic Growth from Resource Consumption?", Journal of Industrial Ecology, Vol. 23 No. 1, pp. 22–35, https://dx.doi.org/10.1111/jiec.12747.

Koide, R., Murakami, S. and Nansai, K. (2022), "Prioritising low-risk and high-potential circular economy strategies for decarbonisation: A meta-analysis on consumer-oriented product-service systems", Renewable and Sustainable Energy Reviews, Elsevier Ltd, Vol. 155 No. October 2021, p. 111858, https://dx.doi.org/10.1016/j.rser.2021.111858.

Lange, S., Kern, F., Peuckert, J. and Santarius, T. (2021), "The Jevons paradox unravelled: A multi-level typology of rebound effects and mechanisms", Energy Research and Social Science, Elsevier Ltd, Vol. 74, p. 101982, https://dx.doi.org/10.1016/j.erss.2021.101982.

Manzini, E. and Vezzoli, C. (2003), "A strategic design approach to develop sustainable product service systems: Examples taken from the 'environmentally friendly innovation' Italian prize", Journal of Cleaner Production, Vol. 11 No. 8 SPEC., pp. 851–857, https://dx.doi.org/10.1016/S0959-6526(02)00153-1.

Metic, J. and Pigosso, D.C.A. (2022), "Research avenues for uncovering the rebound effects of the circular economy: A systematic literature review", Journal of Cleaner Production, Vol. 74 No. 1934, p. 133133, https://dx.doi.org/10.1016/j.jclepro.2022.133133.

Sarancic, D., Metic, J., Pigosso, D.C.A. and McAloone, T.C. (2023), "Impacts, synergies, and rebound effects arising in combinations of Product-Service Systems (PSS) and circularity strategies", Procedia CIRP, Elsevier B.V., Vol. 116, pp. 546–551, https://dx.doi.org/10.1016/j.procir.2023.02.092.

Saunders, H.D. (2008), "Fuel conserving (and using) production functions", Energy Economics, Vol. 30 No. 5, pp. 2184–2235, https://dx.doi.org/10.1016/j.eneco.2007.11.006.

Sorrell, S., Gatersleben, B. and Druckman, A. (2020), "The limits of energy sufficiency: A review of the evidence for rebound effects and negative spillovers from behavioural change", Energy Research and Social Science, Elsevier, Vol. 64 No. February, p. 101439, https://dx.doi.org/10.1016/j.erss.2020.101439.

Tukker, A. (2004), "Eight types of product-service system: Eight ways to sustainability? Experiences from suspronet", Business Strategy and the Environment, https://dx.doi.org/10.1002/bse.414.

Tukker, A. (2015), "Product services for a resource-efficient and circular economy - a review", Journal of Cleaner Production, Elsevier Ltd, Vol. 97, pp. 76–91, https://dx.doi.org/10.1016/j.jclepro.2013.11.049.

Vezzoli, C., Kohtala, C., Amrit, S., Diehl, J., Moi Fusakul, S., Xin, L. and Sateesh, D. (2014), Product-Service System Design for Sustainability, Greeleaf Publishing Limited, Sheffield.

Warmington-Lundström, J. and Laurenti, R. (2020), "Reviewing circular economy rebound effects: The case of online peer-to-peer boat sharing", Resources, Conservation and Recycling: X, Elsevier, Vol. 5 No. July 2019, p. 100028, https://dx.doi.org/10.1016/j.rcrx.2019.100028.

Yin, R.K. (2009), Case Study Research: Design and Methods, Essential Guide to Qualitative Methods in Organizational Research, Vol. 5, https://dx.doi.org/10.1097/FCH.0b013e31822dda9e.