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Circular product development from a multi-level perspective: Adaptations in business networks☆

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ABSTRACT

Product development based on circular economy principles can lead to environmental and economic benefits by addressing resource use in production–consumption systems. This inter-organisational process affects a business network's resources and can therefore entail challenges in the required collaboration and coordination. Based on the need to better understand how inter-organisational interaction enables business networks to address sustainability challenges, the aim of this paper is to investigate inter-organisational interaction in circular product development. The theoretical framework includes the Industrial Network Approach with a focus on resource interaction and adaptations. Moreover, the multi-level perspective for circular product development is explored, discerning micro, meso and macro levels applied in circular economy literature. The paper relies on a case study of circular product development with a focus on products' longevity and recyclability. Applying a multi-level framework of resource interaction highlighted adaptations in the business network and broader perspectives reflecting the systemic, complex nature of the business environment. The paper contributes to literature on industrial networks and circular economy by illustrating circular product development in business networks from a multi-level perspective. The findings demonstrate both minor and complex adaptations in the business network, and an understanding of the different roles of business and non-business actors.

1. Introduction

As the historically inefficient system of resource management has resulted in extensive environmental impacts (United Nations Environmental Programme, 2011), circular economy (CE) has become a policy goal for the European Union (European Commission, 2019). CE is argued to enable sustainable development (Geissdoerfer, Savaget, Bocken, & Hultink, 2017) by reducing, reusing, recycling and recovering resources in production and consumption processes (Kirchherr, Reike, & Hekkert, 2017). In the European context, expectations for realising CE relate, for example, to establishing circular resource flows while decoupling the use of resources from economic growth (Lazarevic & Valve, 2017). Thus, the benefits of addressing resource flows range from reduced material and energy input and related costs to reduced waste and emissions in production–consumption systems (Korhonen, Honkasalo, & Seppälä, 2018).

The inefficient use of resources in production–consumption systems can be addressed in product development. Decisions made at the product development stage determine 80 % of the product's environmental and social impacts, and up to 75 % of the manufacturing costs (IRP, 2018). Product development enables companies to react to changing market conditions through planning, communication and problem solving (Brown & Eisenhardt, 1995). It is an inter-organisational process involving collaboration between sellers and a buyers (Håkansson & Waluszewski, 2002), which affects not only the focal product but also other resources within the business network, such as business units, production facilities, and business relationships (Gressetvold & Torvatn, 2006).

Implementing CE principles in product development provides opportunities to address the inefficient use of resources through a variety of strategies. For example, companies can develop products with long life cycles by addressing durability with actions to extend the life cycles, such as ease of maintenance, repairs and recyclability (Bocken, de Pauw, Bakker, & van der Grinten, 2016). When implementing such strategies, it is essential to evaluate the environmental impacts (Diaz, Schöggl, Reyes, & Baumgartner, 2021) and consider the entire life cycle of the

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products (Wang, SU, Ma, & Kuang, 2021). In addition, companies may need to identify the required skills and capabilities for circular product design (de los Rios & Charnley, 2017), support managerial decision-making (Diaz et al., 2021), and propose the gradual introduction of CE principles in the product development process (Aguiar & Jugend, 2022). Several barriers need to be dealt with, from higher prices (Jensen, Laursen, & Haase, 2021), to a lack of interest by customers, and lack of knowledge of CE principles, such as the use of alternative materials (Jensen et al., 2021; Jugend, dos Santos, Garrido, Siqueira, & Mesa, 2024).

Furthermore, the involvement of different companies, such as manufacturers, distributors and customers, in the development of products based on CE principles requires attention to how resources are combined in production–consumption systems in business networks. Business networks can provide both opportunities and constraints for development (Möller & Halinen, 2017). Advantages can be gained from closer interaction, making it possible to manage a wide range of internal and external stakeholders (Diaz, Reyes, & Baumgartner, 2022). Although coordination of this kind is often a challenge, it is usually required when developing products based on CE principles, especially as sustainability-related issues tend to be complex (Melander & Arvidsson, 2022). The complexity is due to business networks being embedded in business environments (Håkansson, 1982), and thus accounting for diverse interests, including social, economic, technological and political aspects (Möller, Nenonen, & Storbacka, 2020) becomes relevant. Product development is thus characterised by uncertainty regarding suitable actions, as its effects can be both direct and indirect, making them difficult to predict (Gressetvold & Torvatn, 2006).

Since the inclusion of a diverse range of private and public perspectives acts as a precondition for sustainable development (Diaz et al., 2022; Melander & Pazirandeh, 2019), recent studies of business networks have started to consider the impact of non-business actors (e.g. policymakers) (Baraldi & Wagrell, 2022; Brüel Grönberg & Hulthén, 2022; Melander & Lind, 2022). However, the involvement of a variety of actors can lead to conflicts between different value creation goals (Garcia, Wigger, & Hermann, 2019). While the development costs are usually the responsibility of companies in business networks (i.e. micro and meso levels), the environmental value created through collaborative development efforts is commonly captured at the societal (i.e. the macro) level. Companies may therefore be reluctant to change when innovation costs do not necessarily translate into higher returns on investments (Garcia et al., 2019). A focus on inter-organisational interaction and adoption of a multi-level perspective (Garcia et al., 2019; Melander & Lind, 2022) are therefore required when investigating the development of products based on CE principles.

However, despite the growing body of research on product development that implements CE principles in recent years, such studies often take the perspective of a single company (i.e. the micro level). While circular product development strategies are often described internally to a single firm, they usually require the involvement of various business actors from the business network (i.e. the meso level). Thus, a broader business network perspective is required to understand how inter-organisational interaction enables business networks to address sustainability challenges (Aarikka-Stenroos, Chiaroni, Kaipainen, & Urbinati, 2022; Harrison, Prenkert, Hasche, & Carlborg, 2023). Moreover, a better understanding is needed of how to overcome the challenge related to conflicting value creation goals at different levels (Garcia et al., 2019). This involves considering the perspectives of both business (micro and meso levels) and non-business actors (macro level). Especially in various efforts related to resource interaction in business networks, an understanding of the role of non-business actors such as policymakers remains vague (Brüel Grönberg & Hulthén, 2022).

The aim of the paper is to investigate inter-organisational interaction in circular product development from a multi-level perspective. This investigation is facilitated by the use of the Industrial Network Approach (INA), emphasising inter-organisational interaction and long-term relationships in business networks (Håkansson & Snehota, 2006; Håkansson & Snehota, 2017). As inter-organisational interaction is complex and therefore difficult to capture, a possible way to understand such interaction is by focusing on resource interaction, where companies combine and develop resources (Baraldi, Gressetvold, & Harrison, 2012; Håkansson & Waluszewski, 2002). In other words, the previously described sustainability challenges translate into inter-organisational issues (Dubois, Hedvall, & Sundquist, 2023), such as how different actors interact in circular product development. Analysing circular product development through the lens of the INA therefore makes it possible to study a range of directly and indirectly connected resources in the business network. Given the complexity of implementing CE principles, to investigate circular product development it is necessary not only to include the product as a focal resource and related business network resources into the analysis, but to take a multi-level perspective and include resources of non-business actors as well. Based on this reasoning, the following research question is addressed:

> How does resource interaction in circular product development affect the micro, meso and macro levels, and what are the roles of business and non-business actors?

The paper proceeds as follows. First, we present key theoretical notions that provide a basis for structuring the analysis. Then the method description is provided, and the findings are presented and discussed. Finally, we present the conclusions and implications of the study.

2. Theoretical framework

2.1. A multi-level perspective for circular product development

The aim of CE is to *"…replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes…"* (Kirchherr et al., 2017). With a broader goal of improving human well-being and ecosystem functioning (Murray, Skene, & Haynes, 2017), the analysis of CE efforts is separated into the micro, meso and macro levels (Ghisellini, Cialani, & Ulgiati, 2016). These levels have been defined in a variety of ways. For instance, the micro level can include products (Kirchherr et al., 2017), processes (Ghisellini et al., 2016), individual companies (Murray, Skene, & Haynes, 2015) and supply chains (Melander & Arvidsson, 2022). The meso level is often defined as eco-industrial parks (Ghisellini et al., 2016; Kirchherr et al., 2017; Murray et al., 2017), business networks (Melander & Lind, 2022) or industries (Melander & Arvidsson, 2022). The definition of macro level includes governmental agencies and the society locally, regionally, and nationally (Garcia et al., 2019; Ghisellini et al., 2016; Kirchherr et al., 2017; Melander & Arvidsson, 2022; Melander & Lind, 2022; Murray et al., 2017).

Developing solutions (e.g. products) to address sustainability challenges involves collaboration with diverse stakeholders at the micro, meso and macro levels (Garcia et al., 2019), and may thus require extension of the business network. For example, users of the products have better knowledge of which features are relevant and need to be further developed. Consequently, increased customer involvement is necessary (Cantù, Corsaro, & Snehota, 2012). Other important collaboration partners may include universities, research institutions and trade organisations (Melander & Pazirandeh, 2019). Moreover, policies and regulations that aim to enable sustainable solutions impact managerial decision-making (Brüel Grönberg & Hulthén, 2022). Consequently, policymakers may also be important as collaborators in circular product development.

While the multi-level perspective is often emphasised in CE literature, much of the literature does not account for the systemic nature of CE and the role of non-business actors (Dzhengiz, Miller, Ovaska, & Patala, 2023). This may be due to challenges related to influencing and receiving support from relevant actors (Garcia et al., 2019), as well as to acquiring capital and support from authorities through effective

legislation (Rizos et al., 2016). However, when analysing circular product development, it is important to consider that product development is not an internal process, but can involve resources and related actors from a network of connected relationships (Dubois & Araujo, 2006). Moreover, collaboration is needed to make sense of the business environment (Melander & Lind, 2022). We therefore rely on a multi-level approach, which includes the micro-, meso- and macro-level perspectives. These three perspectives have previously been integrated by, for example, Garcia et al. (2019), Keränen, Komulainen, Lehtimäki, and Ulkuniemi (2021) and Melander and Lind (2022).

2.2. Resource interaction at the micro, meso and macro levels

To capture resource interaction as a process of combining and developing resources in product development (Baraldi et al., 2012), the 4R model has proven to be suitable (cf. Gadde, Hjelmgren, & Skarp, 2012; Gressetvold & Torvatn, 2006). The model separates resources into four resource categories: products, production facilities, business units and business relationships (Håkansson & Waluszewski, 2002). While products can involve both single physical items as well as systems of items (including additional services such as training and support), production facilities involve equipment, routines and skills used in development and production of these items. Business units and business relationships are organisational resources which organise products and production facilities based on their experience of earlier interaction (Håkansson & Waluszewski, 2002). Therefore, as a way of "*classifying, mapping, and analysing the processes of resource interaction in inter-organisational networks*" (Baraldi et al., 2012), applying the model makes it possible to systematically map how two or more resources interact (Baraldi et al., 2012; Bocconcelli et al., 2020).

By mapping the four resource categories, it may also be possible to identify solutions to increase the value of the product (Baraldi et al., 2012). While some product features are determined by nature (e.g. the characteristics of raw materials), they can also be developed to make them fit in new resource combinations (Gadde & Håkansson, 2008; Håkansson & Waluszewski, 2002). At a micro level, a win-win situation for both the supplier and the buyer is apparent when a product matches the buyer's existing resources (Hagberg-Andersson, 2006). The product developed may not only increase the individual buyer's perceived value but may also improve the supplier's ability to sell the product to other companies (Gadde et al., 2012; Mouzas & Ford, 2009). As products are developed with both the supplier' s and buyer's context in mind, product features are a result of interaction between those actors (Bocconcelli et al., 2020). When it comes to developing product features in circular product development, opportunities for more sustainable solutions are accelerated by new actors who can provide access to novel resources (Keränen et al., 2021). In other words, these resources are critical, since they act as a driving force that leads to changes in how resource interaction normally takes place (Chou & Zolkiewski, 2012) in business networks (i.e. the meso level).

Focusing on resource interaction in business networks is therefore important in circular product development, since scarcity of resources affects companies directly and unpredictably (cf. Tunisini, Harrison, & Bocconcelli, 2023). However, it is also a problem for the macro level. This highlights the importance of policymakers understanding resource development in business networks so that specific regulations can be used to prioritise and intervene when necessary (Baraldi & Wagrell, 2022). Increasing resource interaction in the business network can raise interest and gain attention from policymakers as possible collaboration partners (Melander & Lind, 2022). This is especially important when companies alone (i.e. the micro level) do not have the resources needed to achieve a common goal. Moreover, mistrust and competition at the network level (i.e. the meso level) may result in companies withholding knowledge and resources from each other (Garcia et al., 2019). Consequently, resource interaction with the macro level is critical to inform new policies, which in turn can accelerate development in the business network by enabling companies to overcome certain challenges.

Involving more actors in resource combinations may initiate conflicts and/or diverse goals (Lind, 2015), since all involved actors need to perceive the new combinations as beneficial (Baraldi & Strömsten, 2006) and usually have different expectations, goals and perceptions about the consequences of alternative solutions (Cantù et al., 2012). While some actors might benefit from change derived from certain resource combinations and therefore support it, other actors prefer stability in order to gain from previous investments (Håkansson & Waluszewski, 2002) and may therefore oppose it (Håkansson, 1990). Hence, companies may assume either an active or a passive role in carrying out certain resource combinations. Those taking an active stance demonstrate greater ambition in structural changes, while those who are more passive aim to preserve existing resource structures (Gadde, Huemer, & Håkansson, 2003). Companies may therefore mobilise parts of the network to either to exploit opportunities or shelter themselves from changes that are less beneficial (Håkansson & Snehota, 1995).

2.3. Adaptations

Companies may make modifications to their products or production processes as a result of changes in external conditions, such as in the business environment (Brennan & Turnbull, 1999). INA implies that adaptation occurs due to interdependencies between actors in the interaction process (Håkansson & Snehota, 1995). Unilateral or mutual adaptations are made to make resource units fit with each other and work as an integrated whole (Gadde & Håkansson, 2001; Hagberg-Andersson, 2006). In other words, as companies search for new resource combinations, they may need to adapt certain resources (Von Corswant, 2005). While minor adaptations occur continuously through day-to-day rationalisations and usually do not have any significant impact on future development, major adaptations occur less frequently and may require large investments that have considerable impact on future resource combinations (Håkansson, 1990). Håkansson and Waluszewski (2002) use the term friction to illustrate "the force" that makes it difficult to change resources because of various investments in interrelated resource interfaces and thus has a stabilising effect on resource development. However, friction also implies that the force for change applied at a certain interface will be distributed to other interfaces and may therefore also have a destabilising effect on existing resource structures.

Two important aspects of friction are heaviness and variety (Håkansson & Waluszewski, 2002). Heaviness refers to the difficulty of moving a resource in a specific direction, i.e. to adapt it to other resources and make it fit in a new resource combination. For example, a company may have made large capital investments in particular facilities and machinery that need to be used for a long time to pay off and are thus difficult to change in the short term. Variety, on the other hand, is an indication of the number of different interfaces a resource has to other resources and the way these interfaces are interrelated and refers to the possibility of using a resource in different resource combinations. Hence, a large number of interdependent interfaces may both impede development due to heaviness created by investments made in various interfaces and enable development due to the variety of ways of creating new combination opportunities (ibid).

When organisations interact and combine their resources, and consequently figure out how these units can be adapted to work together, their knowledge of how to combine and utilise different resources changes through "learning-by-doing" (Arrow, 1962). Hence, adaptation of technical resource units may result in additional changes in the knowledge of the organisational units involved of how to organise and utilise resources. This means that adaptations are not only apparent in changes in resource features, but can also occur in processes such as production processes or information routines (Håkansson, 1982), whether they are planned or not (Brennan & Turnbull, 1999). This implies that as soon as some resource interfaces are changed within a

particular business relationship, there might be effects on the others (Gadde & Håkansson, 2001), thus causing a chain reaction involving several different actors. Adaptations are consequently more complex than simply combining resources in an inter-organisational interaction.

Adaptations can be a question of power. High levels of adaptation indicate high levels of trust and commitment (Hallen, Johanson, & Seyed-Mohamed, 1991). Consequently, actors are more likely to take an active stance and invest in the relationship by purposefully adapting or changing their resources to increase the benefits gained from the specific relationship (Halinen, 1994). However, the stronger the position that a company has in the market, the more the other party should adapt to its counterpart (Hallen et al., 1991). This can indicate that once one actor exploits their power to make adaptations, the relationship cannot be characterised with trust. As a passive form of adapting, the company makes modifications to meet the requirements of its counterpart, or to avoid weakening their relationship. Alternatively, companies can also adapt to the demands and eventual changes of the surrounding context (Halinen, 1994). Regardless of whether adaptations are a result of active or passive actors, they have an impact not only on the relationship in question, but also on subsequent adaptations with other companies (Brennan, Turnbull, & Wilson, 2003; Hagberg-Andersson, 2006).

3. Research method

The study is exploratory in nature and builds on a single case study to investigate inter-organisational interaction in terms of resource interaction in circular product development from a multi-level perspective. A single case study was found suitable, as this makes it possible to capture complexity and to understand a phenomenon in its context (Andersen, Dubois, & Lind, 2018; Dubois & Gadde, 2002), and is thus considered to be an appropriate approach for industrial network research (Halinen & Törnroos, 2005). The case in focus is circular product development taking place within and between multiple levels, with the aim of establishing circular resource flows. This concerns longevity and recyclability. Both enable products and materials to be kept in circulation and require various considerations in terms of production and use settings. With a variety of organisations involved (further described in Section 4 and in Appendix A), different perspectives were captured in a unique setting in which multiple actors collaborated in circular product development.

The study focuses specifically on the textile and apparel industry (T/A) since it represents a relevant context to study. More specifically, the workwear sector is of interest as it is expected to grow globally by 6.1 % from 2021 to 2028. One major reason for the development is related to the increasing need for additional workforce in healthcare due to the recent Covid-19 pandemic (The Insight Partners, 2022). The empirical context focuses on Sweden, since the transition to CE in the region is driven by Swedish and European-level policies (ETC/WMGE, 2019; European Commission, 2014; Swedish Government Offices, 2021). Policymakers at both levels emphasise textile products as a priority product category to be addressed, because of their high and inefficient use of resources. This resource use can be addressed, as Bocken et al. (2016) suggest, by developing products for longevity and recyclability, which has implications for both the production and consumption phases. Lastly, the focus on the specific geographical region is relevant, as the effectiveness and wider adoption of circularity depend on the context and the capacity of the public sector to enable business networks in their efforts to transition to CE. This is especially relevant in the EU context, since European policies emphasise the responsibility of producers and customers in the transition (Ghisellini et al., 2016).

3.1. Data collection using multiple sources

The study builds on complementary data sources (Yin, 2014). The primary source of data was participant observations carried out by the first author during a product development project concerning workwear – a shirt and a pair of trousers. The first author's role in this project was to assess the environmental and economic impact of the possible solutions discussed by the project participants. Participating in the project in a supporting role, while observing the development process, made it possible to capture details and provide a deeper understanding of the context (Grove & Fisk, 1992). In other words, an understanding of possible solutions, as well as the challenges to necessary resource interactions was gained concurrently with the meetings and workshops, instead of interviews based on the participants' recollections.

The data collected includes meeting and observation notes from 27 meetings and two workshops that were held over the course of the project (from April 2020 to December 2021). The encounters ranged from 30 min to whole day events, at which the participating organisations met in different groups for different purposes (further details are provided in Appendix B). The encounters covered the whole development process, starting from ideation, design, environmental and economic considerations, to finalised concepts. The meeting and observation notes include the agenda, participants, discussion points and actions to be taken before the next meeting, as well as the observer's reflections and comments. The notes were revised after each meeting to mitigate observer error by reflecting on the contents discussed immediately afterwards.

As well as providing an opportunity to grasp the complex realities of the phenomenon studied, repeated observations over the course of the project made it possible to build trust with the participants and make them more comfortable providing further information during additional interviews (Saunders, Lewis, & Thornhill, 2009). Interviews were another important source of data since they provided the opportunity to better understand the perspectives of different actors and allowed them to reflect on the product development process. This included aspects related to their business relationships with (and the role of) other actors, resource interactions, and learnings and challenges. Three semi-structured interviews were conducted with managers from three organisations. All interviews were carried out via Zoom because of Covid-19-related restrictions. The interviews lasted between 30 and 60 min and were recorded and transcribed using NVivo. To give the interviewees an opportunity to check the correctness of the data collected and provide supplementary information, member checks were carried out in follow-up meetings and email correspondence.

The interviews helped us to further improve the descriptions of particular resource interactions and the interplay between the project, the business network, and the wider business environment. Other important sources of data for these descriptions include documents on policies and standards, for example material certifications, and product and industrial laundry standards (e.g. SS 8760164:2020, SS 8760120:2020), which needed to be considered and affected the development. Another data source was an online questionnaire providing detailed descriptions of individual organisations as well as their motivations for participating in the project.

Utilisation of the different empirical materials added breath, complexity and richness to the findings (Denzin & Lincoln, 2003). In particular, it contributed to an in-depth understanding of resource interaction within a business network as a result of circular product development, and the interplay between the business network and the wider business environment. Moreover, the multiple sources enabled us to cross-check data by means of triangulation (Lincoln & Guba, 1985) and discover new dimensions to the research problem to further explore by setting out to collect additional data (Miles & Huberman, 1994).

3.2. Case analysis based on systematic combining

The empirical material collected from multiple sources directed the search for theoretical concepts, helping us to understand the phenomenon in its context, as well as to distinguish between different levels of context (micro, meso, macro). This way of confronting a theoretical framework with fieldwork is referred to as “systematic combining” and

is an appropriate approach in case studies (Dubois & Gadde, 2002; Dubois & Gadde, 2014). It involves moving back and forth between theory and empirical data, since one cannot be understood without the other. Additionally, continuous data collection can inform the development of the theoretical framework and vice versa (Dubois & Gadde, 2002). This is especially applicable in single case studies, which provide scope for crafting the case during the research process (Andersen et al., 2018).

The initial, exploratory stages of data collection led us to the 4R model (Håkansson & Waluszewski, 2002) as the primary tool for structuring and analysing data. With the focus on addressing resource flows based on CE principles, the model was found appropriate since it is suitable for investigating resource interaction within industrial networks (cf. Baraldi & Wagrell, 2022; Brüel Grönberg & Hulthén, 2022; Gadde et al., 2012; Harrison & Håkansson, 2006; Hjelmgren & Dubois, 2013; Landqvist & Lind, 2019). Using the data collected, we first mapped resource interaction between the four resource categories, starting from the two focal products' interaction with other resources within the focal supply chain, and then moving out to include the customers and other organisations relevant in the development project. This stage of data analysis led to more focused observations and semi-structured interviews to obtain more detailed descriptions of resource interaction.

Systematic combining of empirical data and the theoretical frame of reference (Dubois & Gadde, 2002) eventually led us to expand our analytical framework to the business environment. In other words, resource interaction with non-business actors became evident, which led us to apply a multi-level approach. This included not only micro- and meso-level perspectives, but also a macro-level perspective incorporating environmental factors such as policies into the analysis (cf. Melander & Lind, 2022). This enabled us to capture how resource interaction at the micro and meso level may interplay with policies and standards developed by loosely coupled actors in the business environment (the macro level). Furthermore, the multi-level approach facilitated an increased understanding of the multiple values at play, and how difficult it is for managers and policymakers to make clear choices about which values, resources, and interfaces to prioritise. In other words, it revealed a distinct set of challenges in circular product development because of complex resource networks and the dual goals of economic and environmental value creation.

3.3. Reflecting on research quality based on Tracy's eight "big-tent" model

To evaluate the quality of the study, we applied Tracy's (2010) model for reflecting on the eight key markers of quality in qualitative research. Considering the significance of the negative impacts of the T/A industry, as well as the challenges of CE, studying the case and context is found to be relevant and timely (i.e. the paper studies a worthy topic). The sample studied was appropriate to explore the research phenomenon in its context, since the organisations provided different perspectives that were captured in a unique setting (further described in section 4). Moreover, data collection and analysis were carried out in line with previous research on case studies (i.e. the paper demonstrates rich rigour).

The methods used have been described transparently (i.e. the paper presents with sincerity). Researcher triangulation was implemented during systematic combining to facilitate consistent (re-)interpretation of data (Tracy, 2010) and agree on the appropriate theoretical concepts (Denzin, 1989). The authors also utilised data triangulation in line with Lincoln and Guba (1985) for an in-depth analysis of resource interaction, along with a rich description of the case provided in section 4 below (i.e. to achieve credibility) (Tracy, 2010). The paper makes both theoretical and managerial contributions that are appropriate in view of the relevant and timely topic, specifically to research on CE and INA. Therefore, the findings of the study may resonate with the respective research streams (i.e. resonance and significant contribution). Ethical considerations included explaining the aims of the study to the participants, as well as ensuring confidentiality of the data collected. Lastly, the findings of the paper achieve the purpose that was set, and the authors used appropriate methods to do so (i.e. the paper demonstrates meaningful coherence) (Tracy, 2010).

4. Case description

The case of circular product development in the context of a product development project is described below. The described inter-organisational interaction between the different business and non-business actors described here is unique since these actors do not interact as closely on a daily basis.

4.1. The focal products

The focal products are a shirt and a pair of trousers used by healthcare professionals. The products were chosen because they are produced and used in large volumes and were assessed to have high potential for reducing the environmental impact. Both comply with garment standards laid down by the Swedish Institute of Standards (SIS), providing guidelines for the choice of materials, product design, manufacturing and laundry processes for workwear used in healthcare. The shirt additionally requires the use materials certified under European Standards (EN) because it is used in surgical rooms. The garments consist of a main textile material,[1] trims (e.g. buttons and labels), and an RFID chip for traceability. The products have functional features such as comfort, opacity, and durability during use and the industrial laundry process. Additionally, the design and choice of materials for the shirt aim to minimise the spread of bacteria-carrying skin particles and to prevent static electricity. Both garments are typically used and washed an average of 120 times before they lose the required features.

The development project was coordinated by a science park and aimed to apply CE principles in the product development phase to facilitate incremental enhancement of sustainability. This included applying the principles of CE to design for longevity and recyclability. In other words, the aim was to provide products with favourable conditions for an extended lifetime and recovery of materials at end of life. The project involved workshops and meetings with various actor constellations depending on the topic in focus. This included both companies that are central to the supply chain for the products and the public organisations that coordinated and facilitated the product development. The project resulted in solutions that enable circular resource flows and therefore made it possible to enhance sustainability. The solutions involved (1) using recycled materials; (2) recycling the garments at end of life; (3) using components and manufacturing processes with lower environmental impacts; (4) reviewing and implementing changes in the laundry process.

4.2. The focal organisations

Four organisations based in Sweden were involved in the product development project. The fabric manufacturer (A) produces the main textile material for the shirt. The garment manufacturer (B) produces both garments. Other manufacturers not involved in the project produce other components, such as trims and the RFID chips. The rental and laundry service provider (C) both purchases and produces certain products and provides access to the products for business customers. C's customers include companies from the private sector and municipal and regional governments. In line with Lind (2015), the micro level of this case was defined as inter-organisational interaction between companies

[1] The shirt is made of a fabric made of 99 % polyester and 1 % carbon fibre blend, and the trousers are made of a fabric made of 65 % cotton and 35 % polyester blend.

A, B and C at the project level. At the time of the project, companies B and C were participating in standardisation work at SIS.

The role of each actor was to contribute to the project based on their role in the supply chain and their expertise. The group's aim was to explore opportunities to develop the chosen products based on the previously described principles, as well as the environmental and economic impact of the potential solutions. This approach differs from a day-to-day setting since the products are produced and used based on standards and closer collaboration therefore only occurs through participation in the technical committees of SIS. However, the closer collaboration via project participation was seen as beneficial for enhancing sustainability, as explained by the managing director of company B: "*I think it's also important that you…when you have the knowledge…and then that you team up suppliers and customers and productions, that you are on the same levels.*" This perspective was supported by the business developer at company A: "*We have taken a huge step forward in the way to have one circular model in action.*"

4.3. The business network within the business environment

Also involved in the product development was a regional government as a potential business customer (D). The region purchases these products through public procurement directly from manufacturers in certain time periods and launders the products in its own laundry facility. This approach to enhancing sustainability was considered important by the environmental strategist at the customer (D): "*I've learned that every part is important, even buttons and other things in the product…parameters that can be changed in a better way or should not be forgotten.*" The organisation, together with other potential business customers and the focal organisations at the micro level, was defined as part of the business network (i.e. meso level).

Additionally, non-profit organisations, such as science parks, universities and trade associations, support knowledge and relationship development in the textile industry. In this case, the science park coordinated the publicly funded development project. Together with the latter two actors and a circular change agency (a company providing software and services for circular design and closed-loop recycling systems), the actors in the business environment facilitated the business network's collaboration on circular product development. This included assessing the feasibility, as well as the environmental and economic impact of the different solutions to enhance sustainability, and initiating new business relationships. In the words of the project manager at the science park, "*…the companies receive inspiration and concrete approaches to enable the development of their own products based on the principles.*" While these actors focus on the textile industry, they are non-business actors and are thus defined as part of the business environment (i.e. macro level).

The workwear sector in Sweden is a part of a broader social and economic system (i.e. business environment at the macro level), which involves organisations such as SIS and policymakers that may provide both opportunities and constraints for product development. Firstly, SIS brings together industry, governmental and non-governmental organisations to influence the development of standards, and to promote best practices that drive the country's competitiveness and sustainable development. Secondly, the Swedish Government Offices and the European Commission have defined the transition to CE as a policy goal. Since textile products are a key product category to be addressed in the transition, the business network is subject to a number of frameworks and action plans with regard to product design and development; production and transportation; and collection and reuse.

5. Case analysis

In the following section, inter-organisational interaction in terms of resource interaction and resulting adaptations are described at the micro and meso levels. Key resources and adaptations in circular product development are presented in Table 3 below. Finally, adaptations emerging from resource interaction with the macro level are presented.

5.1. Adaptations resulting from resource interaction at the micro level

The micro-level resources and resource interactions relating to the manufacturing and use of the shirt (P1) and trousers (P2) are mapped in Fig. 1 and presented in Table 1. The organisational resources include the business units (BU), which are connected by business relationships (BR). The physical resources are products (P) and production facilities (PF). Each physical resource is assigned a two-digit number, which includes two digits. The first digit indicates which BU controls the resource and the second one shows the number of the resource. The fabric manufacturer (BU1) produces the main component (P11) for the shirt (P1) in three production facilities. These include weaving (PF11), dyeing (PF12) and treating (PF13). The main component for the trousers (P2) and additional components for both products are sourced from different suppliers. Subsequently, the main and other components are combined by the garment manufacturer (BU2) at its sewing facility (PF21). Both products are serviced for business customers by the rental and laundry service provider (BU3) at the laundry facility (PF31).

Implementing the solutions (described in Section 4.1) for P1 and P2 will lead to direct and indirect adaptations (indicated with arrows) in terms of which resources need to be combined, added, or developed at the micro level. Firstly, to lower the environmental impact through decreased use of water, BU1 can switch PF12 from a batch-dyeing to a solution-dyeing process. This does not compromise product standards or increase the heaviness of the production facility in relation to other textile materials. Secondly, further lowering the environmental impact of P1 by using recycled textile materials requires the use of recycled fibres for P11 at PF11. Again, adapting to recycled materials does not compromise current product standards, or require further adaptations in the production of BU1. Furthermore, the change to recycled materials does not require adaptations to BU2 and BU3 and related resources.

5.2. Adaptations resulting from resource interaction at the meso level

Moving from the products' focal organisations to the broader business network encompasses several companies and their technical and organisational resources are involved (see Fig. 2 and Table 2). Suppliers, such as BU4, deliver components, such as yarn (P41), from PF41 to the fabric supplier BU1 and the other textile materials supplier BU6. The latter produces other components (P61-x) relevant for the focal products at PF61. The meso level also includes the recycler (BU5) and the recycled fibres it produces (P51), as well as its sorting (PF51) and recycling facilities (PF51). Additional organisations at the are business customers of the product and related services, with one type of customer (D – BU7) having its own laundry facility and therefore only purchasing the products. The other type of customer (BU8) includes those that purchase the laundry service from companies such as BU3 and therefore do not

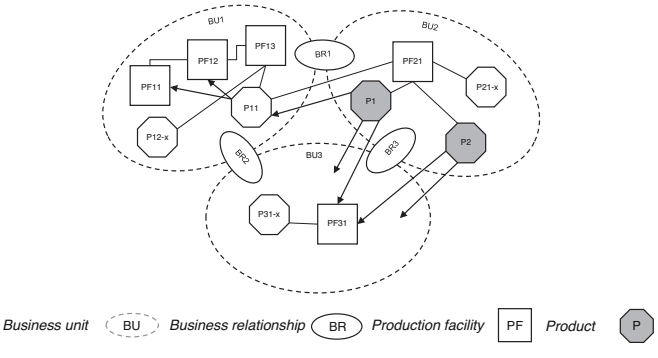

Fig. 1. Adaptations resulting from resource interaction at the micro level.

Table 1
Resources at the micro level.

BUSINESS UNITS		BUSINESS RELATIONSHIPS	
Resource	*Resource description*	*Resource*	*Resource description*
BU1	Fabric manufacturer (A)	BR1	Between BU1 and BU2
BU2	Garment manufacturer (B)	BR2	Between BU1 and BU3
BU3	Laundry service provider (C)	BR3	Between BU2 and BU3

PRODUCTS		PRODUCTION FACILITIES	
Resource	*Resource description*	*Resource*	*Resource description*
P1	Surgical shirt	PF11	Weaving facility at BU1
P12	Main component of P1	PF12	Dyeing facility at BU1
P13-x	Other products of BU1	PF13	Treating facility at BU1
P22-x	Other products of BU2	PF21	Sewing facility at BU2
P32-x	Other products of BU3	PF31	Laundry facility at BU3

own the products. However, both customers own healthcare facilities in which the products are used (PF71 and PF81).

The adaptations at the micro level led to consequential adaptations at the meso level. For example, adapting to recycled materials requires the component supplier (BU4) to use recycled raw materials in its product (P41), (i.e. the yarn for manufacturing the fabric P11). This in turn necessitates the development of a business relationship (BR6) with the recycler (BU5) for purchasing the raw materials. The same approach of developing new relationships needs to be taken by the supplier (BU6) of other components of P1 and P2, in order to use recycled materials in in its products (P61-x). No adaptations to the respective production facilities (PF41 and PF61) are required. Additionally, increased interaction by BU2 and BU3 with their customers BU7 and BU8 is required to improve customer knowledge of the environmental benefits of using recycled fibres, especially as the costs for such materials are currently higher. Resource interaction of this kind is expected to enable customer demand for recycled materials.

To establish wider adoption of recycled materials through decreased prices, it is important for companies such as the laundry provider (BU3) and business customers (BU7) that own the products, to collect used products at end of life (at PF31 and PF72). This will make it possible to generate steady feedstock for the recycler (BU5), which can then scale up the manufacturing to decrease the price of recycled materials (P51 and subsequent products). This in turn is necessary to enable the use of recycled components by the business network. It is also important for the manufacturers' business units (BU1 and BU2) to interact with the facilities in which the products are used (PF71 and PF81). This will allow access to user knowledge and needs in terms of fit and quality to avoid premature product obsolescence and further increase product lifetime. Additionally, developing end-user knowledge of the environmental benefits of recycled or single-origin textile materials for P2 will stimulate further demand for such materials.

There is further potential to decrease the environmental impact of the focal resources by adapting the industrial laundry processes at PF31. However, this change requires further resource interaction with other companies in the business network, as well as working with SIS to develop the industrial laundry standards. In other words, reviewing and implementing laundry processes will lead to adaptations not only at the micro level, but also at the meso level, as the business customers (BU7) that own the products will need to adapt their own laundry processes. Such adaptations include, for example, facilities that use less water or lower water temperatures. In other words, while implementing these solutions will be initiated from the micro level because of the development of the focal products, it will also lead to direct and indirect adaptations at both the micro and meso levels. This includes BU3 directly adapting its resource use at PF31, as well as adaptations to P72 at BU7. This is because of the nature of the products, as their manufacturing and use are regulated by standards.

5.3. Adaptations resulting from resource interaction with the macro level

Resource interaction with the macro level relates to five different actors, including the university and science park, policymakers (locally and at the EU level), SIS, and the circular change agency. Some of these actors' resources interact with specific resources and resource interfaces at the micro and meso levels, as shown in Fig. 3 below. As previously described, the inter-organisational interaction in circular product development was facilitated by the science park and university, whose

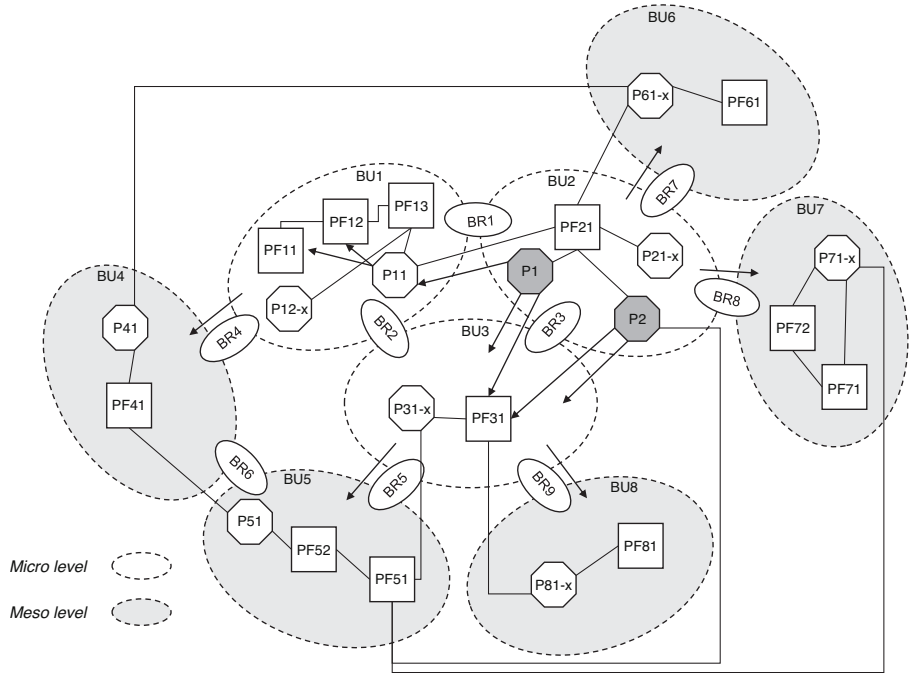

Fig. 2. Adaptations resulting from resource interaction at the micro and meso levels.

Table 2
Resources at the meso level.

BUSINESS UNITS		BUSINESS RELATIONSHIPS	
Resource	*Resource description*	*Resource*	*Resource description*
BU4	Component manufacturer	BR4	Between BU1 and BU4
BU5	Recycler	BR5	Between BU3 and BU5
BU6	Other component manufacturers	BR6	Between BU4 and BU5
BU7	Municipality as B2B customer	BR7	Between BU2 and BU6
BU8	Other B2B customers	BR8	Between BU2 and BU7
		BR9	Between BU3 and BU8

PRODUCTS		PRODUCTION FACILITIES	
Resource	*Resource description*	*Resource*	*Resource description*
P41	Component of P12	PF41	Spinning facility at BU4
P51	Component of P41	PF51	Sorting facility at BU5
P61-x	Other components of P1	PF52	Recycling facility at BU5
P71-x	Other products of BU7	PF61	Production facility at BU6
P81-x	Other products of BU8	PF71	Use setting at BU7
		PF72	Laundry facility at BU7
		PF81	Use setting at BU8

Table 3
Key adaptations resulting from resource interaction in circular product development.

Resource	Adaptation
P11 – fabric	Use recycled fabric
PF11 – weaving facility	Use recycled yarn
PF12 – dyeing facility	Use solution dyeing instead of batch dyeing
P41 – yarn-manufacturing facility	Use recycled components
BR6 – business relationship between component supplier (BU4) and recycler (BU5)	Start a business relationship
BR8 – business relationship between garment manufacturer (BU2) and business customer (BU7)	Develop business relationship through increased interaction with use setting (PF71) and knowledge exchange
BR9 – business relationship between rental and laundry service provider (BU3) and business customer (BU8)	Develop business relationship through increased interaction with use setting (PF81) and knowledge exchange
PF31 – industrial laundry facility	Lower temperatures and shorter drying times

goals of environmental and economic value creation through the transition to circularity align with the goals of Swedish policymakers and the textile and apparel industry. As shown in Fig. 3 below, this is enabled through monetary flows, with the university and science park being funded by the Swedish government to establish and lead a national platform for sustainable fashion and textiles. Moreover, research projects, such the one in focus in this paper, are funded by several different organisations, for example the local region and other governmental agencies.

The funding allowed resource interaction with and at the micro and meso levels in a number of approaches. First, coordinating the project facilitated exchange of specialised knowledge through increased inter-organisational collaboration, which does not happen on a day-to-day basis. Secondly, evaluation tools were provided for assessing the environmental and economic impact of the different components. Additionally, garment design and product quality expertise facilitated the identification of issues and potential solutions for increasing the lifetime of the products. Thirdly, the broader network of these actors will enable the business network to develop new business relationships relevant for implementing the solutions. For example, the circular change agency contributed expertise on developing circular products and facilitating the development of a business relationship with recyclers through their textile-recycling network. The other way around, project results of this kind can inform policymakers on the challenges faced by the industry, enabling them to identify priority areas for support.

The focal products are regulated by standards developed by the Swedish Institute for Standards (SIS). SIS oversees the development and implementation of standards that provide guidelines for the choice of materials, product design, manufacturing and industrial laundry processes for workwear used in healthcare. These standards allow for some flexibility but may also place limitations on adaptations required to advance sustainability. On the one hand, it is possible to adapt to recycled materials and use components and manufacturing processes with lower environmental impacts without requiring adaptations in the standards. However, increased collaboration of the focal actors at the micro level that participate in the technical committees of SIS may be beneficial to initiate work on adapting the standards to guide other actors towards adapting to both components and processes with lower environmental impacts. On the other hand, implementing changes in the laundry process is more challenging as the standards need to be reviewed and adapted by SIS and its technical committees. Here, actors such as the rental and laundry service provider and the local region with its own laundry facilities can evaluate the environmental impact of current practices.

Moreover, as the aim of companies at the micro level is to advance sustainability through circular product development, legislation at the national (Swedish) and European levels should be considered. At both levels, the transitions of both industry and society to circularity are defined in the EU's Action Plan for Circular Economy and Sweden's Circular Economy – Strategy for the transition in Sweden. Both EU and Swedish policymakers have also identified textile products as one of the key product value chains. Therefore, there are a variety of frameworks and action plans impacting the *meso* and micro levels in product design and development; production and transportation; and collection and reuse phases. For example, the Sustainable Product Initiative in the EU Action Plan for Circular Economy emphasises the increase in the proportion of recycled materials in products and circular resource flows as key impact areas. Moreover, producer responsibility for textiles implies that all actors selling textile products need to ensure that they are collected separately for reuse or recycling in accordance with the EU Waste Directive.

The interaction described above relates to the business environment and how related non-business actors may facilitate or challenge the inter-organisational interaction of the micro- and meso-level actors in circular product development. While this kind of interaction is evident from the macro to the meso and micro levels, there are also certain implications the other way around. For example, companies B and C participate in SIS technical committees, along with other companies at the meso level. This means they have opportunities both to initiate changes in the development and implementation of standards in relation to the use of recycled materials, that may be required by the broader business network, and to adapt the standards for the laundry processes.

6. Discussion

Our findings include two interrelated areas discussed below regarding the research question posed. Firstly, resource interaction in circular product development leads to adaptations at the micro and meso levels. Secondly, applying a multi-level perspective to circular product development enables an understanding of the resources and roles of business actors at the micro and meso levels, as well as non-business actors at the macro level, in supporting adaptations in the business network. This in turn facilitates an understanding of how to address the conflicting environmental and economic value creation goals and improves the understanding of how inter-organisational interaction enables the network's transition to CE.

Among CE strategies that enable sustainable development (Geissdoerfer et al., 2017), circular product development entails various minor and complex adaptations between resources in the business network, and these have long-term impacts. Our case study reveals that

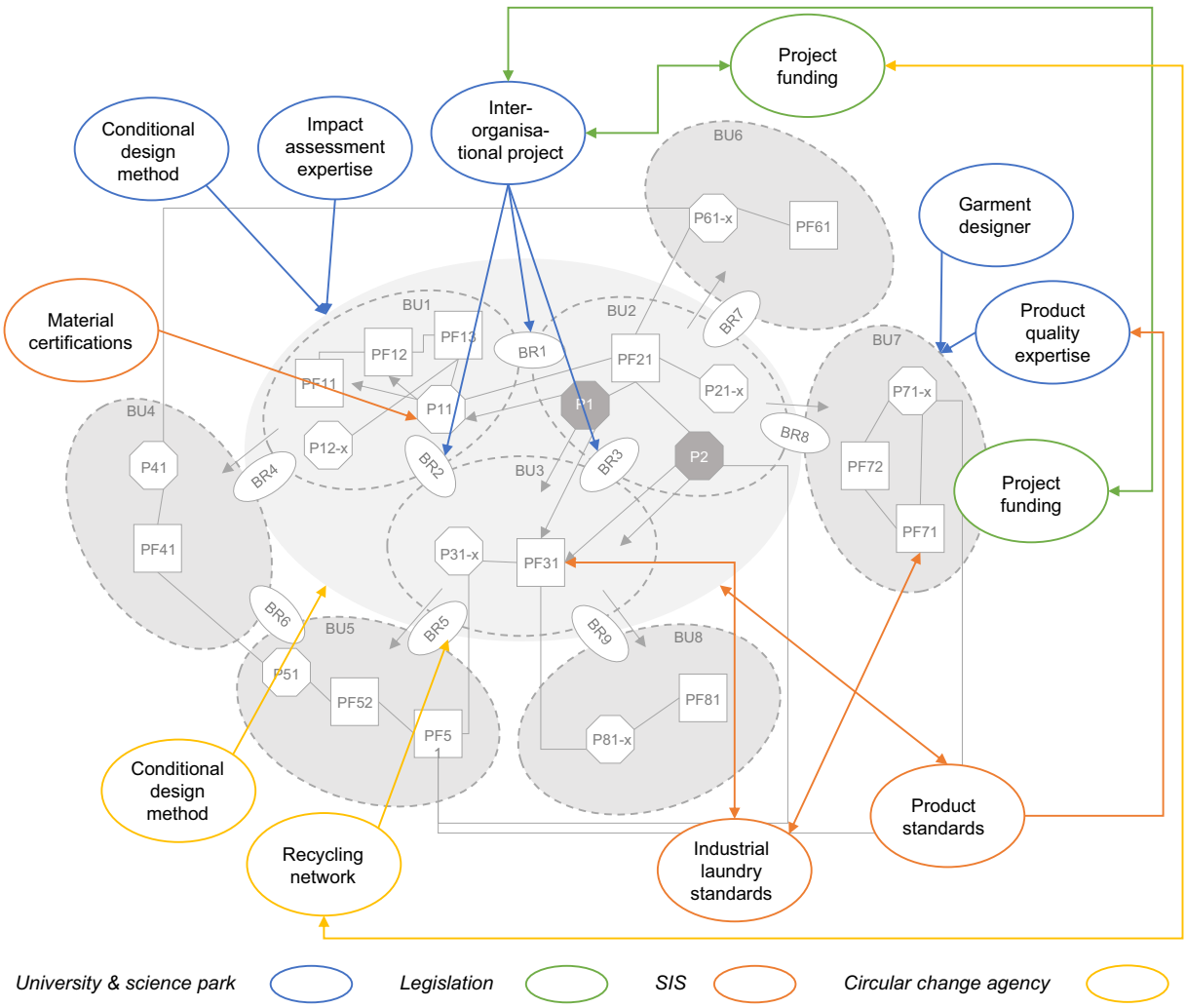

Fig. 3. Resource interaction with the macro level.

these adaptations require the inclusion of a diverse range of actors, which is in line with previous research into advancing sustainability (Aarikka-Stenroos et al., 2022; Melander & Arvidsson, 2022). For example, reduced resource consumption in the production process (Kirchherr et al., 2017) is enabled by the fabric manufacturer implementing new dyeing methods. This particular adaptation might, in itself, be considered a minor adaptation, since it does not significantly impact the heaviness of the production facility (Håkansson & Waluszewski, 2002). Similarly, adapting laundry processes to reduce energy resources by washing at lower temperatures may not have a major impact on the heaviness of the laundry facility. However, since industrial laundry processes are regulated by standards, making the necessary changes to the laundry facilities requires increased collaboration among actors at the micro and meso levels. Additionally, it calls for the involvement of SIS at the macro level to change the standards. Therefore, this adaptation requires the inclusion of actors at all three levels (micro, meso and macro) and thereby contributes to increased complexity.

Other adaptations with long-term impacts (Aarikka-Stenroos et al., 2022) include utilising recycled materials to reduce the use of primary raw materials. Our findings indicate that in such adaptations some actors are more active and set diverse goals for resource interaction (Lind, 2015; Prenkert, Hasche, & Linton, 2019), while other actors who perceive greater risks (Korhonen et al., 2018) may be more reluctant to carry out the necessary changes. The role of the fabric manufacturer was important because of the manufacturer's knowledge and willingness to invest to adapt its materials and production facilities for increased resource efficiency. In other words, the company became an important facilitator for change (Gadde et al., 2003). The findings also indicate that the adaptation to recycled materials may negatively impact economic value creation for the garment manufacturer, which needs low material costs to remain competitive. Therefore, an actor's willingness to adapt can, for example, be influenced by possible economic effects.

While successful interaction in business networks requires every actor to achieve profitability (Baraldi & Lind, 2017), it is important to achieve economic growth without increasing the use of primary raw materials, as specified in the EU's goals for CE (Lazarevic & Valve, 2017). In other words, to lower the cost of recycled materials, it is important to improve circular resource flows. To achieve this goal by scaling up recycling, it is important that used textile products (i.e. the garments) are available in high quantities at predictable frequencies. Therefore, the actors that become the most crucial collaboration partners for CE (Aarikka-Stenroos et al., 2022) are those that own the products (i.e. rental and laundry service providers, business customers with internal laundry facilities). However, this may require increased interaction and educational efforts by other actors in the network, such as those most affected by the high prices (i.e. the garment manufacturer) or those with the required knowledge and relationships (i.e. science park and circular change agency). Therefore, establishing circular resource flows to reduce the use of primary raw materials is a complex adaptation that requires increased long-term interaction, as well as an understanding of the different roles of each actor at the micro and meso levels (Melander & Lind, 2022). In addition, our findings give raise to questions regarding

resource governance to support complex resource adaptation. In our case, the key resources were owned, but is ownership of resources necessary or could control of resources be operationalised in different ways and still form the basis for complex adaptations?

Our study reveals additional opportunities for environmental and economic value creation through certain adaptations with business customers and their employees (i.e. the end-users). While interaction with end-users in circular product development has previously been found to be limited (Diaz et al., 2022) and their limited interest in circular products has been perceived as a major barrier (Jugend et al., 2024), our findings indicate there are possible advantages to initiating direct interaction with end-users. In this case, the employees of healthcare facilities are relevant since their experience of using the products is affected by several different product features. These features include, for example, comfort, suitable sizing, opacity, quality, and durability during use and the industrial laundry process. Manufacturers' interactions with end-users and business customers enable knowledge transfer regarding the use setting and highlight the importance of end-users, which is often overlooked in research on business networks (Harrison et al., 2023). This approach is important for enabling the adaptation to use fully synthetic and recycled materials, which may affect not only the price of the product, but also the end-users' experience of product features (e.g. comfort). In turn, this may enable the garment manufacturer to overcome financial barriers related to higher production costs, which have previously been described as a common challenge (Wang et al., 2021). Therefore, adapting the products to the use settings and CE principles may lead to increased value for end-users and garment manufacturers.

We can conclude from the above that resource interaction in circular product development leads to adaptations in the business network. As well as various adaptations of products and production facilities affecting heaviness in certain directions, adaptations in the network also included changes in the interaction among the actors. However, it is important to consider that different actors may perceive different opportunities and constraints because of conflicting environmental and economic value creation goals. A better understanding of how inter-organisational interaction at different levels can enable the transition to CE (Aarikka-Stenroos et al., 2022), and the required adaptations in the business network improves our understanding of how different actors can contribute to the necessary adaptations in business networks (Harrison et al., 2023).

7. Conclusions and implications

In this paper, we studied inter-organisational interaction in terms of resource interaction in circular product development from a multi-level perspective. To answer the research question, resource interaction in circular product development affects the business network (i.e. micro and meso levels) through minor and complex adaptations. Some adaptations involve physical resources and are minor since they do not impact other resources or their use in other settings, while others are more complex and require increased interaction in the business network and long-term collaboration. Additionally, actors at the micro, meso and macro levels can enable and challenge resource interaction in circular product development. Thus, taking a multi-level approach (Garcia et al., 2019; Melander & Lind, 2022) and separating the business network and business environment into the levels of micro, meso and macro levels lead to a better understanding of the resources and roles of different actors. This understanding makes it possible to address the conflicting goals of environmental and economic value creation (Garcia et al., 2019) by indicating which actors are leading resources interaction to address sustainability challenges (Prenkert et al., 2019) and which may face the greatest risks (Korhonen et al., 2018). This forms the basis for the following implications.

7.1. Theoretical implications

First, applying the resource interaction approach and, specifically resource interaction regarding a focal resource (Baraldi & Wagrell, 2022; Brüel Grönberg & Hulthén, 2022) allowed us to explore resource interaction between a focal product and a number of different resources (products, production facilities, business relationships and business units). The analysis shows how some of the resources interact with specific resources and/or resource interfaces in the business network, while some interact with macro-level resources. Here the resources of actors, such as universities, science parks, policymakers (locally and at EU level), technical committees at SIS, and the circular change agency in Sweden, emerge as key. Responding to calls made by previous research (Sharma, 2020), a broader perspective is taken to reflect the systemic and complex nature of the business environment (Möller et al., 2020). By highlighting the importance of resource interaction with the macro level, we add to INA's frameworks of resource interaction (Baraldi et al., 2012; Håkansson & Waluszewski, 2002; Prenkert et al., 2019) by including resources of actors at the micro, meso and macro levels.

Second, working towards sustainability advancements requires adaptations in business networks, and thus managerial engagement to manage change and stability for dealing with the conflicting goals of economic and environmental value creation. Our study shows a pattern of network forces for stability and change (Håkansson & Waluszewski, 2002) in the transition to CE. Stability occurs through complex adaptations and network management (e.g. customer and end-user involvement, business relationship development) that require long-term collaboration within the business network as well as an understanding of the different roles of actors at all levels (Melander & Lind, 2022). Change occurs by adapting physical resources, such as using new materials and production processes. While these adaptations can be costly, they can be considered minor since they do not affect the heaviness of the resource (i.e. alternative uses of the products or production facilities). Minor adaptations may thus be seen as driving the transition even though there is a need for complex adaptations. Minor adaptations may function as the start.

Third, in circular product development, non-business actors at the meso and macro levels perform important roles that rely on resources that cannot be neglected. For instance, the public actors, such as universities and science parks with industry-specific resources, are recipients of public funding in research projects. By supporting companies with their knowledge and skills, these organisations enable knowledge transfer in the business network, and help to reduce uncertainties due to inadequate information (Ford, Mattsson, & Snehota, 2017) through increased resource interaction within the business network. Such actors therefore act as coordinators for the network and provide access to resources that are novel to the network (Keränen et al., 2021). Additionally, public actors can also be involved in different roles at the meso and macro levels, with different goals apparent for those roles. On the one hand, the local region acts as a customer that through public procurement, purchases products at the lowest price. On the other hand, the involvement of this actor as a policymaker and funder of research projects with the goal of advancing sustainability through CE is relevant since they have an impact in developing legislation that supports the widespread implementation of circular product development in the T/A industry. Consequently, as well as the goals of the actors at different levels being diverse (Lind, 2015) and the content mismatching the funding structure (Baraldi & Wagrell, 2022), the actors' goals can sometimes appear conflicting. The understanding of non-business actors along with minor and complex adaptations add to previous literature on circular product development from a business network perspective.

Lastly, the paper responds to calls for further research on broader perspectives in business marketing research on sustainability (Sharma, 2020) by demonstrating the links between the micro-, meso- and macro-level resource interaction to advance sustainability through circular product development. In other words, the paper addresses the

complexities of the evolving business environment (Möller et al., 2020) by indicating the interplay between the business network (micro and meso levels) and the wider business environment (macro level). Macro-level resource interaction with the business network has been visible not only in coordination but also via monetary flows, which in INA research have commonly been a part of deal structures between suppliers and customers (Håkansson & Olsen, 2015). Our results suggest that the macro-level monetary flows to the business network enable increased resource interaction at the micro and meso level, as well as mitigation of negative economic value for actors at those levels, along with environmental value creation that is captured by the macro level. Moreover, the approach makes it possible to identify short- and long-term trade-offs by the business and non-business actors (Harrison et al., 2023), as well as efforts to increase the visibility of different actors in the network (Ford et al., 2017).

7.2. Managerial implications

There are managerial implications arising from this study. First, managerial engagement in product development is required to manage change and provide stability for dealing with the complexities related to the transition to CE. Minor adaptations, such as new pieces of machinery or refined processes, do not usually impact the heaviness of the resources in relation to other combinations, and therefore do not usually lead to major consequences for the focal companies. However, since these adaptations can be costly, it is important to increase interaction between the actors to facilitate a common understanding, especially among customers. More complex adaptations can be better dealt with by better understanding the required role of each company in the supply chain, the availability of resources within the business network and the business environment, as well as which resource interaction is required for the adaptation.

Second, policymakers' better understanding of the required business network adaptations demonstrated in this study makes it possible to identify which resources and resource interfaces need to be addressed through legislation to support the industry's transition to CE. As well as the monetary flows described in this study, the support can also include incentives and education for actors facing the biggest risks due to higher costs, actors that are product owners and can supply steady feedstock for recycling, and actors entering the industry and scaling up recycling. The unique role of municipal and regional governments needs to be emphasised here, since these actors can support the industry in the transition as both policymaker and an important B2B customer.

7.3. Limitations and further research

There are limitations to the paper, laying the ground for future research. Our study relies on a rich case description based on unique participant observations and multiple sources of data, which guided the definition of the micro and meso levels. Future research should further investigate the nature of micro and meso levels in business networks. This relates to how the levels are defined in terms of the focal actors, which may be dependent on the specific products, product development goals and industry context. Additionally, macro-level actors and their perspectives should be included in data collection to incorporate the logic of these actors and resource interaction at the macro level in interplay with meso and micro levels. While the current paper investigates circular product development within the parameters of an innovation project, future studies may focus on the process and outcomes of such developments to analyse the values created and captured by the different actors.

The empirical context of this study is the T/A industry and workwear sector. This sector is under great pressure to transition to CE. Initiatives such as the product development project studied in this paper serve as the driving force for the transition to CE. However, issues related to the industry's high impacts, future resource shortages and increased resource requirements highlight the need to further investigate how different initiatives involving inter-organisational interaction can enable the transition to CE (Aarikka-Stenroos et al., 2022). The results of this paper, pinpointing the need to extend the business network to the macro level in order to include the social system in the interaction process (Håkansson, 1982), is relevant beyond this empirical setting. For future studies, industry settings facing high levels of pressure may be suitable for learning about early initiatives, and about enablers and constraints. Working with circular product development and similar initiatives needs to be the reality of today for industry and business actors, since it is an absolute necessity for a sustainable future.

CRediT authorship contribution statement

Ann Vellesalu: Writing – review & editing, Writing – original draft, Investigation, Conceptualization. **Daniel Hjelmgren:** Writing – review & editing, Writing – original draft, Conceptualization. **Frida Lind:** Writing – review & editing, Writing – original draft, Conceptualization.

Declaration of competing interest

None.

Appendix A. Organisations involved in circular product development

Organisation	Role of respondent	Description of organisation
Fabric manufacturer	Business developer[2]	Manufacturing and sales of woven materials, other technical textiles and industry textiles, plastic semi-finished products
Garment manufacturer	Commercial & brand manager,[a] sustainability manager, product manager	Design and product development, production, delivery of ready-made products for healthcare
Industrial laundry and rental	Product manager, commercial director	Industrial laundry service, rental of laundry goods, wholesale of textile products
Local region	Environmental strategist[a]	Public organisation governing a region in Sweden, owns a centralised industrial laundry facility for internal use
Science park	Project manager, project leader, designer, coordinator	Open collaborative platform, research, innovation
University	PhD student, senior lecturer, lecturer	Higher education and research
Circular change agency	CEO, circular design strategy lead, circular design strategist	Consultation, education, software development

[a] These participants were interviewed due to their central role in the project (representatives of the industrial laundry and rental were unavailable for interviews). The other organisations participated in the workshops and meetings that were observed in different groups.

Appendix B. Overview of collected data in chronological order

Data source	Involved actors[a]	Duration	Documentation
Planning meeting	Science park (3 participants), university	1 h	Meeting notes
Planning meeting	Science park (3 participants), circular change agency (2 participants), university	1 h	Meeting notes
Online questionnaire	Fabric manufacturer, garment manufacturer, industrial laundry and rental (2 respondents), local region, circular change agency	2 weeks	Questionnaire responses
Planning meeting	Fabric manufacturer, garment manufacturer (2 participants), industrial laundry and rental, local region, science park (3 participants), university, circular change agency	1,5 h	Observation notes
Workshop for ideation	Fabric manufacturer, garment manufacturer (3 participants), industrial laundry and rental, local region, science park, circular change agency (3 participants), university	2 days	Observation notes
Progress meeting	Local region (2 participants), science park (2 participants), university	1 h	Observation notes
Progress meeting	Fabric manufacturer, garment manufacturer (2 participants), industrial laundry and rental, science park (2 participants), university	1 h	Observation notes
Progress meeting and field visit to local region's laundry facility	Science park (2 participants), university, local region (2 participants)	2 h	Observation notes
Progress meeting	Local region, university, science park	1 h	Meeting notes
Progress meeting	Fabric manufacturer, garment manufacturer (2 participants), industrial laundry and rental, science park, university	1 h	Observation notes
Progress meeting	Local region, science park (3 participants), university	1 h	Observation notes
Progress meeting	Industrial laundry and rental (2 participants), science park (2 participants), university	1 h	Observation notes
Progress meeting	Fabric manufacturer, garment manufacturer (2 participants), industrial laundry and rental (2 participants), science park, university	1 h	Observation notes
Progress meeting	Fabric manufacturer, garment manufacturer (2 participants), industrial laundry and rental, science park (2 participants), university	30 min	Observation notes
Project update meeting	Fabric manufacturer, garment manufacturer (2 participants), industrial laundry and rental, science park (2 participants), university	2 h	Observation notes
Progress meeting	Local region, science park (2 participants), university	1 h	Observation notes
Progress meeting	Fabric manufacturer, university	1 h	Meeting notes
Workshop to evaluate environmental impacts	Fabric manufacturer, garment manufacturer (3 participants), industrial laundry and rental, science park, university	2 h	Observation notes
Progress meeting	Fabric manufacturer, garment manufacturer, industrial laundry and rental (2 participants), local region, science park (2 participants), university (2 participants), circular change agency	2 h	Observation notes
Progress meeting	Garment manufacturer, university	1 h	Meeting notes
Semi-structured interview	Fabric manufacturer, university	1 h	Interview transcript
Semi-structured interview	Local region, university	0,5 h	Interview transcript
Semi-structured interview	Garment manufacturer, university	0,5 h	Interview transcript
Progress meeting	Science park (3 participants), university (3 participants)	1 h	Meeting notes
Progress meeting	Science park (2 participants), university (3 participants)	1 h	Meeting notes
Project update meeting	Fabric manufacturer, garment manufacturer, industrial laundry and rental (2 participants), science park (2 participants), university	2 h	Observation notes
Progress meeting	Fabric manufacturer, university	1 h	Meeting notes
Progress meeting	Science park (2 participants), university	0,5 h	Meeting notes
Progress meeting	Garment manufacturer (2 participants), science park (2 participants), university	1 h	Observation notes
Progress meeting	Fabric manufacturer, university	1 h	Meeting notes
Progress meeting	Garment manufacturer, university	0,5 h	Meeting notes
Progress meeting	Garment manufacturer (2 participants), industrial laundry and rental, science park (3 participants), university	2 h	Observation notes
Final meeting	Fabric manufacturer, garment manufacturer, industrial laundry and rental, science park (3 participants), university	3 h	Observation notes

[a] One participant per organisation, unless stated otherwise.

Data availability

The data that has been used is confidential.

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