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Uncovering rebound effects of sufficiency-oriented product-service systems: a systematic review

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Abstract

The discourse surrounding sustainable consumption and production has evolved to encompass sufficiency strategies in addition to efficiency and effectiveness. Product-service systems (PSSs) can promote sufficiency by replacing traditional product-intensive systems with dematerialized services and changes in ownership structures. Sufficiency-oriented PSS may, however, generate rebound effects which offset potential sufficiency benefits or even result in backfire. This paper examines the connection between sufficiency-oriented PSS and rebound reviewing 12 empirical studies addressing rebound.

Keywords: sufficiency, product-service systems (PSS), rebound effects, sustainable design

1. Introduction

Global environmental challenges such as climate change and biodiversity loss require profound changes in production and consumption systems (O'Neill et al., 2010). Over the past few years, the conventional discourse about sustainable production and consumption systems has revolved around efficiency and effectiveness strategies (Braungart et al., 2007). These aim at making production processes and end-use products and services more efficient through technological improvements (Santarius et al., 2016), and at maintaining (or upgrading) effectiveness and productivity of material through circular use (Castro et al., 2022). Nevertheless, efficiency and effectiveness strategies have proven inadequate at addressing the global environmental crises due to the presence of rebound effects (Nørgaard & Xue, 2016).

Sufficiency has emerged as a third strategy, offering a more radical perspective on sustainable production and consumption (Spangenberg & Lorek, 2019). Like the concept of resource conservation, 'sufficiency' refers to the reduction of society's consumption of products and services to minimize environmental impacts (Figge & Thorpe, 2023). Sufficiency strategies are not restricted to *voluntary* or *altruistic* reductions in consumption (Alcott, 2008; Baumgartner et al., 2022; Figge & Thorpe, 2023), but also include strategies which ultimately reduce the volume of products and services through changes in consumption patterns (Sandberg, 2021) and business practices (Niessen & Bocken, 2021).

Product-service systems (PSS) have recently gained attention as potential means to achieve sufficiency (Vezzoli et al., 2021). PSS involve alternative business models that combine tangible products with intangible services (Tukker & Tischner, 2006), and include the access to a product (i.e., use-oriented), performance (i.e., result-oriented), or the provision of additional services, like repair, to an existing product system (i.e., product-oriented) (Kjær et al., 2018). Such 'servitization' of products (Annarelli et al., 2021) can promote sufficiency by replacing the traditional resource-intensive utilization of products with *"the possibility to fulfil consumers' needs through the provision of more dematerialized services … often associated with changes in the ownership structure"* (Mont, 2002, p.238).

More specifically, PSS can promote sufficiency by (1) increasing product longevity, (2) reducing private and/or single-use consumption through optimization of product ownership, (3) providing opportunities for compositional changes to less resource-intensive goods & services (e.g. modal shifts), reducing the consumption of resource-intensive complementary or substitute products & services, and (4) encouraging sufficient consumption through the sale of product performance (Sandberg, 2021; Niessen & Bocken, 2021), such as a pay-per-print service. PSS can also promote sufficiency through (5) voluntary reductions in the number of products & services produced (i.e., 'Refuse' strategy) or by encouraging consumers to question consumption (Niessen & Bocken, 2021). There is still, however, considerable uncertainty about the sustainability performance of sufficiency-oriented PSS. In fact, the same applies to overlapping concepts, such as the service (Stahel, 1997) or functional economy (Stahel, 2005); the sharing economy (Heinrichs, 2013), collaborative consumption (Delgado et al., 2023); access-based consumption (Bardhi & Eckhardt, 2012); and the repair and leasing society (Mont, 2002).
One sustainability challenge that has so far received little attention is the rebound effects of sufficiency-oriented PSS. Rebound effects (RE) are the partial or complete offsetting of potential environmental savings triggered by sustainability-oriented interventions that arise due to changes in human behavior and system structure (Hertwich, 2005; Suffolk & Poortinga, 2016; Makov & Vivanco, 2018; Gava et al., 2020). Rebound can even take the form of backfire, i.e., equal to or more than 100% rebound, meaning that all initial savings are (more than) offset by indirect effects (Saunders, 2000).
Rebound effects triggered by efficiency and effectiveness have often been cited as argumentation in favor of sufficiency, particularly within degrowth research (Lorek & Spangenberg, 2019; Schröter et al., 2017); however, sufficiency strategies introduced in isolation within market economies structurally dependent on economic growth risk giving rise to sufficiency RE (Nørgård & Xue, 2017; Lage, 2022). For example, a sufficiency-led decrease in demand leads to lower overall market prices, producing a 'sufficiency shock' which attracts consumers who are *not* consuming sufficiently, ultimately driving demand (Alcott, 2010). While environmental policies, like carbon pricing, can incentivize sufficiency choices (Sorrell et al., 2020), sufficiency can also be planned in the design of alternative business models, like PSS (Roman et al., 2023). Designers of sufficiency-oriented PSS must, therefore, have a comprehensive and nuanced understanding of relevant triggers, mechanisms, and magnitudes of sufficiency RE to prevent them from occurring (Sarancic et al., 2023).
This paper examines the connection between sufficiency-oriented PSS and RE from conceptual and empirical angles. To this end, it explores the literature on RE of sufficiency-oriented PSS. This involves a systematic literature review of empirical studies of sufficiency-oriented PSS and rebound. Based on this, we identify triggers and mechanisms, as well as estimated magnitudes of RE. Several gaps in the literature are identified. The paper ends with situating sufficiency-oriented PSS within the growth debate (i.e., green-growth, agrowth, and degrowth), and with recommendations for future research.

2. Method

This paper aims to analyze the state-of-the-art of studies exploring the RE of sufficiency-oriented PSS. This is achieved through a systematic review of existing literature based on the framework outlined by Biolchini et al. (2005). The analysis presented here builds upon a larger systematic literature review conducted to systematize and consolidate existing empirical studies on RE. Studies exploring the RE of sufficiency-oriented PSS were selected and subsequently analyzed with respect to the following research questions: (R1) How are RE estimated and/or described in existing empirical studies of sufficiency-oriented PSS?; (R2) What are the primary triggers and mechanisms of RE of sufficiency-oriented PSS?; and (R3) What are the estimated magnitudes of the identified RE of sufficiency-oriented PSS?
The search in the SCOPUS database (November 2022, see search string in supplementary material) produced 1413 results, 320 of which were selected based on the following exclusion criteria: (1) The study does not evaluate the (potential) RE in detail. (2) The study fails to explicitly link the effect/outcome to a sustainability-oriented intervention. (3) The publication is primarily a theoretical paper, a framework paper, a commentary paper or a letter to the editor, or a book chapter using the RE case as an example. Furthermore, backward snowballing (Wohlin, 2014) was applied, involving the cross-referencing of papers in the review, adding 70 publications. In total, the systematic review of existing empirical RE studies consisted of 390 publications. Sufficiency-oriented PSS studies were

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selected from the 390 publications through the filtering of 'product-service systems' and 'sufficiency', resulting in 12 sufficiency-oriented PSS RE publications.

The selected studies were classified as sufficiency-oriented PSS RE studies if: (1) the study explores RE (presumably) caused by PSS; and (2) the PSS is sufficiency-oriented. More specifically, the product system was considered a PSS if it (1a) combines tangible products with intangible services, (1b) and involves an interaction between customers and producers along the value chain (1c) influencing production and consumption structures (Tucker & Tischner, 2006). The PSS was considered sufficiency-oriented if it entails (2a) voluntary reductions in the amount of products & services produced (i.e., 'Refuse' strategy) (Niessen & Bocken, 2021) or strategies to encourage consumers to question and voluntarily reduce their consumption (Gossen et al., 2019), (2b) reductions in the production/consumption of products with increased longevity (direct) or their complements/substitutes (indirect) (Sandberg, 2021), (2c) displacing private and/or single-use consumption through changes in ownership structures, allowing for optimized use of product ownership (Kjær et al., 2018), (2d) qualitative compositional changes to less resource-intensive products/services (e.g. modal shifts) (Sandberg, 2021), reducing the consumption of resource-intensive complements/substitutes, or (2e) encouraging sufficient consumption in use through result-oriented PSS (Tukker, 2004).

In total, 530 rebound instances were identified from the 390 publications (e.g., RE of a variety of sustainability-oriented interventions). Of those, 15 sufficiency-oriented PSS rebound instances were identified from 12 publications (two of the publications (Font Vivanco et al., 2015; Harris et al., 2021) assess the RE of more than one PSS). This large reduction (from 530 to 15 rebound instances) is unsurprising given the fact that over three-quarters (78.11%, 414) of the RE instances assess efficiency strategies, and only 2.45% assess sufficiency strategies. This is to be expected given that the original conception of RE took place in the field of energy studies (Santarius et al., 2016). The large reduction of studies is also due to the fact that sufficiency as a sustainability strategy (Jungell-Michelsson & Heikkurinen, 2022) has received attention in PSS research only relatively recently.

The analysis of the 12 selected publications and 15 instances involved the identification of: (1) the RE, including (1a) descriptive analysis; (1b) quantification of the RE magnitude (if any); (1c) primary RE triggers and mechanisms; and (2) the sufficiency-oriented PSS, including (2a) a description/ classification of the PSS; (2b) argumentation for how the PSS is sufficiency-oriented; and (2c) social needs area targeted by the PSS. 'Mechanism' refers to the cause-effect relationships between the system elements explaining the offsetting of RE (Lange et al., 2021; Guzzo et al., 2023). 'Trigger' refers to the system element that activates the RE mechanism (Guzzo et al., 2023). The classification of PSS types refers to use-oriented, result-oriented, or product-oriented (Tukker, 2004), described in the introduction. The social needs areas fulfilled by the PSS are categorized across mobility, housing, consumables, or nutrition needs (Circularity Gap Report, 2023). Additional information was analyzed regarding the methodological approach, the methods, and the rebound magnitude estimation techniques (see table 1 in supplementary material **DOI**).

3. Results

Only a small share of studies attempts to explain, describe, estimate, or anticipate RE triggered by sufficiency-oriented PSS (i.e., 12 out of 390 studies). The RE of sufficiency-oriented PSS are primarily explored within the mobility needs area - i.e., car-sharing (7 instances of 15), ride-sharing (1), bicycle-sharing (1), and boat-sharing (1) – but also in the consumables social needs areas - i.e., tool-sharing (1), office-sharing (1), and textile leasing (1) – and one study within housing - i.e., smart homes (1). One study explored a mix of PSS cases across multiple social needs areas (1). The types of sufficiency-oriented PSS in this review primarily aim to reduce private and/or single-use consumption through optimization of product ownership as a sharing system, a leasing system, or a mix of both. One PSS, smart home assistance (Chen et al., 2018), encourages consumers to question consumption.

The inclusion of RE in these studies either 1) describe the potential for RE to occur in qualitative terms (Iran & Müller, 2020; Harris et al., 2021; Siderius & Poldner, 2021); 2) anticipate RE behavior in the calculation of the environmental impact of the PSS (modeling the behavior exogenously) in ex-ante simulations (Briceno et al., 2005; Chen & Kockelman, 2016; Menon & Mahanty, 2015; Tsuji et al., 2015); or 3) estimate the RE magnitude ex-post using environmental accounting methods (Amutani et al., 2020; Font Vivanco et al., 2015; Yin et al., 2018; Warmington-Lundström & Laurenti, 2020). The

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studies employ a wide range of estimation methods to quantify the RE, including comparisons of environmental impact before and after the PSS interventions, for example, using consumption data and life cycle assessment (LCA); calculation of indirect rebound using re-spending models (based upon LCA and Input-Out frameworks); and comparisons of environmental impacts of different scenarios using System Dynamics or Monte Carlo simulation. Furthermore, several environmental impact indicators are used to quantify the RE magnitude, including: greenhouse gas (GHG) emission savings, Global Warming Potential (GWP), carbon dioxide (CO_2) emission savings, energy demand, or total power consumption.

3.1. Rebound triggers and mechanisms

Four RE mechanism clusters, that is RE mechanisms with similar causal structure, are identified from the literature (figure 1):

1. ***Re-spending of freed-up resources.*** Sufficiency-oriented PSS may 'free-up' financial, temporal, or moral resources that can be subsequently re-spent on other products, services and activities that also entail environmental impact, such as additional energy consumption - either directly or indirectly along the relevant supply chains (Sorrell et al., 2021).
    a. ***Financial resources*** freed up by the PSS are re-spent either on more consumption of the same product/service (direct rebound) or on more consumption of other (less sustainable) products/services (indirect rebound). This kind of effect is also called price or income effect (Metic & Pigosso, 2022). An example of a re-spending effect is using the monetary savings of a smart-home PSS to consume more energy through increased household temperatures or brightness (Chen et al., 2018). Over half of the RE mechanisms (53.33%, 8 of 15 instances) are related to re-spending of financial resources (Briceno et al., 2005; Chen & Kockelman, 2016; Menon & Mahanty, 2015; Yin et al., 2018; Iran & Müller, 2020).
    b. ***Temporal resources*** freed up by the PSS are 're-spent', or re-allocated, towards more consumption of the same product/service (direct rebound) or towards more consumption or less sustainable consumption of other products, services or activities (indirect rebound). These effects are also called time-use RE (Sorrell et al., 2020). An example of a time-use RE is using time freed up through a PSS, such as a car-sharing system, to engage in consumption-intensive activities, like shopping (see Iran & Müller, 2020).
    c. ***Psychological resources*** are 'freed up' through the moral licensing psychological mechanism, and are 're-spent', or re-allocated, towards less sustainable activities (Sorrell et al., 2020). Moral licensing can be explained as "the cognitive process by which individuals justify immoral behavior (e.g. driving more) by having previously engaged in moral behavior (e.g. purchasing a more efficient car)" (Dütschke et al., 2018, p.1). This is also called 'spillover' (Sorrell et al., 2020). An example of moral licensing is provided in qualitative interviews regarding participation in PSS: "Some participants (four) claimed that they treated themselves when they used alternative consumption offers because they felt they did something right" (Iran & Muller, 2020, p.12-13).
2. ***Systems-level convenience effects***. These effects describe changes toward less sustainable consumption patterns as the result of increased consumer accessibility at the systems-level, which might also be considered a 'consumption efficiency' RE (Metic & Pigosso, 2022). Yin et al. (2018) provide examples of systems-level convenience effects, describing three qualitative changes in travel consumption patterns due to the decreased travel congestion brought about by ride-sharing schemes (i.e., increased road accessibility): 1) mode switching (i.e., replacing public transport or active modes of travel), 2) driving longer distances, and finally, 3) relocating further outside of metropolitan area (Yin et al., 2018).
3. ***Psychological moral hazard effect***. Moral hazard in the context of sufficiency-oriented PSS can be understood as treating products in a PSS with less care due to shared responsibility and risk (Santarius, 2012); e.g., in textile leasing systems (Siderius & Polder, 2021).
4. ***Operational and maintenance effects***. RE which occur due to the creation of new needs for the operation/maintenance of a given PSS. Harris et al., (2021) describe the potential RE of tool-sharing at the macro-scale. RE might occur if tool-sharing creates additional need for travel - via journeys to collect and return tools (Harris et al., 2021).

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These mechanism clusters point to several RE triggers associated with sufficiency-oriented PSS (figure 1), namely (1) financial savings (Briceno et al,, 2005; Chen & Kockelman, 2016; Menon & Mahanty, 2015; Iran & Müller, 2020), (2) time savings (Iran & Müller, 2020), (3) increased accessibility/convenience at the systems-level (Yin et al., 2018); (4) psychological triggers (Iran & Müller, 2020; Siderius & Polder, 2021), including moral credits and moral hazard, and (5) PSS maintenance/operational requirements (see Harris et al., 2021).

It is important to note that the list of RE mechanisms clusters is not exhaustive nor are the mechanisms mutually exclusive. There can be considerable overlap between the clusters given the interrelatedness and interdependencies between RE mechanisms (van den Bergh, 2011). For example, psychological factors, such as bounded rationality and willpower, in addition to moral licensing (Exadaktylos & van den Bergh, 2021), most likely play a role in all RE mechanisms. Another example of possible overlap between clusters is the re-spending of time resources freed up via systems-level convenience effects; e.g., freed up travel time due to systems-level convenience effects of ride-sharing. Systems-level convenience effects are kept distinct from time-use RE to emphasize the interaction of systems-level elements, like road infrastructure, traffic patterns and congestion, etc.

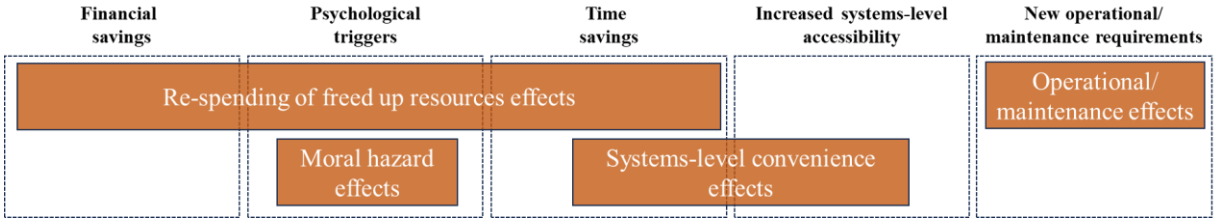

Figure 1. Rebound effect mechanism and trigger clusters

3.2. Magnitudes of rebound effects across sufficiency-oriented PSS

The RE magnitude across various sufficiency-oriented PSS is very wide (2% - 900%) (table 1). The first and most obvious reason for this is that the RE magnitudes found in the studies represent a variety of sufficiency-oriented PSS (i.e., across three social needs areas and various PSS types (as discussed in section 3.1)). But even across the same PSS type (e.g., car sharing systems), the RE magnitude range is still very wide (2%-140%). This can be explained by the variety of estimation methods and environmental impact indicators used for calculating RE magnitudes. Furthermore, the timeframe may affect the estimation of the RE magnitude. Yin et al. (2018) find that the RE magnitude of ride sharing schemes differs depending on the time of day (i.e., either morning or evening rush hour), and also identify three distinct RE magnitudes in the short-term, medium-term, and long-term.

The system boundaries of the studies also play a significant role in the RE magnitude (Greening et al., 2000). Firstly, some estimations of RE magnitude may include more secondary benefits than others for a similar PSS. Secondary benefits refer to 'negative' RE, causing a double-negative (Kjær et al., 2018). For example, Chen & Kockelman (2016) combine *"the effects of reduced vehicle ownership, reduced vehicle-distance traveled, fleet-level fuel efficiency improvements, reduced parking infrastructure demand, and trips shifted to no-auto modes"* (p.283) when calculating the effects of car-sharing scenarios, most likely leading to a lower RE magnitude compared to similar car-sharing studies which exclude these secondary benefits. Secondly, system boundaries play a large role in determining the strength of indirect RE. For example, in the analysis of car-sharing RE, Amutani et al., (2020) include multiple modes of transportation to assess changes in travel patterns, identifying an indirect RE associated with the increase of other modes of transportation, while Tsuji et al. (2020) do not include other modes of transportation and instead use a fixed direct RE estimate. Limiting system boundaries can, therefore, neglect indirect RE or underestimate the magnitude.

Backfire scenarios (i.e., RE magnitude > 100%) were found in one study for both car-sharing (140%) and bicycle-sharing (900%) at the European level (Font Vivanco et al., 2015), and in another study, backfire is experienced by one-third of peer-to-peer boat sharing users (Warmington-Lundström & Laurenti, 2020). Font Vivanco et al., (2015) explain that the RE magnitude will be higher when the PSS results in high income savings which can be re-spent on additional consumption. Briceno et al. (2005)

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report that RE magnitude is particularly high when cost-savings are re-spent on air travel (p.9), a finding also made by Warmington-Lundström & Laurenti (2020) in their study on the indirect RE of a peer-to-peer boat sharing system.

4. Discussion

A limited number of RE studies explore sufficiency-oriented PSS and almost half of the RE cases are limited to car-sharing systems (7 of 15 RE instances). This severely limits the conclusions to be drawn regarding the RE of sufficiency-oriented PSS. The studies in this review are also limited in that the focus is on RE behavior of PSS consumers, and not the providers. The exception to this is the study conducted by Warmington-Lundström & Laurenti (2020) on peer-to-peer boating sharing systems, who find statistically significant differences between lessors and lessees. Another limitation is the use of secondary data to inform the modelled human behavior. For example, in a car-sharing study which estimates RE magnitude using LCA, the authors write: *"these biases include the fact that some prior studies rely on stated (rather than revealed) preference data"* (Chen & Kockelman, 2016, p.283). When the RE behavior is derived from biased estimates, there is a risk that the RE magnitude is under- or over-estimated. Additionally, when the RE behavior is not the primary investigation, important details regarding counteracting secondary benefits are neglected. For example, Warmington-Lundström & Laurenti (2020) find that a large reduction in emissions associated with the P2P boat sharing system comes from re-spending generated income on boat maintenance, extending the products' lifespan and reducing associated emissions. Without the inclusion of this secondary benefit, the RE magnitude would be overestimated. Lastly, a more in-depth analysis of RE phenomena should assess more than one RE mechanism and the interdependencies between them (Madlener & Turner, 2016).

The limited number of studies exploring RE triggered by sufficiency interventions, like sufficiency-oriented PSS, points to a critical blind spot in the discussion surrounding sustainability strategies. Though there may be general agreement regarding the potential sustainability benefits of PSS and/or sufficiency across green-growth, agrowth, and degrowth perspectives, there are diverging views on the use of PSS to promote sufficiency and on associated RE.

As a 'pro-growth' perspective, green-growth advocates would be in favor of PSS if it provides new opportunities for value creation while simultaneously decoupling economic activity from environmental impact through dematerialization (Kjær et al., 2018) via "sustainable product service-systems" (Vezzoli et al., 2021), for example. RE taking the form of increased consumption, such as re-spending of financial resources effects, would be regarded as positive for its contribution to economic growth and "*new economic opportunities*" so long as "*natural assets continue to provide the resources and environmental services on which our well-being relies*" (OECD, 2011, p.17).

The degrowth perspective advocates for *"an equitable downscaling of production and consumption that increases human wellbeing and enhances ecological conditions at the local and global level"* (Schneider et al., 2010) and, in line with this, advocates for sufficiency as an end-goal (Alexander, 2013). Degrowth perspectives typically refer to sufficiency within the context of "voluntary simplicity" (Alexander, 2013), anti-consumerism (Kropfeld et al., 2018), and/or re-distribution of affluence (Alcott, 2008). The focus is on consumers while PSS have not received much attention from degrowth communities within the sufficiency discourse. A degrowth perspective would, instead, highlight the value of non-market provisioning systems and social sharing practices, for example emphasizing concepts like conviviality (Illich, 1973), solidarity (Bauhardt, 2014), autonomy (Deriu, 2015), and decommodification (Gómez-Baggethun, 2015). Degrowth researchers are critical of the decoupling claims of 'servitization' made by green-growth supporters, and have pointed to the overall infeasibility of economic decoupling given the urgency of socio-ecological crises (Hickel & Kallis, 2019). In general, RE of efficiency and effectiveness are given more attention than sufficiency RE within degrowth.

An agrowth perspective - advocating for being indifferent about economic growth, that is, neither supporting a 'pro-growth' or 'anti-growth' strategy (van den Bergh, 2017), would not seek sufficiency as an end goal in and of itself (like degrowth) but also not fear considerable sufficiency at a micro level and associated economic decline at a macro level as an outcome (like green-growth). In addition, it is neutral about (sufficiency) PSS. Finally, to prevent sufficiency RE from occurring, degrowth advocates would highlight the need for transformational changes to growth capitalism (Nørgaard & Xue, 2016),

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while agrowth advocates would highlight the need for widespread environmental public policies which incentivize all actions to reduce emissions, including sufficiency behavior (Sorrell et al., 2018).
This assessment suggests that all perspectives across the economic growth debate should recognize the sustainability challenge posed by sufficiency strategies and to anticipate associated RE.

5. Conclusions

Sufficiency is increasingly seen as a promising sustainability strategy, particularly within the debate on the limits to economic growth. Sufficiency-oriented PSS, however, risk giving rise to RE which offset the potential environmental benefits or even create backfire. The goal of this paper was to explore the literature on RE triggered by such PSS. To this end, the paper reviewed 12 sufficiency-oriented PSS RE studies, and assessed RE triggers, mechanisms and magnitude of sufficiency-oriented PSS. The primary social needs areas examined are mobility (almost half examining car-sharing systems) and consumables (e.g. tools, textiles). The review identified four RE mechanism clusters to account for in the design of sufficiency-oriented PSS; namely, (1) re-spending of freed up resources (i.e., financial, temporal, and moral) effects, (2) systems-level convenience effects, (3) psychological moral hazard effects, and (4) operational/maintenance effects. The results of this review provide an overview of key considerations which can be taken in the early phases of PSS design for the four effects: (1) pricing strategies to address financial effects, incentives for slower usage to address temporal effects, re-considering green marketing design strategies to address moral credits effects; (2) collaborative design with relevant stakeholders, like urban planners and policymakers, to address systems-level convenience effects, (3) tracking systems that monitor user behavior and behavioral nudging strategies to address psychological moral hazard effects, and (4) evaluating network design to address operational/maintenance effects.
This paper also provides an indication of tools that can be employed for estimating RE magnitude. Re-spending of freed up financial resources is the most frequently assessed RE mechanism, typically quantified using re-spending model approaches. The RE magnitude ranges from 2-900% estimated using a variety of estimation techniques and indicators. Backfire is found in three cases of use-oriented PSS - car-sharing, bicycle-sharing, and peer-to-peer boat sharing systems.
The scientific contribution of this paper is the consolidation of literature on RE of sufficiency-oriented PSS. Despite the growing evidence of sufficiency-oriented PSS RE, broader conclusions are limited due to the small number of empirical studies and narrow focus on sharing systems, specifically on car-sharing systems. Future research should expand the research scope to include all types of PSS, for example efficiency- and effectiveness-oriented, testing the RE magnitude across PSS with distinct features and aims. The scope of the research should additionally extend to study potential RE behavior of PSS providers and not only PSS consumers.

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