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INFORMATION AS A CATALYST FOR THE CIRCULAR ECONOMY

Nina Tura, Matias Ståhle, Tuomas Ahola, Jyri Hanski, and Pasi Valkokari

Introduction

Interest in the circular economy (CE) is growing because of unresolved global challenges, such as climate change and resource scarcity, and it is seen as an important driver to achieve green growth and sustainability transition (European commission, COM/2020/98). In general, the CE is understood as an economic system that creates value from waste by capturing and then reusing finite materials and energy (Geissdoerfer et al., 2017; Korhonen et al., 2018; Kraaijenhagen et al., 2016) by slowing down, closing, and narrowing material and energy flows (Bocken et al., 2016). The CE is expected to contribute towards increased resource efficiency, reduced extraction and reduced processing of natural resources; in addition, earlier research has also linked CE to increased business opportunities (McCarthy et al., 2018). Despite these potential benefits and the vast amount of research directed towards CE, the process of transitioning towards CE has been relatively slow. One potential explanation for this might be that the CE literature traditionally recognises two distinct cycles – biological and technical (Braungart & McDonough, 2002; Ellen MacArthur Foundation, 2013) – and even though the previous studies concentrating on these cycles have advanced the discussion on CE, they lack the crucial perspective of information circulation.

In general, paying attention to the management of information circulation has the potential to enhance the efficiency of business processes, reduce surpluses, lengthen the life span of goods and diminish transaction costs (Baines & Lightfoot, 2013; Jäger-Roschko & Petersen, 2022). With information, we generally refer to different levels of a hierarchy consisting of data, information, knowledge, and wisdom (Ackoff, 1989). To understand different CE strategies, consideration should be given to how these different levels are to be managed and how information circulates across various systems and stakeholders, in addition to technological and biological resource cycles. A lack of information may reduce collaboration (Patricio et al., 2018), and incomplete information can hinder remanufacturing process improvements (Despeisse et al., 2017; Kurilova-Palisaitiene et al., 2018). As Tura et al. (2019) concluded, it is essential to understand the importance of information management when designing a circular business concept and that a lack of methods and platforms to share information can hinder this development.

DOI: 10.4324/9781003267492-13

Even though the importance of information has been shown in previous studies, the current discussion on widely used CE models, such as the one from the Ellen MacArthur Foundation (2013), neglects an information circulation perspective. Many of the previous studies consider only technological or biological cycles and are conceptual in nature. The focus in previous CE studies has largely been on identifying and understanding various material flows in economic systems, and has paid significant attention to the recycling of materials (Husgafvel et al., 2016; Milios et al., 2019), CE business models (Lüdeke-Freund et al., 2019; Ranta et al., 2018; Vermunt et al., 2019), and the enablers of and barriers to a CE (Kirchherr et al., 2018; Patricio et al., 2018; Tura et al., 2019), for example. Furthermore, it has been acknowledged that successfully transitioning towards a CE requires collaboration between multiple interdependent actors within the system (Ghisellini et al., 2016; Kraaijenhagen et al., 2016; Marra et al., 2018). Recent research has increasingly focused on the human-centric, social, and institutional changes that are required for transitioning towards a CE (Bocken et al., 2017; Clube & Tennant, 2020; Moreau et al., 2017; Wiener et al., 2018), as well as the implications of a CE for business decision-making (e.g., Mendoza et al., 2017).

Based on the literature and an empirical study of four case companies from the energy, forest, waste management, and information technology sectors, we found that information such as conceptual, procedural, policy, stimulatory, empirical, and directive information types crucially affects the planning of companies' CE initiatives. Therefore, following a design-oriented perspective, this chapter examines the role of *information* as an enabler of the technical and biological resource cycles and poses the following research question: How does information catalyse the transition towards the CE? The results highlight the crucial role of information in facilitating this transition by explaining how – by systematically collecting, processing, and sharing information related to the material flows, resources, capabilities, and goals – new circular business can be enabled. Consequently, information works as a catalyst (i.e., a mechanism of the sustainability change) of the CE. We derive a model that sheds light on the different stages of the information circulation, namely data, information, knowledge, and wisdom (Ackoff, 1989), and their relation to circular business decision-making. Our model emphasises the different levels of information circulation at the intra-firm, network, and societal levels.

Conceptual background

The two-dimensional model of the CE

The CE is expected to gradually replace the traditional and linear so-called end-of-life (EOL) logic, which has been criticised for unsustainable resource consumption (Ghisellini et al., 2016; Lieder & Rashid, 2016). The CE is strongly linked to sustainable development (Murray et al., 2017) because it gives rise to additional opportunities for environmental, social, and economic value creation (Geissdoerfer et al., 2017; Tura et al., 2019).

Traditionally, and as illustrated in Figure 11.1, the CE literature distinguishes between two types of cycles: biological and technical (Braungart & McDonough, 2002). Biological cycles consist of renewable biomaterials, such as timber and cotton. Biomaterials circulate in the system because they can typically be renewed by specific processes, for example, by composting and replanting. Technical cycles include the flows of various product assemblies and the flows of nonrenewable resources. These flows re-enter the economic system through processes that differ from their biological counterparts, through repair, recycling, and remanufacturing (Ellen MacArthur Foundation, 2013).

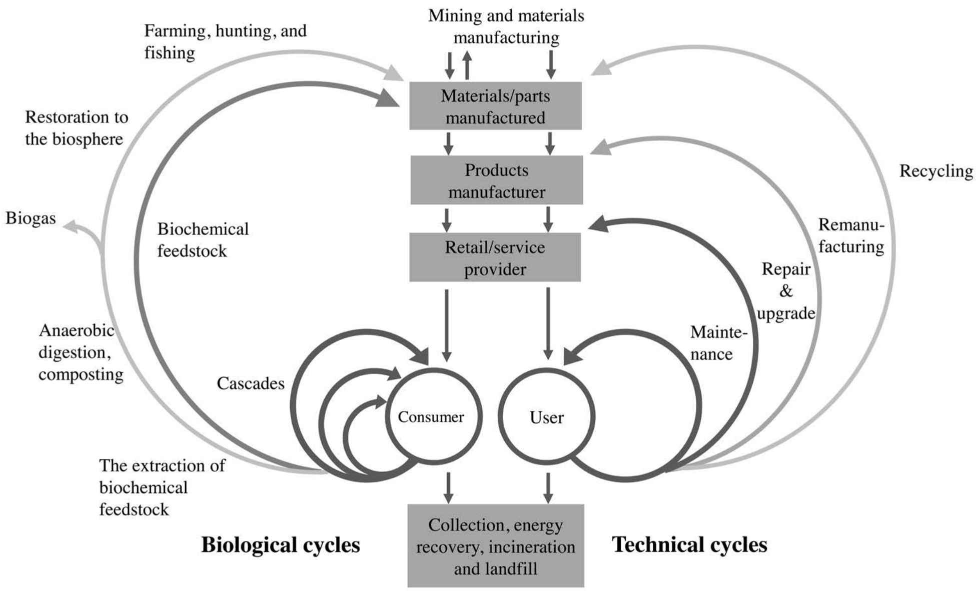

Figure 11.1 The model of the CE.

Source: Adapted from the Ellen MacArthur Foundation (2013).

The CE's underlying driver is the motivation to constantly seek out opportunities for applying the principles of "reduce, reuse, and recycle" (Ghisellini et al., 2016; Jawahir & Bradley, 2016) in both production and consumption. Although these three principles also cover intangible resources, such as human resources and knowledge, the literature has mainly focused on material flows while neglecting information flows (Hanski & Valkokari, 2018). However, business model innovation (Kraaijenhagen et al., 2016), sustainable value creation (Ghisellini et al., 2016), information, and knowledge sharing and collaboration (Centobelli et al., 2020; Marra et al., 2018; Wiener et al., 2018) are acknowledged as being crucial aspects of CE development. In addition, if a system's suboptimisation and so-called rebound effects of CE (see: Kjaer et al., 2019; Korhonen et al., 2018; Millar et al., 2019; Zink & Geyer, 2017) are to be avoided, this requires efficient information gathering and processing throughout the whole system. For example, this information may reveal if reducing energy consumption in one area takes place at the expense of another area. In the following, we proceed to discuss how information may enable additional circular business.

The role of information in circular business

Information and communication technologies (ICT) are seen to have positive environmental, social and economic impacts, being an important contributor towards sustainability transition (El Bilali & Allahyari, 2018), meaning a long-term, multidimensional and fundamental shift of established socio-technical systems to more sustainable modes of production and consumption (Markard et al., 2012). For example, the use of ICT may provide new ways of visualising and measuring impacts, communicating changes, connecting actors, and reducing logistics costs and inefficiencies within value chains (El Bilali & Allahyari, 2018; Elliot, 2011; Watson et al., 2010). Furthermore, the CE is seen to provide multiple opportunities for action to achieve sustainability transition (European

Commission, COM/2020/98) and the use of data and information technologies has the potential to drive the transition towards the CE, renewing the logics of value creation and increasing resource efficiency (Despeisse et al., 2017; Ellen MacArthur Foundation, 2016; Jabbour et al., 2019). Many current CE solutions are supported by – or their existence is even enabled by – data and digital platforms, such as mobile marketplaces for selling leftover food (e.g., ResQ), vehicle sharing (e.g., DriveNow), and IT equipment as a life cycle service (e.g., 3 Step IT) (Sitra, 2019). Information can significantly support firms' attempts to increase the lifetime value of their assets through various actions such as refurbishment and remanufacturing activities (Bocken et al., 2016; Campos et al., 2017; Jäger-Roschko & Petersen, 2022; Kurilova-Palisaitiene et al., 2018).

Many manufacturers have started to look for new circular concepts (Bocken et al., 2016) and are providing their products to customers as a service (Tukker & Tischner, 2006). In these service strategies, the business is typically based on gathering data, for example, on the usage and performance of the product (Rymazewska et al., 2017) and managing the flow of information (Centobelli et al., 2020; Vezzoli et al., 2015). Furthermore, firms experienced in leveraging side streams within their production operations have been collecting data, which, as shared across company boundaries, hold considerable potential for the development of novel circular business solutions (Aminoff & Kettunen, 2016; Husgafvel et al., 2016). Circular business is also closely linked to enhanced information management practices and supporting digital solutions applied to monitoring performance, redefining maintenance requirements, and extending use cycles (Ellen MacArthur Foundation, 2016; Hanski & Valkokari, 2018; Ren et al., 2019). Furthermore, circular business is supported by sharing platforms that provide opportunities for increasing asset productivity by connecting asset owners with asset users (Ghisellini et al., 2016).

With the importance of information being acknowledged in CE business solutions, scholars have presented several CE business frameworks. For instance, Lieder and Rashid's (2016) CE implementation strategy model acknowledges the different levels, from micro to macro, of the CE business landscape and mentions information technology's role as an enabler for product life cycle thinking. Jabbour et al. (2019) integrate the use of large-scale data and the integration of different stakeholders in pursuing CE objectives. Ren et al. (2019) connect big data analytics in sustainable smart manufacturing and discuss the role of accurate information for decision-making. Lüdeke-Freund et al. (2019) propose six major CE business model patterns that have the potential to support the closing of resource flows but fail to look at information flows, such as where to get relevant information on developing a CE business model. Finally, Mendoza et al. (2017) present a framework for how to implement eco-design perspectives into CE business models and discuss information needs in the decision-making process.

The previously mentioned studies address information management aspects in specific contexts and hence do not aim to take a comprehensive view in examining current CE models, especially from an information flow management perspective. Finally, information is often discussed at a rather general level, instead of considering what specific type of information is needed, how it could be gathered, and how and with whom it should be shared.

Information circulation

Building on the literature, Figure 11.2 illustrates the process of information circulation. This process incorporates the creation of wisdom in business decision-making, with emphasis on the aspects related to data, information, knowledge, and wisdom (DIKW) (see Figure 11.2).

Data covers the values and observations from selected variables (Ackoff, 1989; Zack, 1999), such as a temperature or humidity value measured by a sensor in a manufacturing process.

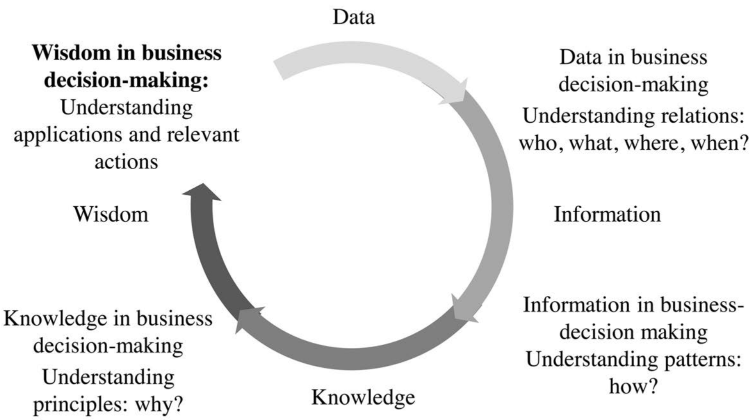

Figure 11.2 Developing wisdom in business decision-making.

Source: Adapted from Ackoff (1989).

Information is inferred from the data, meaning the data is transformed into a meaningful and useful form (Ackoff, 1989; Rowley, 2007), such as a manufacturing process efficiency trend or product failure rate. *Knowledge* is related to know-how and is the ability to interpret trends and put information into productive use (Ackoff, 1989; Kakabadse et al., 2003). For example, this can be the professional skill of understanding information that has developed over time. Last, *wisdom* is the ability to understand relevant alternative actions within the context and time, to compare them, consider the effects on stakeholders, and to make an optimal business decision by utilising the appropriate decision support tools (Kakabadse et al., 2003; Kunttu et al., 2016; Rowley, 2006).

To create wisdom and for a firm to remain competitive, it must effectively and efficiently generate, capture, analyse, and share information and knowledge (Hicks et al., 2002; Kakabadse et al., 2003). Knowledge creation refers to converting data to information and connecting pieces of information together. This information needs to be stored in a specific format, such as in databases or platforms, and leveraged to support business decision-making. For example, analysing resource usage data enables the identification of opportunities for increasing process efficiency or sharing materials with other firms. To remain competitive in complex, interdependent, and dynamic business environments, there is also a need for information and knowledge sharing at micro-, meso-, and macro-levels; making the knowledge available and distributing it internally (such as in maintenance activities) or externally between several organisations (e.g., recycling activities) (e.g., Hicks et al., 2002).

Methodology

The current study follows a design-oriented research approach (van Aken & Romme, 2009) aiming to develop a solution to an identified problem – here being the slow rate at which society has been transitioning towards a CE. Specifically, our objective is the development of a conceptual model that clarifies the relationship between information circulation and CE. Our assumption is that such a model could support organisations in their efforts to develop products, services, and production processes in a manner that is aligned with the well-known CE principles. In addition to earlier quantitative and qualitative studies, we argue that adopting a design-oriented approach would have considerable potential for further enriching scientific knowledge about the

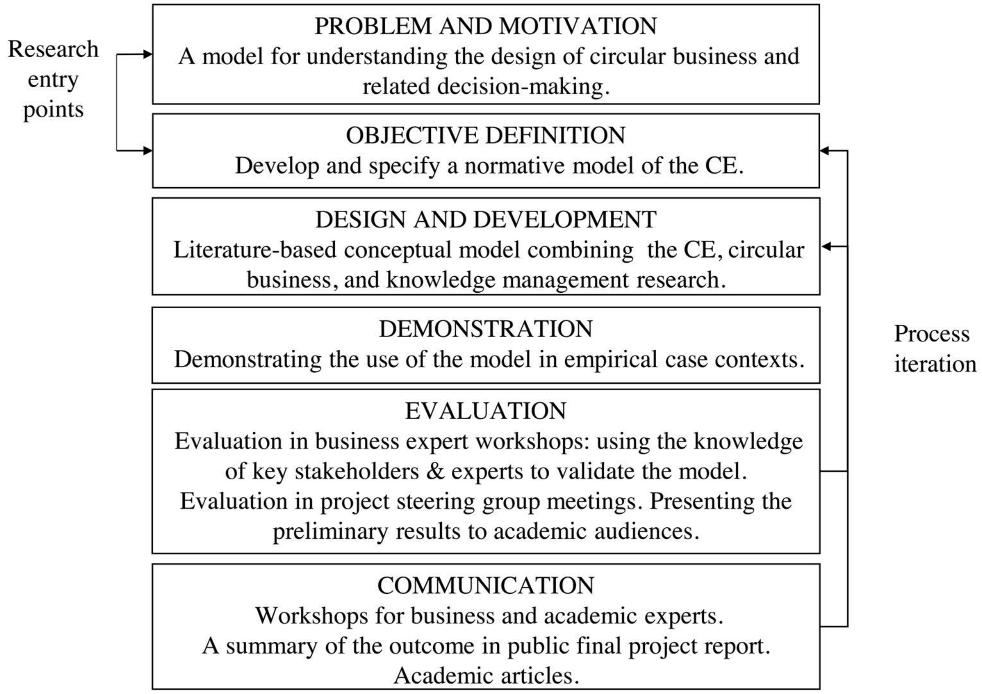

Figure 11.3 The flow of design-oriented research.

Source: Adapted from Peffers et al. (2007).

CE, while bringing the CE a step closer to practical application in organisations (Sein et al., 2011; Tanskanen et al., 2017). This approach is supported by the findings of Peffers et al. (2007), who reviewed multiple cases in which a design-oriented research approach was found to produce findings of high practical relevance and impact.

In this study, insights from earlier literature were combined with empirical research conducted over a 2.5-year research project focusing on the identification and description of the factors enabling the CE. Figure 11.3 describes the research process for design-oriented research (Peffers et al., 2007). The research began with familiarisation of the research context, then proceeded to bridge the conceptual environment and design science activities. This was followed by the design cycle, which included building and evaluating the research process and design artefacts. The research was finalised by a detailed consideration of the research limitations and connecting the findings with existing scientific knowledge and the experiences of practitioners (Hevner, 2007).

In the process of developing the artefact, the model, we drew upon existing literature on the CE, circular business design, and information and knowledge management. In the iterative development efforts that took place, we noted a lack of focus on information in the literature base. Therefore, emphasis was placed on identifying and achieving an in-depth understanding of the specific business contexts and challenges of the four firms involved in our research. We then sought access to case companies that would represent different industries, both process and project-based firms that serve both business and consumer customers, and hold established, stable positions in their market areas.

The four participating firms are as follows: BMH Technology, a provider of customised environmental technology solutions to industrial clients; Fortum HorsePower, a business unit of the energy company Fortum, which leverages synergies between horse stables, power plants, and logistics firms; Solita, an information solutions provider that serves its customers in creating value by sharing information; and UPM, a process industry firm specialised in producing high-quality products from renewable materials. Additionally, we selected a recent CE case from each firm for a detailed analysis. Next, we present the case descriptions

Case descriptions

BMH Technology is a globally operating, medium-sized firm providing its customers with complex fuel production and waste management systems, and services that include spare parts, life cycle maintenance, and modernisation. BMH's systems produce solid recovered fuel (SRF) from collected waste. SRF mainly consists of plastics after separation of other valuable materials, such as biowaste and metals. These technical and biological materials are reused and circulated back to the consumption system. This process results in SRF that is transported to power plants and converted to heat and electricity. As a service concept, SRF is based on the idea of providing an SRF production plant for waste management companies and collecting a monthly fee for delivering a certain capacity and amount of SRF to customers. When BMH operates the production plant, the use of SRF production assets is optimised, resulting in a longer life cycle for the assets.

Fortum is a large energy company offering its customers clean energy solutions, including electricity, heating, and cooling to improve resource efficiency. The HorsePower business concept is based on the idea of linking material flows across forest, farming, and energy industries. Sawdust, a by-product of the forest industry, is delivered to horse stables for use as a bedding material, where it gradually becomes covered by and combined with horse manure. The resulting material is then retrieved as part of Fortum's waste management service and delivered to power and heating plants; it is then utilised as bio-based fuel material in energy and heat production. Combustion ash, a side stream of energy production, is further utilised as forest fertilizer and in civil engineering.

Solita is a medium-sized digital business consultancy firm. The company provides a variety of services, including enterprise architecture, service design, e-commerce, analytics, business intelligence, and cloud services. One of Solita's customers is Amer Sports, a provider of consumer market sporting goods. The Amer Sports information platform, developed in collaboration with Solita and Amer Sports, connects the production, sales, retailers, and users of sport watches, providing real-time sales forecasts for production, sales, and retailers. Through a platform, the increased transparency and predictability of the sales of certain types of watches in certain locations translates into an optimised number of specific products to be manufactured. This optimisation, in turn, results in decreased material costs and waste, reduced storage costs, avoidance of sales loss, and avoidance of costs related to preparing sales forecasts. This solution is an example of using sharing platforms to enhance the sustainability and resource efficiency of consumer markets.

UPM is a large, globally operating company in the bio and forest industries. UPM produces a variety of products, including biofuels, biocomposites, biochemicals, paper, and pulp. The concept of refurbishing and reusing equipment and components is linked to UPM's strong focus on life cycle thinking and the urge to seek operating efficiency through effective maintenance and asset management. The concept is based on the idea that the circulation of technical materials exploits the economic value committed to the equipment and components in EOL pulp and paper plants. The technical cycle includes actors such as UPM's reuse function as well as internal and external clients. CE principles are addressed through the lifetime extension of components and equipment, although the materials for unwanted devices are recycled. The desired components and equipment are collected from the EOL plants and refurbished when necessary. After this, they are sold to internal and external customers.

Data collection and model development

In the four firms, 36 semistructured interviews were carried out with senior members of the organisation involved in the development of CE initiatives. The interviewees represented different functions (e.g., sales, technology, services, R&D) and levels (e.g., workers, managers, directors) of the studied organisations. The role of the ensuing workshops was to jointly develop and evaluate specific CE concepts, plan their implementation, and discuss the experiences from piloting concepts with clients. An early version of the model was tested and further developed during project steering group meetings and workshops held between 2016 and 2019 in close collaboration with representatives of the case companies, project members, and research organisations. Table 11.1 describes the role of different data sources in the research process.

The analysis was cyclical and inductive in nature (Locke, 2007) and followed the principles of data triangulation (Jick, 1979). The authors facilitated the workshops and steering group meetings, and two researchers took detailed notes of the discussions. In addition, memorandums describing initial interpretations were produced after workshop debriefings. The summaries of the produced reports and other results were provided for participant validation, and the preliminary findings were reviewed and discussed among the research team. Furthermore, the principles of the model were presented to academics in research conferences for review and to attract ideas for further development.

Information – A catalyst for CE

Drawing on CE, circular business, and knowledge management perspectives, Figure 11.4 is a model describing how the circulation of information supports technical and biological cycles, working as a catalyst for CE. This model emphasises the data, information, knowledge and wisdom hierarchy, and the hierarchy's relations that enable circular business. The following discussion explains this figure in more detail.

As illustrated in Figure 11.4, much as in biological and technical cycles, information circulation can take place within a small circle of actors, such as within an organisation's business unit, or can include multiple actors across society. When moving from micro to the meso- and macro-levels, an increasing amount of effort is required to transform data into wisdom. At a minimum, data and information are generated, captured, analysed, and shared inside an organisation to create knowledge that is utilised in business decision-making; for example, the acquired knowledge is used to seize business opportunities or to utilise production process waste. This type of micro-level, intra-firm information circulation such as information about the condition of the production assets, can take place across the whole organisation or between smaller groups or business units.

The second level in our model places attention on information circulation among multiple network actors. For example, a mine operator collects information on the production process efficiency and technical condition of equipment, such as pumps and reactor vessels. If this information is shared with another firm that provides maintenance services, the service provider may be able to detect problems with the customer's equipment before a serious malfunction occurs, thus being able to offer pre-emptive maintenance services that help the customer lengthen the

Table 11.1 Information about the workshops and meetings

Data source	*Purpose*	*Information*
36 semistructured interviews in autumn 2016 and spring 2017	1 Identification of circular business challenges 2 Motivation for the research	45 informants from 4 case companies
9 project steering group meetings • 2 in 2016 • 2 in 2017 • 4 in 2018 • 1 in 2019	Results (preliminary): review and feedback	10–14 participants in each meeting: • 4 company representatives • 6–9 academic representatives • 1 facilitator
3 expert workshops 2016–2018 15 company workshops 2016–2018 2 expert workshops with a co-research project	1 Review of circular business challenges 2 Model assessment Results: review and feedback	10–14 participants in each workshop: • 4 company representatives • 6–9 academic representatives • 1 facilitator 3–10 case company members 20–23 participants in both workshops • 7–9 company representatives • 9–12 academic representatives • 2 facilitators
8 academic conferences • 2016, Luleå, Sweden • 2017: Tampere, Finland; Lappeenranta, Finland; Melbourne, Australia; Oregon, USA • 2018: Stavanger, Norway; Fukuoka, Japan; Bangkok, Thailand	Preliminary research validation and communication	International academic and managerial audiences
1 public research seminar (January 2019)	Communication and validation of results	National academic and managerial audience

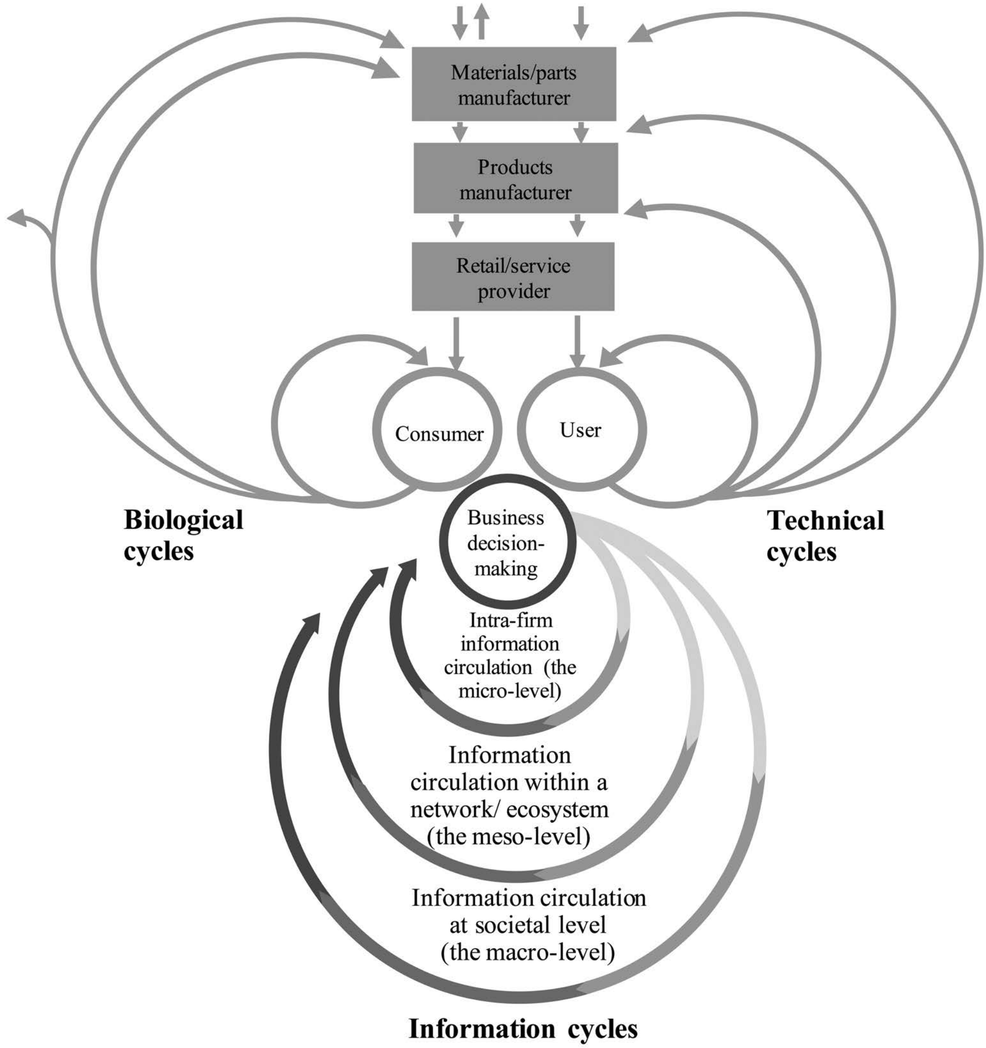

Figure 11.4 Circulation of information enabling CE.

life span of costly equipment and avoid production stoppages. At this level, managing the practices for information sharing and distribution are especially crucial, as problems related to data ownership, security, governance, and distribution channels often exist and require remediation.

The third level of our model addresses the societal level. This is the largest level in which the DIKW process involves multiple actors, including from business, academic, and governmental levels. For instance, producing energy from waste requires enabling legislation on both a national and global level, for example EU regulations, hence the need for actors at different levels to share and process information effectively is increased. By adding the institutional and social dimension to CE models, companies face increased pressure to obtain relevant information at the societal level. In addition, to feed valuable materials back into circulation, the public may require education on how and why to recycle the materials correctly.

Empirical illustrations of information as a catalyst for CE

The designed model was tested and further developed in close collaboration with the four firms. In this chapter, the information dimension is illustrated by the case companies. Table 11.2 provides a summary of information circulation at different levels within the cases.

BMH technology: Solid recovered fuel as a service

BMH acts as a central information node that captures information concerning end users, waste management companies, power plants, and their various requirements and expectations. Internally, data and information about the composition and amount of waste is crucial for the optimisation of production systems and for the quality of service delivery to waste management companies. Externally, detailed information is required about the materials separated from the waste to be shared with external recyclers that reuse and deliver them back in different forms. Furthermore, waste management companies hold information about multiple phases of logistics (e.g., delivery and collection times, locations, and available vehicles) that is vital in delivering the

Table 11.2 A summary of the information circulation identified in the case studies

	Information circulation within firms	*Information circulation within a network of firms*	*Information circulation at the societal level*
BMH Technology: Solid recovered fuel as a service	Intraorganisational information exchange to optimise the production process and promote the new business concept	Interorganisational information exchange to promote the service concept to customers and orchestrate the network	• Sharing the best practices across nations with different cultural and political contexts • Convincing traditional industries of the possibilities to utilise waste as a resource
Fortum HorsePower	Intraorganisational information exchange about the requirements for equipment and the composition of horse manure to be used in the development of biofuel	Interorganisational information exchange to enable the utilisation of material flows across industries	• Advancing political decision-making by an information exchange among organisations, academia, and authorities • Supporting wider structural and system-level shifts towards the CE
Solita: Amer Sports information platform	Intraorganisational information exchange to improve process optimisation and increase material efficiency	Utilising end-user data to provide demand forecasts and orchestrate the network	Highlighting the potential of both digitalisation and platforms as enablers of circular business development
UPM: The refurbishment and reuse of equipment and components	Intraorganisational information collection and exchange of equipment-related data to recognise opportunities for reuse	Interorganisational information exchange to evaluate the reuse possibilities of different equipment and components	• Recognising the possibilities for the reuse of equipment and components across industrial and national borders • Sharing best practices

waste and SRF to the right places at the right times. In the end, to orchestrate the network and apply this type of service concept in a traditional industry requires wisdom on the part of BMH. This CE concept requires the understanding of different actors and their needs and the capabilities to process different types of data and information flows and transform them into knowledge used in decision making. The whole business model of SRF as a service can be considered as new, especially for the waste management businesses; therefore, the model would transform the entire business logic among the companies involved. Finally, international collaboration and information sharing are needed to convince different societies and traditional industries of the possibilities of utilising waste as a resource. Depending on the country and the market, waste is not always considered a valuable energy source and is not always even permitted to be used in the generation of energy. In these societies, active information sharing between actors and policymakers about the possibilities of utilising SRF as an energy source would be required.

Fortum HorsePower

At HorsePower, information is circulated between different actors (e.g., authorities, customers, service partners, suppliers). Fortum analyses and summarises this information to understand the patterns and relationships. As such, HorsePower works as an information platform that integrates multiple data sources from multiple actors and then transforms this into knowledge that can be used in business decision-making. For example, forest industry companies have information about properties of available material. This information is combined with additional data on the volume and type of requested material and the pick-up times. Stables possess information about the amount of horse manure, the required needs for bedding material, and operational performance; they require information about the availability of bedding material and reliability of the material delivery and pick-up, as well as the price of the waste management service. Based on calculations related to the information about the amount and exact physical characteristics of the composition of the delivered manure (e.g., the moisture percentage), plant operators can optimise their processes in a manner that ensures an efficient burn process that fulfils environmental regulations and site-specific permits. Logistics service partners have information about the available vehicles and estimates for delivery times but require logistics-related data, such as the weight, size, characteristics of delivery, collection/delivery time, and destination. Fortum combines all the data from the actors with regulatory and energy price information. All the data needs to be analysed to create an understanding of the relationships and information needs among different actors and to transfer this information into wisdom to be used in business decision-making; one goal is to optimise the complex logistics puzzle and thus keep costs under control.

Circulating information among organisations, academia, and authorities is needed to advance political decision-making to support the wider structural and system-level shift towards CE. This allows for so-called ‘matchmaking activities’, where one person’s waste is another person’s treasure. Furthermore, allowing the utilisation of waste materials such as horse manure as an energy source not only provides possible solutions to waste management challenges, but it also creates new opportunities for innovations within various industries.

Solita: The Amer Sports information platform

At Solita, the aim of information circulation is to manage data and information from various sources, including consumers, production, sales, and retailers. The information platform serves as a tool for managing the network of suppliers, connecting data on activated products by users, transforming this data into on-demand information for specific products in specific markets, and further transforming this data into knowledge on how to plan production and optimally respond to the demand. In addition, the availability of information on specific products is important from the deliveries and sales perspectives. The solution produces more accurate demand forecasts throughout the value chain, which can be further transformed into the wisdom to understand applications and relevant actions, such as the wisdom to orchestrate the network and utilise the possibilities for reverse logistics by combining the different information sources. The success of the solution depends on the quality of data, the accuracy of analytics solutions in forecasting the demand, and combining and sharing the forecasting-related information in a suitable format with production, sales, and retailers. Across different industries and contexts, the business concept highlights the potential of digitalisation and platforms as the enablers of a circular business. Connecting real-time information with the key actors in the business network as presented in this case is highly transferable to other business-to-consumer sectors (e.g., textiles and consumer electronics) to provide similar benefits at a societal level. Therefore, the information platform has the potential to considerably increase the sustainability of consumer-to-business sectors by decreasing their material, energy, and waste footprints.

UPM: The refurbishment and reuse of equipment and components

Information circulation focuses on basic equipment and components-related information from the EOL plants and the equipment demand and criticality information. UPM acts as a central node regarding the availability of information related to reusable components and equipment. This data is combined with the criticality analyses of different equipment and customer demands, enabling the creation of knowledge and wisdom with which to make decisions regarding the reuse of installed equipment. This is important for customers, especially when planning larger renovations or replacement investments. When the component is in reuse, operational data is collected and transferred into knowledge and wisdom to support the decision-making related to continuous improvements and to take advantage of potential further reuse possibilities. This results in more sustainable use of the used components and equipment. The solution depends on connecting the pieces of data from various sources, translating this data into information and knowledge, and sharing this internally with different network actors. Furthermore, translating this knowledge into wisdom means the creation of expertise in evaluating the reuse possibilities of the different components used by different customers and operating environments. Creating a transparent market of EOL equipment and components would be a major step forward for enhancing the sustainability of asset-intensive sectors such as the pulp and paper industry. The concept is also transferable to other asset-intensive sectors such as heavy machinery, mining, water, sewage, and electricity networks to provide more extensive societal-level sustainability impact. Extending the life cycle of these assets reduces their carbon and material footprint and is also a viable business for firms.

Discussion

The current study contributes to the CE literature by discussing the information as a catalyst for CE. Previous research on CE has mainly examined business concepts through biological and technical material cycles (Braungart & McDonough, 2002; Ellen MacArthur Foundation, 2013), but recently, the role of information has also been increasingly noticed as a crucial factor contributing to the success of these concepts (e.g., Despeisse et al., 2017; Jäger-Roschko & Petersen, 2022; Marra et al., 2018; Wiener et al., 2018; Winans et al., 2017). For instance, the use of data, information technologies, and emerging platforms has the potential to renew value creation logics, enable increases in resource efficiency, and discover new types of cross-sectoral business models by facilitating multidisciplinary information sharing and promoting collaboration (e.g., Aminoff & Kettunen, 2016; Ellen MacArthur Foundation, 2016; Ghisellini et al., 2015; Husgafvel et al., 2016; Tura et al., 2019).

The developed model sheds additional light on the different stages of information circulation, moving from understanding the data and information to transforming these into the knowledge and wisdom required to understand applications and the relevant actions required for making decisions regarding circular business solutions. The current study stresses the importance of the DIKW cycle (Ackoff, 1989) and knowledge management practices (Kakabadse et al., 2003) in circulating information from various sources and within different levels of actors in circular business development. To understand what kind of knowledge and wisdom can be created and what is needed often requires an understanding of what data and information flows exist and what their relationships to each other are (Rowley, 2007). As the case studies showed, data inputs assume different forms (e.g., information about processes, products, resources, needs and requirements) depending on the business concept. Some concepts require detailed information about a firm's internal processes and production equipment, as in UPM's case, while others expand outside the focal company's boundaries and consider the various needs of the network actors, as in Fortum's HorsePower and BMH's SRF as a service. In addition, different types of information pose different challenges for the required technologies and managing actions. The solutions can be centred on data, information concerning production processes, or information describing the status or condition of the production equipment. In other cases, orchestrating the whole network of actors requires deeper knowledge and the creation of wisdom regarding the needs of different actors, or how to apply new CE concepts to traditional ways of working.

In addition, the model for information use that is presented in this chapter emphasises the different levels of information circulation: the intra-firm level, which enables operational optimisation; network-level circulation, which facilitates multidisciplinary business development; and societal-level circulation, which supports wider system-level change towards the CE. As observed in the four case studies, although information circulation happens at the micro- or meso-levels, many CE solutions also have the potential to support the wider system-level shift towards CE, which has previously been acknowledged to be important in the achievement of sustainable development goals (cf. Korhonen et al., 2018; Schroeder et al., 2019). Thus, information works as an important catalyst in the on-going sustainability transition. However, further development calls for more concrete actions for information circulation to be made by different actors within a society, including local, national, and international authorities, academics, and business actors across industry boundaries. As previous studies show, unclear information management practices and a lack of methods and platforms can hinder the development of a CE business (e.g., Tura et al., 2019). Geng et al. (2019) argue that globalising CE requires the conservation of resources and energy, requiring the establishment of a global database to capture the trends and links between resource uses, and the development of a platform to share knowledge and experiences to both learn about CE and to coordinate industrial policies and trade.

It can be concluded that to circulate scarce materials, information needs to circulate as well; circulation may be a prerequisite for biological and technical material circulation. By generating, capturing, analysing, and sharing the DIKW, CE solutions can focus either on improving the efficiency of existing cycles or discovering entirely new cycles. Applying the developed model for empirical cases not only helped in specifying the most crucial information sources and related actions, but also highlighted the potential links with which to utilise the created knowledge and wisdom to enhance wider CE development.

As is the case with all research, our research has its limitations. As a methodological approach, design-oriented research is usually relatively context-specific. To enhance the generalisability, the developed model was tested in close collaboration with various actors from business and academia. However, developing and testing the model in other contexts is suggested. It has not yet been empirically explored how the type of business (e.g., a manufacturing or project-based business) affects the need to process information across different levels and what type of information is needed in various CE concepts. This chapter has predominantly focused on the role of information as an enabler of CE solutions. However, information-based solutions have their own extensive carbon, energy, and material footprints (e.g., Eerola et al., 2021).

Managing and refining information flows requires infrastructure and specialised competencies that can be expensive and difficult to obtain. Therefore, when designing CE solutions, firms should always consider the necessity and extent of collecting and analysing information to produce and maintain the solution. In addition, public and private organisations have somewhat different motivations and needs when it comes to implementing CE practices, and the availability and transparency of the information differs across these contexts.

Although the DIKW hierarchy has been widely used, it has been criticised for its oversimplification of the process of transforming data and information into knowledge and wisdom (Frické, 2019). Criticism has been directed at knowledge and wisdom being ‘filtered’ from information and data instead of resulting from a far more complex social, goal-driven, contextual, and culturally bound process (Weinberger, 2010). The criticism of the DIKW model was considered when developing this chapter’s model, which accentuates the importance of collecting and refining data according to specific business needs to enable a CE business.

Although information was acknowledged to be based also on human resources, many of the studied concepts were based on considering information circulation regarding technical processes, products, and equipment. Thus, following Clube and Tennant (2020), future studies could focus more closely on examining the circulation of knowledge and its impacts on circular business development. Also, because many CE solutions are currently established at the intra-firm or network level, further studies could examine the requirements of information circulation at the societal level. The creation of circular solutions on a wider societal level necessitates the creation of mutually beneficial business relationships within heterogeneous networks of business actors, as well as relationships with nonbusiness actors.

Conclusion

The present study illustrated that information plays a crucial role as a catalyst in the development of a new circular business. To increase the rate at which societies are gradually transitioning towards CE, the role of information as an enabler for CE was discussed, complementing the previously emphasised biological and technical dimensions. CE solutions leveraging information may focus either on improving the efficiency of existing material flows or discovering entirely new opportunities for value creation. Information flows in CE solutions may relate, for example, to the condition of assets, the composition of material flows, relevant partners, and stakeholders. Including the role of information more closely in the research and design of CE models shows the potential for the development of more impactful circular business solutions at the firm, network, and societal levels. Thus, it promotes not only firm-level efficiency improvements, but also the development of multidisciplinary circular business, and provides support for wider structural and system-level shifts of economies towards CE.

Educational content

Information plays a crucial role as a catalyst in the development of a new circular business. How should the current CE model be revised?

Including the information more closely in the research and design of CE models is crucial in increasing the impact of circular business solutions at the firm, network, and societal levels. How can information support the research and design activities within these levels?

How can information circulation promote efficiency improvements, the development of multi-disciplinary circular business, and support wider structural and system-level shifts of economies towards CE?

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