

The circularity of product-service systems: The role of macro-, meso-, and micro-level contextual factors

Abstract

Purpose: This paper aims to examine the relationships between macro-, meso-, and micro-level contextual factors that enable or inhibit the contribution of Product Service Systems (PSS) to circularity. It is informed by the Natural Resource-Based View (NRBV) and the multi-level perspective as theoretical lenses.

Design/methodology/approach: A theory elaboration approach is used through three in-depth case studies of UK and German manufacturers. Case studies provide use- and result-oriented PSS for personal computers, power tools, and wind turbines. Multiple sources of evidence, including 20 semi-structured interviews, company documents, and quantitative data, are triangulated to improve the validity of the results.

Findings: Empirical evidence for relationships between macro-, meso-, and micro-level contextual factors show significant barriers to the extending and cycling of resource loops, primarily through maintenance, repairs, and refurbishment. A firm's environmental awareness has a determining role in the contribution of PSS to circularity. The evidence from two use-oriented PSS reveals different circularity maturity levels.

Originality: This research makes three key contributions. Firstly, it elaborates on NRBV by showing that a firm's environmental awareness determines product stewardship. The type of product stewardship practices depends on the enabling and inhibiting effects of macro- and meso-level factors. Secondly, it shows that use-oriented PSS have different circularity profiles and proposes three circularity maturity levels. Finally, it provides an empirically validated framework of macro-, meso-, and micro-level enablers and barriers and how they interact to enable or inhibit circularity in PSS.

Keywords Circular economy, product-service system, circular business model, servitisation, multi-level perspective

1 Introduction

Circular economy (CE) is an emerging concept that aims to overcome the current take-make-dispose linear production and consumption system by transitioning into an economic paradigm where resource use is minimised and the value of products, materials, and resources is maximised (Geissdoerfer *et al.*, 2020; Kirchherr *et al.*, 2017). In contrast, a traditional linear economy is wasteful with its focus on “take-make-dispose”. At the organisational level, the CE literature focuses on the diffusion of so-called circular business models. Circular business models are defined as “business models that are cycling or extending, intensifying, and/or dematerialising material and energy loops to reduce the resource inputs into and the waste and emission leakage out of an organisational system. This comprises recycling measures (cycling), use phase extensions (extending), a more intense use phase (intensifying), and the substitution of products by service and software solutions (dematerialising)” (Geissdoerfer *et al.*, 2020, p.7).

The CE literature puts forward different types and taxonomies of circular business models (Geissdoerfer *et al.*, 2020; Lüdeke-Freund *et al.*, 2019; Urbinati *et al.*, 2017). Product-service systems (PSS) are among the most widely cited potential circular business models (Geissdoerfer *et al.*, 2020; Smart *et al.*, 2017; Tukker, 2015). PSS business models are closely linked to the servitisation phenomenon in the manufacturing industry (Baines and Lightfoot, 2013; Lightfoot *et al.*, 2013; Rabetino *et al.*, 2018). There are three types of PSS: product-oriented, use-oriented, and result-oriented (Tukker, 2004). While product-oriented PSS still focus on selling products with additional service add-ons, use- and result-oriented PSS are more service-oriented. Use-oriented PSS provide functionality through leasing, renting, or sharing, while result-oriented PSS provide a result or performance outcome instead of a specific product (Tukker, 2004). Especially use- and result-oriented PSS are considered to have a high potential to contribute to circularity, since the manufacturer delivers product functionality in these business models instead of selling products (Kühl *et al.*, 2019; Tukker, 2015; Yang *et al.*, 2018).

In recent years, there has been an increasing focus on examining the circularity contribution of PSS business models (Kühl *et al.*, 2022; Matschewsky, 2019; Yang *et al.*, 2018). This literature shows that overall PSS business models appear to positively contribute to circularity, particularly regarding the extending and cycling of resources. However, the emerging literature on circular business models shows that the degree of the circularity contribution depends on the presence of enabling and inhibiting contextual factors (Guldmann and Huulgaard, 2020; Tura *et al.*, 2019; Urbinati *et al.*, 2021; Vermunt *et al.*, 2019). Even though these studies provide

a good foundation, there are still significant gaps to investigate the circularity contribution of PSS business models in manufacturing contexts (Bjørnbet *et al.*, 2021).

Firstly, even though previous studies have put forward several potential inhibitors and enablers, the relationships and interplay among these different factors, particularly across different levels of analysis, are still not fully understood (Hina *et al.*, 2022; Urbinati *et al.*, 2021). Specifically, more studies are required to understand how contextual factors enable or inhibit organisations and how firms can leverage enabling factors and overcome inhibiting factors (Urbinati *et al.*, 2021). Examining this interplay provides important insights into wider micro-, meso- and macro-level factors preventing the diffusion of circular business models (Hina *et al.*, 2022; Sarasini and Linder, 2018; Urbinati *et al.*, 2020). By studying the dynamics between contextual factors in affecting circularity outcomes of PSS, we contribute to the understanding of how and why PSS business models in manufacturing industries contribute to sustainability and circularity (Bjørnbet *et al.*, 2021).

Secondly, there is a lack of a theoretical foundation in both the PSS and CE fields (Korhonen *et al.*, 2018; Kowalkowski *et al.*, 2017; Rabetino *et al.*, 2018). For example, a literature review showed that 94% of reviewed articles based their theoretical development on previous research within the community instead of theories (Rabetino *et al.*, 2018). In both cases, gaining legitimacy as scholarly communities hinges on the adoption of research styles from other adjacent fields, such as importing concepts and methods from established disciplines (Hambrick and Chen, 2008).

The purpose of this study is to fill these important gaps in our knowledge and to provide guidance to managers by answering the following research question: *How do macro-, meso-, and micro-level contextual factors enable and inhibit the contribution of PSS business models to circularity?* We answer this question through the lens of the Natural Resource-Based View (NRBV) (Hart, 1995) by applying the multi-level perspective from transition research as an analytical framework to guide the examination of circularity enablers and inhibitors in PSS (Geels, 2002). NRBV is well-suited to explain the contribution of PSSs to circularity since it encapsulates the study's underlying phenomenon of circular business model innovation well. It focuses on the potential for firms to derive competitiveness from environmental business practices and outlines the similar concepts and mechanisms that explain how and why PSSs contribute to circularity. According to Hart's (1995) product stewardship strategy, firms can reduce product's environmental footprint through stakeholder integration. In the case of PSSs and circularity, it is the increased integration of the manufacturer with the entire product life cycle and the customer's use of the product, for example by retaining product ownership, which enables extending and cycling of resource loops (Matschewsky, 2019; Yang *et al.*, 2018). The multi-level perspective is an analytical framework that conceptualises transition processes as

the result of the interplay of developments at three analytical levels: the micro-level (business model level), meso-level (socio-technical level), and the macro-level (societal level) (Geels, 2011; Joore and Brezet, 2015).

We adopt a theory elaboration approach (Ketokivi and Choi, 2014) to situationally ground the research in the context of circular PSS business models in manufacturing firms. We examine the implementation of the product stewardship strategy outlined in NRBV (Hart, 1995) using data collected through twenty interviews with managers at three case companies. We triangulate the interview findings with documentary evidence, such as internal presentations and reports.

The remainder of the paper is structured as follows: Section 2 reviews the literature on PSS, the NRBV, and the multi-level perspective. Section 3 explains the research methodology. Section 4 presents the findings. Section 5 develops propositions and discusses the empirically supported framework. Finally, Section 6 presents our theoretical and practical contributions, limitations of the work, and future research directions.

2 Literature Review

2.1 PSS and circularity

In recent years, several studies examined the contribution of different PSS business models to circularity. For the purpose of this study, circularity is conceptualised as focusing on the extending and cycling of resource loops, since these are the principal modes of value creation in CE (Bocken *et al.*, 2016; Hofmann, 2019). Extending of resource loops focuses on the extension of the product lifetime through long-lasting design, maintenance, and repair, whereas cycling focuses on reuse, refurbishing, remanufacturing, and recycling (Geissdoerfer *et al.*, 2020).

Sousa-Zomer *et al.* (2018) and Manninen *et al.* (2018) investigated the implementation of CE practices in innovative PSS business models of SMEs and start-ups. Yang *et al.* (2018) and Yang and Evans (2019) investigated the phenomenon of ‘circularity’ in supply chain operations, and showed that result-oriented PSS, have tighter and more efficient circularity of supply chain operations. Matschewsky (2019) examined the use-oriented PSS of an industrial company and found that while relative improvements over product sales are identified, e.g. resulting from reuse or remanufacturing, opportunities for additional enhancement are found, e.g. in adjustments of the PSS design process. Finally, Kühl *et al.* (2022) also applied NRBV to the PSS and CE context. Their survey of UK equipment and machinery manufacturing SMEs

showed limitations of PSS' contributions with use-oriented PSS contributing to practices associated with the extending and cycling of resource loops and result-oriented PSS not contributing to practices associated with a cycling of resource loops. While this stream of literature shows the potential circularity benefits of use- and result-oriented PSS, they also point to existing systemic shortcomings, such as reconciling economic growth with circularity (Matschewsky, 2019) or lacking economic and regulatory incentives for remanufacturing or recycling products at end-of-life (Yang *et al.*, 2018).

2.2 PSS and NRBV

The contribution of PSS to the circularity of resource loops can be explained by using the tenets of the NRBV (Hart, 1995). Similar to the resource-based view (Wernerfelt, 1984), NRBV argues that a firm's competitive advantage derives from exploiting its idiosyncratic resources and capabilities. Hart (1995) expands on the RBV arguing that competitive advantage is also rooted in environmentally sustainable economic activity. NRBV has been used already in the context of circular PSS business models (Kühl *et al.*, 2022) and circular operations and supply chains (McDougall *et al.*, 2022a, 2022b). Similar to Kühl *et al.* (2022), this paper focuses on the product stewardship strategy outlined in NRBV to explain how and why use- and result-oriented PSS contribute to circularity.

Product stewardship aims to minimise a product's environmental impacts across the life cycle, for example by implementing reverse logistics or closed-loop supply chains (Hart, 1995; Vachon and Klassen, 2008). According to Hart (1995), creating sustainable competitive advantage through product stewardship relies on a firm's stakeholder integration, since implementing activities such as repairs or recycling is socially complex. Stakeholder integration is the organisational ability to collaborate with stakeholders to solve environmental issues (Sharma and Vredenburg, 1998). In the context of use- and result-oriented PSS, there is a closer integration of manufacturer and customer due to the nature of the contractual arrangement (Gaiardelli *et al.*, 2014). In both use- and result-oriented PSS, the manufacturer retains product ownership and conducts product life cycle management activities, such as maintenance and repairs, that would otherwise be carried out by the customer in a traditional product sales business model (Gaiardelli *et al.*, 2014; Tukker, 2015). As a result, the manufacturer has more information about the location, quality, and usage of the product, which facilitates extending and cycling of resource loops (Baines and Lightfoot, 2013).

2.3 PSS, circularity, and the multi-level perspective

As outlined above, a shortcoming of the existing literature is that it focuses too much on the PSS type, when explaining the contribution to circularity. There is an implicit assumption that use- and especially result-oriented PSS have a high circularity contribution, since they retain product ownership and are responsible for product life cycle management activities (Tukker, 2015; Yang *et al.*, 2018). One aspect that is understudied is the role that wider micro-, meso-, and macro-level factors play in circular business model implementation (Hina *et al.*, 2022). Integrating a wider systems perspective is necessary, because even though PSS business models have potential to increase circularity, their success rests upon transformations at different levels. Overall, value creation and value capture in business models are contingent on factors at different levels, making it important to understand how these multi-level dynamics work (Lepak *et al.*, 2007; Sarasini and Linder, 2018).

One way to extrapolate the role of micro-, meso-, and macro-level enablers and barriers is to use the multi-level perspective from transition theory (Geels, 2002, 2012; Joore and Brezet, 2015). Transition theory examines large socio-technical shifts and aims to elucidate implications around how these transformations can be steered or managed (Sarasini and Linder, 2018). Even though it typically focuses on the diffusion of technological innovations, recent studies have highlighted the potential applicability of this theory to analyse the diffusion of business models, such as PSS (Bidmon and Knab, 2018; Sarasini and Linder, 2018; van Waes *et al.*, 2018).

The multi-level perspective is an analytical framework that conceptualises transition processes as the result of the interplay of developments at three analytical levels: the micro-level (business model level), meso-level (socio-technical level), and the macro-level (societal level) (Geels, 2011; Joore and Brezet, 2015). The multi-level perspective argues that transitions come about through interacting processes within and between these levels (Geels, 2011).

In the CE literature, similar approaches were followed. Yap and Devlin (2016) applied a multi-level perspective to argue that the firm-level actions and strategies to develop industrial symbiosis networks depend on the conditions in the external environment, such as market factors, policies & regulations, and cultural norms. They argue that the development of industrial symbiosis networks is path-dependent and contingent on a broad range of contextual conditions. More recently, Zhu *et al.* (2022) and Malik *et al.* (2022) developed conceptual frameworks outlining the various micro-, meso-, and macro-factors influencing the adoption of CE in emerging market SMEs. Urbinati *et al.* (2021) developed a framework of micro-, meso-, and macro-level enablers and barriers and assessed the importance of each in a survey of the Italian automotive industry.

2.4 Macro-, meso-, and micro-level enablers and inhibitors of circularity in PSS

A vast body of literature investigates various enablers and barriers for circularity in PSS business models (Bjørnset et al., 2021; Bocken and Geradts, 2020; Govindan and Hasanagic, 2018; Guldmann and Huulgaard, 2020; Hina et al., 2022; Ingemarsdotter et al., 2020; Jaeger and Upadhyay, 2020; van Keulen and Kirchherr, 2021; Kirchherr et al., 2018; Meath et al., 2022; Tura et al., 2019; Vermunt et al., 2019). The literature review provides a comprehensive understanding of the different enablers and barriers that exist for circular business models (see Table 1).

INSERT TABLE 1 HERE

The macro-level constitutes the wider societal context that outlines a set of deep and structural trends that shape the character of a society, such as cultural changes, societal values or worldviews, changes in political views and ideologies, and wider macro-economic trends (Geels, 2002, 2012). Potential changes may be an increasing societal sense of urgency and awareness for the need to transition into a more circular economy (Vermunt et al., 2019).

The socio-technical regime at meso-level describes the current set of regulations, cultural beliefs, technologies, user patterns, infrastructures, and cultural discourses related to a specific system or societal function (Geels, 2005). Developments at this level, such as emerging customer demands or legislation, may enable or inhibit the forming of new business models (Bidmon and Knab, 2018; Joore and Brezet, 2015). The review at this level pointed to various technological, regulatory, market, and supply chain enablers and barriers that could potentially affect the circularity of PSS business models. From the geographical proximity of supply chain partners (Delgadillo Jaime et al., 2021), to market-making policies or regulations (Hina et al., 2022; Tura et al., 2019; Urbinati et al., 2021) to market-related factors, such as customer acceptance (Hina et al., 2022; Kirchherr et al., 2018; Vermunt et al., 2019).

The micro-level captures the wider firm-level factors affecting how a firm proposes, creates, captures, and delivers value for its stakeholders in the context of a circular economy (Joore and Brezet, 2015). At this level, the review identified organisational factors linked to strategy, culture, structure and processes (Bocken and Geradts, 2020; Kirchherr et al., 2018; Tura et al., 2019), financial barriers, such as increased complexity or costs associated with managing multiple product life cycles (Hina et al., 2022; Ingemarsdotter et al., 2020; Kirchherr et al., 2018; Linder and Williander, 2017), or technology-/knowledge-related inhibitors and enablers (Ingemarsdotter et al., 2020; Zeeuw van der Laan and Aurisicchio, 2020).

Overall, the literature review unearthed a wide array of enablers and barriers at the micro-, meso- and macro-level that affect circularity in PSS. While these provide an important foundation, the relationships and interplay among these different factors, particularly across different levels of analysis is needed to establish the contribution of PSS to circularity (Hina *et al.*, 2022; Urbinati *et al.*, 2021). Examining this interplay provides important insights into wider micro-, meso- and macro-level factors preventing the diffusion of circular business models (Hina *et al.*, 2022; Sarasini and Linder, 2018; Urbinati *et al.*, 2020). By studying the dynamics between contextual factors in affecting circularity outcomes of PSS, we contribute to the understanding of how and why PSS business models in manufacturing industries contribute to sustainability and circularity benefits (Bjørnbet *et al.*, 2021). Beyond the theoretical contribution, this can provide key insights to policymakers and business leaders in adjusting the wider systemic context to facilitate the transition to circular economy.

3 Methodology

3.1 Research strategy

We follow a theory elaborating research strategy (Ketokivi and Choi, 2014) focusing on the logic of the NRBV's product stewardship strategy in the context of PSSs and circularity. We elaborate on the NRBV by exploring contextual factors that enable and inhibit product stewardship strategies (Hart and Dowell, 2011) by using the multi-level perspective (Joore and Brezet, 2015) to analyse the case studies. We deduce a framework from the literature (Table 1) identifying the contextual factors at the three levels (micro, meso, and macro), and this is elaborated through the case studies by understanding the interrelationships between the contextual factors both within and between the different levels.

The multiple case study meets the duality criterion, by introducing the multi-level perspective concept to reconcile the NRBV firm level perspective with the empirical context of PSSs (Ketokivi and Choi, 2014). The cases are three manufacturers that offer PSSs in UK and Germany, enabling the phenomenon to be studied within its real-life context. Case selection was based on literal replication logic, such that findings are expected to be similar across all cases, thus corroborating each other (Yin, 2018).

3.2 Case study context: PSSs in manufacturing

UK and German equipment manufacturing firms are selected as they are representative of existing sectors and countries in the PSS literature (Luoto *et al.*, 2017). Three case study selection criteria are used. First, companies are required to offer a use-oriented or result-oriented PSS, as they are considered to have a higher circularity potential, compared to product-oriented PSS, since the manufacturer is incentivised to reduce the costs of delivering product functionality by maximising resource productivity (Tukker, 2015; Yang *et al.*, 2018). Second, incumbent CE pioneer companies are selected so that they already have a position in their market (they are not start-ups) and they have implemented extending and cycling practices in their PSS business models (Bocken *et al.*, 2016; Frishammar and Parida, 2019). Their pioneering role in transition into CE is evidenced by case studies published in peer-reviewed academic journals and by reputable CE practitioner organisations (e.g., the Ellen MacArthur Foundation, SITRA - the Finnish Innovation Fund). This purposeful recruitment of case study companies helps improve theoretical sampling as the focal phenomenon of product stewardship is likely to occur in these cases. Third, to increase the external validity of the findings, context diversity is sought in terms of industry and speed of product innovation cycles, which is previously identified as a potential barrier to circularity (Linder and Williander, 2017). The key characteristics of the three case companies are provided in Table 2.

INSERT TABLE 2 HERE

3.3 Data collection

Construct validity is ensured through both method and source triangulation (Yin, 2018). Method triangulation is achieved by using semi-structured interviews, documentary or database evidence, and observations (Yin, 2018). Data are triangulated by using multiple informants and documents. Data collected are both quantitative (e.g., product returns) and qualitative evidence (e.g., innovation focus) to develop a more holistic understanding of the cases (Eisenhardt, 1989). Interviews are conducted with 20 key informants between July 2019 and April 2020. Each interview is between thirty minutes and one-and-a-half hours and is transcribed verbatim for coding and analysis. Only two interviews are conducted with Computerco because the interviewees are highly knowledgeable of the studied phenomenon, hence we didn't have the need to conduct further interviews. One interviewee is responsible for increasing sustainability of business services and the other is Computerco's global lead for CE implementation, so they were able to cover all three levels of the MLP (micro, meso and macro). Further, there is a large amount of documentary evidence (e.g. reports and studies) available on the company's CE transformation so we were able to use 23 documents for

triangulation. Finally, at Toolco, repair and decommissioning processes are observed in person.

3.4 Data analysis

Theory elaboration emphasizes abductive reasoning, which involves “modifying the logic of the general theory in order to reconcile it with contextual idiosyncrasies” (Ketokivi and Choi, 2014). In other words, during data analysis, researchers constantly move between the existing theory and data, to reaffirm existing constructs, relationships, or sequences between them, but also to introduce new, or split existing constructs, redefine specific relationships between constructs or a sequence of events (Fisher and Aguinis, 2017). This approach allowed us to reaffirm existing contextual enablers and inhibitors and develop their associated relationships. An initial *a priori* coding structure is used based on the literature review and in particular the contextual enablers and inhibitors (which are defined according to their MLP level and thus categorised in Table 1) and circular business model frameworks to outline and structure aspects around the extending and cycling of resource loops (Geissdoerfer *et al.*, 2020) to find relevant information (King, 2012). Through theory elaboration, new relationships between contextual factors and between the MLP levels were induced from the findings, thereby enabling theory elaboration. To ensure reliability and construct validity, the data are independently coded by two researchers and iteratively discussed until consensus is reached (Armstrong *et al.*, 1997). The research team conducted a multitude of meetings comparing the emerging findings within and between cases and building explanations for their emergence both on their own and in relation to the constructs and relationships of the general theory. Cross-case analysis is performed by summarising the within-case data into display tables to enable the identification of patterns, differences and commonalities (Yin, 2018). Finally, propositions are developed to explain how contextual factors affect the extending and cycling of resource loops in PSS.

4 Findings

Building on the notion of the multi-level perspective that transition processes result from the interplay of factors at three analytical levels, our analysis revealed relationships between contextual factors at micro-, meso-, and macro-level that inhibit or enable the contribution of PSS to extending and cycling of resource loops. We first provide a description of the PSS business models and their contribution to circularity (Section 4.1 and Table 3), followed by the enablers and inhibitors at macro-, meso-, and micro-level (Sections 4.2 to 4.4.3 and Table 4).

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4.1 Description of the PSS business models

Computerco offers a leasing agreement (use-oriented PSS) for notebook computers to B2B customers for 3-5 years. Customers choose the equipment and select a service level in which Computerco provides additional IT security, damage protection, and support services in return for a fixed monthly lease fee. Since Computerco retains product ownership, the devices are returned after the end of the lease agreement. The company recovers around 75% of the notebooks after the end of the lease contract, of which around 80% are refurbished and 20% recycled. The refurbished notebooks are resold for a second lifetime between one and three years. At present, Computerco does not recover refurbished notebooks, but it has piloted offering leasing agreements for refurbished computers to B2B and B2C customers to recover equipment as well after the second or even third life cycle.

Toolco offers a leasing agreement (use-oriented PSS) to B2B customers for 2 to 4 years, depending on the tool type. For a monthly lease fee, customers can use the tool and receive extra protection against product breakdowns, theft, and losses, such as free repairs and replacement tools to help increase customer's productivity. Toolco retains ownership of the tools, which means that the tools need to be returned at the end of the lease agreement. In use-oriented PSS, customers return around 85% of the leased tools. Around 60% of these are still usable. Of tools returned, 1-3% are in good condition to be reused as loan tools. The rest are decommissioned and subsequently recycled. Before decommissioning, Toolco recovers the rotor and electronics (about 10% of the tool value), which are remanufactured and reused in repair services.

Windco offers availability contracts (result-oriented PSS) for wind turbines. Windco is responsible for engineering, planning, and managing the operation and maintenance activities under a long-term, shared-risk and shared-reward contract. The payment mechanism depends on a time-based availability (minimum 95%) contract including sharing mechanisms in case the agreed upon results are not reached or exceeded. Since wind turbines are large industrial assets with long lifetimes of around 20 years, retaining ownership of wind turbines would employ too much of Windco's working capital. Instead, the customer outsources operation and maintenance activities to Windco, while turbine finance is provided by banks or investors. It is a highly customised offering that may also include coordination of electrical infrastructure and training. Windco can optimise maintenance and reduce operating costs to provide the customer with a viable business case for a lifetime extension of up to 10 years. Since Windco does not retain product ownership, they do not recover materials at end-of-life. There are, however, cycling benefits from component refurbishment. Due to the size and immobility of wind turbines, remanufacturing occurs on a component level for generators, gearboxes, main

bearings, shafts, blades, and electronic components. These are kept in a closed loop and refurbished and added to a stock of remanufactured components.

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4.2 Macro-level factors

4.2.1 Cultural factors

4.2.1.1 Cultural enablers

There were two underlying societal trends that enabled the extending and cycling of resource loops. Firstly, as frequently stated by the interviewees, there is a growing societal awareness of sustainability and circularity, which created a sense of urgency and legitimacy among stakeholders and the PSS providers. This was particularly pronounced in the Computerco case, where an increasing awareness of customers for sustainability resulted in a higher customer demand and acceptance for refurbishment or recycling services. As Computerco's Circular Economy Director pointed out:

"There is a rising awareness for circular economy and environmental protection. People are realising that they need to think about how products are treated at end-of-life and want the assurance that the products do not end up in landfill or being burnt in a developing country."

The growing societal awareness for sustainability was also observed in the Windco case, where it enabled the inclusion of sustainability and circularity concerns in the product development process. As one Windco Sustainability Manager pointed out:

"In the last 2 to 3 years, there has been a tipping point. Environmental topics have become more important to our stakeholders, particularly for investors. This has made it much easier for us to get green ideas into product development, but now we get more invitations to support the process."

In both Windco and Computerco case, this growing awareness for sustainability topics enabled circularity. In the Computerco case, there was increased customer demand for circular business models, whereas in the Windco case, it was external stakeholder pressures that enabled the inclusion of circularity and sustainability aspects in the product development process.

The second wider enabling societal trend was the growing acceptance of subscription models, which enabled a wider customer acceptance of PSS business models, particularly in the

Computerco case. Commenting on this underlying cultural change, the Computerco Circular Economy Director highlighted that:

“There is a mindset shift underway, as the millennial generation is more willing to buy subscription services and to rent/lease products over buying compared to previous generations. It’s the Netflix and Spotify effect, and it will eventually make its way into corporate accounting.”

However, this mindset shift did not count for all customer types equally. In the case of Computerco, public sector customers often did not have the capacity to procure services over products. As the Circular Economy Director pointed out:

“It requires a mindset shift for customers to go from buying a product to procuring a product as a service: both for private and public sector buyers. Particularly in the public sector budgets are typically annualised, which makes it difficult to plan forward over a 3-5-year life cycle. Innovating their accounting and budgeting processes is often very difficult even for quite advanced firms.”

The enabling effect of this cultural change was confirmed by a Toolco Marketing Manager who confirmed that this cultural change enabled the adoption of use-oriented PSS: “Customers are much more open to leasing tools than they used to. It reflects a wider acceptance of new concepts, such as the sharing economy.” Testament to the increasing popularity and willingness to buy product functionality over the product itself was that around 55% of products were acquired via the use-oriented PSS over a tool purchase.

4.2.1.2 Cultural barriers

Regarding barriers, the analysis found the cultural desire for novelty as a key barrier to the cycling of resource loops. For both the customer and Toolco, product innovation was perceived as desirable, giving an impression of being modern and progressive. As a product manager pointed out:

“We are market leaders in innovation and want to make sure that we always provide state-of-the-art solutions to our customers. (...) If they want, our customers can trade their tools in early. It’s part of our value proposition that customers always have the most up-to-date portfolio.”

This cultural perception manifested itself in a meso-level preference of customers to purchase new tools and at the micro-level, where it supported Toolco’s organisational linear lock-in and resistance to innovate the business model around product refurbishment. In addition, there was a cultural norm or image present in the construction industry around having a careless attitude towards equipment. Even though Toolco designed the tools for durability, quality, and

facilitated repairs, this cultural norm, particularly in medium and large construction companies, where tool ownership was shared, inhibited the extension of resource loops. As one Toolco marketing director explained:

“In the construction industry, there is a culture or image of not really caring. Some individual tradesmen will really take care of the tools, but for most projects, there is no individual ownership and hence, people do not care about the tools.”

4.2.2 Political factors

4.2.2.1 Enablers

In the Toolco case, one enabling political factor was the presence of the UK government's 2025 national construction strategy and roadmap, which focused in part on increasing the sustainability of the industry. This contributed to sustainability becoming top-of-mind for many senior executives in the construction industry and enabled Toolco managers to market the circularity benefits of the use-oriented PSS. As a Marketing Director said:

“The construction strategy shows that sustainability is becoming a massive mega trend in the industry. For me as a salesperson that means that talking about sustainability and circular economy and how it ties in with regulation allows me to access higher levels in organizations. When you reach a senior level in the company, you want to talk about how the topics that we have, such as durability, fit to these higher topics and pain points that these companies care about.”

For Toolco, the growing contextual pressure, around sustainability and circular economy, as evidenced by the UK government's construction strategy, increases the acceptance of customers for circular business models and provides an entry point for Toolco to market its products, services, and value proposition around durability and circular economy.

4.2.2.2 Barriers

In regard to political barriers, the findings from the three case studies showed overarching barriers, particularly to the extending and cycling of resource loops. Specifically, the existing funds, taxation, and subsidy policy failed to create a level-playing field for circular business models. As Computerco's Circular Economy Director summarised this barrier as follows:

“Governments need to make efforts to... support a transition to a low carbon economy. Market-based mechanisms such as a price on carbon can provide the appropriate price signals to account for negative externalities and create innovation and competition.”

There is a need for price signals to incentivise innovation and competition for circular and sustainable practices, such as using recycled over virgin materials in products. This was confirmed in the Toolco case, in which a lack of policy incentives and regulations inhibited the financial business case for repair. The Toolco Head of Repairs mentioned:

“Beyond a certain point, the high labour costs compared to the costs of a new tool make it financially unattractive to repair products – but this is true for all industries. To change this, you’d either have to reduce labour costs or increase the costs of producing new products.”

A Toolco Marketing Director summarised the lack of a regulatory push for circularity as an overarching problem facing circular business model innovation by saying:

“The concept is there, but there is not a very tangible product or business case for circular economy yet. At some point it will have to be regulation to push the agenda and to create the customer need that we can tap into.”

In the Windco case on the other hand, there was a lack of incentives for lifetime extension, where the 20-year subsidy entitlement in came to an end. As a result, turbines older than 20 years would not further receive subsidies, even though turbines were designed for a 25-30 year lifetime. While Windco can minimise maintenance and operation costs, problems remain for customers on the revenue side. Most old systems have lower hub heights and larger area coverage and will only be able to feed in electricity at higher wind speeds, when market prices are lower due to increased supply. Regulators could prevent the decommissioning of wind turbines after 20 years, by raising the CO2 price for electricity generation or by introducing additional financial support mechanisms. As one Windco Product Life Cycle Management Director stated:

“Without the subsidy and with the currently low prices on spot markets, it will be financially unattractive for many operators to continue to run their turbine beyond the 20-year subsidy period. Depending on their operating costs, they can decide to continue to operate the turbine until the end of the technical life, upgrade to a larger new turbine or decommission the site.”

4.3 Meso-level factors

4.3.1 Market enablers

Among the market enablers, high resource and input prices enabled the extension and cycling of resource loops. Particularly in the Computerco case, an increased demand and value of scrap IT equipment enabled Computerco to cycle products. As Computerco's Manager for Sustainability and Services said:

“When we first started in the UK, there was a lot of IT equipment, but now you will find very little in municipal waste schemes, which tells you that there is a market to sell these devices. There is a growing industry from refurbishment to recycling seeking to valorise this old equipment, particularly corporate IT equipment.”

Together with the organisational enablers, this enabled Computerco to innovate their PSS business models according to CE principles. Chiefly, the company was in the process of changing their business model to prevent losing refurbished products to the open market. Specifically, they piloted models in which customers could lease refurbished equipment, requiring them to return it at the end-of-life. As the Circular Economy Director stated:

“What you will see very soon is that we will extend the leasing offer to refurbished products. That way we will keep them in our economic cycle and prevent them from going to the open market.”

Instead of reselling refurbished computer equipment, Computerco would also offer lease agreements for refurbished equipment, thereby ensuring that products would return to them after the second and possibly even third lifecycle and that they could recover the retained economic value.

4.3.2 Market barriers

The speed of fashion and technological changes inhibited the extending of resource loops, due to the speed at which products became obsolete. In the Toolco, an increasing trend to digitisation and cordless tools as well as innovations around ergonomics, noise reduction, and dust-free operation was observed to lead to shorter product life cycles and to drive their innovation activities. These shortening product life cycles inhibited the extending and cycling of resource loops in two ways. Firstly, they incentivised Toolco to introduce new products at shorter intervals. This can be explained by Toolco's strategic focus on core competency of being a technology and innovation leader in its industry. Secondly, customers were more inclined to trade-in old tools for new tools before the end of the initial lease period. About a quarter of use-oriented PSS customers chose to trade-in tools early (on average three months) before the end of the contract. As one Account Manager explained:

“We have set relatively short-term cycles for our fleet tools to ensure that our customers always have the newest technology available. Especially in the last two years, product life cycles have become shorter since we are introducing more products into the market faster to keep up with trends and evolving customer needs.”

Together with the desire macro-level desire for novelty, this growing speed of fashion and technological changes inhibited the cycling of products. In addition, a lack of customer

acceptance was also identified as a barrier to the extending of resource loops at Toolco. Compared to customers in other markets, such as Scandinavia, UK customers cared less about the product durability and quality value proposition of Toolco products and instead more for price. As a result, Toolco had a much higher market share in Scandinavia than in the UK.

In the Windco case, market barriers around the speed of fashion and technological changes were also identified. As the Product Life Cycle Management Director pointed out:

“Life cycles have become extremely squeezed due to high competition. Instead of 10-11 years, we now have 1-2 years to develop a new product and to run it for 3-4 years, before we phase it out again.”

These shortening product life cycles make it more attractive for customers to upgrade to larger and more powerful wind turbines after the end of the regular 20-year lifetime. Repowering to larger turbines allows more efficient generation of wind power. Even though this puts a pressure on lifetime extension, old turbines are often rebuilt in developing countries.

“One important current topic in Germany is repowering, because the best sites have the oldest turbines and therefore the lowest productivity. Repowering means that these plants are dismantled and new plants with higher capacity are built there. The old plants are often reused in developing countries to use the remainder of the technical lifespan.”

4.4 Micro-level factors

4.4.1 Organisational factors

4.4.1.1 Organisational enablers

As observed in our data, organisational factors enabled the extending and cycling of resources particularly in the Computerco case. In this case, the importance of environmental awareness within the company was mentioned as a key enabler. At Computerco, environmental sustainability and awareness were deeply embedded in the firm culture, giving employees a sense that sustainability and circular economy were aligned with the company's vision and mission. As the Circular Economy Director pointed out:

“Our commitment to CE is a natural evolution from our 25-year-old recycling programmes. From the beginning, our founders had the principle of ‘Global Citizenship’ behaving well towards the society that we are in is one of our core values.”

Having a pro-environmental culture and CE integrated into company strategy down to the business unit enables extending and cycling of resource loops, because it encourages employees to find ways to increase the circularity contribution of its PSS. The company's

culture promotes experimentation that incentivises employees to develop innovative lighthouse projects that increase circularity. As the Services & Sustainability Manager stated:

“Being a responsible company is part of our DNA and people are measured on that... There is a lot of thought around doing things better, such as cutting down onsite repairs, doing preventive maintenance before the unit is broken to help consolidate the customer visits.”

This was confirmed by the Circular Economy Director:

“We are always looking for ways to improve and to find new circular economy business cases.”

This organisational commitment to CE and willingness to experiment enabled Computerco to keep products and materials in the loop longer, even though they had the fastest speed of fashion and technological cycles among the three case companies. This manifested itself, for example, in the introduction of pilots to cascade and keep equipment in within their economic cycle for multiple use cycles through customer segmentation. Depending on the type of customer, the company could cascade used equipment from users with high needs, such as a graphic designer to users with lower needs such as schools and then eventually retirement homes, for example.

4.4.1.2 Organisational barriers

Contrary to Computerco's enabling organisational awareness around CE, there were a range of barriers in both Toolco and Windo organisations which inhibited the extending and cycling of resources. In the Toolco case, cycling is inhibited by organisational linear lock-in and the prevailing linear mind-set and company structure. Even though the company is widely regarded as a CE pioneer for its high-quality products, repair services, and leasing business model, its environmental strategy is still relatively young. The first top-down environmental strategy is formulated just the year prior to the study, causing hesitancy and resistance to cycling resource loops through refurbishment, as the Sustainability Director confirmed:

“Up to now there has been a bit of reluctance within the company regarding refurbishment just because we are a premium brand and there was no appetite to create a secondary brand or cannibalise the market...”

Even though the products are of high-quality, durable, and in many instances, still usable, Toolco do not refurbish but instead, recycle them. In the use-oriented PSS, around 60% of the returned tools are still usable, and about 1-3% of these are in good enough condition to be reused as loan tools. For the others, refurbishment would be technically possible, but the company instead decommissions and recycles them. This contradicts CE principles of always

keeping products and materials at the highest utility and value. This inconsistency can be attributed to the company's underlying linear business logic, focused on new product sales and a desire to protect the brand against offering an inferior refurbished product. Another factor that contributed here was the strategic positioning of Toolco. As a Toolco Product Manager pointed out:

“One option to make the current use-oriented PSS more circular is a model where you buy capacity, so having many tools of a specific type. This way, we could have more options to exchange tools, maybe even use refurbished ones. The main barrier for such a sharing model is that we could compete with some of our customers, who are tool-hire companies.”

Even though the company has a strong foundation with high-quality tools and a well-developed repair network, it fails to maximise the circularity potential of its offering. This becomes apparent when comparing the way that the organisation engaged with CE. While Computerco pursued an ambitious vision around keeping products in their own life cycle, Toolco wasn't that far yet.

4.4.2 Financial barriers

In the case of Windco, the cycling of resources was also inhibited by financial barriers and the increased complexity, cost, and financial risks of circular business models. Since Windco does not retain product ownership, they do not recover components and materials at end-of-life. For Windco, offering recycling services was not considered a potential business model due to the low margins, low volumes currently in the market, and the difficulty of building a scalable business model around it. As the Business Development Manager noted:

“Turbine decommissioning is difficult for us. There simply aren't the volumes yet in the market, but apart from that, it has relatively low margins and is nothing that you can build a scalable process around. It is more suitable for smaller, more agile companies than us.”

Due to these financial barriers, however, Windco ultimately fails to recover the components and materials embedded in the turbines.

4.4.3 Technology & knowledge-related enablers

Across all three cases, circularity was enabled by a range of technology- and knowledge-related factors. Regarding the ability to design products for circularity, all three companies were leaders in their respective industries, designing their products for circularity. Computerco, for example, has a dedicated strategy on product design for sustainability that focuses, among

others, on designing products for repair, reuse, refurbishment, and recycling. As Computerco's Manager for Services and Sustainability stated:

"Our product design teams consider the end of service and questions such as spare part availability, ease of disassembly, materials identification, and the ability to separate materials already from the start of the design process. This helps us in the service department do a better job at keeping the products in use and recovering and reusing as much material as possible at the end of life."

One example from Toolco stood out, in which the company recently re-designed the rotor to be more easily remanufactured. As a result, rotors from decommissioned products could be remanufactured and used in repair services. By remanufacturing the rotor and the tool electronics, the company can recoup around 10% of the original tool value. For the Head of Repair Services, this was a notable achievement:

"The remanufacturing and reuse of rotors and electronics is an important part of the circular economy strategy for the repair services. It allows us to deliver the same repair quality while also allowing us to recoup around 10% of our tool value. In the future, we could also apply this to other spare parts, such as cables. Ultimately, the decision for remanufacturing components depends on whether it negatively affects repair quality and whether it is an economical process."

Even though digital capabilities were present across all three cases, they were most prevalent in the Windco case. Windco utilises a range of remote diagnostic services in its result-oriented PSS, which help extend resource loops through preventive maintenance and upgrades. As one Windco Operations Manager note:

"We use remote monitoring and vibration diagnostics, which help us catch faults, such as gear or main bearing damage, before they develop into serious damage, thereby helping extend the initial lifetime of products. Using these tools is key for our profit margin: preventive interventions and upgrades cost on average 80% less than corrective actions."

Overall, the use of these technologies enables circularity by keeping a turbine's operating costs low, thereby creating a viable business case for lifetime extension.

5 Discussion

The CE literature espouses that PSS are a way to foster the transition to a circular economy. There is an implicit assumption that use- and especially result-oriented PSS have a high

circularity contribution since they retain product ownership and are responsible for product life cycle management activities (Tukker, 2015; Yang *et al.*, 2018). This assumption can be explained through NRBV and the tenet that stakeholder integration is a key organisational capability for product stewardship (Hart, 1995). This paper elaborates on the NRBV by identifying various macro-, meso-, and micro-level enablers and barriers and their interrelationships in affecting the contribution of PSS to circularity as shown in Figure 1. It shows that the contribution of PSS to circularity depends on the presence of wider contextual enablers and inhibitors. By connecting the effects across the macro-, meso-, and micro-level, this study proposes specific ways for PSS providers to overcome meso- and macro-level inhibitors.

Our findings elaborate on the NRBV by showing that product stewardship is not just determined by stakeholder integration but also by a firm's awareness of environmental issues and commitment to sustainability. The positive role and impact of a firm's awareness of environmental issues have been shown (Bocken and Geradts, 2020; Chan *et al.*, 2012). This study extends this earlier work by showing that the type of business model is an important enabler for supporting circular business model innovation, particularly to overcome the inhibiting effects of high speed of fashion and technological changes.

In the case studies, this became apparent in the comparison of Computerco and Toolco. Both companies had very similar use-oriented business models, with both retaining product ownership throughout the lifecycle. Compared to Toolco, Computerco operated in a business environment with a higher speed of fashion and technological changes, which has been shown to inhibit the potential for cycling products due to the risks associated with multiple product life cycles (Linder and Williander, 2017; Urbinati *et al.*, 2021). Computerco managed to overcome the higher speed of fashion and technological changes by cascading refurbished products to customer segments with lower demands for product performance and novelty. Toolco, on the other hand, decommissioned and recycled the vast majority of tools, even though they were still usable. This can be explained by Computerco's environmental awareness within the company and the company's strong values around product stewardship and environmental protection. These values are communicated and shared throughout the company and disseminated to employees, thereby supporting the development of CE-related projects and initiatives. On the other hand, Toolco did not have a strong internal environmental awareness and only started to prioritise environmental performance, as evidenced by the fact that it only introduced the first top-down environmental strategy just a year prior to the study. Even though there was no refurbishment at product-level, Toolco did innovate to remanufacture components, such as the rotor and the electronics, thereby recovering around 10% of the original tool value. While this is only a first step, it suggests that firms may start with component

remanufacturing before progressing to more complex and advanced practices, such as product refurbishment.

This finding contradicts previous studies that suggested that a firm's environmental awareness did not have an enabling effect on the contribution of PSS to circularity (Kühl *et al.*, 2022) and reinforces the notion that the effective implementation of circular PSS business models hinges on the ability of PSS providers to internalise, identify, and capture value creation opportunities based on CE principles (Hofmann, 2019; Matschewsky, 2019). This leads us to propose the following:

P1: Environmental awareness within a company enables the cycling of resources through refurbishment in use-oriented PSS business models, even in contexts with high speed of fashion and technological changes.

Returning to the NRBV (Hart, 1995), our research suggests that the type of product stewardship practices that are enacted by a firm depend on the presence of wider contextual factors. Specifically, our research points to significant contextual inhibitors to the extending and cycling of resource loops, thereby providing important empirical evidence to a growing argument in literature against the potential of circular business models, especially regarding the inner loops of maintenance, repair, and refurbishment (Hofmann, 2019; Kühl *et al.*, 2022; Mayers *et al.*, 2021). This research extends previous classifications of enablers and barriers by showing that there are wider macro-, meso-, and micro-level factors that inhibit the contribution of PSS to the extending and cycling of resource loops (Urbinati *et al.*, 2021; Vermunt *et al.*, 2019).

This is particularly visible in Toolco case, in which a macro-level cultural desire for novelty, a meso-level increasing speed of fashion and technological changes, and a micro-level organisational linear lock-in inhibited the refurbishment of still usable tools. This finding extends existing frameworks by uncovering the cultural desire for novelty as a new enabler. The increasing speed of fashion and technological changes incentivised Toolco to introduce new products at shorter intervals, providing customers with the most up-to-date technology. In addition, the company is limited by its existing self-identity as a premium brand and the potential brand image risks of refurbishing tools, which could also lead to the cannibalisation of new product sales. For Toolco, the company's existing focus on product innovation and brand differentiation is enhanced by the increasing speed of industry innovation cycles, which further inhibits the cycling of resource loops through refurbishment. Organisational linear lock-in limits the potential for the extending and cycling of resource loops by incentivising both Toolco salespeople and customers to prioritise new products over maintaining and repairing/refurbishing old ones. This leads to the following proposition:

P2: The cultural desire for novelty and high speed of fashion and technological changes encourages organisational linear lock-in, which inhibits refurbishment and is a barrier to the cycling of resource loops in use-oriented PSS.

In addition, the findings also point to the inhibiting effect of the current political factors on the financial business case for circular activities. Previous classifications of enablers and barriers have pointed to the potentially inhibiting effect of political factors, such as a lack of political incentives that promote value retention (Hina *et al.*, 2022; Kirchherr *et al.*, 2018; Tura *et al.*, 2019; Urbinati *et al.*, 2021). This study builds on these arguments by showing that this factor primarily inhibits the extending of resource loops by decreasing the business case for lifetime extension activities. This became particularly evident in the Windco and Toolco cases, in which lifetime extension was technically possible but inhibited by a lack of appropriate incentives. The adverse effect of the regulatory environment is evident in the Windco case, where a lack of policy support mechanisms for lifetime extension risks the decommissioning of wind turbines before the end of their technical lifetime. The difficult market situation due to low prices on spot markets, in addition to the removal of subsidies, makes the financial business case for lifetime extension difficult for customers regardless of the potential services and cost savings offered by Windco. This is a problem for the energy transition in Germany due to the risk of wind turbines being decommissioned before the end of their lifetime and without a suitable replacement. In the case of Toolco, this manifested itself in high repair costs vis-à-vis new products due to high value-added taxes. Even though an increasing focus of policymakers on extending resource loops is starting to emerge since the time of data collection, as evidenced by recent movements to enhance the “Right-to-Repair”, there is still significant room for policymakers to incentivise an extending and cycling of resource loops (Domenech and Bahn-Walkowiak, 2019; European Parliament, 2022; House of Commons Library, 2021). This leads us to propose the following:

P3: The lack of political incentives limits the financial business case for lifetime extension and is a barrier to the extending of resource loops in use- and result- oriented PSS.

Overall, these findings elaborate on the NRBV by showing that the type of product stewardship practices that a firm implements depend on the presence of macro- and meso-level inhibitors. In regard to CE, it provides empirical evidence for the assertion that with the current system conditions in place, PSS will not radically affect the extending and cycling of resource loops (Hofmann, 2019).

INSERT FIGURE 1 HERE

The study also extends existing models and the understanding of how the contribution of PSS business models to circularity develops over time as shown in figure 2. To date, the literature has not examined different circularity maturity profiles of PSS business models. This study extends the existing literature by making a first approach to uncovering how circularity practices change and develop (Frishammar and Parida, 2019; Yang *et al.*, 2018).

Both use-oriented PSS business models of Toolco and Computerco had similar characteristics, providing equipment leasing services and retaining product ownership, but different approaches to circularity. The reviewed PSS can broadly be categorised into three levels. In the first level, the circularity maturity profile focuses on extending a single product life cycle and recovering components and materials at end-of-life. This is evidenced by Toolco, in which the PSS focused on extending resource loops through product lifetime extension (e.g., design for durability and maintenance) and the cycling of resource loops through component remanufacturing and recycling. In the second level, the circularity maturity is increased, by adding an additional product life cycle through refurbishment and resale (cycling), as evidenced by the Computerco case. In the final maturity level for use-oriented PSS, the circularity profile is then increased again by cascading refurbished products across multiple life cycles and recycling products and materials at end-of-life in a closed-loop (cycling). This was evidenced by Computerco's pilot projects for extending the existing use-oriented PSS.

This approach extends previous research on PSS and circular business models by putting forward a categorisation of different circularity maturity profiles within PSS business models. Yang *et al.* (2018) provided a static view of circularity profiles across PSS types. Frishammar and Parida (2019) examined the transformation of incumbent firms moving from linear to circular business models, both not accounting for different maturity levels within PSS. Sehnem *et al.* (2019) did develop a maturity model for circular business models but focused primarily on organisational and less on the operations and supply chain practices associated with specific maturity levels. Overall, this provides an interesting insight into the different phases that use-oriented PSS business models pass through as well as the practices that managers can implement to increase the circularity of their offering. This leads us to propose the following:

P4: The circularity contribution of use-oriented PSS can be categorised into three maturity levels: i) maintenance/repairs, component remanufacturing, and recycling; ii) adding product refurbishment and resale; iii) cycling refurbished products across multiple life cycles.

INSERT FIGURE 2 HERE

6 Conclusion

6.1 Theoretical contribution

This study set out to examine the role of macro-, meso-, and micro-level enablers and inhibitors on the contribution of PSS to circularity while also elaborating on the NRBV. It answered the following research question: *“How do macro-, meso-, and micro-level contextual factors enable and inhibit the contribution of PSS business models to circularity?”* By conducting three case studies of manufacturing firms that provided use- and result-oriented PSS, we gathered evidence to show that the circularity contribution of PSS business models depends on the presence of enabling and inhibiting contextual factors. Our contributions to theory are explicated in three domains.

Firstly, this study elaborates on NRBV (Hart, 1995; Hart and Dowell, 2011) in two ways. It shows that product stewardship is not just determined by stakeholder integration but also by a firm's environmental awareness. This extends previous work (Urbinati *et al.*, 2021) by showing that it can offset the inhibiting effect of high speed of fashion and technological changes on refurbishment in use-oriented PSS. In addition, this study elaborates on NRBV by showing that the presence of macro- and meso-level cultural, political, and market enablers and inhibitors determines whether product stewardship strategies are more focused on extending or cycling of resource loops. This also provides important empirical evidence explaining why PSS business models are limited in their contribution to extending and cycling of resource loops (Hofmann, 2019; Kühl *et al.*, 2022; Mayers *et al.*, 2021).

Secondly, this study shows that there are different circularity maturity levels within use-oriented PSS. It proposes that use-oriented PSS pass through three maturity levels with increasing circularity levels, focusing on: i) maintenance/repairs, component remanufacturing, and recycling; ii) adding product refurbishment and resale; iii) cycling refurbished products across multiple life cycles. This extends existing literature by making a first approach to uncovering circularity maturity levels within PSS and how circularity practices change and develop over time (Frishammar and Parida, 2019; Sehnem *et al.*, 2019; Yang *et al.*, 2018).

Thirdly, this study draws on transition theory's multi-level perspective (Geels, 2002, 2011; Joore and Brezet, 2015) to understand the enabling and inhibiting effects and relationships between factors at micro-, meso-, and macro-level contextual factors. It puts forward a framework (shown in Figure 1) on enablers and barriers for circularity in PSS that extends existing work (Tura *et al.*, 2019; Urbinati *et al.*, 2021; Vermunt *et al.*, 2019) by eliciting new relationships, such as the inhibiting effects of a cultural desire for novelty, lack of political incentives, speed of fashion and technology, and organisational linear lock-in on the cycling of

resource loops, through refurbishment. In addition, it identifies two new cultural enablers: 1) growing awareness of sustainability and 2) acceptance of subscription-based business models and a new cultural inhibitor around the desire for novelty. Overall, the findings provide empirical evidence that shows that these strong enabling and inhibiting systemic forces effect the extending and cycling of resource loops (Hofmann, 2019; Mayers *et al.*, 2021). This fills existing research gaps around understanding the effects of macro-, meso-, and micro-level contextual factors on circular business model implementation models (Hina *et al.*, 2022; Sarasini and Linder, 2018; Urbinati *et al.*, 2020) and builds a further empirical base around the circularity implications of PSS business models in manufacturing (Bjørnset *et al.*, 2021).

6.2 Managerial and policy implications

This study has several implications for managers and policymakers. It offers managers a framework for understanding the interrelationships between various contextual factors and how they affect the circularity contribution of PSS (see Figures 1 and 2). This shows the importance of organisational factors in enabling and inhibiting the circularity contribution of PSS. This implies that companies wishing to implement a circular PSS business model should invest in strengthening the internal environmental awareness and orientation. This could be done by embedding circularity in key organisational departments (e.g., supply chain), encouraging employees to start innovative circularity projects, and providing top management support and commitment. By doing so, they could provide new insights and impulses to innovate their business model according to CE principles and unlock the potential economic and environmental benefits. Secondly, it provides companies with an initial understanding of circularity maturity levels in use-oriented PSS. The study suggests that there are three maturity levels and circularity profiles in use-oriented PSS. Managers can leverage this understanding to assess the maturity of their own use-oriented PSS and identify potential improvement opportunities.

Policymakers can use our findings to adapt some of the macro- and meso-level contextual factors that inhibit the extending and cycling of resource loops. There are three policy recommendations that emanate from this research. Firstly, policymakers are advised to provide stronger incentives to extend and cycle resources, for example, by introducing a CO₂/resource tax, which would make primary production and virgin resource use less economically attractive, and to incentivise repairs and refurbishment, for example, by lowering the value-added tax for these services. Secondly, policymakers need to address cultural inhibitors, such as the desire for novelty. This could be done by expanding on the right-to-repair initiatives or by funding information campaigns to make lifetime extension and refurbished/remanufactured products more attractive to customers. Finally, policymakers need

to strengthen regulatory requirements for the cycling of resource loops through refurbishment, for example, by mandating manufacturers to repair or refurbish still usable products.

6.3 Limitations and future research directions

There are certain limitations that need to be considered when interpreting our findings, which, however, also provide avenues for further research. Firstly, this study relied on purposefully chosen cases, which may limit the external validity of the findings. This study was limited to three large multinational firms that operate in a variety of different business-to-business environments. As with all case study research, instead of statistical generalisation, this study aimed for a theoretical generalisation of findings (Yin, 2018). The cross-case comparison was intended to increase the generalisability of the findings (Eisenhardt, 1989). Even though all cases are leading examples of PSS implementation, they may not necessarily be archetypal for all manufacturing firms that offer PSS.

This research took a focal firm perspective to test the tenets of the NRBV regarding the circularity implications of PSSs, but this could be expanded on to employ a dynamic capabilities perspective (Teece *et al.*, 1997) to elaborate on how firms make the transition from a linear to circular business models and how they develop the necessary capabilities. In addition, the research could expand on the focal firm perspective and include a value network or ecosystem perspective (Frishammar and Parida, 2019; Geissdoerfer *et al.*, 2020) to identify how manufacturing firms innovate their ecosystems to align their value creation, delivery, and capture processes to circularity. Moreover, future research can test the propositions developed. An interesting research avenue could focus on testing and further developing the proposition on the circularity maturity levels and expand it from use-oriented to result-oriented PSS and to other types of circular business models.

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Table 1 Overview of enablers and barriers from the literature

Multi-level Perspective	Enablers	Source	Barriers	Source
Macro-level (Societal level)				
Cultural			<i>Focus on maximising shareholder value:</i> Fosters uncertainty avoidance and short-termism	(Bocken and Geradts, 2020)
			<i>Lacking sense of urgency:</i> awareness and sense of urgency in society to transition to sustainability	(Vermunt <i>et al.</i> , 2019)
Political	<i>Directing targets and regulations:</i> Regulate implementation of circular practices (e.g. product standards)	(Tura <i>et al.</i> , 2019; Urbinati <i>et al.</i> , 2021)	<i>Lack of political incentives:</i> Few incentives that promote value retention over material consumption (e.g., no resource / CO2 tax; value-added tax)	(Govindan and Hasanagic, 2018; Hina <i>et al.</i> , 2022; Kirchherr <i>et al.</i> , 2018; Vermunt <i>et al.</i> , 2019)
			<i>Lack of clarity over waste, by-product and resource status:</i> inhibit cross-border transport, repair, and recycling	(Hina <i>et al.</i> , 2022; Vermunt <i>et al.</i> , 2019)
			<i>Lacking quality standards:</i> erode customer trust in repaired or refurbished products	(Vermunt <i>et al.</i> , 2019)
Meso-level (Socio-technical level)				
Market	<i>High prices and price volatility of resource inputs:</i> Incentivises extension and cycling of resource loops	(Urbinati <i>et al.</i> , 2021)	<i>Speed of fashion and technological changes:</i> High speed of fashion and technological changes, limit customer demand for long-lasting or repaired/refurbished products.	(Linder and Williander, 2017; Urbinati <i>et al.</i> , 2021)
	<i>Resource scarcity of key input materials:</i> incentivises extension and cycling of resource loops to ensure business continuity	(Urbinati <i>et al.</i> , 2021)	<i>Lack of customer acceptance:</i> Inhibits uptake of use- and result-oriented PSS business models or of refurbished/ remanufactured products.	(Hina <i>et al.</i> , 2022; Kirchherr <i>et al.</i> , 2018; Vermunt <i>et al.</i> , 2019)
			<i>Difficulty of predicting customer demand for products with multiple life cycles:</i> increases financial risks for circular business models.	(Guldmann and Huulgaard, 2020; Linder and Williander, 2017)

Multi-level Perspective	Enablers	Source	Barriers	Source
Supply Chain	<i>Geographical proximity of supply chain partners:</i> enables circularity, by facilitating collaboration, reducing costs	(Delgadillo Jaime <i>et al.</i> , 2021; Urbinati <i>et al.</i> , 2021)	<i>Lack of willingness to collaborate:</i> Inhibits CE practices (e.g., lack of information sharing on product designs inhibits refurbishment.	(Hina <i>et al.</i> , 2022; Vermunt <i>et al.</i> , 2019)
	<i>Availability of collaboration platforms:</i> provide advisory and support for industry actors	(Meath <i>et al.</i> , 2022)	<i>Lack of availability of suitable secondary raw materials:</i> Inhibits use of recycled materials.	(Vermunt <i>et al.</i> , 2019)
			<i>Lack of suitable partners:</i> Inhibits ability to implement circular practices (e.g., recycling).	(Tura <i>et al.</i> , 2019; Vermunt <i>et al.</i> , 2019)
Micro-level (Firm-level)				
Organisational	<i>Environmental awareness within the company:</i> Increases awareness for CE and sustainability.	(Urbinati <i>et al.</i> , 2021)	<i>Hesitant company culture:</i> Inhibits willingness to engage in CE projects with lower initial returns / higher risk profile.	(Bocken and Geradts, 2020; Kirchherr <i>et al.</i> , 2018; Tura <i>et al.</i> , 2019)
	<i>Integration of CE into company strategy:</i> Prioritises CE vis-à-vis other initiatives.	(Tura <i>et al.</i> , 2019)	<i>More complex management and planning process:</i> Inhibits willingness to implement the reverse supply chain.	(Linder and Williander, 2017; Vermunt <i>et al.</i> , 2019)
	<i>Long-term orientation of management:</i> Increases willingness of management to engage in CE projects with higher risk profile.	(Bocken and Geradts, 2020)	<i>Risk of product sales cannibalisation:</i> inhibits implementation of product refurbishment.	(Linder and Williander, 2017)
			<i>Organisational linear lock-in:</i> Lack of willingness to innovate business model from linear to circular.	(Guldmann and Huulgaard, 2020; Tura <i>et al.</i> , 2019)
			<i>Lack of communication, silo thinking, and unclear roles and responsibilities:</i> Misalignment between departments inhibit implementation of cross-functional CE practices	(Bocken and Geradts, 2020; Jabbour <i>et al.</i> , 2020)

Multi-level Perspective	Enablers	Source	Barriers	Source
Financial			<i>Incentive structure supports existing linear business model:</i> Existing incentives inhibit circularity (e.g. focus on fast project payback periods)	(Bocken and Geradts, 2020; Guldmann and Huulgaard, 2020)
			<i>Increased complexity, cost, and financial risks of circular business models:</i> Demand and value of products across multiple life cycles is difficult to predict.	(Hina et al., 2022; Ingemarsdotter et al., 2020; Kirchherr et al., 2018; Linder and Williander, 2017)
			<i>High up-front capital expenditures and investment costs:</i> Costs for setting up operations (e.g., reverse logistics or remanufacturing operations)	(Hina et al., 2022; Linder and Williander, 2017; Urbinati et al., 2021; Vermunt et al., 2019; Wrålsen et al., 2021)
			<i>Lack of resources (i.e., time, money):</i> Lacking resources to implement circular business models and supply chains	(Bocken and Geradts, 2020; Guldmann and Huulgaard, 2020; Hina et al., 2022; van Keulen and Kirchherr, 2021; Malik et al., 2022)
Technology & Knowledge	<i>Ability to design products for circularity:</i> Facilitates lifetime extension, reuse, repair, refurbishment, reman, recycling	(Zeeuw van der Laan and Aurisicchio, 2020)	<i>Lack of CE knowledge in identifying and assessing business model innovation opportunities:</i> Inhibits potential to identify new CE opportunities	(Bocken and Geradts, 2020; Guldmann and Huulgaard, 2020; Hina et al., 2022; Witjes and Lozano, 2016)
	<i>Ability to use digital capabilities and tools:</i> Use of digital tools (e.g. IoT) enables use of product information & data to optimise life-cycle management.	(Ingemarsdotter et al., 2020; Zeeuw van der Laan and Aurisicchio, 2020)	<i>Lack of access to digital technologies:</i> Prevents utilisation of tools to optimise product life-cycle management (e.g., Internet of Things)	(Hina et al., 2022)
			<i>Low or variable quality and quantity of returned products:</i> Increases complexity of extending & cycling resources	(Urbinati et al., 2021)
			<i>Unsuitable product design, due to high complexity in materials and number of components:</i> increases difficulty of extending and cycling resources	(Urbinati et al., 2021)

Multi-level Perspective	Enablers	Source	Barriers	Source
			<i>Technological trade-offs between product quality and circularity:</i> limit the potential to for circularity (e.g., use of recycled instead of virgin feedstock)	(Hina <i>et al.</i> , 2022; Yang <i>et al.</i> , 2018)
			<i>Insufficient training and availability of skilled personnel:</i> Inhibit implementation of CE practices (e.g., refurbishment)	(Hina <i>et al.</i> , 2022; Tura <i>et al.</i> , 2019; Vermunt <i>et al.</i> , 2019)

Table 2 Overview of case companies

	Computerco	Toolco	Windco
Case Companies			
Organisation	North American manufacturer of office equipment	European manufacturer of power tools	European manufacturer of wind turbines
Product description	Computer notebooks	Power tools for construction industry	Wind turbines
Speed of industry innovation cycles	~3-5 years	~5-7 years	~7 years
No. of employees	50,000+	25,000+	8,000+
Annual Turnover	~£45 Billion	~£5 Billion	~£8 Billion
Geography	United Kingdom	United Kingdom	Germany
Unit of Analysis			
Product-service system	Leasing contract (use-oriented PSS)	Leasing contract (use-oriented PSS)	Availability contract (result-oriented PSS)
Data Collection			
Interviews	2	9	9
Interviewees	Manager Sustainability Services & Stewardship; Senior Director for Global Sustainable Impact Operations (Global CE lead)	Marketing Director, Marketing Manager, Sustainability Director, Account Manager (x3), Product Manager, Head of Repair Services, Logistics Manager	Business Development Manager; Operations Manager (x2); Product Life Cycle Management Director; Research & Development Manager; Service Director (x2); Sustainability Manager (x2)
Documents (e.g., reports, presentations, press briefings)	23	17	33
Observations	-	1 (2-hour visit to service and repair centre)	-

Table 3 Extending and cycling of resource loops across the three case studies

	Computerco <i>Use-oriented PSS</i>	Toolco <i>Use-oriented PSS</i>	Windco <i>Result-oriented PSS</i>
Extending resource loops			
<i>Long-lasting product design</i>	Average product quality in industry. Lifetime of 2-4 years.	High quality and durable product designs. Expected lifetime 3-5 years or more, depending on use intensity.	20 years standard lifetime, but often up to 25 years. Windco is a quality leader in industry.
<i>Maintenance</i>	Maintenance and product support included in offering. Service level depends on customer preferences.	Maintenance services included in use-oriented PSS.	Extension by up to 10 years possible, due to optimised preventive maintenance, corrective maintenance and upgrades.
Cycling of resource loops			
<i>Reuse</i>	N/A	About 85% of tools are returned. About ~1-3% in good enough condition to be reused as loan tools.	Customer has the potential to decommission site and sell for reuse abroad.
<i>Repair</i>	Repair services included in use-oriented PSS.	Repair services included in use-oriented PSS.	Repair services included in result-oriented PSS
<i>Product refurbishment</i>	Around 75% of products returned. Of these ~80% of all returned products are refurbished and resold. Refurbished products currently lost to open market. Pilots in place to lease refurbished tools to recover products.	N/A	N/A
<i>Component remanufacturing</i>	N/A	Recovers the rotor and electronics (about 10% of the tool's value), which are remanufactured and reused in repair services.	Closed-loop remanufacturing of generators, gearboxes, main bearings, shafts, blades, and electronic components. Old components are exchanged for remanufactured ones and then remanufactured.
<i>Recycling</i>	Around 75% of products returned. Of these ~20% are recycled. Closed-loop recycling for plastics.	Around ~85% of tools recovered after end of contract. Of these around ~97-99% are recycled.	Windco does offer decommissioning & recycling services, due to low volumes & margins. Customers responsible for recycling.

Table 4 Enablers and barriers at macro-, meso-, and micro-level

Enablers and barriers	Computerco (use-oriented PSS) Effect/Explanation	Toolco (use-oriented PSS) Effect/Explanation	Windco (result-oriented PSS) Effect/Explanation
MACRO-LEVEL (SOCIETAL)			
Cultural Factors			
<i>ENABLERS</i>			
*Growing societal awareness for sustainability	Extending & Cycling: Resulted in increased customer demand for circular business models.		
*Societal shift to subscription-based economy	Extending & Cycling: Changing social norms around product ownership are making it easier to sell service solutions.		Extending & Cycling: Increasing sustainability awareness of external stakeholders increased willingness of internal stakeholders to engage in sustainability-related projects.
<i>BARRIERS</i>			
*Cultural desire for novelty		Extending & Cycling: Customers desired new products, enjoyed experience of buying new products	
Political Factors			
<i>ENABLERS</i>			
Directing targets and regulations:	Cycling: Regulatory requirement to recycle products at end-of-life	Extending & Cycling: UK Government's 2025 national construction strategy prioritised importance of sustainability to construction industry. Cycling: Regulatory requirement to recycle products at end-of-life	Cycling: Regulatory requirement to recycle products at end-of-life
<i>BARRIERS</i>			
Lack of political incentives:	Extending & Cycling: Lack of incentives decreases competitiveness of circular business models.	Cycling: High costs of labour vis-à-vis production limit business case for repairs.	Extending: Phase out of government subsidies make a customer's business case for lifetime extension more difficult.
Lack of clarity over waste, by-product & resource status:	Cycling: Limitation for coordinating cross-border repair & recycling networks.		
MESO-LEVEL (SOCIO-TECHNICAL)			

Enablers and barriers	Computerco (use-oriented PSS) Effect/Explanation	Toolco (use-oriented PSS) Effect/Explanation	Windco (result-oriented PSS) Effect/Explanation
Market Factors <i>ENABLERS</i> High prices and price volatility of resource inputs: <i>BARRIERS</i> Speed of fashion and technological changes Lack of customer acceptance	Cycling: Value of equipment on secondary market incentivised Computerco to recover equipment, by cascading use-oriented PSS.	Extending & Cycling: Innovations around cordless tools create need in the market for new tools, make it more attractive for customers to upgrade to new equipment. Extending: Customers do not value premium value proposition of durability as much as in other markets.	Extending: Shortening product life cycles make it more attractive for customers to upgrade to larger turbines. Limit lifetime extension opportunities.
MICRO-LEVEL (FIRM-LEVEL)			
Organisational Factors <i>ENABLERS</i> Environmental awareness within the company: Integration of CE in company strategy	Extending & Cycling: Top management encourages employees to identify innovation opportunities, for example by cascading products across multiple life cycles. Extending & Cycling: Prioritised CE as a key innovation framework and value driver.		
<i>BARRIERS</i> Organisational linear lock-in Risk of product sales cannibalisation	Cycling (not present): Overcame risks of product cannibalisation, by marketing refurbished equipment to different market segments.	Cycling: Refurbishment of products and perceived lower product quality regarded as undermining premium brand image. Cycling: Company wants products returned from lease to ensure decommissioning, prevent cannibalisation of new product sales.	
Financial Factors <i>BARRIERS</i>			

Enablers and barriers	Computerco (use-oriented PSS) Effect/Explanation	Toolco (use-oriented PSS) Effect/Explanation	Windco (result-oriented PSS) Effect/Explanation
Increased complexity, cost, and financial risks			Cycling: Decommissioning and recycling turbines not seen as a viable business model, due to low margins and volume.
Technology & Knowledge			
<i>ENABLERS</i>			
Ability to design products for circularity	Extending & Cycling: Considered durability and circularity aspects already in design to extend lifetime, facilitate cycling.	Extending & Cycling: Considered durability and circularity aspects already in design to extend lifetime, facilitate cycling (e.g., re-designed rotor to enable remanufacturing)	Extending & Cycling: Considered durability and circularity aspects already in design to extend lifetime, facilitate cycling (e.g., design components for remanufacturing)
Ability to use digital capabilities and tools		Extending: Use of remote monitoring to optimise maintenance activities.	Extending: Extensive use of remote monitoring and diagnostic technology helps prevent component damage, keep operation costs low, thereby extending product lifetime.

*Denotes newly identified enabler or barrier

Figure 1: A conceptual framework illustrating the contextual factors and their affect on extending and cycling for use and result oriented PSS business models.

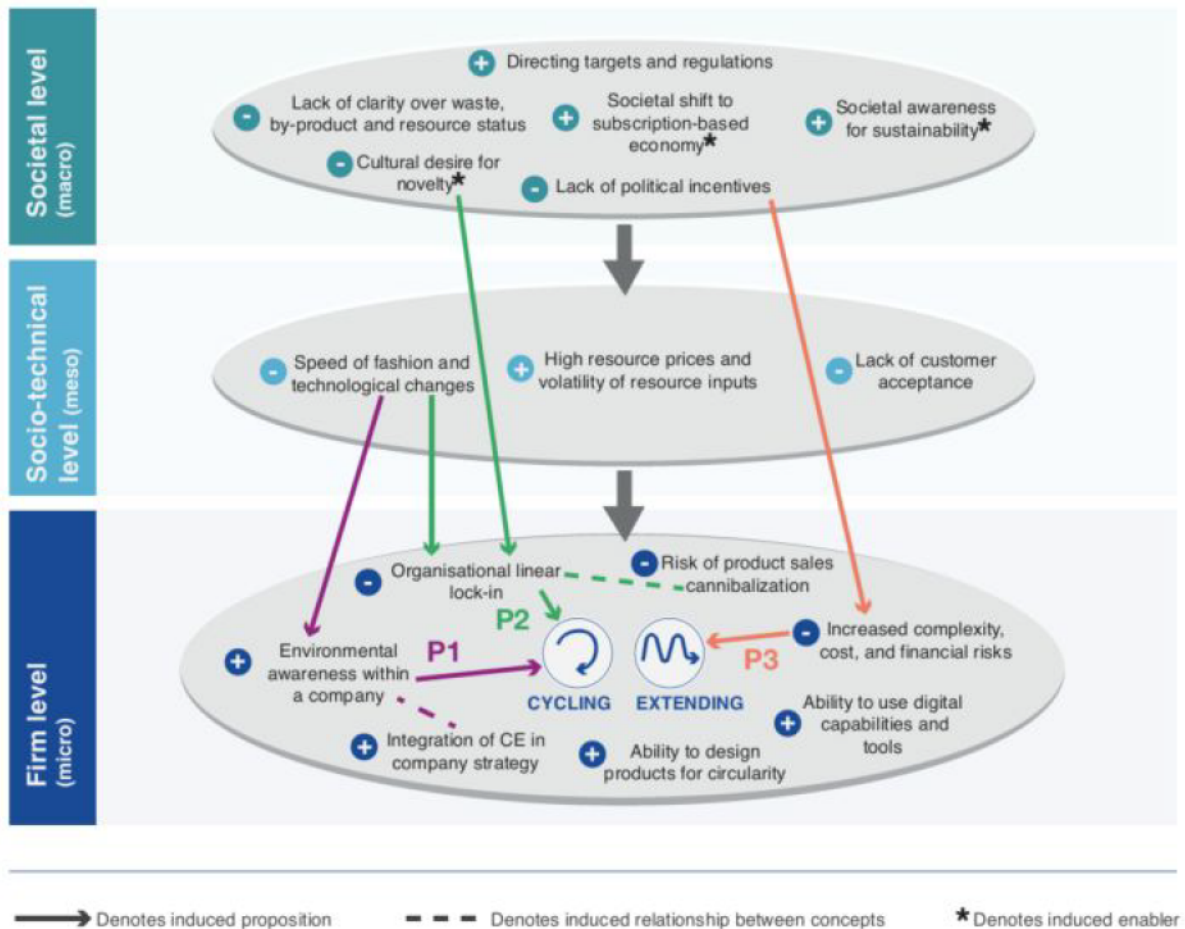


Figure 2: A conceptual framework showing the contribution of PSS business models for three circularity maturity levels

