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Circular Economy in the building sector: Three cases and a collaboration tool

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ABSTRACT

The Circular Economy (CE) gained significant traction in business and academia. While in the building sector issues around energy efficiency are being widely explored, CE is still a relatively new topic. This article reports on three CE pilots in the Dutch building sector and develops a collaboration tool for developing and operating circular buildings and their supply chain collaborations. First, a conceptual framework is developed to study supply chain collaboration in circular buildings, which uses theoretical building blocks for visions, actor learning, network dynamics and business model innovation. Second, a case study is presented where the framework is applied to three cases using semi-structured interviews and document analysis. Third, an empirically-based tool is developed to enhance collaboration for CE in the building sector. The cases include a newly built project, a renovation project and a demolition project. It was found that developing circular buildings requires (i) a new process design where a variety of disciplines in the supply chain is integrated upfront, (ii) the co-creation of an ambitious vision, (iii) extension of responsibilities to actors along the entire building supply chain, and (iv) new business and ownership models.

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1. Introduction

The concept of the Circular Economy (CE) is proposed to change current production and consumption patterns that put a significant burden on our planet and its environmental capacity. This requires not only closing loops by reusing 'waste' and resources, but also slowing material loops by developing long lasting reusable products (e.g. Bocken et al., 2016; EMF, 2012; Kok et al., 2013). The concept of a circular economy goes back to Boulding (1966) who wrote about a *"Cyclical ecological system which is capable of continuous reproduction of material form even though it cannot escape having inputs of energy"* (Boulding, 1966, p. 8). Other scholars (Andersen, 2007; Greyson, 2007; Jackson et al., 2014) trace the CE concept back to Pearce and Turner (1989) who worked on a model for a CE. The concept is rooted in Industrial Ecology (IE), which focuses on analyzing and optimizing industrial systems (e.g. Graedel and Allenby, 1995; Stahel, 1994) and developing a new economic model of production and consumption with closed material loops (Ghisellini et al., 2016; Yuan et al., 2006; Zhu et al., 2011). Cradle to Cradle® (C2C) also links to the CE in its biomimetic approach to the design of products and systems, where biological and technical material cycles are separated (McDonough and Braungart, 2002). Recently, the concept of CE gained ground thanks to the Ellen MacArthur Foundation (EMF) who published a series of reports (EMF, 2012, 2013, 2014) promoting the opportunities of a CE. Several definitions of the CE have been proposed, but in this paper we build upon the EMF definition (EMF, 2013) that has been widely adopted by industry, government and academia: *"A Circular Economy is an economic and industrial system where material loops are closed and slowed and value creation is aimed for at every chain in the system"*.

Whereas the concept of CE is getting global momentum in politics, business and academia, the knowledge and tools for bringing it into practice still largely need to be developed (Bocken et al., 2017; Lacy and Rutqvist, 2015). This is especially true for the building sector, where innovation diffuses rather slowly (BIS, 2013;

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Fernie et al., 2006), and where the focus has been on issues like energy use and energy efficiency (Lucon et al., 2014). Indeed, according to the IPCC (Lucon et al., 2014), buildings accounted for 32% of total global final energy use in 2010. Moreover, the building industry consumes 40% of the materials entering the global economy (Khasreen et al., 2009), while only an estimated 20–30% of these materials are recycled or reused at the end of life of a building (EMF, 2014). With an increasing population, there is a dual need for quality retrofitting and sustainable new construction (Lucon et al., 2014). In view of these challenges, many stakeholders regard the CE concept as an important step to create more financial, social and environmental value by taking a systemic view on the whole life cycle of buildings and by using new technologies and design approaches. This enables to move away from a 'take-make-dispose' paradigm to a circular perspective on material reuse (ARUP and BAM, 2017; Pomponi and Moncaster, 2017).

This paper investigates the built environment as a key contributor to problems like resource depletion, climate change and pollution (Van Bueren, 2012). Circular principles can reduce the environmental impact of buildings significantly (Circle Economy et al., 2014; Smol et al., 2015). The building and construction sector is one of the five priority sectors in the European CE package (Bourguignon, 2016). Based on the previous discussion, as well as on strategies and principles defined by Lacy and Rutqvist (2015) and Circle Economy et al. (2014) we define the CE approach for (circular) buildings as *"A lifecycle approach that optimizes the buildings' useful lifetime, integrating the end-of-life phase in the design and uses new ownership models where materials are only temporarily stored in the building that acts as a material bank"*. This definition is more extensive than the one by Pomponi and Moncaster (2017, p. 711) who define a circular building as *"a building that is designed, planned, built, operated, maintained, and deconstructed in a manner consistent with CE principles"*.

This paper emphasizes supply chain collaboration across the entire lifetime of buildings from design to end-of-life. When closing and slowing material loops, it is essential to include the supply chain as a whole, and to involve all parties from design and raw material suppliers to end users, service providers and recyclers, including the associated information flows (Seuring and Müller, 2008). Social relationships and collaboration between supply chain partners are considered key to creating closed loop supply chains (Bocken et al., 2016; Green and Randles, 2006; Lai et al., 2010), and need to be taken into account for a transition towards CE (Genovese et al., 2017; Ghisellini et al., 2016). Based on the concept of sustainable supply chain management and definitions by EMF (EMF, 2013) and Lacy and Rutqvist (2015) we define CE in supply chain collaboration as *"connecting a network of actors in their supply chain by managing data transparency, material flows and exchanges, responsibilities, predictability and sharing benefits"*. This goes beyond the concept of reverse and closed loop supply chains (Genovese et al., 2017; Guide and Van Wassenhove, 2002) by taking a strategic perspective on the new role of organizations to redevelop supply chains through collaboration to close and to slow down resource loops.

This paper uses insights from innovation studies and supply chain management to address the following research question: how can new ways of supply chain collaboration contribute to the transition towards CE in the Dutch building sector? The focus on circular buildings is particularly relevant for supply chain collaboration because a building is a complex "object" with several layers, such as the facade, the service equipment and the structure (Brand, 1994) each having their own time frame for operation (Pomponi and Moncaster, 2017). These different time frames are linked to many parties along a building's supply chain making the closure of material loops along the total lifecycle of a built object highly challenging.

The paper is structured as follows: Section 2 provides a theoretical background through a literature review to analyze CE in building projects, resulting in a conceptual framework. In Section 3 the methodology is described. Section 4 presents three cases. Based on these cases, a collaboration tool for circular buildings is developed in Section 5. Section 6, draws conclusions and includes final reflections on the conceptual framework and the collaboration tool.

2. Towards a conceptual framework

This section develops a conceptual framework for studying CE in supply chain collaboration in the built environment. It is based on a literature review of several relevant concepts that were identified in the early phase of the study and build on earlier work of the authors (e.g. Kraaijenhagen et al., 2016; Quist, 2007; Quist et al., 2011). The concepts identified include (i) future visions, (ii) actor learning, (iii) network dynamics and (iv) business model innovation, which can all be seen as essential elements for studying CE in supply chain collaboration, cf. Seuring and Müller (2008) and Barratt (2004). Each concept is briefly discussed and described, before combining all concepts into a conceptual framework.

2.1. Visions of the future

Visions of the future are important in transition studies (e.g. Smith et al., 2005; Quist et al., 2011) and in CE (e.g. Kraaijenhagen et al., 2016; Prendeville et al., 2018), in particular in an early stage when first pilots and demonstration projects are started. Visions do not only provide an image of a possible future, but also provide coordination among heterogeneous actor groups, and guidance and orientation for joint action towards that future (Borup et al., 2006; Quist, 2007) through collective goals and alternative rule sets (Van der Helm, 2009). Future visions can be seen as a key element in the transition to a circular building sector, as well as early demonstrations and pilots.

Analyzing visions and their dynamics can be done in different ways. When looking at CE in supply chain collaboration and circular building pilots, the concepts of future visions as developed by Quist (2007) and Van der Helm (2009) are useful for analyzing visions at an operational level due to their focus on the actual functioning of visions. Van der Helm (2009) provides a framework for analyzing visions consisting of three elements. The first element concerns the transformational elements in a vision, describing the contrast between what is in the present and what could be in the future. Metaphors are often used to describe such transformational elements (Van der Helm, 2009). The second element concerns the explicitness of words and images to describe and discuss visions. The third element is about the attractiveness of a vision in the way that it is inspiring, guiding and motivating people (Van der Helm, 2009). This also relates to leadership for which the term 'vision champion' has been proposed when provided by key persons (Quist, 2007; Quist et al., 2011). Building on the concepts by Van der Helm (2009) and Quist (2007), visions are analyzed in this paper as follows:

- Vision image: including (1) potential metaphors used and (2) the explicitness of the vision in words and images (Van der Helm, 2009).
- Vision guidance: in (1) clear collective goals, (2) presence of alternative rule sets, (3) leadership (Van der Helm, 2009; Quist, 2007).
- Vision orientation: via motivation, inspiration and direction (Van der Helm, 2009).

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