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Smart-circular systems: a service business model perspective

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Abstract
The Internet of Things and the amplified capabilities of smart products can be increasingly utilised for the development of feedback-rich systems and loops throughout the entire product life cycle. By adopting the IoT and collecting data during product utilisation, companies can replace the end-of-life concept with product life extension and circular loops. In this sense, service business models hold the greatest potential to optimise the utilisation of goods over time. These models allow a reduction of the overall life cycle costs and contribute to resource-efficiency and the transition towards a circular economy. This paper introduces the concept of smart-circular systems that reflects the interplay between the Internet of Things, the circular economy and service business models and presents a conceptual framework for further empirical analysis of this phenomenon. The framework focuses on product-service systems and more broadly on services business models that optimise the utilisation of goods over time through the amplification of circular activities by the introduction of smart enablers. It also considers three main business models types and tactics for successful implementation of service business models.

Introduction

Two concepts have recently attracted the attention of scholars and practitioners: the circular economy (CE) (Ghisellini, Cialani, & Ulgiati, 2016) and the Internet of Things (IoT) (Porter & Heppelmann, 2014, 2015). The CE has been proposed as an alternative to replace the current linear economic system of production that implies significant loses of value, higher materials risks and negative effects for the environment (EMF, 2013). The adoption of the IoT brings about a new set of opportunities among practitioners for replacing the end-of-life with CE concepts like maintenance, reuse, repair, remanufacturing, and recycling loops. The capabilities of smart products, such as the possibility to monitor and report their own condition and environment (Porter & Heppelmann, 2015), are unlocking new ways of value creation by enabling information gathering and analysis after the product has left the production facility or distribution centre (EMF, 2016). Service business models (SBM) are a growing trend among practitioners and researchers and have great potential towards sustainable resource use and a CE (Stahel, 2016), but most companies struggle to successfully design and implement SBM. Hence, this research investigates the emergent opportunities to design and implement circular SBM considering the interplay between the IoT and the CE. This research address the following question: What is the role of the IoT in developing and implementing circular SBM? Given that this research is still in an early stage, the aim of this paper is to develop a (preliminary) conceptual framework based on an integrated literature review (which shall serve as the basis for qualitative empirical analysis in future steps).

Literature Review

The Circular Economy

The CE is an emerging topic that is receiving increased attention from scholars, policymakers and practitioners (Bocken, Pauw, Bakker, & van der Grinten, 2016; Geissdoerfer, Savaget, Bocken, & Hultink, 2017; Ghisellini et al., 2016; Lieder & Rashid, 2016). The CE is viewed as a solution for several environmental impacts of industrial societies and business-as-usual economic systems such as the rising scarcity and price volatility of natural resources, environmental pollution, and waste generation (Ghisellini et al., 2016; Lieder & Rashid, 2016). The concept of the CE has been evolving and integrates concepts and constructs from several disciplines like industrial ecology, environmental science, business managements, supply chain management, among others (Lieder & Rashid, 2016). The approach harmonizes different schools of thought through the shared idea of closed loops for extending or closing the product life cycle (Geissdoerfer et al., 2017) and includes activities like maintenance, reuse, repair, remanufacture and recycling (EMF, 2013). A prominent understanding of the CE has been framed by the Ellen MacArthur Foundation, introducing it is as "an industrial system that is restorative or regenerative by intention and design" (EMF, 2013, p. 7).

The Internet of Things

We are currently confronted with the convergence of a set of technologies that emphasize the interaction among objects through the internet beyond traditional objects like personal computers, servers and smartphones (Li, Xu, & Zhao, 2015; Mishra, Gunasekaran, Childe, Papadopoulos, & Wamba, 2016). The IoT, or "the networked connection of physical objects" (EMF, 2016, p. 15), refers to everyday objects like washing machines, cars or doors and any kind of industrial machinery like cranes, engines or pumps that are equipped with a variety of identifying, sensing, networking and processing technologies. These new capabilities allow objects and products to process data and information, to communicate with other devices over the internet and to even automatically actuate according to specific purposes (Whitmore, Agarwal, & Xu, 2015). Smart components not only amplify the capabilities and value of physical products, but they bring about a fusion of the digital and physical world. Some of these capabilities even exist outside the physical product itself in a digital form or what is known as the product cloud (Porter & Heppelmann, 2014).

One of the advantages of physical and digital components is their flexibility. Different components can be embedded and developed into products according to the additional value the organisation wants to offer to the market (Noll, Zisler, Neuburger, Eberspächer, & Dowling, 2016). The resulting "smart product" (Novales, Simonovich, & Mocker, 2016, p. 3) is built with a specific set of technological building blocks (e.g., Noll et al., 2016) or *smart enablers* that amplify its physical capabilities, add new value (Noll et al., 2016; Porter & Heppelmann, 2014) and enable the implementation of circular activities. Smart enablers can be divided in physical components, digital components and technological services. Table 1 provides a list of selected smart enablers.

Service Business Models

Research on the CE has focused on environmental issues and resource scarcity while disregarding business and economic perspectives (Lieder & Rashid, 2016). Additionally, advances in technological, material and production capabilities are carried out incrementally, while the design and implementation of radical solutions through new business models is seen as a key pathway for disruptive transformation towards a CE (Geissdoerfer et al., 2017; Lieder & Rashid, 2016). The business model concept refers to the "design or architecture of the value creation, delivery, and capture mechanisms" of a firm (Teece, 2010, p. 172) and can be deliberately extended to consider wider social and environmental issues (Schaltegger, Hansen, & Lüdeke-Freund, 2016). Moreover, the business model is a key lever to address life cycle improvements in innovation management (Hansen, Grosse-Dunkler, & Reichwald, 2009), which enables the implementation of circular activities along the whole life cycle.

Smart Enablers	
Physical	Sensors Actuators Wearables Hardware (in general)
Digital	Mobile Applications Platforms Software (in general)
Technological Services	Location Tracking Wireless Connectivity Storage Services Data Analytics Condition Monitoring (status, availability) Remote Usage and Control Intelligent Robotics Virtual/Augmented Reality

Table 1. Smart Enablers

In contrast to product and product-oriented business models, SBM hold the greatest potential to generate positive environmental benefits and contribute to resource-efficiency and the CE (Tukker, 2004, 2015). They can lead to: (1) a higher use rate of capital goods, (2) a design that accounts for true life cycle costs to optimize energy and consumables, (3) less use of energy in the use phase, (4) efficiency gains due to economies of scale and (5) application of radically different technologies (Tukker, 2004). SBM also decouple value creation from resource throughput, allowing continued ownership and zero transaction costs, a reduction of the overall life cycle costs, a preservation of value over time and job creation (Stahel, 2010, 2016). Both, Tukker (2004) and Stahel (2010) identify different SBM (rental, leasing, sharing, outsourcing, functional result, among others) that emerge out of the efficient utilisation of goods and resources. Such SBM require the implementation of product life cycle extension strategies (producing long-life products, reusing, repairing, remanufacturing, upgrading and recycling) and offer profitable opportunities for innovative firms (Stahel, 2010).

Operational-level tactics has been recognized as being central for ensuring successful implementation of SBM (Reim, Parida, & Örtqvist, 2015), because many companies struggle to engage in SBM (Huikkola, Kohtamäki, & Rabetino, 2016; Reim et al., 2015; Tukker, 2015). Tactics are understood as residual choices at an operational level after the firm has chosen a particular business model through which it intends to compete (Casadesus-Masanell & Ricart, 2010). There is a range of tactical sets available to the firm according to the business model it has chosen (Reim et al., 2015). After a literature review, Reim et al. (2015) identified five influential tactics for implementing SBM: (1) contracts, (2) marketing, (3) networks, (4) product/service design and (5) sustainability. However, this list is not complete and a more comprehensive list of tactics based in empirical data is required. In addition, the interaction between these tactics and the different internal and external conditions can have an important influence in the success of the implementation of SBM.

A preliminary framework for a business model perspective on smart-circular systems

Smart-circular systems

According to Lieder and Rashid (2016), technological developments seem sufficiently mature to support the implementation of the CE at large scale. As the usage of the IoT grows, the capabilities of smart products, such as monitoring and reporting their own condition and environment (Porter & Heppelmann, 2015), can be increasingly utilised to allow for the development of feedback-rich systems and loops throughout the entire product life cycle (EMF, 2016). Smart products and digital tools enable better performance monitoring, data-driven design, and an extension of the product life cycle. They also remove barriers and offer the infrastructure to keep materials in circulation (EMF, 2016). For example, by assigning a unique identifier to smart products, companies are able to collect data during product utilisation, allowing for IoT-enabled full life product traceability (Whitmore et al., 2015). Moreover, smart products could adopt the characteristics of software products (Porter & Heppelmann, 2015) and be dynamically adapted or upgraded during the use phase according to new developments, user needs or the natural environment (Erler & Rieger, 2016). From this perspective, products change from something that is sequentially developed, manufactured and used into something that is dynamic and evolving (Erler & Rieger, 2016).

In order to better understand and conceptualize the scope of the transition of the industrial economy to a CE in the light of the emergence of smart products and the IoT, the authors introduce the concept of **smart-circular systems** (Figure 1). Smart-circular systems refer to product-service systems (PSS) (Tukker, 2004) and SBM that optimise the utilisation of smart products over time by introducing smart enablers that amplify circular activities like maintenance, reuse, repair, remanufacture and recycle.

Business models for smart-circular systems

Smart products and their amplified capabilities are reshaping the way value is created and enabling organisations to develop and offer new SBM (Lerch & Gotsch, 2015; Porter & Heppelmann, 2014, 2015). Their ability to remain connected and generate product life cycle data has led manufacturing and industrial companies to shift to SBM in order to maximize the value they provide to customers over time (Porter & Heppelmann, 2015). Companies like Caterpillar have begun to offer services like predictive maintenance powered by IoT and big data analysis (Marr, 2017).

Smart capabilities and the IoT can also expand the boundaries of an industry (Porter & Heppelmann, 2014). Companies are now offering a "set of related products that together meet a broader underlying need" (Porter & Heppelmann, 2014, p. 13). Therefore, the business model transits from offering products and a minimal number of services to offering a bundle of smart products and services (Lerch & Gotsch, 2015; Porter & Heppelmann, 2014) or smart PSS (Valencia, Mugge, Schoormans, & Schifferstein, 2015). In this sense, smart products and the IoT emerge as what might be the missing link in the widespread development and adoption of circular SBM. Moreover, moving from products towards "total system performance" (Porter & Heppelmann, 2014, p. 14) expands the scope of the business model towards an economy based in services or a "performance economy" (Stahel, 2016, p. 436) where the focus of the business model changes from production to utilisation (and end-of-life) of goods over time. The expansion of the traditional business model focus allows for a classification of distinctive business models types: (a) Product sales with quality services (traditional business model), (b) use-oriented business models and (c) performance-oriented business models (cf. Tukker, 2004) that can be linked to specific operational-level tactics to facilitate the design and implementation of SBM among practitioners.

Conclusions

This paper contributes to the body of knowledge by providing with a conceptual framework that establishes generic links between the IoT, the CE and SBM and serves as basis for further analysis of this emergent phenomenon. We also introduced the concept of smart-circular systems to highlight the interplay of these concepts in the transition towards a CE.

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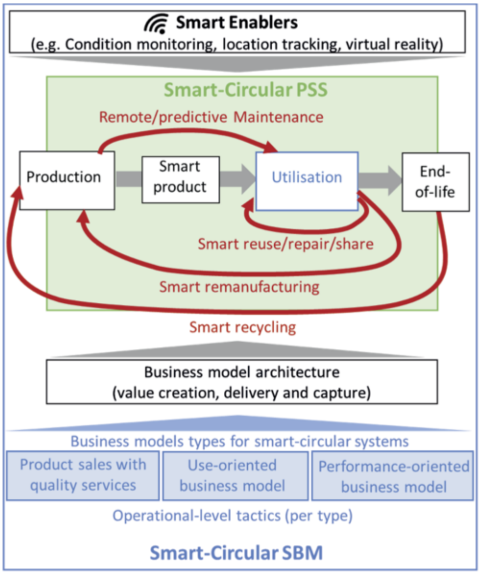

Figure 1. Smart-circular systems

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