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Knowledge obstacles when transitioning towards circular economy: an industrial intra-organisational perspective

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ABSTRACT
Circular economy (CE) is necessary for achieving sustainability goals. Nonetheless, the distillation of CE practices into business operations has been unsatisfactory as firms struggle to transition to CE. There is an increase in studies that have attempted to identify challenges impeding the implementation of CE practices. However, most of these studies focus on technical and external aspects affecting CE, leaving intra-organisational aspects such as organisational learning and knowledge largely unexplored. The latter aspects can play a significant role in CE transitions, and thus warrants further research. To address this research gap, this study draws on lean thinking as an organisational learning system and accentuates knowledge obstacles, seen as wastes, that can stifle a transition to CE. Subsequently, it deploys action-learning research, involving collaboration between researchers and the participants in the action to generate actionable knowledge. The analysis of the findings is used to develop a novel framework including six measures that can be implemented to counteract knowledge obstacles and lay a foundation for a CE transition. The proposed framework can be the basis for further research on lean and intra-organisational aspects that can help firms restructure the current linear mode of production, and thus accelerate a smooth CE transition.

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1. Introduction

Besides exposing the fragility of global supply chains, the COVID-19 pandemic has shown that the linear economic model is failing and a transition to circular economy (CE) is necessary (Yuan et al. 2021). This assertion is consistent with the view held even before the pandemic, that CE is critical for promoting economic growth and for achieving sustainability goals (Fehrer and Wieland 2021). From a systemic point of view, CE is an alternative industrial model (Mendoza et al. 2017), where industrial processes are seen as a means to contribute to sustainable development, and not as the inevitable cause of natural resource exploitation, and waste generation. Thus, to maintain competitive advantage firms have started to observe that the adoption of environmentally conscious practices in product-, production- and manufacturing operations is a necessity (Sarkis and Zhu 2018, 743). Despite the current rise of publications heightening the many benefits of CE, there is paucity of research focusing on firms' transformative capacity to progress beyond the linear economy (Zwiers, Jaeger-Erben, and Hofmann 2020). This is crucial for manufacturers as production is a transformative process itself. After all, the process of input of material transformed into outputs is achieved by the use of intangible- and tangible resources, organised in a production system (Kurdve and Bellgran 2021). However, academic studies find that firms are struggling and thus lagging with their CE transitions (Masi et al. 2018; Santibanez Gonzalez, Koh, and Leung 2019).

There is a recent increase in publications focusing on how firms can succeed with sustainable operations, covering aspects such as green manufacturing (Chuang and Yang 2014), cleaner production (Scheel 2016), green supply chain management (Green et al. 2012; Kumar et al. 2015), smart manufacturing's role in sustainable production (Kusiak 2018; Powell, Romero, and Gaiardelli 2022), lean and green (Inman and Green 2018) and supply chain operations for CE (Batista et al. 2018). These contributions offer valuable insights about the need of 'greening' firms' supply chain functions, and they show the importance of inter-organisational aspects in particular. However, evidence of understanding and utilising knowledge

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required to support this transition is limited (López-Torres et al. 2019, 813–814). Whilst the 'greening' of supply chains and other inter-organisational aspects are important, intra-organisational aspects such as organisational culture, learning and knowledge (also referred to as soft aspects) are just as important to investigate in order to succeed in the transition towards CE (Bertassini et al. 2021; Scipioni, Russ, and Niccolini 2021). This is because the operations of practices remain within a firm rather than across the supply chain (Masi et al. 2018). Thus, to succeed with sustainability and CE, firms must also overcome organisational obstacles posed by internal factors. Nevertheless, such aspects are claimed to be less researched empirically (Kirchherr et al. 2018; Chowdhury et al. 2022). The neglect of an internal foci is rather interesting though, as firms usually need to 'get their house in order' with regards to sustainability aspects before expanding their focus to external environments (Sarkis and Zhu 2018, 750).

Hence, while circularity and sustainability principles are inevitable for any industry to tap into, lean thinking has been highlighted as a means to achieve such a transition because of its strong simultaneous focus on people and waste elimination (Liker and Morgan 2006; Åhlström et al. 2021). Ultimately, organisational structures and operations are interlinked processes whose impact on product and service outcomes is great and thus, on the people performing these tasks. Accordingly, to succeed with CE, there is a need for manufacturers to take ownership of their performances (Cherrafi et al. 2019; Kurdve and Bellgran 2021) and continue engaging in developing the people dimension of their organisations (Nujen et al. 2021).

Adding to these aspects are the alterations needed for product development (PD) strategies, since until recently most manufacturers have competed on issues related to traditional consumer demands for high-quality products, shorter product life cycles and advancements in production technologies (Shankar et al. 2013; Zhang et al. 2017). While some of these demands remain valid, there is a significant change in customer demands towards sustainable products and most preferably products with circular life cycles. Consequently, instead of shorter product life cycles, firms must rethink their strategies toward extending and reshaping their PD processes and thus also their production methodologies (Kusiak 2018). To succeed, firms must understand how embedded organisational learning and knowledge can contribute and affect their PD processes in line with new sustainability requirements (Boks and Stevels 2007; Stenholm 2018). Especially as the entry point of any important sustainability effort is the firms' product (Kusiak 2018).

Recently, a review of 69 publications associated with topics on sustainability and eco-design was conducted by Bertassini et al. (2021), where the authors show that the majority of the reviewed publications did not focus on the soft side of CE, neither on what was happening inside organisations when transitioning to CE. Instead, most focus was devoted to understanding customers' behaviour and technological development as well as public legislations (Bertassini et al. 2021). On a similar note, the review by Sarja, Onkila and Mäkelä (2021) showed that in one of the categories of their study, in which learning and knowledge are mentioned as crucial aspects to CE transitions, topics dealing with internal factors in CE transitions were underrepresented. Hence, the remark that most research efforts appear to concentrate on finding solutions for, e.g. eco-innovations and eco-design in PD rather than on identifying what the real obstacles are (originally made by Boks and Stevels, already in 2007), still seems to be valid. As such, factors affecting sustainability in manufacturing firms are still an open question for observation and investigation, especially within the field of production and operations management (Sarkis and Zhu 2018; Ciano et al. 2019). Accordingly, there is a need for further research on intra-organisational obstacles which manufacturing firms might face when transitioning to CE (Sarja et al. 2021).

To reduce this research gap, the study at hand will devote its foci on intra-organisational aspects where knowledge obstacles, seen as wastes, are accentuated from the perspective of lean thinking, where the latter is applied as an organisational learning system. In doing so, a separate investigation of intra-organisational obstacles is achieved. Such an investigation is important as the transition towards CE will most likely require a learning and knowledge-focused strategy (Scipioni, Russ, and Niccolini 2021). The investigation is then used to develop a novel framework including eight measures that can be implemented to counteract knowledge obstacles and lay a foundation for a CE transition. This is conducted through action learning research (ALR), which has been accentuated as a suitable approach to adopt when investigating internal aspects in a CE context (Bertassini et al. 2021). Although not widely applied, Coughlan and Coghlan (2002) postulate ALR as a beneficial approach in production and operations management studies, which recently was exemplified by Coreynen et al. (2018), who investigated the internal levers necessary to increase firms' servitisation capacities when implementing a product-service system (PSS) – which is a strategy to be found in CE. Similarly, Prasad et al. (2018) developed an optimisation model for health care behaviour, in which action-oriented research methods were deployed. Hence, this study does not focus on the framework developed by the researchers *per se*, but rather on the knowledge obstacles explored in a real-world setting from a lean thinking and organisational knowledge perspective. As such, this study contributes to the production and operations management theory and practice by providing recommendations that can accommodate for the necessary awareness of intra-organisational obstacles and the actions needed when transitioning to CE.

The paper proceeds as follows. Section 2 presents the theoretical background related to organisational learning and knowledge, and organisational learning and knowledge in CE transition. Section 3 describes the methodology employed, followed by findings and analysis in Section 4. In section 5, the developed framework and the managerial recommendations are presented. Section 6 provides the closing remarks and outlines the contribution and the limitations of the study.

2. Theoretical background

2.1. Organisational learning

As indicated above, lean is perceived and applied as an organisational learning system to gain competitiveness through continuous improvements and learning, without neglecting waste elimination. In fact, it has been postulated that continuous improvement without learning is not lean thinking (Netland and Powell 2017). Hence, herein lies the strong emphasis on the people dimension. Organisational learning is at its core a status of continuous change since changes follow when organisations acquire experiences (Argote and Guo 2016). These experiences affect both cognitive and behavioural learning patterns or outcomes. For instance, learning patterns, which can be equal to operational learning, are often a step-by-step task (e.g. operating a piece of machinery) that can be captured in routines which later plays it out in know-how (Nujen et al. 2021). The cognitive element of experience is related to what Kim (1993) refers to as conceptual learning, since it has to do with the thinking behind why things are as they are. This form of learning sometimes challenges prevailing conditions and thus leads to new frameworks in the form of mental models. The new frameworks in turn can lead to new opportunities for discontinuous steps of improvement by reframing a problem in radically different ways (Kim 1993, 55). As such, learning can be understood as a process that emerges when an organisation gets to know something new and acquire the knowledge to transform it into actions, without necessarily acting upon it (March and Olsen 1975). This is similar to what Argyris and Schön (1978) heighten in their theories of action, when they stress that actions represent a measure of what is actually learned. Others define organisational learning as the process of improving action through better knowledge and understanding (Fiol and Lyles 1985, 803). It is important to note that this does not mean that the level of improved actions or the absence of new actions necessarily is equal to what the organisation has learned. This is because new knowledge can lead to the understanding of the necessity of not acting, or actions that require organisational unlearning. The term unlearning can be a bit problematic as it has been viewed as a process of memory elimination (Akgün et al. 2007), which can be associated with concerns regarding knowledge losses that can lead to obstacles in PD, new recruitments, reversed knowledge transfers and acquisitions, as well as firms' absorptive capacity, etc. (Shankar et al. 2013).

Despite these concerns, unlearning should not be viewed as an unhealthy process. On the contrary, it is a pivotal process of firms' actions. This is because the absence of unlearning can lead to path-dependencies that are difficult for firms to break or change. Hence, the lack of unlearning increases the risks of core-competencies becoming core-rigidities (Imai, Nonaka, and Takeuchi 1984; Stenholm 2018). Extant literature accentuates that established beliefs and methods persuade firms to neglect advancements in technologies and markets, due to deep emotional investments in 'old' ways of working, hampering firms to produce new products or to respond to new business requirements and/or opportunities (Akgün et al. 2007, 208), which can hinder a CE transition. To ease the potential of such hinderances, firms need to accept to unlearn parts of established beliefs, knowledge, methods and operations (Akgün et al. 2007). Accordingly, for manufacturing firms to be able to fully adhere to CE they need to activate organisational learning processes (Scipioni, Russ, and Niccolini 2021), which requires a stronger focus on intra-organisational aspects such as organisational knowledge (López-Torres et al. 2019).

2.2. Organisational knowledge

Organisational knowledge can be described as the dimension of knowledge that relates to how firm-principles shape the social structure of coordination, and the organisational members' perceptions, behavioural routines and work practices (Nonaka and Takeuchi 1995). Despite this notion, knowledge as a concept is challenging to clarify as it embodies two kinds of awareness: a focal identifiable (explicit) object and a subsidiary (where tacit knowledge is embedded), unidentifiable one which are mutually exclusive and represents the structure of all acts of knowledge (Polanyi 1962). While, explicit knowledge can be identified and thus articulated, tacit knowledge is highly personal and difficult to communicate by verbal articulation. Moreover, the source of tacit knowledge creation is a result of experiences performed by the individual(s) (Nonaka and Takeuchi 1995). This indicates that individuals of an organisation are captors of know-how and hence, agents of knowledge transfer(s), as they are the users of the organisational system (López-Torres et al. 2019). As such, knowledge obtained can be embedded in a variety of repositories, including individuals and their routines. Consequently, changes in one of these repositories prompt changes in organisational knowledge, which again co-shapes and pre-structures practices, and thus stimulates organisational learning (Argote and Guo 2016).

Within the context of lean, it is therefore not enough to acknowledge that organisations and their employees must learn. Equally important is how organisations do when they learn what they need to know (Ballé, Chaize, and Jones 2019). Accordingly, to meet the required transition toward CE, firms must nurture the enhancement of organisational knowledge. Such enhancement relies on the mechanisms underpinning the sharing-, internalising-, disseminating and reusing of knowledge (Urwin and Young 2014), all of which depend on people (Polanyi 1962). Thus, the process of enhancing knowledge also depends on existing knowledge and should therefore not be restricted to merely concern new knowledge being created or acquired. After all, the ability to utilise external knowledge and apply it to commercial ends depends on a firm's ability to assimilate it, which is contingent on a firm's extant knowledge base (Cohen and Levinthal 1990). Regarding the choice or possibilities of knowledge reuse, a plethora of researchers (e.g. Boks and Stevels 2007; Wu et al. 2014; Zhang et al. 2017; Batista et al. 2018) have accentuated its importance, especially when investigating PD. For instance, it has been argued that the reuse of knowledge can be accomplished through up-to-date documentation of earlier projects and set-based concurrent engineering (Womack 2006) trade-off curves (showing subsystem knowledge from which design alternatives are evaluated and narrowed until an optimal design is chosen) and storytelling of lessons learned (Liker and Morgan 2006), as well as knowledge-driven decision making (Zhang et al. 2017). As can be seen, most of these 'strategies' are merely focusing on codified knowledge that can be communicated explicitly, which by all means can enhance knowledge reuse (Urwin and Young 2014). However, most often the critical knowledge is to be found in the heads of the employees (tacit) and does not therefore lend itself to be shared and reused in a simple way. Researchers have therefore stressed more interactive approaches such as cross-functional teams and conscious overlap of PD activities (León and Farris 2011). Despite the difficulty of its tacitness, however, it is important to aim for knowledge to be re-generated and acted upon since it supports how products can be best produced (Urwin and Young 2014; Wu et al. 2014) and thus be considered as valuable also for other functions within a firm.

However, valuable knowledge which leads to actions in one context can become problematic when working across functions, since its application might be hard to grasp, or it may be rejected due to unwillingness to change existing praxis. Closely related to this is the inherent ambiguity regarding operational and practical responsibilities owing, for instance, an inadequate commitment among diverse functions (Rossi, Taisch, and Terzi 2012).

2.3. Organisational learning and knowledge in a CE transition

As noted in the introduction, a shift to CE requires learning and knowledge, and eco-innovations of resources to manifest the needs of environmental resilience (Scheel 2016). CE is, thus, seen as the panacea for an economically successful and environmentally sustainable future (Tonelli and Cristoni 2019). Consequently, the CE has quickly moved from theory to practice and the demand for innovative business models and novel approaches to sustainable product design, material management and value retention – those that allow to continually circulate flows of products, components and materials at their highest utility into production systems – has grown accordingly. However, in existing business operations, such principles are rather difficult to implement as the transition from the linear mode of production to the circular one needs specific capabilities and knowledge of stakeholders within and outside the firms (Govindan and Hasanagic 2018; Loon and Van Wassenhove 2020; Prieto-Sandoval et al. 2019). This is a typical instance of organisational learning, which is seen as a process that facilitates partnership between actors to advance new PD as well as the firm's overall performance (Lyles 2014).

In this context, learning processes can occur within the firm by not only actively engaging stakeholders (Levering and Vos 2019) but also from information found in their external environment. Thus, closer collaboration with stakeholders from the external environment is important for the provision of circular flows (Govindan and Hasanagic 2018; Loon and Van Wassenhove 2020). This is because the needed – and sometimes specific – skills and capabilities, might reside outside of the firm boundaries (Levering and Vos 2019). Following Zucchella and Previtali (2018), circular value creation and value delivery may therefore have a different impact on the environmental ecosystems, which indicates that such differences also are linked to the changes in the knowledge ecosystems of the focal firm. Changes that can require firms discarding existing knowledge and practices (Akgün et al. 2007). Thus, new knowledge will be created with new actors and new practices, as well as new patterns and new processes will emerge of how to acquire, capture, analyse, utilise, store, reuse and share the knowledge. In general, not only does the management of knowledge play an essential role in sustainable and competitive value creation reflected in the firm's performance (Schiuma, Carlucci, and Lerro 2012) but it also plays the crucial role for designing adequate products and thus not only accommodating the CE promoting knowledge ecosystem (Boks and Stevels 2007; Stenholm 2018). Consequently, intra-organisational knowledge aspects of the focal firm are hard to disregard or bypass.

3. Research methodology

This study deploys a normative research approach as it seeks to evaluate the extant situation and determine directions for future improvement. Specifically, the study adopts action-learning research (ALR) to identify knowledge-related obstacles encountered during an ongoing CE project and to generate actionable knowledge to positively shape the project. Recently, Powell and Coughlan (2020) provided a succinct account of the method within the context of operations management. This research method is problem-focused, involving collaboration between researchers and the participants in the action to generate actionable knowledge (Coughlan and Coghlan 2016; Powell and Coughlan 2020). Therefore, the researcher and the firm's employees interact as co-researchers collaborating to resolve or to improve the issue at hand. ALR can be expressed in terms of three cyclical systems: alpha, beta and gamma (Powell and Coughlan 2020). System alpha identifies and frames real organisational problems, while system beta focuses on exploring the problem-solving process, through multiple cycles of action and reflection. As for system gamma, the focus is on the interpretation, critical reflection and evaluation of the researcher's involvement in the action learning to underpin the emergent actionable knowledge. The three cycles were also vividly demonstrated by Saabye and Powell (2022), in a study that focuses on how manufacturers could foster insights and improvements by develop a learning-to-learn capability – which they postulate as a necessity to succeed with industry 4.0 implementation. The remainder of this section presents key methodological choices implemented in the study, including research setting, participants, data collection and analytical approach.

3.1. Research site

Since ALR is context-driven and problem-focused, it is crucial that the research initiative originates from practice. The research site for this study was at a European medical engineering firm, a world-leading provider of training, educational and therapy products for lifesaving and emergency medical care (herein after MedLife). The firm has a broad portfolio of products and actively operates on several continents. As part of the firm's commitment to value creation, it has always embraced continuous improvement. In the spirit of such improvements, MedLife embarked on a project in 2020 to facilitate the development of a CE business model combined with its existing lean thinking philosophy. The CE elements in the model aimed to be implemented were derived from the '3R principles': reduce, reuse and recycle (Su et al. 2013). With regards to reduce, the firm emphasises a need for reduction of materials and waste in production (eco-efficiency), while reuse concerns the many components and parts of its products, which MedLife hopes to harvest at end-of-life stage. As for recycling, the focus is on plastics, which currently represent 60% of the products' composition (eco-friendly). The project initiation was not only vital in achieving the firm's ambition of carbon-neutrality, but also when it came to its intra-organisational knowledge foundation and dissemination during this ongoing transition. This therefore constitutes the problem that needs to be addressed.

Like in other research methods, the scope of the study is an important methodological choice in action-oriented research (Coughlan and Coghlan 2016). Given the broad range of MedLife's products, it was necessary to narrow the focus and pursue a deeper action learning. Thus, we decided to focus on one of MedLife's new products, a patient simulator (herein after SmartX), which aims to be designed and produced according to CE principles.

3.2. Data collection

In this study, data collection and learning derived through five interventions. First, through a Gemba walk where participants observed processes to understand the context and learn about the dynamics involved. Second, an enterprise-wide value stream map (EVSM) was created together with knowledgeable managers on operational level using MURAL, a digital workspace for visual collaboration. This involved a stepwise visualisation of the entire value stream at an enterprise level. Powell and Bartolome (2020) contend that EVSM can help organisations discover improvement opportunities through value analysis (i.e. solving problems in the existing production system), and value engineering (i.e. solving deeper engineering problems to better fit the capabilities of the production system and customer needs). Third, 12 semi-structured interviews were conducted with team managers and members selected from among the personnel involved in the production of SmartX. All interviews lasted 1–2 h, were audio recorded and later transcribed verbatim. Fourth, a workshop with members from all the functions was conducted, in which a revised EVSM was presented. Fifth, by the means of Obeya (big room/war room), in which the researchers and MedLife representatives discussed and shared information about potential solutions to knowledge obstacles diagnosed and the project in general. This intervention was crucial because it facilitated the acquisition, clarification and internalisation of knowledge among team members. To gain additional insights, the researchers engaged in informal conversations with managers from some of the teams. The conversation focused on issues related to the operations at MedLife, which helped to deepen understanding of the processes and the wider context of the study. Other, unobtrusive supplementary sources were collected to gain additional viewpoints on significant issues pertaining to the production processes of SmartX. The knowledge derived from the preceding data generation and learning activities went through several rounds of reflections, both individually and in collaboration with participants. These exercises elicited an awareness among the participants of how their way of working and thinking impacted on what they registered as why things are as they are (cyclic thinking).

3.3. Analytical approach

To analyse the generated learning, two approaches were applied: iterative reflection and streamlined codes-to-theory coding approach. Following Coughlan and Coghlan (2016), the reflection process involved stepping back from the experience of each action cycle to process what the process meant, the relevance of the insights generated, and the relationships between them. Three forms of reflection were engaged: content, process and premise reflection. That is, the researchers stepped back to think about the issues that emerged during the action cycles (content reflection), strategies, procedures and how things are being done at MedLife (process reflection), and the relevance of the underlying assumptions and perspectives (premise reflection). Subsequently, following Saldaña (2021), the researchers generated a pool of themes that were firmly rooted in the empirical evidence. This involved a streamlined codes-to-theory coding approach, which allowed transcending from empirically derived concepts to higher-level constructs, which are aggregated into a conceptual framework that delineates knowledge obstacles as wastes. Figure 1 portrays the process undertaken from data collection to the conceptualisation of the framework. It shows the six approaches used to induce learning and generate data, specifying the outcome of each activity. Subsequently, the figure presents streamlined code-to-theory coding approach and iterative reflection as analytical tools applied to generate actionable insights in the form of a conceptual framework that delineates knowledge obstacles as wastes.

4. Findings and analysis

As demonstrated by recent publications in the International Journal of Production Research (Carvalho, Scavarda, and Lustosa 2014; Coreynen et al. 2018; Prasad et al. 2018), action-oriented approaches can involve different types of data collection methods, including those used in traditional research. However, unlike other research methods, ALR involves data generation as well as interventions that occur through interactions between researchers and participants during action cycles (Coughlan and Coghlan 2016). As indicated in the previous section, our interventions were structured as action cycles at individual (individual interviews), group (EVSM) and organisational (Gemba, cross-functional workshops and Obeya) level. Thus, we posit that the Gemba walk and the EVSM, represent the activity of 'learning to see' while the dialogical interviews and especially the workshops and the Obeya represent the activity of 'questioning the insights' as suggested by Powell and Coughlan (2020). Accordingly, the interactions during the action cycles generated data and learning for the researcher(s) and the participants in the action, which will be further elaborated in this section.

4.1. Interventions: learning to see

Cycle1: In the context of lean, the Gemba walk provides an opening for employees at all levels to go and see the impact of what is happening at a workplace outside their immediate area of responsibility and interest. As such it provides an opportunity to gain knowledge about how others perform their work and why they do so (Womack 2011). Consequently, we decided that a Gemba walk would be the starting point of our interventions. Here, participants from different functions and the researchers were given the opportunity to understand how the work at MedLife was performed. But more importantly, it provided a direct opportunity to meaningful conversation across the firm. Hence, this increased the ability to relate to other departments and how work is conducted at the diverse workstations. It also helped to identify obstacles (lean and CE/sustainable wastes) experienced from diverse perspectives. As one participant reflected: '… we do not lack initiatives, but there are many more sustainable possibilities we can explore'. Although MedLife follows a lean philosophy, most of the participants, who are

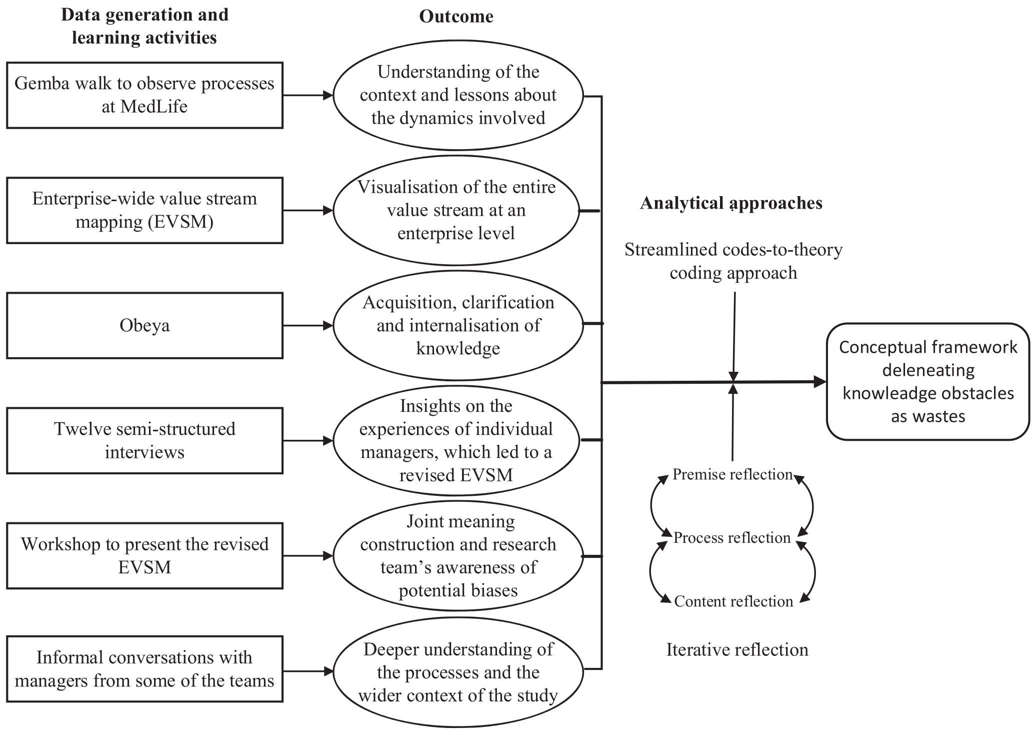

Figure 1. Methodological approach.

professionals with long work experience, were prior the Gemba mostly concerned with their own work processes and obstacles in their immediate work environment. However, the Gemba walk identified a design issue with an add-on part to SmartX that meant production had to make an older version of the product if this add-on was to be included. After the Gemba, a digital meeting took place to share the newly obtained insights and lessons learned, which provided a second round of reflection among the Gemba participants. Based on the Gemba discussion, the product family director stated: 'I am starting to see how these cross-functional Gemba walks can be a source of discovery for my team, along with other counter parts such as manufacturing'. The statement indicates that they had not managed to look at potential solutions to their obstacles from a systems thinking lens. Thus, conducting Gemba walks can be an impactful intervention when linking lean and CE for manufacturers, as both paradigms promote the actions of identifying wastes (Inman and Green 2018) as well as fostering opportunities for new knowledge to be obtained. Hence, the basic tenet of a Gemba is to involve the entire firm to harness cross-functional thinking. In so doing, it creates an environment for reflections and learning, and thus decreases the potential obstacles firms can encounter during transitions focusing on sustainability aspects (Cherrafi et al. 2019).

Cycle 2: To enhance the insights derived from the Gemba further, the next cycle of intervention was conducted through an EVSM. This methodology is effective in identifying tangible processes in the production flow and links it with the intangible flows often to be found in PD, while simultaneously emphasising wastes and thus prompts continuous improvements on both intra- and inter-firm level. Accordingly, its aim is to 'leaning out' the process from the bottom-up, while realising the most effective use of resources in the targeted firm functions (Powell and Bartolome 2020). This action allowed for increased insights as it activated reflections and learning. One of the participants explained this in a simple way: '… the work (EVSM) we are doing now is an eye opener'. Hence, capturing firm-level details through visualisation across the entire organisation, helps creating a consensus on what is valuable and what is waste, which is extremely important for the ideals of CE. Yet, some waste and value aspects were more difficult to identify while yet identified. Examples of such wastes were for instance, the amount of knowledge- and information dissemination between the customer/user team (which is a team that works in close collaboration with external stakeholders, e.g. customers, universities and test centres) and the PD. This was because the dissemination of the collected information from external stakeholders' experiences was not focused, it was perceived as a situation of 'information overload'. When not knowing what the information aims at contributing to, it decreases the possibilities for redesigning their products to become more user-friendly or more environmentally friendly. Other wastes identified were the lack of effective communication between PD and distribution functions leading to non-eco-friendly packaging, too many iterations causing rework for the PD and the manufacturing function. Before the EVSM, these wastes were overlooked, which was confirmed by one of the engineers: '… it is much easier to see now, as the waste in most of our operations become clearer'. Arguably, EVSM resonances the cycles that can be found within a CE context, since the latter is a systemic concept which requires collaboration and commitment enterprise wide (Kvadsheim et al. 2021). Hence, in a transition towards CE, it is crucial that a firm aims to guide and inform the integration of different types of value and perspectives as well as the consideration of multiple means and actors that must be addressed for transformative actions (López-Torres et al. 2019; Zwiers, Jaeger-Erben, and Hofmann 2020). Whilst EVSM enhances the possibilities for learning to see and reflecting about the current state, the aspect of consensus however requires further discussions to enable a transition in the right direction. Therefore, it was important to involve additional team managers and participants in the affected functions. The involvement took place through 12 individual interviews which reinforced additional awareness concerning wastes but also an understanding of potential valuable knowledge and thus, an enforcement of questioning of insights.

4.2. *Interventions: questioning the insights*

Cycle 3: Each interviewee was asked to explain the in- and outbound workflow affecting their functions. Additionally, they were asked to present one or more critical knowledge obstacles that they encountered in their work with regards to CE and the SmartX. Hence, while most of the workflow wastes were detected through the learning to see interventions, the narratives used in the following section question those insights and are thus representative of the range of waste and knowledge obstacles experienced by MedLife.

A first glance of the EVSM revealed instances of physical (i.e. non-eco-friendly) and time-consuming wastes, which often were generated by the sourcing and the manufacturing functions. When asked about it, the sourcing function admits to these wastes while at the same time questioning them when stating that these wastes originate from obstacles caused by untimely exchange of information and knowledge with the PD function. They explained that designers generally have the initial responsibility for preparing the technical specs for products and the materials that go into them, and therefore influence the amount of time the sourcing team has to handle an assignment. When these obstacles were presented to PD participants, they did not question them, rather they supported the premise that sharing knowledge and information with other functions provides adequate visibility, enabling them to make good decisions. The waste, however, is connected to when exactly is the right time to share the knowledge and information. As stated by one of the engineers:

> … it does not make sense to have the sourcing team on board too early. Because, then we do not have any information to give them, after all this is before we know which parts, we might need … we do not know ourselves what we are building.

The sourcing team understands this, however, accentuates it as a rather huge waste-post, as follows:

> … the knowledge and information sharing between our function and PD definitely creates waste and it is hard to get it lean because if they involve us too early, we would be second developers for all the individual items asking a lot of irrelevant questions. But if they involve us too late, they have predefined the 'cable' so much that we cannot use any other supplier than the one they have, thus finding the 'right' or a new one will be too time-consuming.

Hence, sharing knowledge at an earlier stage or a latter one is a waste-source, thus choosing the right time is crucial. This is because decisions made by the PD function seem to play a key role in a CE transition as they control what raw materials to use, and thus also how to manufacture the products. Accordingly, if information sharing with other functions is delayed, untimely waste (e.g. disposal of obsolete parts, rework and disposal of built prototypes) is generated at MedLife, thereby hampering the possibility of adopting the reduce principle. Hence, in addition to when exactly (i.e. at the right time) the information and/or the knowledge should be shared, the obstacle also implies that it is just as much about the aspects of sharing and presenting the information and knowledge to the right people and with the proper level of detail (Stenholm 2018) for it to bypass becoming a waste. The latter aspect was a recurring theme among the participants, especially when questioning MedLife's existing knowledge base and its application to accommodate CE requirements.

Closely related to the above is the waste that comes with loss of tacit knowledge, which most noteworthy was claimed to be because: '… engineers and designers were leaving for greener pastures'. This can have an impact on MedLife's growth and economic competitiveness as the technical elements (know-how) are crucial during PD and hence, often shared or obtained through human interactions. While the cognitive elements are crucial with regards to the transition CE requires. Accordingly, within the context of CE, this might be a severe obstacle as it could mean that all the CE non-codified, disembodied know-how that is acquired via the informal absorption of learned behaviour and procedures at MedLife can be lost with the CE experts resigning from their jobs (Nujen et al. 2021). This waste was not only restricted to individuals leaving, but also targeted existing knowledge gaps leading to consequences that could weaken the knowledge base of the entire firm. Hence, the latter notion magnifies the potential obstacles that can emerge between the manufacturing function and the PD with regards to knowledge mismatch which can impact the entire life cycle of the SmartX. For example, lack of material know-how can result in unnecessary design features or increase environmental damages, while weak technical know-how can result in massive rework.

Having said that, MedLife does possess knowledge that is of importance for a smooth CE transition, however, not always as easily tapped into or embraced. For instance, it was mentioned that due to the high level of knowledge heterogeneity in PD, it was difficult to reuse existing knowledge, resulting in problems to coordinate resources, hinderance in analysing and solving problems better, and creating new solutions for CE. The obstacle was explained by the head designer as a waste that could: '… lead to designers not being able to draw lessons from earlier successes or failures … causing an increase in human resources and (re)producing mistakes'. In the same line of thought, another engineer contends that '… with almost every new project that we have, there is often a new constellation of designers and engineers who work together during a limited time. This makes it even more challenging for us to reuse knowledge from previous projects'. Accordingly, it is of utter importance to be able to reuse knowledge to know what knowledge aspects that need to be abandoned or unlearned. An interesting reflection made by one of the designers connected to such issues was:

> We know it is the SmartX we should focus on, but we have many mannequins that actually can be argued to be quite sustainable with really long-life cycle … I mean the 'problem' with them are that they are of too high quality, they never break … how many products of this category do you know of that can be used for up to 20 years?

The customer/user team aired similar thoughts stating: '… it is very unusual for us to get back any products, they are used over and over again … and when something gets broken the customers often lap them up together themselves … with the exception of production errors'.

These statements confirm that MedLife's products are of high quality, which is good, but they also indicate that there might be a risk of vicious circles of unsustainability and reactive environmental strategies not being broken (Prieto-Sandoval et al. 2019). Although not directly connected with internal knowledge obstacles, an aspect closely related to unsustainability and reactive environmental features in their current products, is that if they are not being returned to MedLife in good time after they break, it limits them to embark on a take-back strategy which decrease opportunities to operate with CE principles, as the broken parts might be sent off to landfills instead of being reused or recycled. Accordingly, one should not underestimate the need of reusing extant knowledge or integrate external knowledge in the realm of PD, as both can help with more sustainable operations that require organisational unlearning. Another redundant knowledge obstacle heightened concerned different perceptions of what was regarded as valuable. Hence, depending on what one function meant was important could be perceived as non-valuable by another function and thus not acted upon. As stated by a participant from manufacturing: '… how they develop the products and what they decide over there (in PD) I do not care so much about, unless I know it will affect what machines we must use'. Thus, the element of discarding knowledge in such a context indicates a deliberate act of unlearning as the knowledge is extant in PD, however, not used by the manufacturing function.

Moreover, a waste that was experienced by all participants, was misused human resources which are known as the eight waste in lean but also fall under CE. This type of waste contributes to the loss of general improvements opportunities like skills, time, upgrades and learning and knowledge sharing (Womack and Jones 2003). It occurs when employee skills, talent and capabilities are underutilised, not adequately used, or simply not utilised at all (Ohno 1988). Hence, such situations indicate that if knowledge (valuable such) is not adequately identified and shared, evaluated or understood, it will lead to knowledge wastes. Both with regards to the knowledge's beneficial traits as well as its inadequacies. Accordingly, what type of knowledge that should be of value and therefore reused as well as what type that needs to be unlearned are the actions of proactively questioning the status quo, which is a fundamental aspect of lean thinking and CE.

Cycle 4: The joint action of the EVSM combined with the knowledge obtained from the dialogical interviews brought about a more holistic understanding of the processes and functions involved in the production of SmartX. This prompted us to revise the EVSM and present it at a workshop. To encourage engagement and discussions, themes and additional research questions were formulated in advance. The workshop enabled a comprehension of all the teams' experiences from their point of view, which also helped the researchers to be aware of potential biases. More importantly, asking questions enabled a clarification of the knowledge obstacles aired while at the same time stimulating for alternative solutions. For instance, the sourcing function expressed the importance of upgrading the environmental competence for all functions at MedLife:

> … it is not just the PD function that needs this knowledge, we are also affecting the company's ambitions of circular products … just think about the problems with ineffective materials' purchase … these wastes are a result of us also lacking material knowledge so to say.

In addition to lack of material knowledge, which decreases the possibilities for purchasing eco-friendly materials and thus also recycling efforts, ineffective material purchase will most likely inhibit the reduce principle to materialise. Thus, it seems there is a lack of knowledge hindering the production of products for circularity. While for PD, one was occupied with questioning and finding solutions to all the time being spent searching for available engineers to perform critical mechanical tasks as it creates a lot of waiting. Both can be major obstacles as they indicate a lack of multi-skilled human resources that can respond quickly as environmental product demands changes. In sum, the workshop acted as a learning arena where learning occurred through asking questions to their internal context and thus catalyse on how to deal with the transformation needed for cyclic thinking in products and the wider organisation.

Cycle 5: To accommodate some of the insights obtained from the previous cycles, the research team initiated a fifth intervention by the means of a digital Obeya. Digital due to the ongoing COVID-19 pandemic. From the spring of 2021, a cross-functional team that includes key resources from manufacturing, sourcing and procurement, PD, distribution, and engineering, met weekly. Prior to every meeting, each participant communicates some potential actions (e.g. in strategic A3 form) as a response to the breakthrough goals set by MedLife as well as what they learned from the ongoing project. All suggestions are then discussed and reported on in terms of functional and cross-functional impact, intended or unintended. As such, clear standards can be displayed, and deviations can be highlighted immediately, leading to corrective actions and thus assisting in easing potential knowledge obstacles. Hence, widening the scope of involvement helped to facilitate cross-functional collaboration in problem solving and learning, and not least on deciding on what knowledge obstacles to act upon. For instance, it was mentioned that: 'The Obeya allows us (manufacturing) to better understand the priorities of PD and the PD to better understand our issues that arise due to poor design'. On a similar notion, it was raised that '… the Obeya prompt us to have a discussion on design for assembly and dis-assembly'. Hence, this can have a big impact on the development of the SmartX and ease the adoption of CE principles which are required for a successful transition. Creating a milieu where planned actions and suggestions can be questioned and agreed on in collaboration allows for cross-functional learning. In doing so, it initiates the ability among the personnel regarding the important capability of learning-to-learn (Saabye and Powell 2022).

Accordingly, the use of Obeya stimulates the participants to clarify why things are as they are (cyclic thinking), to acknowledge other knowledge domains (reuse knowledge) and accentuate aspects of abandoning established practices (learning/unlearning) on a cross-functional level. According to the technical product manager, the Obeya is such of value in this transition that: '… we are actually expanding it (Obeya) by incorporating it to the full product family line-up'. This is an important decision since engineering and manufacturing are not necessarily collocated, thus, the Obeya functions as a communication hub, which is essential when it comes to CE. Broadly, lack of collaboration and delay in information- and knowledge sharing can be one of the impediments to MedLife's effort to build circular products and as such also supply networks, as sourcing may not be able to communicate CE requirements made by their engineers and designers to their own suppliers, much less enforce them. Moreover, since CE intrinsically requires a systems thinking approach, it is crucial that MedLife strengthens their internal integration before attempting to integrate themselves with external chain actors. This supports the contention that information- and knowledge sharing within a firm should precede the information- and knowledge sharing between firms (Sarkis and Zhu 2018). It reinforces the notion made in the introduction; that firms must overcome organisational obstacles posed by internal factors. In sum, the five cycles of interventions in addition to the informal conversations, led to the identification of antecedents and implications of knowledge obstacles as wastes in PD, sourcing and manufacturing. Combined, the implications of knowledge obstacles inhibit the transition to CE (Figure 2).

5. Actionable managerial recommendations

Taken together, the findings of this study provide basis for actionable managerial recommendations on how to address knowledge obstacles as wastes in PD and its

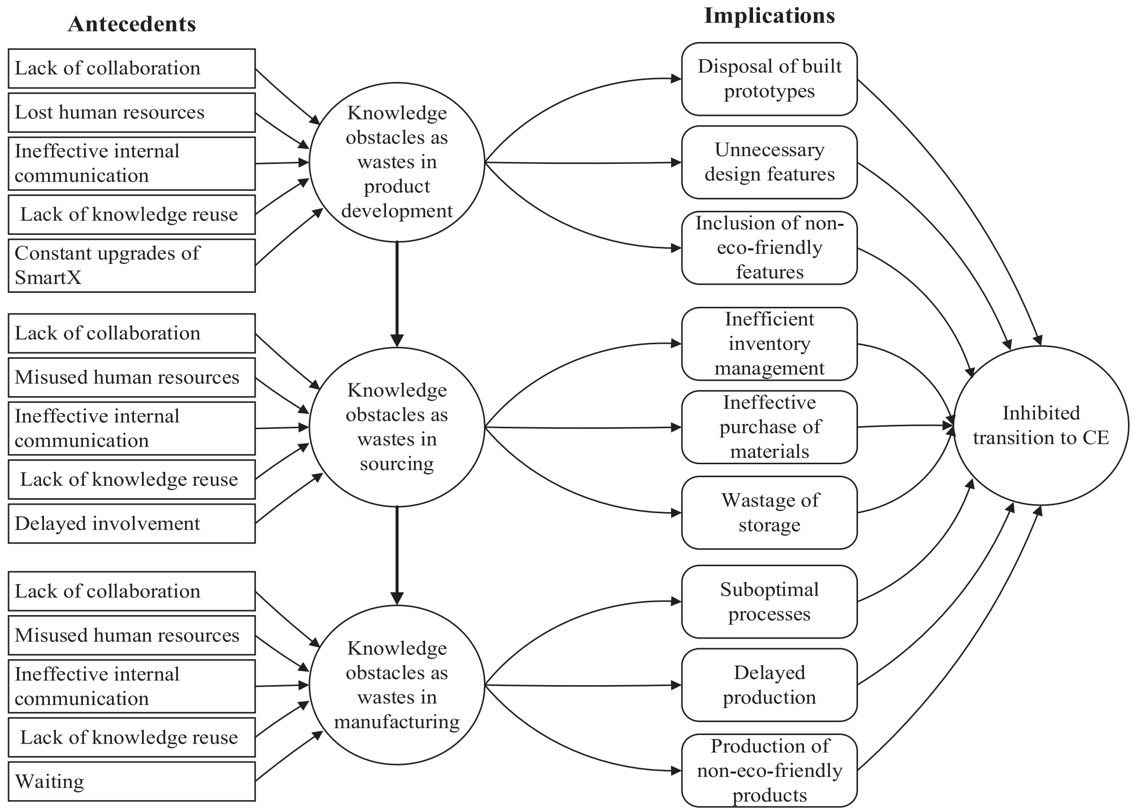

Figure 2. Knowledge obstacles as wastes in product development, sourcing, and manufacturing.

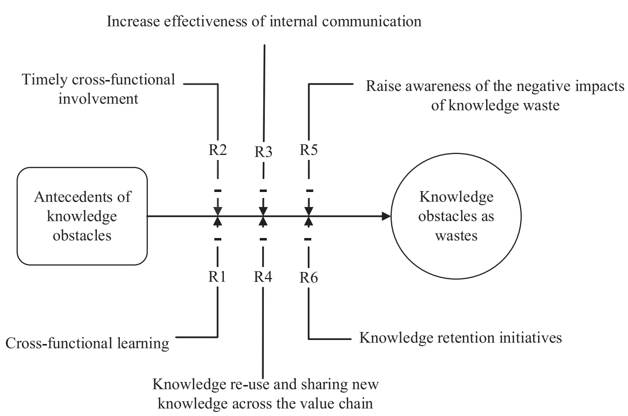

Figure 3. Actionable managerial recommendations.

counter parts. Figure 3 presents the recommendations, followed by clarifications.

As shown in Figure 3, six measures can be implemented to counteract the antecedents of knowledge obstacles identified in this study and hence lay a foundation for the implementation needed in a CE transition. Firstly, firms must embrace cross-functional learning as a mechanism for disseminating knowledge across the value chain and for creating an organisation-wide understanding of the initiatives to implement CE. More so, cross-functional learning allows teams across the firm to appreciate the role played by other teams in enhancing the implementation of CE. Secondly, timely cross-functional involvement is crucial. To be able to enhance the implementation of CE, teams across the value chain must be involved at the time when their insights can be incorporated into a given output. For instance, the PD function should involve the sourcing function at a stage where pro CE decisions pertaining to the acquisition of materials and components can be incorporated in the final design of a given product. Thirdly, effective internal communication is essential. As revealed during the intervention cycles, ineffective internal communication was a considerable antecedent to knowledge waste and thus managers intending to embed CE practices in their operations should increase effectiveness of internal communication. For instance, through effective feedback, after-sales team can inform PD team about unnecessary product features that can be eliminated and subsequently reduce materials associated with the inclusion of such features. The latter notion shows that such efforts can enhance the possibilities for implementing the reduce principle. Fourthly, PD should embrace knowledge reuse and continuously update their knowledge base where necessary. This includes actions of unlearning, since knowledge reuse can indicate what type of knowledge can lead to vicious cycles of unsustainable praxis. Succinctly put, unlearning is required to develop transformative capacity as this can brake path dependency and rigidities, which can create room for CE principles to be adopted. Thus, to effectively implement CE, firms should build on the existing knowledge and make necessary adjustments based on both new knowledge and what needs to be unlearned. The insights should be shared with other teams across the value chain. By doing so, other teams can incorporate the insights and improve their processes. Fifthly, raising awareness of the negative impact of knowledge waste can help mitigate it. As revealed in this study, the action-learning interventions elicited awareness among the participants from MedLife regarding the negative impact of knowledge waste and as a result they were motivated to find potential solutions. Finally, firms must implement initiatives to retain knowledge pertaining to the implementation of CE. In addition to explicit knowledge that can be stored in the information system of the firm, it is essential to retain tacit knowledge. This includes identifying employees who have such knowledge and ensure that they are retained in the organisation. Efforts to keep such employees should go hand in hand with imparting the knowledge to other employees. The localisation, sharing and dissemination of both explicit and tacit knowledge are important in developing sustainable and circular products. This elucidates that lean thinking, and a knowledge-focused strategy is imperative during a transition towards CE.

6. Closing remarks

This study set out to investigate intra-organisational aspects and identified knowledge wastes as an inhibitor of the transition to CE from the perspective of lean thinking as an organisational learning system. To the best of our knowledge, this is among the first studies to explore the intersection of lean thinking and organisational knowledge, and their implications to a CE transition. Based on the cycles of interventions and the subsequent analysis, this study fully implemented the cyclical systems of ALR, namely systems alpha, beta and gamma. While system alpha focused on identifying and framing problem(s) in practice to better understand the firm's processes and challenges (through Gemba), system beta focused on linking and integrating information gained from each team (through interviews/EVSM) to have a holistic view and creating new meanings by linking with other views or thoughts gained through the intervention cycles. Finally, system gamma focused on installing new learning by transforming current understanding of the teams' knowledge obstacles through critical reflection on the action learning process. From a system gamma perspective, the analysis revealed that the Obeya enhanced organisational learning, as it encouraged cross-functional collaboration. It also aided the creation of a supportive learning environment. Overall, the teams realised the power of interaction between and across functions as a way of resolving the identified obstacles, and thus, promoting a holistic and systemic approach.

In CE, collaboration and integration of external stakeholders and knowledge acquisition are important if firms are to be able to fully abandon the take-make-dispose model of production and consumption. However, its implementation seems to be determined by internal mechanisms. Accordingly, manufacturing firms working to improve their products environmental and sustainability performance should take the time and effort needed to identify intra-organisational knowledge obstacles as solving them can act as a catalyst toward CE implementation. If not aimed at, intra-organisational mechanisms can risk resulting in a filter rejecting valuable and required knowledge, and thus become a significant inhibitor for sustainable and circular operations. A way for firms to bypass this is by implementing and conducting lean thinking through the means of Gemba, EVSM and Obeya, as it allows for a framing, analysis, and reflection upon whether the available knowledge, systems, methods, task and tools or communication structures are sufficient internally when transitioning to CE.

Hence, firms will have a hard time embarking on a CE transition using traditional thinking. Thus, in the context of a CE transition, lean thinking will provide firms with an alternative approach when applied as an organisational learning system, as such a system facilitates and eases the process of identifying organisational problems posed by internal factors – knowledge obstacles as wastes – as well as helping them to address these obstacles in collaborative action. Accordingly, once this alternative approach is accommodated, it is possible to create learning interventions focusing on breaking vicious circles in new products and thus accelerate the restructuring of the linear mode of production which increases the possibilities for a smooth CE transition.

By applying an intra-organisational perspective, this study shows that intra-organisational knowledge and learning is both pivotal and representative when transitioning to CE. This is reflected in our contributions. Firstly, by theorising on lean thinking as an organisational learning system and organisational knowledge, we accentuate how knowledge obstacles may have implications on a CE transition. Although these two aspects are useful ways to derive important insights when transitioning to CE, there are scarce studies that embrace them theoretically. Secondly, a novel framework including six measures that can be implemented to counteract knowledge obstacles have been developed. Hence, this framework assists firms to lay a foundation for a CE transition. Future research could explore cost implications associated with the implementation of these counteractive measures. Thirdly, by revealing the antecedents and implications of knowledge obstacles which inhibit the transition to CE, six actionable managerial recommendations that should be acted upon are offered. Lastly, we contribute from a methodological point of view by deploying ALR, which is scarce within operations and production research. As such, the theoretical and methodological approaches applied to contribute to the understanding of firms' CE transitions from an intra-organisational perspective have been strengthened and diversified further.

In terms of limitations, this study addressed intra-organisational aspects of knowledge obstacles within the context of a transition towards CE which is based on a single firm, limiting the degree to which the insights can be generalised. Future studies can draw samples from a focused industry sector or departments to compare potential intra-organisational obstacles with this study. Second, we did not conduct an in-depth analysis of specific CE strategies that manufacturers could implement, something that could have provided more specific CE recommendations with regards to how to handle the identified knowledge wastes. More work is needed to assist firms in avoiding potential knowledge obstacles. The development of tools that can help manufacturers to overcome internal challenges imposed by intra-organisational mechanisms hampering CE implementation during their transition journey deserves further attention. Third, as some of the interventions were conducted digitally, the full potential of ALR might not have been accomplished. More physical intervention might have made the result more robust, something future researchers should consider when choosing an ALR approach.

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Data availability statement

The data that support the findings of this study are available from the corresponding author, Bella B. Nujen, upon reasonable request.

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References

Åhlström, P., P. Danese, P. Hines, T. H. Netland, D. Powell, R. Shah, M. Thürer, and D. H. van Dun. 2021. "Is Lean a Theory? Viewpoints and Outlook." *International Journal of Operations & Production Management* 41 (12): 1852–1878. doi:10.1108/IJOPM-06-2021-0408.

Akgün, A. E., J. C. Byrne, G. S. Lynn, and H. Keskin. 2007. "Organizational Unlearning as Changes in Beliefs and Routines in Organizations." *Journal of Organizational Change Management* 20 (6): 794–812. doi:10.1108/09534810710831028

Argote, L., and J. M. Guo. 2016. "Routines and Transactive Memory Systems: Creating, Coordinating, Retaining, and Transferring Knowledge in Organizations." *Research in Organizational Behavior* 36: 65–84. doi:10.1016/j.riob.2016.10.002.

Argyris, C., and D. A. Schön. 1978. *A Theory of Action Perspective*. Reading, MA: Addison-Wesley Publishing Company.

Ballé, M., J. Chaize, and D. Jones. 2019. "Lean as a Learning System: What Do Organizations Need to Do to Get the Transformational Benefits from Toyota's Method?" *Development and Learning in Organizations: An International Journal* 33 (3): 1–4. doi:10.1108/DLO-11-2018-0147.

Batista, L., M. Bourlakis, Y. Liu, P. Smart, and A. Sohal. 2018. "Supply Chain Operations for a Circular Economy." *Production Planning & Control* 29 (6): 419–424. doi:10.1080/09537287.2018.1449267.

Bertassini, A. C., A. R. Ometto, S. Severengiz, and M. C. Gerolamo. 2021. "Circular Economy and Sustainability: The Role of Organizational Behaviour in the Transition Journey." *Business Strategy and the Environment* 30 (7): 3160–3193. doi:10.1002/bse.2796.

Boks, C., and A. Stevels. 2007. "Essential Perspectives for Design for Environment. Experiences from the Electronics Industry." *International Journal of Production Research* 45 (18-19): 4021–4039. doi:10.1080/00207540701439909.

Carvalho, Andréa N., Luiz Felipe Scavarda, and Leonardo J. Lustosa. 2014. "Implementing Finite Capacity Production Scheduling: Lessons from a Practical Case." *International Journal of Production Research* 52 (4): 1215–1230. doi:10.1080/00207543.2013.848484.

Cherrafi, A., S. Elfezazi, B. Hurley, J. A. Garza-Reyes, V. Kumar, A. Anosike, and L. Batista. 2019. "Green and Lean: A Gemba–Kaizen Model for Sustainability Enhancement." *Production Planning & Control* 30 (5-6): 385–399. doi:10.1080/09537287.2018.1501808.

Chowdhury, S., P. K. Dey, O. Rodríguez-Espíndola, G. Parkes, N. T. A. Tuyet, D. D. Long, and T. P. Ha. 2022. "Impact of Organisational Factors on the Circular Economy Practices and Sustainable Performance of Small and Medium-Sized Enterprises in Vietnam." *Journal of Business Research* 147: 362–378. doi:10.1016/j.jbusres.2022.03.077.

Chuang, Shan-Ping, and Chang-Lin Yang. 2014. "Key Success Factors When Implementing a Green-Manufacturing System." *Production Planning & Control* 25 (11): 923–937. doi:10.1080/09537287.2013.780314.

Ciano, M. P., R. Pozzi, T. Rossi, and F. Strozzi. 2019. "How IJPR has Addressed 'Lean': A Literature Review Using Bibliometric Tools." *International Journal of Production Research* 57 (15-16): 5284–5317. doi:10.1080/00207543.2019.1566667.

Cohen, W. M., and D. A. Levinthal. 1990. "Absorptive Capacity: A new Perspective on Learning and Innovation." *Administrative Science Quarterly*, 128–152. doi:10.2307/2393553.

Coreynen, Wim, Paul Matthyssens, Roel De Rijck, and Ivo Dewit. 2018. "Internal Levers for Servitization: How Product-Oriented Manufacturers Can Upscale Product-Service Systems." *International Journal of Production Research* 56 (6): 2184–2198. doi:10.1080/00207543.2017.1343504.

Coughlan, P., and D. Coghlan. 2002. "Action Research for Operations Management." *International Journal of Operations & Production Management* 22 (2): 220–240. doi:10.1108/01443570210417515.

Coughlan, Paul, and David Coghlan. 2016. "Action Research." In *Research Methods for Operations Management*, edited by Christer Karlsson, 2nd ed., 352. London: Routledge.

Fehrer, J. A., and H. Wieland. 2021. "A Systemic Logic for Circular Business Models." *Journal of Business Research* 125: 609–620. doi:10.1016/j.jbusres.2020.02.010.

Fiol, C. M., and M. A. Lyles. 1985. "Organizational Learning." *Academy of Management Review* 10 (4): 803–813. doi:10.2307/258048.

Govindan, Kannan, and Mia Hasanagic. 2018. "A Systematic Review on Drivers, Barriers, and Practices Towards Circular Economy: A Supply Chain Perspective." *International Journal of Production Research* 56 (1–2): 278–311. doi:10.1080/00207543.2017.1402141.

Green, K. W., P. J. Zelbst, J. Meacham, and V. Bhadauria. 2012. "Green Supply Chain Management Practices: Impact on Performance." *Supply Chain Management: An International Journal* 17 (3): 290–305. doi:10.1108/13598541211227126.

Imai, K., I. Nonaka, and H. Takeuchi. 1984. *Managing the new Product Development Process: How Japanese Companies Learn and Unlearn*. Boston, MA: Division of Research, Harvard Business School.

Inman, R. A., and K. W. Green. 2018. "Lean and Green Combine to Impact Environmental and Operational Performance."

International Journal of Production Research 56 (14): 4802–4818. doi:10.1080/00207543.2018.1447705.

Kim, D. H. 1993. "A Framework and Methodology for Linking Individual and Organizational Learning: Applications in TQM and Product Development." Doctoral diss., Massachusetts Institute of Technology.

Kirchherr, J., L. Piscicelli, R. Bour, E. Kostense-Smit, J. Muller, A. Huibrechtse-Truijens, and M. Hekkert. 2018. "Barriers to the Circular Economy: Evidence from the European Union (EU)." *Ecological Economics* 150: 264–272. doi:10.1016/j.ecolecon.2018.04.028.

Kumar, V., D. Holt, A. Ghobadian, and J. A. Garza-Reyes. 2015. "Developing Green Supply Chain Management Taxonomy Based Decision Support Systems." *International Journal of Production Research* 53 (21): 6372–6389. doi:10.1080/00207543.2014.917215

Kurdve, M., and M. Bellgran. 2021. "Green Lean Operationalisation of the Circular Economy Concept on Production Shop Floor Level." *Journal of Cleaner Production* 278: 123223. doi:10.1016/j.jclepro.2020.123223.

Kusiak, A. 2018. "Smart Manufacturing." *International Journal of Production Research* 56 (1-2): 508–517. doi:10.1080/00207543.2017.1351644.

Kvadsheim, N. P., B. B. Nujen, D. Powell, and E. Reke. 2021. "Realizing Value Opportunities for a Circular Economy: Integrating Extended Value Stream Mapping and Value Uncaptured Framework." In *IFIP International Conference on Advances in Production Management Systems*, 739–747. Cham: Springer.

León, Hilda C. Martínez, and Jennifer A. Farris. 2011. "Lean Product Development Research: Current State and Future Directions." *Engineering Management Journal* 23 (1): 29–51. doi:10.1080/10429247.2011.11431885.

Levering, Roland, and Bart Vos. 2019. "Organizational Drivers and Barriers to Circular Supply Chain Operations: New Research Perspectives." *In: de Boer, L., Houman Andersen, P. (eds) Operations Management and Sustainability. Palgrave Macmillan, Cham* 43–66. doi:10.1007/978-3-319-93212-5_4.

Liker, Jeffrey K., and James M. Morgan. 2006. "The Toyota Way in Services: The Case of Lean Product Development." *Academy of Management Perspectives* 20 (2): 5–20. doi:10.5465/amp.2006.20591002.

Loon, Patricia van, and Luk N. Van Wassenhove. 2020. "Transition to the Circular Economy: The Story of Four Case Companies." *International Journal of Production Research* 58 (11): 3415–3422. doi:10.1080/00207543.2020.1748907.

López-Torres, G. C., J. A. Garza-Reyes, G. Maldonado-Guzmán, V. Kumar, L. Rocha-Lona, and A. Cherrafi. 2019. "Knowledge Management for Sustainability in Operations." *Production Planning & Control* 30 (10-12): 813–826. doi:10.1080/09537287.2019.1582091.

Lyles, Marjorie A. 2014. "Organizational Learning, Knowledge Creation, Problem Formulation and Innovation in Messy Problems." *European Management Journal* 32 (1): 132–136. doi:10.1016/j.emj.2013.05.003.

March, J. G., and J. P. Olsen. 1975. "The Uncertainty of the Past: Organizational Learning Under Ambiguity." *European Journal of Political Research* 3 (2): 147–171. doi:10.1111/j.1475-6765.1975.tb00521.x.

Masi, D., V. Kumar, J. A. Garza-Reyes, and J. Godsell. 2018. "Towards a More Circular Economy: Exploring the Awareness, Practices, and Barriers from a Focal Firm Perspective." *Production Planning & Control* 29 (6): 539–550. doi:10.1080/09537287.2018.1449246.

Mendoza, Joan Manuel F., Maria Sharmina, Alejandro Gallego-Schmid, Graeme Heyes, and Adisa Azapagic. 2017. "Integrating Backcasting and Eco-Design for the Circular Economy: The BECE Framework." *Journal of Industrial Ecology* 21 (3): 526–544. doi:10.1111/jiec.12590.

Netland, T. H., and D. J. Powell. 2017. *The Routledge Companion to Lean Management*. New York: Routledge.

Nonaka, I., and H. Takeuchi. 1995. *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*. New York Oxford: Oxford University Press.

Nujen, B. B., N. P. Kvadsheim, D. Mwesiumo, E. Reke, and D. Powell. 2021. "Transition Towards Circular Economy: An Intraorganizational Perspective Identifying Knowledge Wastes." In *IFIP International Conference on Advances in Production Management Systems*, pp. 758–766. Cham: Springer.

Ohno, T. 1988. *Toyota Production System: Beyond Large-Scale Production*. New York: CRC Press.

Polanyi, M. 1962. *Personal Knowledge Towards a Post-Critical Philosophy*. London: Routledge & Kegan Paul.

Powell, D. J., and C. P. F. Bartolome. 2020. "Enterprise-wide Value Stream Mapping: From Dysfunctional Organization to Cross-Functional, Collaborative Learning and Improvement." IEEE International Conference on Industrial Engineering and Engineering Management, 2020 December, 551–555.

Powell, D., and P. Coughlan. 2020. "Rethinking Lean Supplier Development as a Learning System." *International Journal of Operations and Production Management* 40 (7–8): 921–943. doi:10.1108/IJOPM-06-2019-0486.

Powell, D. J., D. Romero, and P. Gaiardelli. 2022. "New and Renewed Manufacturing Paradigms for Sustainable Production." *Sustainability* 14 (3): 1279. doi:10.3390/su14031279.

Prasad, Sameer, R. P. Sundarraj, Jasmine Tata, and Nezih Altay. 2018. "Action-Research-Based Optimisation Model for Health Care Behaviour Change in Rural India." *International Journal of Production Research* 56 (21): 6774–6792. doi:10.1080/00207543.2017.1414329.

Prieto-Sandoval, Vanessa, Carmen Jaca, Javier Santos, Rupert J. Baumgartner, and Marta Ormazabal. 2019. "Key Strategies, Resources, and Capabilities for Implementing Circular Economy in Industrial Small and Medium Enterprises." *Corporate Social Responsibility and Environmental Management* 26 (6): 1473–1484. doi:10.1002/csr.1761.

Rossi, M., M. Taisch, and S. Terzi. 2012. "Lean Product Development: A Five-Steps Methodology for Continuous Improvement." 2012 18th international ICE conference on engineering, technology and innovation, 1–10. IEEE.

Saabye, H., and D. J. Powell. 2022. "Fostering Insights and Improvements from IIoT Systems at the Shop Floor: A Case of Industry 4.0 and Lean Complementarity Enabled by Action Learning." *International Journal of Lean Six Sigma*. doi:10.1108/IJLSS-01-2022-0017.

Saldaña, J. 2021. *The Coding Manual for Qualitative Researchers*, 1–440.

Santibanez Gonzalez, E. D., L. Koh, and J. Leung. 2019. "Towards a Circular Economy Production System: Trends and Challenges for Operations Management." *International*

Journal of Production Research 57 (23): 7209–7218. doi:10.1080/00207543.2019.1656844.

Sarja, M., T. Onkila, and M. Mäkelä. 2021. "A systematic literature review of the transition to the circular economy in business organizations: Obstacles, catalysts and ambivalences." *Journal of Cleaner Production* 286, Article 125492. doi:10.1016/j.jclepro.2020.125492

Sarkis, J., and Q. Zhu. 2018. "Environmental Sustainability and Production: Taking the Road Less Travelled." *International Journal of Production Research* 56 (1-2): 743–759. doi:10.1080/00207543.2017.1365182.

Scheel, Carlos. 2016. "Beyond Sustainability. Transforming Industrial Zero-Valued Residues Into Increasing Economic Returns." *Journal of Cleaner Production* 131: 376–386. doi:10.1016/j.jclepro.2016.05.018.

Schiuma, Giovanni, Daniela Carlucci, and Antonio Lerro. 2012. "Managing Knowledge Processes for Value Creation." *Vine* 42 (1): 4–14. doi:10.1108/03055721211207815.

Scipioni, S., M. Russ, and F. Niccolini. 2021. "From Barriers to Enablers: The Role of Organizational Learning in Transitioning SMEs Into the Circular Economy." *Sustainability* 13: 1021. doi:10.3390/su13031021.

Shankar, R., N. Mittal, S. Rabinowitz, A. Baveja, and S. Acharia. 2013. "A Collaborative Framework to Minimise Knowledge Loss in new Product Development." *International Journal of Production Research* 51 (7): 2049–2059. doi:10.1080/00207543.2012.701779.

Stenholm, D. 2018. "Reuse of Engineering Knowledge: Perspectives on Experience-Based Codified Knowledge in Incremental Product Development. Chalmers Tekniska Hogskola (Sweden)." PhD Diss.

Su, B., A. Heshmati, Y. Geng, and X. Yu. 2013. "A Review of the Circular Economy in China: Moving from Rhetoric to Implementation." *Journal of Cleaner Production* 42: 215–227. doi:10.1016/j.jclepro.2012.11.020.

Tonelli, M., and N. F. Cristoni. 2019. *Strategic Management and the Circular Economy*. New York: Routledge.

Urwin, E. N., and R. I. M. Young. 2014. "The Reuse of Machining Knowledge to Improve Designer Awareness Through the Configuration of Knowledge Libraries in PLM." *International Journal of Production Research* 52 (2): 595–615. doi:10.1080/00207543.2013.839894.

Womack, J. P. 2006. "A Lesson to be Learned." *Manufacturing Engineer* 85 (2): 4–5. doi:10.1049/me:20060211.

Womack, J. P. 2011. *Gemba Walks. Lean Enterprise Institute*. Cambridge, MA: Cambridge.

Womack, J. P., and D. T. Jones. 2003. "Banish Waste and Create Wealth in Your Corporation." *Recuperado de*. http://www.kvimis.co.in/sites/kvimis.co.in/files/ebook_attachments/James.

Wu, Z. Y., X. G. Ming, L. N. He, M. Li, and X. Z. Li. 2014. "Knowledge Integration and Sharing for Complex Product Development." *International Journal of Production Research* 52 (21): 6296–6313. doi:10.1080/00207543.2014.923121.

Yuan, X., X. Wang, B. Sarkar, and Y. S. Ok. 2021. "The COVID-19 Pandemic Necessitates a Shift to a Plastic Circular Economy." *Nature Reviews Earth & Environment* 2 (10): 659–660. doi:10.1038/s43017-021-00223-2.

Zhang, C., G. Zhou, Q. Lu, and F. Chang. 2017. "Graph-based Knowledge Reuse for Supporting Knowledge-Driven Decision-Making in new Product Development." *International Journal of Production Research* 55 (23): 7187–7203. doi:10.1080/00207543.2017.1351643.

Zucchella, Antonella, and Pietro Previtali. 2018. "Circular Business Models for Sustainable Development: A 'Waste Is Food' Restorative Ecosystem." *Business Strategy and the Environment* 28 (2): 274–285. doi:10.1002/bse.2216.

Zwiers, Jakob, Melanie Jaeger-Erben, and Florian Hofmann. 2020. "Circular Literacy: A Knowledge-Based Approach to the Circular Economy." *Culture and Organization* 26 (2): 121–141. doi:10.1080/14759551.2019.1709065.