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Implementing circular economy principles: evidence from multiple cases

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ABSTRACT

With an orientation on sustainability and economic growth, the concept of circular economy (CE) emerges to tackle socio-environmental challenges. Current literature has provided important frameworks from CE operations and business model perspectives. However, in practice, companies are still facing the challenges of insufficient knowledge, lack of standard procedure, and resource constraint. Thus, this paper aims to answer the research questions: *how can companies effectively implement CE principles in their operations? And how can such implementation result in value creation such as new products or service solutions?* Through conducting seven case studies mainly in Wales, UK, our paper identifies the key activities of CE implementation projects, proposes a holistic process model, and further addresses three different CE scenarios. Our study contributes to the understanding of CE process and circular business models with empirical evidence. Findings can provide future research direction as well as implication for business and policy makers.

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Circular economy; sustainability; waste management; case studies; SDG 17: Partnerships for the goals

1. Introduction

The 21st century has experienced multiple economic, environmental, and social crises, evidencing that organisations operate in a volatile, uncertain, complex, ambiguous (VUCA) world (Persis et al. 2021). Meanwhile, the United Nation (UN) Intergovernmental Panel on Climate Change (IPCC) Climate Change Report (Shukla et al. 2019) warns of future existential crises if public and private sector actors do not make radical operational and strategic changes. With an orientation on sustainability and economic growth, the circular economy (CE) concept emerges as a means to tackle socio-environmental challenges (Ghisellini, Cialani, and Ulgiati 2016). It is regarded as a restorative and regenerative process by design, aiming to keep products, components, and materials at their highest utility and value, which is hugely different to the conventional linear – take, make, waste – economy (Ellen MacArthur Foundation 2015). The CE necessitates a paradigm shift, requiring changes in the way that society legislates, produces, and consumer goods and services (Walpole et al. 2022; Prieto-Sandoval, Jaca, and Ormazabal 2018). Among the various definitions of CE, it is interpreted by the Ellen MacArthur Foundation (2015) as

> A CE aims to redefine growth, focusing on positive society-wide benefits. It entails gradually decoupling economic activity from the consumption of finite resources and designing waste out of the system. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural, and social capital.

Accordingly, there are three core principles of CE: 1) Design waste and pollution out of systems; 2) Keep products and materials in use; and 3) Regenerate natural systems (Ellen MacArthur Foundation 2015).

Theoretically, CE is widely explored in the operations and supply chain literature mainly as a series of improvement activities such as reduce, reuse, repairing, refurbishing, remanufacturing, repurpose, recycling etc. (Echefaj et al. 2024; Batista et al. 2018; Ellen MacArthur Foundation 2015) as well as close-loop design to minimise waste generation and reducing cost (Bag et al. 2022; Ortner, Tay, and Wortmann 2022; Yang et al. 2018). CE also represents a transformation where product, materials and resources are maintained at the highest value (Zils, Howard, and Hopkinson 2023). Thus, from a value creation perspective, circular business models (CBM) are proposed including the ReSOLVE framework (Ellen MacArthur Foundation 2015) and Product-service Systems (Ellen MacArthur Foundation 2015; Tukker 2015). Increasingly, the concept has been advanced alongside the emergence of Industry 4.0 technologies. Among them, big data analytics, artificial intelligence (AI), blockchain and Internet of things (IoT) demonstrate potentials to facilitate decision making and solve the complexity within business operations and stakeholder engagement, and thus enable a sustainable CE (Echefaj et al. 2024; Kamble and Gunasekaran 2023; Sahoo, Upadhyay, and Kumar 2023; Schöggl et al. 2023; Upadhyay et al. 2023; Kouhizadeh, Zhu, and Sarkis 2020; Gupta et al. 2019; De Angelis, Howard, and Miemczyk 2018). In a wider context, CE practice relies on information sharing, learning and collaboration (Jraisat et al. 2023; Liu et al. 2023; Zils, Howard, and Hopkinson 2023; Walpole et al.

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2022) as well as transformational policies to address sustainability challenges (Clifton and Walpole 2023; Hayter and Link 2020; Fagerberg 2018; Raven and Walrave 2020; Schot and Steinmueller 2018). Thus, to fully capture the elements and process of CE practice, there is a need to integrate various strands of literature and elaborate their connections.

Nevertheless, when it comes to the implementation of CE, there is insufficient knowledge and practical approach (Mangla et al. 2018), and business is uncertain on how the frameworks and solutions can affect their performance (Eisenreich et al. 2022; Mangla et al. 2018). Among the available CBMs, organisations are not sure which are most practical to their specific sector and business scenario (Zils, Howard, and Hopkinson 2023; Rosa, Sassanelli, and Terzi 2019). Thus, an important motivation for the research here is to scope out means by which initiatives to address a broader societal issue – the need to urgent climate action – can be translated into practical examples and mainstreamed into business practices in ways which can increase adoption at the level of the individual actor or firm, and via which a direction of travel towards these outcomes can be facilitated and tracked.

CE transformation relies on the understanding of various factors (Echefaj et al. 2024; De Angelis, Howard, and Miemczyk 2018) and requires capabilities to cope with dynamic changes, which many organisations do not have (Liu et al. 2021). This requires a holistic view, engaging with supply chain partners and diverse stakeholders, which results in more complexity (Echefaj et al. 2024; Burke, Zhang, and Wang 2023; Eisenreich et al. 2022). Whilst internal barriers include financial, organisational, knowledge and technology barriers, companies also face challenges from supply chain, market and institutional factors in the CE practice (Shao et al. 2023). Thus, to solve emerging challenges, a comprehensive understanding of the organisation-level CE implementation process concerning various industry scenarios and interacting factors is needed. This should also address the urgent need to develop a CE guidance to inform managerial practices focusing on value proposition, collaboration and customer engagement (Zils, Howard, and Hopkinson 2023; Rosa, Sassanelli, and Terzi 2019).

In this study, we ask the following two research questions:

1. How can companies effectively implement CE principles in their operations?
2. How can such implementation result in value creation such as new product or service solutions?

In response to these questions, there are three specific research objectives. First, the paper will investigate the process and stages for companies to implement CE principles in the form of designing waste out of the system, keeping materials in use, and regenerating natural systems (Ellen MacArthur Foundation 2015). Second, the study will analyse the activities across the organisation and its supply chain levels. Third, based on the empirical evidence, main patterns and scenarios of CE implementation will be identified. Findings contribute to understanding of CE by providing a holistic view linking the perspectives of CE operations process, business model, and other interacting factors together. Practically, the paper serves as a guideline for organisations to follow, connecting their motivations, capabilities and stages of CE practice development.

The remainder of the paper is structured as follows. Section 2 reviews current literature on CE and identifies the research gaps. Section 3 describes the research methodology. This is followed by the case analysis in Section 4. Section 5 details findings from the data. Section 6 is further discussion based on the new process model, which is followed by the concluding remarks.

2. Literature review

2.1. Circular economy operations

In the supply chain and operations management literature, CE implementation and process have been investigated at the organisational, supply chain, and industry network levels (Murray, Skene, and Haynes 2017). At the firm level, restorative processes take place in the forms of environmentally friendly design initiatives or product recycling via the reuse of materials through a transformation with new items and materials (Illankoon and Vithanage 2023; Meath et al. 2022; Batista et al. 2018).

To extend the operations of CE towards the inter-firm level, a circular supply chain is a restorative production system aiming to optimise resource utilisation and minimising waste throughout the product life cycle through reuse, remanufacturing, and recycling (Genovese et al. 2017). Such practice concerns various stages of procurement, production, and logistics by designing a closed-loop supply chain (Bag et al. 2022), while reducing cost through resource optimisation and customer engagement (Ortner, Tay, and Wortmann 2022). Accordingly, the features of circular supply chains are summarised by Yang et al. (2018) as: 1) The inner cycles are prioritised over outer ones, e.g. prioritising reuse and recover over recycle; 2) Slowing the cycles by using resources for as long as possible; 3) Reducing waste at all stages; and 4) Reduce, reuse, recycle and recover resources. In addition, a circular supply chain also concerns the flow of waste and by-products, creating cascading use of the resources (Loomba and Nakashima 2012, Ellen MacArthur Foundation 2015). Nevertheless, barriers remain in terms of inadequacy in knowledge and awareness of CE, ineffective planning of CE implementation, lack of regulations, lack of CE adoption approach, lack of technology transfers, and lack of collaboration (Mangla et al. 2018).

Initially, concentrating just on waste management, the application of 3 R principles – reduce, reuse, and recycle – is considered (Ellen MacArthur Foundation 2015). CE strategies then expanded to cover the entire economy (Kirchherr et al. 2023) and the implementation of the additional three principles on top of that was highlighted, which brings them to 6 R and includes reuse, reduce, recycle, redesign, recover, and remanufacture (Illankoon and Vithanage 2023). Based on literature review, a most recently developed conceptual

framework further includes refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, and recovery, thus expanding the CE practice to 10 R (Echefaj et al. 2024).

Moving beyond a supply chain is the broader industry level or meso-level which includes to the development and maintenance of eco-industrial parks involving organisations from various sectors (Kirchherr et al. 2023). The term industrial symbiosis or partnerships are used to eco-industrial aiming for a CE, where resources can be shared and waste and by-product can be utilised among the organisations (Meath et al. 2022). Accordingly, traditionally separated industries can seek collective approach exchange materials, energy, water, and/or by-products, whereby achieving competitive advantage and sustainability (Shi et al. 2023; Chertow 2000).

When organisations converge at the industry level since the fundamental aim is to turn one industry's by-product into a resource for another (D'Amato et al. 2017) there is a significant focus on cross-industry interactions which has been developed as part of the CE model from the early 2000s using strategies like industrial and urban symbiosis (Kirchherr et al. 2023). This provides a chance for industries to gain from supply chain circularisation (Meath et al. 2022) and circular business ecosystems (Kanda, Geissdoerfer, and Hjelm 2021). However, implementing such sustainable industrial networks – which deal with business choices among several supply chain participants in various industries – is not a simple endeavour (Kirchherr et al. 2023).

2.2. Circular business models

From a value creation perspective, the transition to a CE requires relevant changes throughout the value chain. CBMs are focused on retaining the economic value embedded in products, and thus require a set of return flows from end users to producers, sometimes via intermediaries (Linder and Williander 2017). Initially, the Ellen Macarthur Foundation (2014) highlighted the important value drivers of CE as: 1) The power of the inner circle, meaning maintaining materials and resources at their highest value; 2) The power of circling longer, referring to the extension of product use; 3) The power of cascaded use, which seeks for the retain, reaction and capture of materials across the supply chains; and 4) The power of pure circles, involving systematic product design decisions on future life cycles.

Later, Product-Service System (PSS)-based CBM was introduced as a simple strategy towards CE (Rosa, Sassanelli, and Terzi 2019; Ellen MacArthur Foundation 2015; Tukker 2015). Since manufacturers provide services apart from products, PSS can be classified as product-oriented, use-oriented and result-oriented (Yang et al. 2018; Tukker 2015). Increasingly, manufacturing firms are adopting CBMs from servitisation, where customers purchase the service outcome rather than the product, offering new opportunities for value creation and recovery (Kreye 2023; Zils, Howard, and Hopkinson 2023; De Angelis, Howard, and Miemczyk 2018). Such movement also brings more complexity to the value chain and need further investigation supply chain relationships, customer collaboration (Kreye 2023) and digitally enabled systems (De Angelis, Howard, and Miemczyk 2018).

Meanwhile, the ReSOLVE framework defined by the Ellen MacArthur Foundation (2015) is a well-accepted CBM with a set of principles. Focused on supporting companies and governments during the definition of CE policies, the framework identifies six different ways to be circular. Specifically, Regenerate - or actions focused on: 1) shifting on renewable energy and secondary materials, 2) reclaiming/retaining/restoring health of the ecosystem, or 3) returning recovered biological resources to the biosphere; Share - or actions focused on: 1) sharing assets, 2) reuse/second hand or 3) prolonging product lifetime through maintenance principles; Optimise - or actions focused on: 1) increasing performance/efficiency of products, 2) removing waste in production and supply chains or 3) leveraging big data, automation, remote sensing and steering; Loop - or actions focused on: 1) remanufacturing of products/components, 2) recycling of materials, 3) anaerobic digestion of wastes or 4) extraction of biochemicals from organic wastes; Virtualise - or actions focused on direct/indirect dematerialisation of products; Exchange - or actions focused on: 1) replacing old materials with advanced non-renewable ones, 2) applying new technologies in traditional processes or 3) transforming products/services.

Whilst the above CBMs provide comprehensive notions of value creation deriving from CE principles and activities (De Angelis, Howard, and Miemczyk 2018), most recently, CBMs are specifically explored in the context of start-ups, and accordingly six typologies are identified as are design-based (using core technology to increase usage efficiency), waste-based (recycling and recovering materials to realise industrial symbiosis), platform-based (facilitating sharing of products and materials), service-based (similar to PPS), and nature-based (using renewable natural resources to deliver services), and other archetypes (Henry et al. 2020). Meanwhile, key building blocks relating to successful CE value creation are identified as designing products and services, connecting to business model to incentivise future high value (e.g. moving towards service), and reverse logistics (Vlajic, Mijailovic, and Bogdanova 2018; Mishra, Hopkinson, and Tidridge 2018). Further, based on a longitudinal approach, Zils, Howard, and Hopkinson (2023) identify three stages to build a pathway to CE, which are identification of opportunities, initiation of pilot projects and implementation at scale.

Following an extensive review of the CBM literature, Rosa, Sassanelli, and Terzi (2019) identify four overarching opportunities for new research relating to CBM: 1) Which CBMs are most appropriate/practical in which sectors? 2) Developing a taxonomy of CBMs in order to inform managerial practices focusing on value proposition, customer involvement and supply chain management; 3) How better to pursue the as yet under-represented 'Exchange' archetype (integrating CE and Industry 4.0); and 4) Developing an assessment tool for practitioners, quantifying benefits deriving from CE. This view is further advanced in recent studies as while value creation during CBM is highlighted through product design and reverse flow (Vlajic, Mijailovic, and Bogdanova 2018; Mishra,

Hopkinson, and Tidridge 2018), there is still a lack of empirical foundation or evaluation of the existing CBMs (Zils, Howard, and Hopkinson 2023).

2.3. Circular economy in a wider context

CE practice is indeed situated in a broader context, interacting with multiple stakeholders alongside policy and technological factors. CE related policies and strategies promote the potential to produce positive social change (Centobelli et al. 2020) and contribute to the public good (Mazzucato 2013). However, challenges remain due to the lack of precise CE standards and regulations, whilst the simultaneous interaction of economic, environmental, and social aspects is required (Meath et al. 2022). Lack of CE concept awareness in business (Masi et al. 2018) is also a main barrier to CE adoption, in addition to a slow consumer acceptance rate (Kirchherr et al. 2023) inadequate government support policies, insufficient awareness and education, and insufficient legislation (Liu et al. 2021).

To address the challenges, there is recently a strand of studies exploring the role of Industry 4.0 technologies to enable CE implementation in the manufacturing sector (Kamble and Gunasekaran 2023; Kumar et al. 2023; Upadhyay et al. 2023; Gupta et al. 2019; De Angelis, Howard, and Miemczyk 2018), the two of which are complementary (Echefaj et al. 2024; Kumar et al. 2023). Based on multiple case studies, it is found that big data analytics can facilitate CE practices and tackle the complexities of stakeholder engagement (Gupta et al. 2019). This is consistent with a modelling-based study on manufacturing companies in Europe, indicating an indirect positive effect of big data analytics on sustainable performance (Riggs et al. 2023). Among the Industrial 4.0 technologies, it is suggested the IoT being the most effectively digital technologies to facilitate CE development, followed by big data analytics, artificial intelligence and blockchain (Schöggl et al. 2023). Based on multiple case studies linking blockchain application to ReSOLVE, results show the positive support provided by blockchain in terms of transparency-traceability, reliability-security, smart execution and financial incentivisation (Kouhizadeh, Zhu, and Sarkis 2020). Nevertheless, the study is based on secondary data (Kouhizadeh, Zhu, and Sarkis 2020). Through the lens of stakeholder theory, an empirical analysis shows a partial mediation effect of low-carbon practice on companies' sustainable performance and their digital supply chains (Sharma et al. 2022). From a resource-based view, a quantitative analysis indicates that the integration of Industrial 4.0 and CE can result in a synergistic effect from economic and environmental perspectives (De Sousa Jabbour et al. 2022). This is further explained in a modelling-based study incorporating dynamic capability view theory, showing CE practices serve as a partial mediator for the influence of big data analytics capabilities on environmental performance (Sahoo, Upadhyay, and Kumar 2023).

Furthermore, the transition towards a CE and sustainability relies on collaboration. This is seen in early studies on information sharing and buyer-seller relationships in the supply chain dyadic collaboration (Aggarwal and Srivastava 2016; Bailey and Francis 2008). Collaboration mechanisms are further explored in terms of triads in sustainable supply chains, involving diverse actors (Jraisat et al. 2023). To practise CE beyond supply chain interactions, collaboration is seen in the forms of community and business ecosystems (Kanda, Geissdoerfer, and Hjelm 2021). For instance, through participating in public-funded communities of practice, practitioners can co-create CE related knowledge, which results in changes in their organisational practice (Liu et al. 2023; Walpole et al. 2022). The circular business ecosystem concept, on the other hand, emphasises the unitisation of complementary resources during remanufacturing and reuse (Kanda, Geissdoerfer, and Hjelm 2021).

2.4. Identification of the research gaps

To solve the research problem and capture the process of CE implementation, there are various theoretical lenses which can be summarised from the literature review. Nevertheless, there are some research gaps. First, operations and supply chain management research has viewed CE as continuous improvement. Activities such as 6 R - reuse, reduce, recycle, redesign, recover, and remanufacture (Illankoon and Vithanage 2023; Genovese et al. 2017) and its extended version 10 R (Echefaj et al. 2024) provide general guidance to be adopted at firm level and supply chain level (Echefaj et al. 2024; Yang et al. 2018). However, the interfaces among firm and inter-firm CE implementations need a detailed practice-oriented view of stakeholders and changes for circularity (Eisenreich et al. 2022). Whilst the focus in literature is around waste reduction and resource e.g. material efficiency (Ellen MacArthur Foundation 2015; Loomba and Nakashima 2012), it is unknown how these continuous improvement activities can be extended to cross-industry networks or ecosystems (Kirchherr et al. 2023; Kanda, Geissdoerfer, and Hjelm 2021).

Second, the CE concept is studied in the strategic management research community with the theoretical underpinning business models (Zils, Howard, and Hopkinson 2023; Rosa, Sassanelli, and Terzi 2019; De Angelis, Howard, and Miemczyk 2018; Tukker 2015) and entrepreneurship (Henry et al. 2020). The focus of this approach is value creation in the form of new products, new service solutions, and accordingly new market exploration (Zils, Howard, and Hopkinson 2023; Linder and Williander 2017). Although a range of best practices may be provided for companies from specific industries addressing CE, practical guidelines towards a real adoption of CE in either products or services are often still lacking (Zils, Howard, and Hopkinson 2023; Rosa, Sassanelli, and Terzi 2019; De Angelis, Howard, and Miemczyk 2018). The overall understanding of CBMs is not sufficient (Yang at el. 2018), and it is unknown in practice which CBMs are most appropriate/practical in which sectors (Zils, Howard, and Hopkinson 2023). Indeed, the complex industry setting needs to be further explored, and the adoption and extension of CBMs needs a comprehensive understanding and theory building (Dora, Bhatia, and Gallear 2016). In particular,

empirical research is needed to further validate the frameworks and models, concerning the inter-relationships among various elements of CE (Dewagoda, Ng, and Chen 2022).

Third, other relevant theoretical approaches include stakeholder theory provide important insights on collaboration, policy support and digital technology implementation (Kamble and Gunasekaran 2023; Kumar et al. 2023; Liu et al. 2023; Sahoo, Upadhyay, and Kumar 2023; Upadhyay et al. 2023; Walpole et al. 2022; De Angelis, Howard, and Miemczyk 2018), yet they are from a specific perspective. Indeed, a holistic approach is needed to identify key activities, relations and processes of CE implementation and link them with innovative actors as well as macro environmental factors (Echefaj et al. 2024; Kamble and Gunasekaran 2023; Hopkinson, De Anelis, and Zils 2020), which can address different motivations and industry scenarios.

Based on the literature review, an initial conceptual framework is proposed as Figure 1 which highlights the process of CE implementation and connects various views of CE and addresses the research gaps. Our research questions are: *How can companies effectively implement CE principles in their operations? How can such implementation result in value creation such as new product or service solutions?*

3. Methodology

3.1. Research setting

Our research explores the implementation of CE principles in organisations across manufacturing and service sectors in Wales, UK. In this region, there is a transformative policy to highlight sustainability transition (Schot and Steinmueller 2018), as the Welsh Government's present ambition to be world leading in reducing, reusing, and repairing (Liu et al. 2023) has provided significant support for the CE (Welsh Government 2021). In 2021, the Beyond Recycling strategy document stated the ambition to '*use the powers and levers that we have … to accelerate our transition to a circular, low carbon economy*' (Welsh Government 2021, 4). Moreover, the Wellbeing of Future Generations Act places a statutory obligation on public services to make decisions based on the social, economic, cultural, and environmental well-being of current and future generations (Welsh Government 2015). Wales presents appropriate research setting for the understanding of CE practice, and findings can be potentially transferred to other regions which are seeking to facilitate CE transformation approaches to achieve sustainability both economically and environmentally.

3.2. Research method

To address the research questions set above, an open and explanatory manner, an interpretivist paradigm guided by a constructivist ontology (Ponterotto 2005) is suitable. Interpretivism posits that reality is socially constructed and there are multiple, context-specific interpretations of the world rather than a single reality (Ponterotto 2005). It is believed that interpretivists interpret the human and social reality by gaining insights from individual cases (Crotty 1998) and inductive reasoning can help logically frame theory development (Rahi 2017). Accordingly, we adopted a qualitative research approach which interprets a contemporary phenomenon in the real-life context to understand the meanings that people bring to them (Denzin and Lincoln 2005). The qualitative approach has been widely applied in the operations and supply chain research to advance deeper understanding of on-going complex phenomena in supply chain management (Wieland, Tate, and Yan 2024; Voss, Tsikriktsis, and Frohlich 2002).

Specifically, to address the research objectives which seek to investigate details of activities and generate rich theoretical and practical insights, we employed the multiple-case study method (Eisenhardt 1989). This method has been effectively applied in sustainable supply chain research (Hu et al. 2023; Jraisat et al. 2023; Song et al. 2017; Niall and Rich 2015) and thus can achieve our research objectives (set in Section 1).

We considered theoretical sampling in selecting cases which can highlight theoretical issues (Eisenhardt 1989; Yin

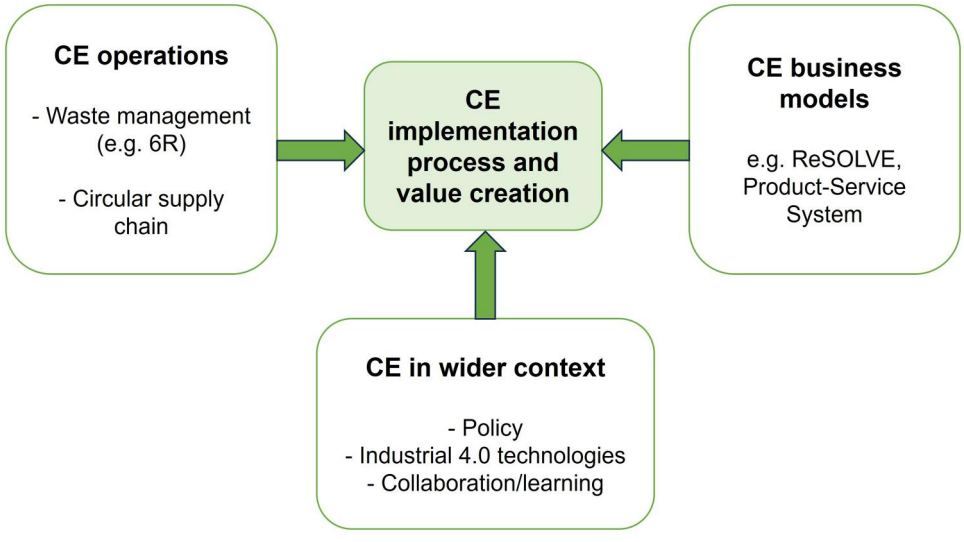

Figure 1. Initial conceptual framework.

2018) relating to CE implementation. Specifically, the case selection criteria were: 1) the case organisation has successfully implemented CE elements, or have clearly conducted CE projects; 2) the implementation can be conducted internally or externally through the engagement with partners; 3) there is abundant qualitative data to form the evidential chain e.g. good access to primary data and company's archive; and 4) cases concerns various settings ranging from large to small organisations, manufacturing to service sectors. This resulted in the researchers engaging with seven case companies which have operations in Wales, shown in Table 1.

Among the cases, there are four traditional manufacturing companies (C2,4,5,7) and one company involving production e.g. material processing and service (C6). The other two companies are from the service sector, yet due to CE implementation they have managed to develop and make sustainable products, and thus also engage with production (C1,3). Moreover, servitisation is acknowledged in the PSS-based CBMs (Yang et al. 2018). For another, the cases are included to reflect the latest view in the production management field that exploration on service-based organisations can provide an interesting comparison to those in the pure manufacturing sector (Kreye 2023; Zils, Howard, and Hopkinson 2023). Thus, the sample captures a wide spectrum of companies involving full and partial production, findings of which are applicable to a wider context of production. According to Eisenhardt (1989), seven cases represent an adequate number for theory development. The cases carefully selected based on the above criteria will allow the generalisation of findings.

During the data collection period, 10 semi-structured interviews (Eisenhardt 1989; Yin 2018) across seven case companies were conducted in 2022. The interviewees were those in the position of owner, R&D manager or sustainability specialists who had a full understanding of the CE implementation projects in the case company. Each interview lasted around 1 hour, generating a transcript around 5,600 words. Table 2 shows the interview protocol, which is generated based on the research questions. Other questions were also asked tailored to each case company. In addition, we collected secondary data including the case companies' websites and news releases, for the purpose of data triangulation (Eisenhardt 1989; Voss, Tsikriktsis, and Frohlich 2002; Yin 2018).

Our data analysis followed Gioia's methodology 'to developing a data analysis that can meet the rigorous standards of trustworthy research' through three key stages (Magnani and Gioia 2023, 1; Gioia, Corley, and Hamilton 2013): 1) Creating codes/categories assembled into a coding structure with 1st order codes, 2nd order themes and aggregate dimensions; 2) developing a grounded theory model via constant comparison across data, informants and time; and 3) presenting findings through a data-based narrative. Moreover, we referred to the examples set in the recently published operations and supply chain-related qualitative case studies, including those articles by Hu et al. (2023), Jraisat et al. (2023), James et al. (2022), Abushaikha, Wu, and Khoury (2021) and Quarshie and Leuschner (2020), making sure the analysis process was consistent with these works. Hence, the data analysis was conducted as an iterative process comprising five steps, as illustrated below.

First, all interviews were recorded and transcribed (Hu et al. 2023; James et al. 2022; Quarshie and Leuschner 2020). Second, all members of the author team coded the transcripts independently (Hu et al. 2023; James et al. 2022; Quarshie and Leuschner 2020). These were then collected by the lead author, who coordinated the discussion among the divergences until all authors agreed on the primary codes (Abushaikha, Wu, and Khoury 2021). These codes concern activities (Quarshie and Leuschner 2020; Gioia, Corley, and Hamilton 2013;) relating to CE implementation such as daily operations and learning activities. Third, all authors jointly identified and refined the analytical themes (James et al. 2022; Jraisat et al. 2023; Quarshie and Leuschner 2020; Gioia,

Table 2. Interview protocol.

CE project related questions:
- When did you start the CE implementation?
- Why did you start it?
- Who do you work with?
- Who funded the project?

CE process related questions:
- What did you do first? What came next?
- What are the prioritised areas?
- What is the progress to date?

CE product and solution related questions:
- Are there any new products developed during the project?
- How about new solutions?

CE learning related questions:
- How did you develop the CE knowledge?
- Who do you share the knowledge with?
- What were the enablers?
- What hindered the CE implementation, and how did you cope with that?

Other questions:
- What does the term CE mean in the context of your organisation and industry?
- What other support is needed?
- What do you plan to do next?
- Questions tailored to each case organisation

Table 1. Overview of the case companies.

Case	Business sector	Business size	Production element	Start of CE implementation	Interview times
Case 1 (C1)	Holiday Park	Large	Repurposed/recycled furniture accessories e.g. bed runners	2019	2 + Emails + Document
Case 2 (C2)	Steel	Large	Steel products	2010	3 + Emails + Document
Case 3 (C3)	Hair and Beauty	SME	Hair broom and mats	2020	1 + Emails + Document
Case 4 (C4)	Healthcare	SME	Plastic processing, plastic bricks	2015	1 + Emails + Document
Case 5 (C5)	Home and Personal Care	Large	Home and personal care products e.g. soap and detergents	2012	1 + Emails + Document
Case 6 (C6)	Paper	SME	Repurposed/recycled paper products e.g. bird bed	2015	1 + Emails + Document
Case 7 (C7)	Beverage	SME	Cider	2016	1 + Emails + Document

Corley, and Hamilton 2013; Braun and Clarke 2006). Fourth, collaboratively all authors actively searched for patterns and generated aggregated dimensions (Hu et al. 2023; Quarshie and Leuschner 2020; Gioia, Corley, and Hamilton 2013; Braun and Clarke 2006). Fifth, the researchers then brought together the themes and aggregated dimensions as theoretical constructs (Quarshie and Leuschner 2020) looking for explanation and causality (Hu et al. 2023; Voss, Tsikriktsis, and Frohlich 2002), and elaborated the relations among them (Quarshie and Leuschner 2020; Gioia, Corley, and Hamilton 2013). This resulted in the integration of findings into a model addressing the theoretical constructs and their linkage (Hu et al. 2023; Quarshie and Leuschner 2020; Gioia, Corley, and Hamilton 2013). As an iteration process, the above data analysis is repeated until theoretical saturation (Hu et al. 2023; Jraisat et al. 2023; James et al. 2022; Quarshie and Leuschner 2020; Voss, Tsikriktsis, and Frohlich 2002; Eisenhardt 1989).

4. Case analysis

4.1. Case 1

C1 is a large holiday park in the west of Wales. It employs over 770 people, and the site consists of 344 timber lodges, cottages and studio apartments set in 500 acres. It has been dedicated to sustainability since opening in 2008. In 2019 the company introduced a range of initiatives and ongoing strategies to maximise the positive impacts of the business, while benefiting the community and environment. The company's CE project focuses on biodiversity, energy, waste and community. It aims to maximise biodiversity across the site. There is an energy management plan to increase the use of renewable energy, ensure efficient use of energy, and to reduce energy use per guest night. The company has been on a Green Tariff for electricity since 2019. In terms of waste management, it maximises reduction, reuse and recycling of waste. For example, it is the first UK resort to ban the sale of water in plastic bottles. It is also the first resort in the world to recycle disposable nappies, reducing over 400,000 pieces of single use items. It has selected a new laundry supplier, together eliminating 200,000 single-use plastic laundry bags per annum. To implement a CE widely, the company actively engages with local schools, charities, and communities. Develop partnerships with local farmers and charities. It works with community partners to reuse, upcycle and recycle used sofas. Working with a local college, the company turns 1000 bed runners into blankets each year for homeless and disaster charities. It also works with a neighbouring farm to utilise 100's of tonnes of cut grass to the manure reserve to create natural fertiliser for crops. As a pioneer in the CE transformation, C1 organisation actively promote its practice through social media and industry events organised by the Welsh government and Wales based universities. In recent years, the organisation has been rolling out a significant digital transformation programme to enhance the work system and guest services. For instance, through working with a technology specialist, a new digital platform was launched to share news and updates including those relating to CE projects initially among the staff. Then, this also aims to assist a smoother communication among the stakeholders who are essential during the CE transformation. This has resulted in more engagement between employees, teams and senior management. Another digital system has been developed to improve the flow of information such as guest activity bookings, as well as enhance the efficiency of day-to-day work.

4.2. Case 2

C2 is a steel factory based in Cardiff and is the largest producer of reinforcement bar and long steel products in the UK. The company directly employs more than 500 staff and several hundred sub-contractors in South Wales. In 2009, it became the first steel manufacturer certified to a recognised responsible sourcing standard, Eco-Reinforcement (BES 6001 Sector Standard), for its reinforcing products. CE practice is across the entire organisation. Initially, the company investigated its internal process, by examining the material resource flow through the organisation. Then it became easier to explore circularity externally. With a consideration on how to bring a service solution back to the industries, it collaborated with the construction sector, with the aim of connecting both ends of the supply chain. For example, in 2019 the company undertook a pilot project to redevelop a cinema to a community hub, during which it managed to recycle and reprocess materials from the demolition. According to the company, the first and foremost is the ability to recycle at large scales. Within the UK, it can recycle 1.2 million tonnes of scrap material of end-of-life resources from other industries. The second element is that the company now has the capability to melt the material, cast it into billets which then can be rolled and produced into new commodity products. Rather than continuing to be a commodity steel producer, it is looking at how to be facilitator and collaborator for the idea of a closed loop circular steel supply. The company is also exploring collaboration opportunities with automotive, electronics and construction industries to unitise these by-products as critical resources. In 2021, funded by the Welsh Government C2 initiated a collaborative project alongside Cardiff Metropolitan University co-deliver CE training to Cardiff-based schools and business. In 2024, the company started collaboration with a blockchain technology specialist to further advance its supply chain transition towards a CE. This was based on a funded project by the Welsh Government to explore the possibilities of using Industry 4.0 technologies to promote CE. This is based on the idea that blockchain technologies can enable new layers of data integrity, transparency, and traceability in mitigating the unforeseen economic costs that often plague steel supply chains.

4.3. Case 3

Founded in 2020, C3 is from the hair and beauty sector. It was established in 2020 by three individuals who were former hairdressers and sustainability experts, and now it has 10 staff.

During the first lockdown in 2020, it had 50 salon members. By the first year, the number reached 500. Now it has around 1000 salons throughout the UK and Ireland. The company considers CE in its process design and actively promotes its recycling programme, and investigates solutions to recycle salon waste, separating metal, paper, plastics, and other types of waste, to reduce the risk of cross-contamination. According to the company, between the linear economy and CE, there is the recycling economy, which is a critical part but still incredibly resource intensive. Thus, it continually rethinks a whole solution, finding value in waste materials and turning them into resources. In this way, the industry can help improve the world socially and environmentally, as well as generate profits. To become members, salons need to purchase a starter kit. Subsequently, they purchase return boxes via a pay-as-you-go system, and fill the boxes with bags of hair, foil, colour tubes etc. The company then works with third party companies to collect the waste from member salons. Some of the waste streams are handled in their facilities, some are sent to the headquarter and some are sent to partners for recycling or composting. To make it easier for member salons to be involved, the organisation is trying to automate some of the waste collection process. Through collaboration, the company has also managed to make products out of the salon waste including hair, metals, towels, chemicals. For instance, they produce sustainable hair mats to clean up oil spills, while clean energy is generated with discarded PPE. With machinery imported from the USA, the company has also become a manufacturer of hair brooms and mats. In 2022, the organisation saved 72 tons of salon waste from landfill, and 642 KGs of waste from the sector. As for the challenges involved in developing and implementing these CE solutions, at present there is no policy support for this specific sector, where investment is needed to address major changes like procurement, not least switching to more ethical products suppliers. Moreover, the sector is dominated by micro-businesses who lack the capacity to implement significant business model changes. To address some of these issues, C3 created their own resource of educational articles which they shared with partners and member salons. This is consistent with the belief that partners and salon members should adopt new ideas collaboratively, rather than seeing themselves as competing in the traditional way. With the recycling process now established, the company now focuses on education and research into better sustainable solutions. These efforts not only help member salons to become more sustainable, but also have a long-term social impact through donating profits from selling recycled materials and products to charities such as The Water Fund and Haircuts4Homeless.

4.4. Case 4

C4 organisation was founded in 2014 and specialises in sustainable waste, carbon reducing, environmental impact systems providing cost effective solutions to common waste management problems. As an SME of 20-30 people, the company recovers and recycles polystyrene in packaging and polypropylene widely used in the healthcare sector. It has a system to reengineer light polymers into solid materials that can be returned to the supply chain for new products. It has developed a range of products that contribute to the CE by reducing waste volume through recovery and reuse. The initial focus was on very light and problematic polypropylene and polystyrene. For many years, the company has been recovering materials diverting them from landfill, making sure they can be reused in the UK. Drawing upon successful experiences, the organisation hopes to replicate the good practice in the rest of the world. Hence, it develops solutions that can be broadly adopted apart from selling its machines. The organisation has developed tangible solutions to recover and recycle plastics. For example, it has designed and developed machines that melt and compress used polypropylene (e.g. face masks, gowns and curtains) at 350 C to produce one metre rectangular blocks. The blocks of polypropylene can then be re-engineered into items like chairs, garbage bins and bottle caps. While hospitals are the biggest users of polypropylene, the machines designed by the organisation are compatible for use in the shipping, construction and military industries. Externally, it engages actively with sustainability managers and circular economy champions, especially from the NHS and healthcare sectors to share knowledge and resources. In addition, the company is actively promoting the CE concept though attending events organised by the Welsh Government and Wales based universities. Their plastic blocks are sold to companies that want to repurpose the plastic into commercial product. C4 is also investigating the technologies to convert blocks into filament that can be used for domestic 3D printing for example, cups and cutlery. The company is keen to share the concept through the Internet and social media, so that values can be generated from the plastic waste in the everyday life.

4.5. Case 5

C5 designs and produces home and personal care products, established in 2012 in mid Wales. It is an SME with less than 50 staff. The original premise was to be a completely zero waste company, with a focus on cutting out plastic waste, particularly single use plastics. It is the world's first refillable washing up liquid, shampoo, and conditioner manufacturers. One example of its concentrated products is the refillable hand wash, one refill pouch will fill a standard bottle six times. By applying circular economy principles, the company takes back used refill pouches and either re-use them, reprocesses them into new, higher value products. Raw materials arrive at one end of its factory and Royal Mail collects finished goods from the other. The fact that there is no middleman, minimal waste and no excess transport makes the production and distribution processes efficient. Where possible, raw materials are source from the UK or mainland Europe. Meanwhile, the company is also conscious of the price of the products at a comparable level to mainstream competitors. It has utilised the principles of the circular economy to design their processes and products. Since 2022, the company is developing their retail sales and since January 2022 their products have launched in over 90 stores across

the UK. The products are designed to have a strong colourful brand image which actively promotes the CE concept and the products as a CE example in action. The company has recently received grants from the Welsh Government purchase specific pieces of equipment, such as a pouch filing machine, refills despatch machine and an industrial blender. C5 also considers that the support from local customers and businesses has allowed sales to grow as consumers look to support local manufacturers. Current retailers include farm shops, health food shops and smaller supermarket chains.

4.6. Case 6

C6 was established in 2015, an organisation that provides confidential paper shredding services, archive storage, and document scanning. The operations team have 60 staff and the main 1,200 customers ranging from small businesses such as accountants and solicitors, to large public sector organisations including schools, colleges, NHS trusts and local authorities. Once received, documents and cardboard are shredded and bailed by the organisation for onward recycling at a facility in North Wales. The organisation continues to develop the business so it can provide opportunities for disabled people and people experiencing disadvantage to gain knowledge and skills, and progress within their communities. Meanwhile, it continues to broaden the range of products it takes for recycling and the development of sustainable products which reduce waste and divert it from landfill, making it easier for organisations across Wales to recycle. The key materials recycled are paper and cardboard, but they also repurpose and recycle plastic and metal such as the components found in document folders. C6 has a growing number of local authority contracts following registration on the National Procurement Service. In 2021, it launched an environmentally friendly animal bedding product, using mixed corrugated cardboard cut finely into small strips, which helps to increase absorbency whilst maintaining a warm insulated barrier. Subsequently, the organisation received further funding from WRAP, a climate action NGO funded the Welsh Government. This has enabled them to purchase a bespoke animal bedding machine and links have recently been established with a haulage company to fulfil orders in England and Wales. Moreover, it has received a partnership innovation grant from the Welsh Government for a project which involves the repurposing of plastic for the NHS in Wales. The next development will be to install solar panels across five units on their site. It plans to sell energy back to tenants and for machines within the business. It is also phasing in EVs into their fleet with the aim of using renewable energy throughout the entire cycle of production. Currently the company is utilising digital technologies in terms of monitoring manufacture and sales, and some AI for marketing. It actively shares the experience of CE through attending events organised by the Welsh Government and regional universities.

4.7. Case 7

C7 is a craft cider brewery located in North Wales. It is operated on a small scale, with fewer than 10 employees and 2-3 additional staff, who help out with pressing the fruit between October and December. When the company first started in 2016, it operated by exclusively using donated apples and pears from the local community. This process was entirely framed using the owner's previous experience of fermenting using only waste fruit. The scale of donations grew exponentially after opening, allowing the cidery to establish its own shop, as well as supply 45 other outlets in Wales. With this increased scale also came an increase in waste from the fermentation process in the form of apple pomace. To reuse this waste whilst also meeting increased demands, Case 7 donated pomace to local pig farms so that it could be reused as a feedstock. Any excess pomace is composted nearby. Unlike other cideries, this company relies on a traditional, manual fruit press to process the apples and pears, rather than modern machinery. Although being more labour intensive, this decision mitigated the steep upfront costs of sourcing modern fermentation equipment, which in turn keeps operating costs lower. In the theme of keeping costs low, the company repurposed many old wooden supports when renovating the rustic style barn they now operate in, using them as decorative panelling within the shop, rather than treating them as a waste product. The company's main future goal is to increase cider production, so that it can further limit the amount of wasted local apples. The company promotes the concept of sustainability and local community in its product through digital marketing and social media. It has also been working with the waste solution specialist Pennotec as well as Bangor University with the aim of producing a food product from the waste apple pomace. Local community support has been vital in C7 achieving its success to date. These efforts have so far positively impacted local economy by turning waste into high-quality products and creating sustainable revenue streams. This also have a broader impact on encouraging responsible consumption among within the community. However, challenges do exist regarding business expansion beyond the immediate locality. Some of these derive from the investment required new production facilities (as noted above the manual press negated the need for significant early investment) and the related R&D. Moreover, given the nature of the business model, marketing and particularly customer relationship development will require significant resource (including staff time).

5. Findings

Based on the above case analysis, Table 3 shows the data structure and findings, which follows the data analysis approach described in Section 3.2. Four aggregated dimensions relating to CE implementation are identified as internal process, product and solution, external collaboration, learning and changing, and government policy.

Table 3. Data structure and findings.

Initial codes	Second order themes	Aggregated dimension
• Internal material resource flow examination (C1,2,5)	Waste management	Internal process
• Reuse material, turning them into internal resource (C1,2,5,7)		
• Reduce, reuse and recycle materials (C1,2,3,4,5,6,7)		
• Analysis the internal resource to optimise the process flow (C1,2)	Process improvement	
• Working with experts on new process design (C1)		
• Reusing components and recycling on a project-to-project base (C2)		
• Investigating better product solution e.g. ingredient (C1,3,5)	Product development	Product and solution
• Exploring the value of by-products (C2,5,6)		
• Investing technology/machines to develop products (C2,3,4)		
• Moving from producing products or selling machines to providing service (C2,4)	Service solution	
• Providing solution to a specific industry (C3)		
• Engaging with local schools, charities and community (C1,3,4,6,7)	Community engagement	External collaboration
• Promoting CE concept to customers and partners (C1,2,3,4,5,6,7)		
• Employing local workforce (C1,6,7)		
• Sourcing from local suppliers (C1,3,5,7)	Supply chain partner	
• Persuading existing suppliers to implement CE (C1,2)		
• Working with new suppliers who are committed to CE principles (C1,2)		
• Collaboration with other industry sectors (C2,3)	Cross-industry Collaboration	
• Providing by-product for other sectors (C3,4)		
• Working with partners and external experts e.g. university (C1,2,3,4,7)	Continuous learning	Learning and changing
• Iteration and experience-based learning (C1,2,3,4,6)		
• Attending and coordinating knowledge exchange events (C1,2,3,4,5,6,7)		
• Cultivating a culture/mindset of change (C1,2,3,4,5)	Mindset changing	
• Recruiting people based on value and passion for sustainability (C3,7)		
• Promoting CE concept externally e.g. to customers (C1,2,3,4,5,6,7)		
• Digital platform to share CE information internally/with stakeholders (C1)	Digital technologies	
• Blockchain technologies to trace the information internally and across the supply chain (C2)		
• Digital marketing/social media of CE projects/concepts (C1,2,3,4,5,6,7)		
• Early attempts to automatise process (C3)		
• Funding to support industry-university collaborative CE training (C2)	Government policy	Government policy
• Funding to support new ideas, technology and solutions (C2,5,6)		
• Facilitating knowledge sharing e.g. event in the region (C1,2,4,5,6)		

5.1. Internal process

It is seen that all companies follow CE practice in terms of internal process design and reconfiguration, investigating processes and resources, and eventually improving process flow to reduce waste or realise circularity.

5.1.1. Waste management:

All cases prioritise reducing waste such as packaging. They investigate process flow (C1,2,5), finding value to reuse materials (C1,2,5,7). For manufacturing companies, recycling can bring significant benefits in terms of saving cost and achieving efficiency (C2,4,5). According to one interview,

> [C2 company] recycles about 1.2 million tonnes of scrap material of end of life resources from other industries. When you multiply that across the whole of [C2 group] we can process up to 8,000,000 tonnes of materials every year. So we can start delivering resource efficiency at scale. - C2

Similarly, the adoption of renewable energy, as well as reducing and reusing materials are widely observed in all cases (C1,2,3,4,5,6,7).

5.1.2. Process improvement:

Companies improve and reconfigure internal processes such as optimising internal process flow and resource utilisation (C1,2). For example, C2 points out that the international process should be as simple as possible. C2 has not developed a specific CE process, but considered elements such as reusing components, recycling on a project-to-project basis.

5.2. Product and solution

Apart from designing and reconfiguring internal processes to reduce waste, companies are seeking new solutions, investing technologies for the possibility of circularity. This potentially results in new products, services, and business models which can be applied to or benefit a specific industry, e.g. healthcare sector (C4).

5.2.1. Product development

Based on new processes and technologies, companies are keen to improve product ingredients and materials (C1,3,5), turn by-products or waste materials to resource (C2,5,6), and invest in new technologies (C2,3,4). For example, C2 melts materials into new commodity products. Investing with a hair mat machine, C3 realises a general solution to deal with waste in the hair salon sector. With an emphasis on R&D, C3 develops environment friendly products including hair mats which can help salons to become zero waste. With technology advancement, C4 mainly produces machines to turn single-use light plastic from the healthcare sector to solid bricks, which can be returned to the supply chain.

> We've developed a system that reengineers these very light polymers into solid materials that can then come back into the supply chain and be used in new products that we've developed. By developing that process, we've also manufactured them, because we make these machines, so we are making sure that the components, whenever possible, are made from reuse. So stuff that comes back into the supply chain as well … What we're doing here in the UK can be copied and replicated anywhere in the world. So we are developing a solution that other people can copy wherever we sell our machines. - C4

5.2.2. Service solution

Besides exploring tangible technologies and products, companies also test new solutions, not only for internal purposes, but also to benefit the whole industry (C3). For example, C3 works with hair salons across the UK and Ireland to promote their recycle programme. As reflected in the interview,

> We're looking at making sure that our current recycling services are really the best options and then I help to find new improved solutions for every single waste stream we encounter, as well as trying to better understand what's happening in the industry and how we can improve. – C3

There is a trend for manufacturing-based companies to shift towards providing services (C2,4). For instance, drawing upon its success in the UK healthcare sector, C4 is exploring wider opportunities as a service provider to tackle broader sustainability related challenges to global customers.

5.3. External collaboration

All case companies realise that a true circularity needs collaboration. This includes engaging with customers to promote the CE concept and sustainable consumption (C1,2,3,4,5,6,7), employing local people (C1,6,7), acting locally to reduce carbon footprint (C1,5,7,8,9) and support the community (C1,3,6,7), engaging with supply chain partners to improve the process (C1), and collaborating with wider industry sectors to seek new solutions and opportunities (C2,3,4).

5.3.1. Community engagement

Through community engagement, companies utilise local resources including materials, human resource, and in turn benefits the local charities, schools etc. Thus, it not only reduces carbon footprint, but also creates circular solutions (C1,3,4,6,7). For instance, C1 worked with a range of local charities to upcycle the used sofa to create circular solutions, whereas the local people and community are very motivated to help when it comes to sustainable projects.

> Everything's on the table now as we explore how we can get the most value for our local community out of our offset programme. and that we can point our guests and our stakeholders to where we get our carbon credit from when we need to get it … and we've created some incredible relationships with the local community. and we're proud of that. and the organisations are able to develop wider relationships with us around other areas. so we've developed new projects off the back of this. - C1

5.3.2. Supply chain partner

Companies actively engage with existing suppliers, persuading them to implement CE elements (C1,2). As for choosing new suppliers, the ethical and sustainable performance (C1,2), as well as local supplier (C1,3,5,7) is prioritised in the criteria.

5.3.3. Cross-industry collaboration

A further move from internal process and supply chain optimisation is to provide by-products for other sectors (C3,4) and seek opportunities across business sectors (C2,3). For instance, C3 addresses the usage of the hair mat as a sustainable solution to oil industry and garage services. C4 is investigating wider solutions for sectors beyond healthcare. C2 not only engages with partners directly linked to the steel industry, but actively approaches companies from construction, automotive and electronic sectors.

> Rather than continuing to be a commodity steel producer, we are now looking at how we can be facilitators and collaborators for the idea of a closed loop circular steel supply. We also have a circularity team on the executive committee who are looking at the wider aspects of the circular economy, including extraction of critical resources from by-products … the idea that actually going forward we can start to explore connections and collaborations with wider organisations. So instead of continually looking at working with suppliers, we are starting to look now more readily with strategic partnership and developing those strategic partnerships, which can help us collectively deliver on that circular agenda. – C2

5.4. Learning and changing

The cases demonstrate the importance of learning, knowledge sharing, and mindset changing during the CE transformation. While learning provides tangible skills and tools, the CE is regarded by the companies as a cultural and mind change, which requires common understanding across the organisation, passion and teamwork.

5.4.1. Continuous learning

Companies regard the CE as a journey and involving process (C1,2,3,6) with the areas of focus in flux (C2,4), for example from recycling to product design and to education (C3). They update CE knowledge through sharing with partners (C1,2,4), working with research institutions (C7) and experts (C1,2,3,4), attending industry forums (C3) and events organised by universities or government (C1,2,4,5,6,7). Also, the fact that no standard framework applies to the industry often requires learning and sharing of knowledge.

> I would say that with all the [circular economy] contents, all of the shared knowledge, though there doesn't seem to be appear to be like one unifying framework for this industry to adopt circular economy principles … especially for the SMEs, there are many things to try regarding circular economy, including things that don't exist elsewhere right now. So there's definitely room for improvement. - C3

5.4.2. Mindset changing

CE projects in the case companies are largely driven by passion of the team (C3,7), as they actively promote the concept to business partners and customers (C1,2,3,4,5,6,7) and recruit people based on passion for sustainability (C3,7). When reflecting on a project involving recycling and reprocessing construction materials, C2 highlights the fact that CE means mindset changing. Accordingly, fear of change is the biggest barrier.

> Circularity does not have to be a complex … It doesn't have to be a complex solution, and it doesn't have to address complex issues or challenges. It can be as subtle a change as a subtle shift and ultimately if you're a designer and you have the ability to create new and to create the future … We can still use the same tools, the same knowledge, same mechanism, we just apply it in a very different way. – C2

5.4.3. Digital technologies

Companies regarded digital marketing and social media as effective ways to promote the CE concept (C1,2,3,4,5,6,7). It is also noted from C1 and C2, the adaptation of digital technologies such as digital platform, blockchain can enable traceability of materials and information sharing. This can improve the internal process, supply chains, and stakeholder relationship. For instance, when referring to the recent project to harness blockchain technologies in the company's circular economy transition, C2 said.

> With this project, we were trying to understand how blockchain could be utilised as a form of traceability, not only through the process of scrap to steel production, but also to measure levels of engagement throughout the construction sector. - C2

5.4.4. Government support

In addition, cases (C1,2,4,5,6) highlighted the essential role of government in providing a platform for knowledge sharing such as holding events or providing guidance on CE principles. In addition, financial support (C5,6) helped organisations to innovate and try new technologies and solutions. For instance, the Welsh government funded a project for C2 to adopt blockchain to advance its supply chain circularity. C5 highlighted the Welsh Government fund that has been key to its ongoing learning and ultimately the development of its product range. Government also provided funds to industry and universities, so that they jointly deliver training to promote CE concepts and practice (C2). It is evident that such support can facilitate the sharing of locally-embedded CE knowledge, best practice, and digital technologies, as well as raise the awareness of sustainability and ethical consumption to business and the society.

6. Discussion

6.1. Towards a framework of CE implementation

To elaborate the relations among second order themes and aggregated dimensions analysed in Section 5 and to address our research objectives set earlier, a process model is developed and shown as Figure 2.

The model shows that the implementation of CE principles usually starts with an internal process phase (Stage 1), in the form of waste management and process design/redesign (see examples, C1,2). While waste management can follow the practice of 6 R - reuse, reduce, recycle, redesign, recover, and remanufacture (Illankoon and Vithanage 2023) or the extended version of 10 R (Echefaj et al. 2024), our case studies highlight the importance of reduce, reuse and recycle in particular. This demonstrates that the understanding of CE in practice is consistent with the original 3 R (Ellen MacArthur Foundation 2015). Such a priority is consistent with the mainstream research in CE operations addressing recycling and the reuse of materials (Illankoon and Vithanage

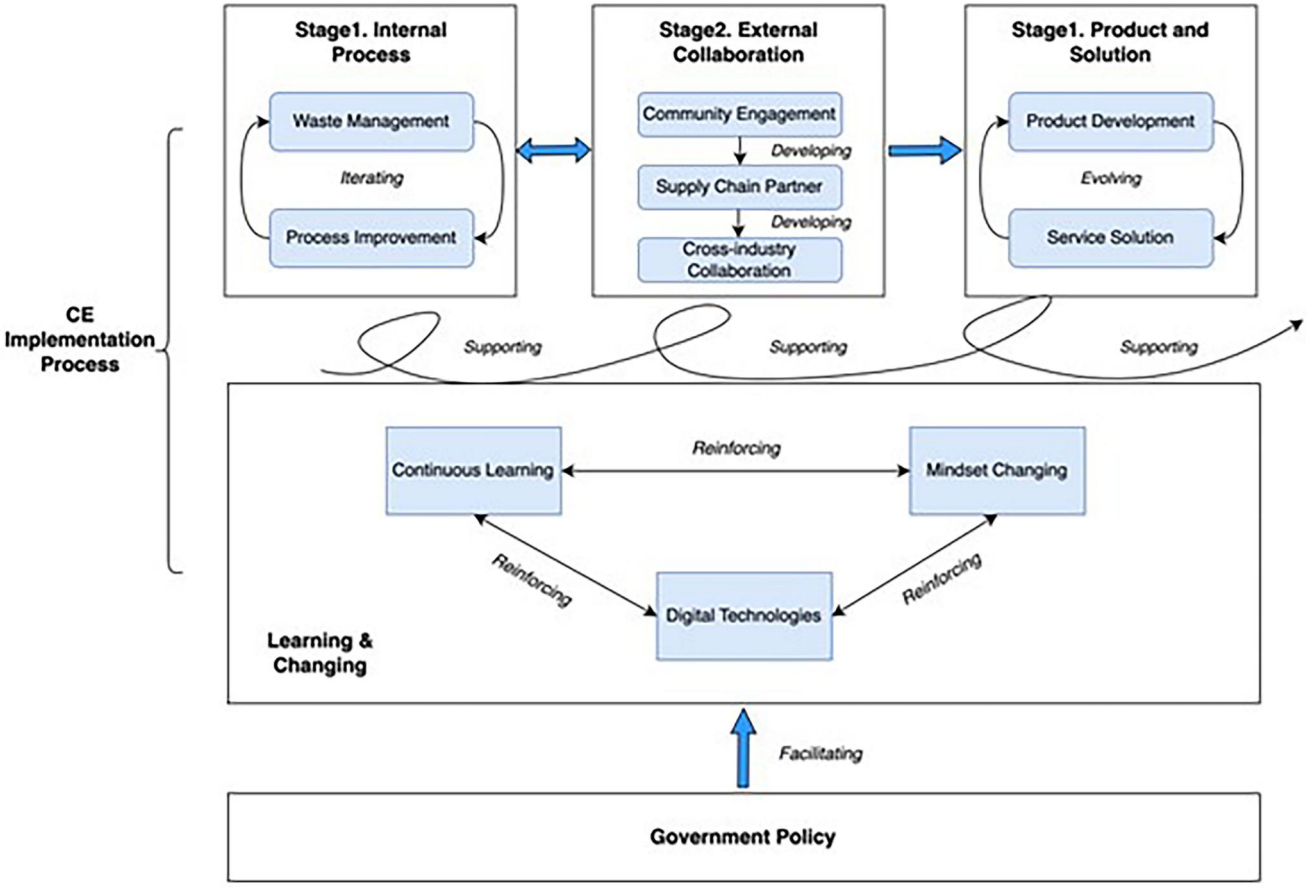

Figure 2. A Process model of CE principles implementation.

2023; Meath et al. 2022; Batista et al. 2018). Moreover, the case studies show organisations also consider CE principles during the early stages of process design in a proactive way (see example C3). This shows similarity with the design-based and waste-based archetypes in the CBM literature (Henry et al. 2020), and further confirms the argument that waste areas should be considered during product and process design stages (Burke, Zhang, and Wang 2023). In fact, waste management and process redesign are regarded as an iterative process, re-enforcing each other, based on the case studies.

The next phase in Figure 2 is external collaboration (Stage 2). Accordingly, organisations engage with community and supply chain partners. Community involvement can raise consumer acceptance, which is a significant barrier to CE transformation (Kirchherr et al. 2023; Ortner, Tay, and Wortmann 2022). It is evident from our case studies that to realise a truly circular system, the CE needed to be implemented at supply chain level (see example, C2). This is consistent with the circular supply chain related studies (Burke, Zhang, and Wang 2023; Ortner, Tay, and Wortmann 2022; Yang et al. 2018). Specifically, collaboration mechanisms are seen beyond a conventional supply chain relations dynamic (Aggarwal and Srivastava 2016; Bailey and Francis 2008) and towards the coordination of diverse actors (Jraisat et al. 2023). In fact, our study indicates that through community engagement, companies can identify new suppliers –particularly local (see example, C1) - which can help reduce carbon footprints in the logistics system, establish a closed-loop system (Bag et al. 2022), reduce cost (Ortner, Tay, and Wortmann 2022), and ultimately regenerate regional resources. Also, with new supplier involvement, there can be the potential of new product development collaboratively. Within a single organisation, or at least across organisations that do not compete directly for funds and resources, aligning incentives is potentially easier. Analogously, firms in vertical or symbiotic relations or indeed sector-based groupings are not necessarily in direct competition with each other.

In addition, there is a trend for organisations to seek collaborations beyond their existing supply chains and industry sectors (see example, C2). This includes the industrial symbiosis by exchange of materials and by-products (Kirchherr et al. 2023; Meath et al. 2022; D'Amato et al. 2017; Chertow 2000) and the collaboration with a wider industry, stakeholders and ecosystem partners (Kanda, Geissdoerfer, and Hjelm 2021). However, our case studies also reveal such attempts are at an early stage, and indeed there are various barriers to cross-industry collaboration, requiring for: 1) policy support (Liu et al. 2023), not only policies to provide funding but also to facilitate CE knowledge creation and sharing (see example, C3); 2) organisational and cultural change (Lu, Zhao, and Liu 2024; Centobelli et al. 2020), meaning to change the mindset of people, understanding the fundamental elements of CE and its benefits; 3) knowledge exchange (Mangla et al. 2018) sometimes beyond the supply chain or industry scope; 4) information sharing (Jraisat et al. 2023) regarding the latest technologies, best practice, and common challenges during CE implementation; 5) and learning (Liu et al. 2023; Walpole et al. 2022) continuously based on practice and collaboration with wider industry. It is noted that Stage 1 and Stage 2 do not always happen sequentially. Sometimes organisations can rely on external collaboration first, especially if the business is more embedded in a local community (see example, C7) and CE transformation is inspired or required by stakeholders. Then through community engagement and collaboration, organisations can further improve the internal CE process.

Subsequently, CE practice within and between organisations results in new product and service solutions, which can evolve from process improvement and collaboration (Stage 3). Thus, this phase shows the implementation of CE can not only reduce waste, but also create value, demonstrating the transformation towards a new CBM (Yang et al. 2018; Tukker 2015). Indeed, designing products and services lays an important foundation for successful CE value creation and capture (Hopkinson, De Angelis, and Zils 2020). It is noted in our study that even for manufacturing companies which traditionally prioritise product development, there is a trend for them to evolve from product towards CE service solution development (see examples C2,4). This reflects an increasing research need in value creation when companies adopt CBM from servitisation (Kreye 2023; Zils, Howard, and Hopkinson 2023; De Angelis, Howard, and Miemczyk 2018). More importantly, findings also reveal an opposite direction where service organisations incrementally become involved in production or processing materials (see examples C1,3). For one thing, this diversifies the business portfolio as a new way of value creation. For another, service development can be a result of the companies collaborating which partners during CE practices. Indeed, product and service development can be complementary.

The above CE transformation is supported by learning and changing across all stages as shown in Figure 2. It consists of three mutually interactive and reinforcing elements, continuous learning, mindset changing, and digital technologies. Learning activities and mindset changing reinforce each other at both organisational and inter-organisational levels. These apply not only to the awareness of CE concepts which remains a barrier to CE implementation (Masi et al. 2018), but also the appreciation of the role of digital technologies to solve complex issues during the CE transformation (Zils, Howard, and Hopkinson 2023; Kumar et al. 2023; Sahoo, Upadhyay, and Kumar 2023; Schöggl et al. 2023; Upadhyay et al. 2023; Gupta et al. 2019).

Findings demonstrate an increasing awareness of harnessing digital technologies to achieve a CE, which in return reinforces knowledge sharing, learning and mindset changing. This is observed both within the organisation and across its supply chains. However, whilst most cases are interested in learning the potential of digitalisation, only a small number of organisations start adopting blockchain or platform Apps to engage with suppliers and stakeholders, which echoes the view that collaboration and shared learning are needed during both digital and CE transformation (Kumar et al. 2023; De Angelis, Howard, and Miemczyk 2018). In particular, the application of blockchain can ideally enable traceability, data

sharing, alongside financial benefit, yet in reality, such application is mostly at the demonstration and piloting stage (Kamble and Gunasekaran 2023; Kouhizadeh, Zhu, and Sarkis 2020). Indeed, the integration of digital technologies and CE implementation remains a critical topic (Echefaj et al. 2024; Kumar et al. 2023), whereas the cases presented provide early attempts in practice.

Finally, this study indicates that government policy serves as overarching building block of the model (Figure 2). Local/regional governments can facilitate knowledge sharing and technology advancement, and promote the CE concept with regulatory action, though there is still limited practical guidance to specific industry sectors. This further addresses the importance of a transformative policy to address sustainability and grand challenges (Hayter and Link 2020; Fagerberg 2018; Raven and Walrave 2020; Schot and Steinmueller 2018). The value creation and capture of the CE relies on a range of system enablers including policy support (Hopkinson, De Anelis, and Zils 2020). While traditionally, government can promote innovation through funding new technologies or stimulating the demand of products, new frameworks are needed to connect various innovative actors (Schot and Steinmueller 2018), particularly in relation to the CE (Clifton and Walpole 2023). At a regional level, the co-evolution of government, university and industry can co-create CE knowledge, developing partnerships, forming industry standards, and disseminating best practice (Liu et al. 2023; Clifton et al. 2024). Overall, the model shows the evolving process of CE practice with continuous improvement and collaboration, within a generally supportive regional governance structure.

6.2. Different scenarios of CE implementation

The cases also show different features of CE projects. According to their driving forces, three scenarios of CE implementation can be summarised as internal process-driven, solution-driven and entrepreneurship-driven.

6.2.1. Process-driven

Companies mainly focus on waste reduction, optimising internal and supply chain processes to develop a circular loop. The representative cases here are C1,2,5,7. These companies have considered sustainability practices in their process design and daily operations. In particular, established large organisations tend to focus on widespread strategies like recycling rather than directly adopting radical changes which may be beyond their change capabilities (Henry et al. 2020; Stewart and Niero 2018). This is also reflected in our case studies, where CE implementation can be a top-down approach and are strategically enforced and formally practised across the entire organisation. The cases demonstrate successful examples and procedures for others to follow, including companies from other sectors. In general, organisations in this category have adopted the ReSOLVE framework (Ellen MacArthur Foundation 2015) internally and are looking for a customised process. Process improvement here can evolve from the organisational level to the inter-organisational level with wider industry engagement, which is not addressed in the current ReSOLVE framework (Ellen MacArthur Foundation 2015). Such an evolving view is consistent with the concept of circular business ecosystems, and advances the understanding beyond PPS systems at firm and supply chain levels (Kanda, Geissdoerfer, and Hjelm 2021).

6.2.2. Solution-driven

Cases in this group can focus on providing new products, technologies or solutions for others to achieve CE outcomes. We refer to this scenario as solution-driven CE implementation. The representative companies are C3,4. They focus on a niche sector, and prioritises technology, R&D, and thus ultimately deriving new CE solutions. Being niche players, they face the challenges of expanding their business model and following standard procedures. This can be a particular issue with a mature business model (such as C4,6) and therefore CE implementation that changes the business model can impact the entire industry sector. Overall, this scenario is consistent with the product-oriented or service-based PSS CBM (Henry et al. 2020; Yang et al. 2018; Tukker 2015), but here we extend the model with a combination of product and service solution development.

6.2.3. Entrepreneurship-driven

Furthermore, among the solution-driven scenarios, it is also noted that CE implementation can be driven by the entrepreneurial passion of the business founders, who pursue the trial and roll out of CE ideas (C3). Compared to the other established solution-driven CE implementation (see example, C4), this represents an early-stage of CE implementation. Thus, we label it as entrepreneurship-driven CE implementation. This scenario has initially been explored in the context of circular start-ups in the forms of design-based, waste-based, platform-based, service-based and nature-based archetypes (Henry et al. 2020). Nevertheless, our findings indicate that a mixed approach can be applied in the early stages of CE practice, e.g. combining eco-design, waste reduction, alongside new service development. It is also noted that solution-driven CE scenarios can occur in small organisations with new experiences of the CE, as seen in C3. Here the CE is a learning experience, during which they seek funding, work with other entrepreneurs who share their passion, and raise CE awareness. This type of CE implementation is potentially more transformative in the longer run as these companies introduce new CE-driven products and services, rather than seeking to make 'conventional' pre-existing more resource efficient. Resource limitation and low awareness from potential customers and business partners can be the main barriers. This further raises the attention of applying circular entrepreneurship as a theoretical lens to understand the deep motivations and unique lifecycles of CE practice, which is still a novel area in the CE literature (Henry et al. 2020). This also highlights the need to engage SMEs in CE transformation, as these organisations often lack resource or formal CE implementation procedures (Clifton and Walpole 2023).

7. Conclusion

In response to the urgent need to combat climate change and environmental crises, the CE concept has emerged as a solution to redefine economic growth, promote resource optimisation, and encourage regenerative practices. The nascent research presented here has outlined some promising practices that organisations can adopt to implement CE principles. It also provides important practical insights for practitioners and policymakers. The model and scenarios we propose enables organisations to position themselves in CE adoption by prioritising internal and external resources during different stages of CE implementation. Moreover, policy makers can also draw on the framework and scenarios to provide more tailored support. For instance, policies to encourage entrepreneurship-driven organisations to engage with established solution-driven organisations for mutually beneficial learning.

Our study has contributed to the developing research on how organisations can implement CE principles and enhance their value proposition. Firstly, it has identified processes and practices that can facilitate the implementation of CE principles. The main stages are internal process development, product and solution enhancement, external collaboration, and organisational learning and change, which are supported by government policy. Secondly, the proposed process model has highlighted the importance of learning and value creation across various levels, which is linked to the CE practice stages. Thirdly, based on the empirical evidence, we have identified three CE implementation scenarios of, internal process-driven, solution-driven and entrepreneurship-driven. In doing so the study has also contributed to the literature by linking important strands of CE literature including CE operations, circular supply chains, and the inter-relationships among CE activities more generally (Zils, Howard, and Hopkinson 2023; Dewagoda, Ng, and Chen 2022; Eisenreich et al. 2022; Rosa, Sassanelli, and Terzi 2019). In particular, the scenarios of CE implementation have broadened the understanding of CBMs (Zils, Howard, and Hopkinson 2023; Henry et al. 2020; Rosa, Sassanelli, and Terzi 2019; Yang et al. 2018; Ellen MacArthur Foundation 2015; Tukker 2015).

In terms of policy implications, this paper presents empirical evidence that suggests facilitated networks or communities or practice reaching across functional and sectoral silos and incorporating both SMEs and larger firms could provide a more systematic model for inter-organisation collaboration and capacity-building this paper has shown to be invaluable. Universities can naturally play a convening role along with government stakeholders for a holistic triple-helix ecosystem approach to CE development. Such endeavours would of course necessitate strategic foresight, sufficient resources, and notably, clear delineation of roles as an impartial advisor external to governmental spheres.

There are limitations to the study presented here; in turn these provide direction for future research. The study draws upon seven cases mainly in Wales, UK, which may not represent CE practice across regions and sectors, not least given Wales as a CE 'early adopter'. The three scenarios we have articulated should be further explored to provide greater understanding – for example more case studies could be conducted, focusing on a specific scenario, e.g. process-driven CE, to develop mini activities and enrich our process model. In addition, this study suggests that future research could fruitfully explore the application of the proposed model of CE principle implementation in regions with varying environmental policies, economic structures and innovation policy 'directionality', such as the global south, or territories with more or less proactive environmental legislation. Prior research has demonstrated the efficacy of a communities of practice approach to developing CE innovation within public and third sectors (Liu et al. 2023), and these could also be a valuable tool for SMEs with suitable resource and network facilitation (Walpole et al. 2022). While this study focused on manufacturing activities, further work could extend the framework to other sectors, such as high-tech industry and on to services, to assess the broader applicability of CE principles. e.g. how digital transformation influences the proposed model efficiency. Moreover, longitudinal studies tracking the success and scalability of CE initiatives could provide deeper insights into the macro-environmental impact and long-term viability of the proposed model.

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Ethical approval

This research has been approved by the Cardiff School of Management Research Ethics Committee, Cardiff Metropolitan University. The approval reference number is 2021DE0037.

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