SPRINGER

https://www.springer.com/gp/open-access/publication-policies/self-archiving-policy

An acknowledgement in the following form should be included, together with a link to the published version on the publisher's website:

"This is a post-peer-review, pre-copyedit version of an article published in Circular Economy and Sustainability. The final authenticated version is available online at: http://dx.doi.org/10.1016/B978-0-12-821664-4.00030-3".

Circular economy in the building sector:

Towards a holistic framework for implementing circular business models

Fatima Khitous [1, §], Andrea Urbinati [1], Davide Chiaroni [2], Raffaella Manzini [1]

[1] LIUC Università Cattaneo, School of Industrial Engineering, Castellanza (VA), Italy

[2] Politecnico Di Milano, School of Management, Milan (MI), Italy

[§] Corresponding Author: fkhitous@liuc.it

Abstract

The purpose of this work is to highlight how companies operating in the building industry design a circular business model (CBM) and how collaborative relationships across the building supply chain enforce this CBM. Thereby, first, based on the literature, a framework is designed, and subsequently, is validated based on the historical analysis of the activities of four Italian companies considered as circular economy (CE) champions. This work enhances the understanding about the phases and procedures followed by companies operating in the building sector to successfully implement a CBM and the role of collaborative relationships among the supply chain actors of this industry to increase their degree of circularity. The paper offers empirical structured direction to managers intending to implement CBMs, and directions on how they can leverage collaborations across the building supply chain. The paper considers that in a supply chain value can be co-created throughout collaboration between the focal firm and other stakeholders and acknowledges the peculiarities of the building sector.

Keywords: *circular economy, business model, building sector.*

1. Introduction

This research shades light on the phases and procedures that companies follow and implement for their shift to circular economy (CE), along with the role of stakeholders' involvement to allow this influence. The CE is a paradigm intended at creating sustainable economic, social, and environmental

values. It turns obsolete goods into resources, thus, closing loops in industrial ecosystems (Stahel, 2016). However, CE requires the adoption of cleaner production systems, an increase of awareness and commitment from both producers and consumers, use of renewable energies and materials, and implementation of suitable political and economic tools (Ghisellini, et al., 2016).

In companies, embracing the CE requires the design of circular business models (CBMs), which require to implement circular practices in three main dimensions of business model: (i) the *value proposition,* which emphasizes a product and/or a service offer (Boons & Lüdeke-Freund, 2013); (ii) the *value creation and delivery,* which leads to new opportunities to create and deliver value (Teece, 2010; Beltramello et al., 2013); (iii) the *value capture*, which emphasizes how a product and/or a service offer generates revenues (Teece, 2010). Moreover, every dimension should have a *"long-term orientation"* of implemented practices, which emphasizes the importance of sustaining positive outcomes for the long run (Geissdoerfer et al., 2018). Nevertheless, the academic literature lacks frameworks on how companies can redesign their current business model (Planing, 2015, Nußholz, 2017). Therefore, this research firstly explores CE implementation at the business model level, considering the company and its activities as units of analysis.

The interplay of the three dimensions of the business model (i.e., *value proposition, value creation and delivery, value capture)* determines the degree of circularity of a company's business model, which could range between linear to fully circular (Urbinati et al., 2017). Yet, the literature lacks empirically tested frameworks indicating a practical implementation of CBMs in several sectors of activity (Lewandowski, 2016), among which the building sector that represents the most polluting industry, especially in Italy where the waste of inert recyclable materials is estimated at 40 million tons/year, with only 10% recovery rate (Legambiente, 2017).

The research is structured as follow. First, we design a research framework that highlights the phases and procedures to reach CBMs. Second, based on the methodology of historical analysis, we present a comparative analysis of four companies operating in the building sector. Finally, we conclude with some research directions.

2. Literature review, research questions, and research framework

To understand the concept of circular economy (CE) and its development in the building industry, we first review the CE business model literature, and subsequently the literature addressing CE implementation in the building sector.

2.1. Circular economy in companies' business models

A business model relies on *value proposition, value creation and delivery, and value capture* (Richardson, 2008). It indicates how a company leverages its capabilities and resources to create economic value (Teece, 2010). Nevertheless, CE transcends economic value to also environmental and social values throughout business model innovation (BMI) based on technological, social, and organizational innovation (Boons & Lüdeke-Freund, 2013).

At the business model level, recent research agrees that the shift from a linear economy to a CE requires several alterations to companies' current business model (Centobelli et al., 2020; Linder & Williander, 2017). Examples of these changes include: (i) altering the typical activities in the supply chain, e.g., backing the forward supply chain with a reverse supply chain; (ii) designing of a new value proposition, e.g., the company adopts a "product-as-a-service" approach with the customer; (iii) altering the relationships with customers, e.g., increased interactions with customers along the lifecycle of products; (iv) altering revenue flows, e.g., revenues relying on use-oriented and result-oriented business models.

Therefore, a complete design of a CBM requires a dramatic redesign of all the business model dimensions. However, the academic literature still falls short to provide theoretical frameworks that illustrate this process (Planing, 2015; Nußholz, 2017).

Accordingly, the first research question we aim to address in this research is: ***"****What phases and procedures do companies follow and implement to build a CBM?"*

2.2. Collaborative relationships across circular supply chains

Circular economy (CE) designates a framework where companies interacting within the same supply chain and beyond can create shared value throughout sustainable operations (Genovese et al., 2017). Thereby, CE requires fundamental changes, among which fostering strong collaboration between stakeholders (EEA, 2018). For instance, the goals of reusing, recycling, and reducing materials and products are not achievable without internal and external collaboration (Oghazi & Mostaghel, 2018). Circular supply chains generally rely on a staged approach where a company's outputs are the receivable of another (Ellen MacArthur Foundation, 2013). Thus, circular supply chains rely on a broader conception of the whole production system, where the aim is to re-enter residuals and end-of-life products in the production process. They foster the opportunity of value recovery and reuse of waste in the manufacturing of secondary products (Genovese et al., 2017). However, under circular supply chains, social relationships and collaboration between actors are crucial for closing the loop (Bocken et al., 2016; Green & Randles, 2006; Lai et al., 2010), and are necessary for a transition towards CE (Ghisellini et al., 2016; Genovese et al., 2017). Circular supply chains might rely on new

flows, namely reverse supply chains, which are catalyzed by their synchronization with existing forward supply chains, thereby resulting in a closed-loop system (Guide & Van Wassenhove, 2002). Indeed, collaboration in circular supply chains is about connecting a network of actors by leveraging data transparency, transactions, duties, and sharing profit.

2.3. Circular business models and collaborative relationships in the building sector

The building sector is among the most resource intensive industries where only 20% to 30% of the used resources are recycled or reused (Ellen MacArthur Foundation, 2014). Therefore, it is necessary to incorporate circular economy (CE) in the building sector, as a paradigm that is "restorative and regenerative by design" and enables an enduring optimization of products and their components (Ellen MacArthur Foundation, 2013).

Incorporating CE in the building sector results in circular buildings that reflect "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" (Leising et al., 2018, p. 977).

Nonetheless, contractors and suppliers not only lack interest in green investments, but also face several barriers such as: (i) steering mechanisms (e.g., fiscal tools and incentives); (ii) investors and customers misperceive circular buildings (e.g., require greater investment while having low market value); process barriers (e.g., procurement and tendering); (iii) knowledge availability (Häkkinen & Belloni, 2011). Furthermore, the predominant temporary relationships between supply chain actors of the building sector need to be redefined, throughout fostering long term collaborations (Leising, 2018; Häkkinen & Belloni, 2011; Albino & Berardi, 2012), which could rely on clear agreements and mutual trust (Antikainen & Valkokari, 2016; Kok, 2013).

In Italy, circular buildings are hindered by normative barriers (Legambiente, 2017), poor knowledge of certification programs (ANCE, 2011), inter-companies relationships driven by labor-only subcontracting based on the cheapest option (Albino & Birardi, 2012). However, the case of Italy opens significant insights, since 62.5% of extracted materials are inert with just 10% recovery capacity versus 90% in other neighboring countries (Legambiente, 2017).

Ünal et al. (2019) found that adopting CBMs in the building sector requires the adjustment of the value creation process to internal and external contextual conditions, among which sustainability initiatives of the supply chain partners. Indeed, given the complexity of the building sector's supply chain, despite the inherent opportunities of CBMs, their implementation may entail some tensions that can hinder their viability if not managed properly.

Accordingly, the second research question we aim to address in this research is: *"How can collaboration relationships among the supply chain actors enforce CBMs in the Italian building sector?"*

3. Methodology and empirical analysis

The research was set-up in two main phases. First, to answer the first research question we built the research framework. Second, we tested the framework based on the historical analysis of the activities of four Italian companies considered as circular economy (CE) champions.

3.1. Research framework

To answer to the first research question, we investigated current research at the intersection of circular economy (CE) and the building sector, which resulted into a collaboration-oriented framework (Figure 1). This framework highlights the phases and procedures for an effective implementation of circular business models (CBMs). Our literature review uncovers the need for new tools to improve inter-firm relationships to foster circular buildings (Albino & Berardi, 2012; Leising, et al., 2018).

The depicted framework consists of five sequential blocks, namely, (i) "creation of shared circular vision", (ii) "collaboration", (iii) "CBM and design activities", (iv) "implementation", and (v) "long term alliance for closing the loop", and a continuous block, i.e., (vi) "ongoing learning" that spreads between the blocks "creation of shared vision" and "CBM and design activities" to emphasize CE knowledge as a catalyst to CBMs. It provides an inclusive approach by putting every stakeholder in its core with the aim to support all the stakeholders to achieve long-term shared goals based on trust and a collaboration-oriented approach.

****Insert Figure 1 about here****

i. *Creation of shared circular vision*. It is fundamental given the complexity of CE projects. This block directly impacts "CBM and design activities", for that collaboration is essential for sustainable business model innovation and developing circular supply chains (Bocken et al., 2016). It also impacts "Collaboration", since a shared vision fosters a shared understanding and goals, and trust among actors (Leising et al., 2018).
ii. *Collaboration*. It relies on a shared circular vision and is centered on design, implementation, innovation, and maintenance since sustainability-oriented projects require trust, collaboration,

and multidisciplinary teams to fuel innovations and parties' involvement in creating value (Albino & Birardi, 2012).

iii. *CBM and design activities*. The business model should rely on CE principles and collaboration, whereas design should be considered since the project's early stages (Carra & Magdani, 2017). Tools include the building integrated modelling (BIM), which combines people, processes, and technology to drive efficiency, and the trace of electronic data about products' residual value (Carra & Magdani, 2017; Leising et al., 2018).

iv. *Implementation*. It is undertaken according to a strategic plan that considers financial and environmental constraints through the contribution of various actors in the supply chain (Carra & Magdani, 2017). Therefore, practices such as BIM and certification systems can catalyze trust and data sharing (Albino & Berardi, 2012; Carra & Magdani, 2017).

v. *Long term alliance for closing the loop*. It maintains buildings and materials via reuse, repair, recycling, and upcycling throughout take-back schemes and material marketplaces (Leising et al., 2018). It is fostered by digital platforms and cooperation between actors of the supply chain (Green & Randles, 2006; Lai et al., 2010).

vi. *Ongoing learning*. It allows to understand the socio-ecological system, CE principles, opportunities, and barriers for a long-time relationship. It directly impacts the blocks "creation of shared circular vision" and "CBM and design activities". First, developing a shared vision relies on detecting issues in the supply chain related to the learning process and understanding CE transition lessons. Second, CBM implementation necessitates an ongoing educational and awareness-raising process (Bocken et al., 2014), while circular design entails providing designers with the best available information (Sodagar & Fieldson, 2008).

3.2 Historical analysis

To answer the second research question, we analyzed four Italian companies based on the historical analysis (Gottschalk, 1969), a methodological process of gathering, critically investigating, and summarizing information related to past events (Chiesa & Frattini, 2011). Historical analysis is convenient for assessing phenomena that appeared in the past and progress throughout the time, as it is the case of implementing CE at these companies.

This methodology offers several advantages comparing to others (i.e., surveys or interviews). First, it builds on data collected at the first appearance of the studied phenomenon. Thus, lowering the risk of post-hoc rationalizations. Second, data are collected from multiple sources, thus researchers access

primarily factual data. Third, it is well suited for analyzing the chronological dimension of past events, although it completely relies on secondary data. Moreover, it implies the use of multiple secondary sources, thus allowing for cross-comparisons and triangulation of information. The units of analysis are the company and its activities, analyzed based on a research protocol. Lastly, given that CE is a new paradigm in firms (Geissdoerfer et al., 2018), our study relies on a qualitative approach, i.e., case study, aimed at theory testing (Brown & Eisenhardt, 1997).

To select the cases, we used a convenience sampling technique based on an iterative process that stops once the required size is achieved (Saunders et al., 2009). First, we identified several successful companies operating in the building sector with a CBM (as a guarantee of the feasibility and success of the actions implemented). Second, after excluding start-ups and firms with uncertain future, we identified two clusters: (i) big-medium companies and (ii) small companies. Third, we considered the availability and accessibility of information from secondary resources.

Finally, we chose the cluster "big-medium companies", and selected Companies A, B, C and D, which were analyzed following the sequential steps of our research framework, based on data that were collected from several open access, verified web-based sources.

3.3 Presentation of case studies

Company A is an international company founded in 1937 in Milan. It aims to play a key role in improving people's life throughout creating sustainable chemical products, which for instance appears in its adoption of the concept "green innovation", integration of the strategic raw materials supply, and directing 5% of its annual turnover to research and development (R&D) activities mainly centered on eco-sustainable and eco-compatible products. The company's Milan research center acts as the central hub to its research centers scattered all over the world characterized with ongoing collaboration with other research institutes and universities. Among the group's CE products, there is a bi-component powder additive, made of special polymers and inorganic composites, used to recover all returned concrete with zero impact on the environment. Additionally, all its packaging allows for efficient use of resources. The company is certified ISO 9001, meets the requirements of the European Construction Product Regulations, applies an Environmental Management System compliant with ISO 14001, considers the green programs LEED and BREEAM, and holds many other certifications. Furthermore, its design and technical teams are involved until projects' post-completion.

Company B is an international ceramic manufacturer headquartered in Modena, born 50 years ago. Over the last five years, the company invested 300 Million Euro in production and logistics' innovations, while its investments in environmental projects exceeded 9 Million Euro in 2017. These

efforts of combining technology-oriented assets with aesthetic design, were crowned with the *NYCxDESIGN* Award in 2018. The company displays good financial performance, i.e., in 2017, the annual growth of sales and earnings before interests, taxes, depreciation and amortization (EBITDA) reached 4.5%, and 14.5%, respectively. Likewise, it endeavors for preserving the environment throughout sustainability practices. Indeed, the company recovers 100% of its used water, relies on renewables to produces 73% of its electricity needs, and provides the general public with a recycling point. It makes its packaging from recycled paper and partly from recycled plastic. Similarly, the company strives for human resources diversity and environment and safety training and promoting healthy lifestyles to local communities. The group holds a variety of environment, health, and safety certifications (e.g., EN ISO 14001, EN ISO 50001, BH OHSAS 18001), while many of its brands are certified Ecolabel.

Company C was founded in 1882, based in Udine. It is vertically integrated and is the world's leader in manufacturing medium density fiberboard (MDF) panels, low density fiberboard (LDF) among other products. The company stands amongst Europe's CE champions, i.e., it recycles 80% to 98% of its products, relies on raw materials originating from the maintained forestry resources and recyclable wood. The company pays a particular attention to packaging (i.e., pallets), using recyclable materials and managing packaging recovery of big supplies. Additionally, it leverages design to prolong products' life, implements life cycle assessment (LCA), and offers free disposal of recyclable wood. The company holds several certifications (e.g., UNI EN ISO 9001:2008, Forest Stewardship Council (FSC) and PEFC for its panels, ISO 14001:2004, LEED mapping for some products), and is currently expanding its operations in North Africa and Asia Minor.

Company D is an innovative kitchens manufacturer founded 35 years ago with a 33 Million Euro of turnover in 2017. The company was acquired in 2015 by the Italian Creation Group and is currently expanding its international operations throughout 370 worldwide showrooms. It embraced sustainability practices during the 1990s throughout the design of revolutionary products in terms of ergonomics and environmental protection. The company defines itself as *Sustainability Driven Innovation Oriented*, which shapes its environmental impact, where design is crucial and directed towards dematerialization, recycling and reuse, minimization of toxic emissions, and timeless lifecycle. The company combines functionality and aesthetics throughout CE offers. It is the unique player in its market with a life-long responsibility guarantee, making a public commitment to take-back its cabinets at their life cycle end. It also preaches sustainability throughout collaboration with other companies, creation of learning spaces, and various certifications (e.g., ISO 14001).

4. Results

The analysis of the cases along the building blocks of our research framework outlines the following results:

Company A (Figure 2):

i. *Creation of shared circular vision*. The vision of Company A is shaped by its stakeholders' needs. The company's green strategy is driven by: (1) its green programs and certifications; (2) its collaborations for research and development (R&D) and technical service with external bodies.

ii. *Collaboration*. Company A establishes solid and systematic relationship with scientific and business communities. These collaborations rely on trust following the group's code of ethics, and highly consider its intellectual property rights.

iii. *CBM and design activities*. Company A relies on: (i) maximizing material and energy efficiency, (ii) creating value from waste, (iii) encouraging sufficiency, (iv) repurposing for society and environment and (v) developing scale-up solutions. In parallel, Company A supports design teams and establishes conventions with several design-chartered bodies in the construction sector. Thus, Company A's business model allows the creation of economic value (i.e., positive growth), environmental value (i.e., eco-sustainable and durable products), and social value (i.e., meet local communities' needs).

iv. *Implementation*. Company A fosters external cooperation and devotes 70% of its R&D resources to eco-sustainable products. Internationally, Company A relies on acquisition and local investment, added to virtual implementations. Additionally, Company A's mobile application allows stakeholders to easily access technical information and prevent waste of resource.

v. *Long term alliance for closing the loop*. Company A has a dedicated team specialized in product' life cycle and invests largely in closing the loop.

****Insert Figure 2 about here****

Company B (Figure 3):

i. *Creation of shared circular vision*. Company B promotes its "greener" approaches to both internal and external partners, for instance through consulting services and certification.

ii. *Collaboration*. Company B accompanies designers and customers since projects' early stages. Its collaborations are driven by its code of ethics promoting trust, integrity, legitimacy, and reciprocal respect.

iii. *CBM and design activities*. Company B's business model innovation relies on: (i) replacing with natural processes and renewables, (ii) creating value from wastes, (iii) adopting a stewardship role, (iv) encouraging sufficiency, and (v) repurposing for society and environment. Additionally, Company B relies on contemporary design using green materials, sponsorship of postgraduate courses, and hosting design events. Thus, Company B's business model enables economic value (i.e., positive growth), environmental value (i.e., photovoltaic panels), and social value (i.e., job creation).

iv. *Implementation*. Company B invests in R&D and partnerships and emphasizes safety trainings. Moreover, it relies on virtual implementations to promote its circular activities and to facilitate collaboration with stakeholders (i.e., virtual realization of buildings), increase efficiency, reduce waste, and integrate operations.

v. *Long term alliance for closing the loop*. Alliances allowed Company B to reach 100% recycling of some wastes, establish a public recycling point, and use recycled paper and plastic in packaging.

****Insert Figure 3 about here****

Company C (Figure 4):

i. *Creation of shared circular vision*. The vertical integration strategy of the Company C's group led to a valuable internal knowledge that is further enhanced throughout R&D with external partners (e.g., University of Udine).

ii. *Collaboration*. Company C's group comprises seven companies that are vertically integrated with the aim to collaborate in projects' development, R&D, ventures, and promote relationships with local communities and authorities (e.g., collaboration with the regional administrations for recovery of wood resources and cleaning riverbeds).

iii. *CBM and design activities*. Company C's business model relies on: (i) substitution with renewables, (ii) creating value from waste, and (iii) developing scale-up solutions. Thus,

Company C's business model allows for environmental value (i.e., durable, and recyclable products), social value (i.e., valorization of students' engagement), and economic value.

iv. *Implementation*. To face environmental challenges, Company C capitalizes on investments, R&D, and partnerships (e.g., it invested 80 Million Euro to improve its wood recycling capabilities). Moreover, Company C prioritizes employees' training and safety.

v. *Long term alliance for closing the loop*. Centered on innovation (i.e., medium density fiberboard (MDF) panels from recycled wood, use of 100% recycled wood for most panels).

****Insert Figure 4 about here****

Company D (Figure 5)**:**

i. *Creation of shared circular vision*. Company D's vision fosters CE related innovation, communication, and education (i.e., founding the "Academy" to train employees on kitchens' technicity and art, health and safety).

ii. *Collaboration*. Company D's internationalization strategy relies on collaborating with local partners (i.e., "Cleanup Corporation" in Japan; Lifegate in Italy). Furthermore, it founded a non-profit organization focused on the industry and the environment.

iii. *CBM and design activities*. Company D emphasizes: (i) creating value from waste, (ii) replacing with natural processes and renewables, (iii) developing scale-up solutions, (iv) maximizing material and energy efficiency, (v) re-purposing the business for society and environment. Company D's business model allows for the creation of environmental value (i.e., reducing materials use throughout lightweight kitchen) and economic value.

iv. *Implementation*. Company D's efforts appear in being the first kitchen maker in Italy to obtain ISO 14001 environmental certification among other certifications, and its collaboration with CATAS, the wood biggest Italian research institute.

v. *Long term alliance for closing the loop*. Appears throughout its free disposal service to recover its old kitchens where most materials are re-usable, and recyclable based on components' modularity.

****Insert Figure 5 about here****

Therefore, a cross-case comparison is reported in Table 1 and summarized hereafter.

i. *Creation of shared circular vision*. The analyzed CE champions consider a balanced relationship between people and nature (Bocken et al., 2016; Leising et al., 2018) as a starting point for their vision.

ii. *Collaboration*. The four CE champions emphasize trustful, transparent, long-term collaborations, and multidisciplinary teams to face the high complexity of sustainability-oriented projects in the building sector (Albino & Birardi, 2012).

iii. *CBM and design activities*. The four CE champions emphasize design activities with multiple stakeholders (i.e., internal schools, laboratories, external collaborations) (Carra & Magdani, 2017; Leising, et al., 2018). The design of their CBMs mainly rely on: (i) creating value from waste, (ii) replacing with natural processes and renewables, (iii) developing scale-up solutions, and (iv) maximizing material and energy efficiency (Bocken et al., 2014).

iv. *Implementation*. The adoption of cutting-edge technologies plays a pivotal role to embrace CE in the four companies (i.e., manufacturing technologies for the cascading use of wood, virtual implementations for design and built, support service, and personalized offer). The importance of these technologies further spans from the technological maturity of the building sector (Albino & Berardi, 2012; Carra & Magdani, 2017).

v. *Long term alliance for closing the loop*. The four CE champions commit to recycling, maximum recovery of materials, and high reliance on internal energy production (Leising et al., 2018). Moreover, they develop take-back schemes for end of life products, a novelty compared to the typical ways of operating in the building sector (Green & Randles, 2006; Lai et al., 2010).

vi. *Ongoing learning*. The four analyzed companies display exemplary efforts centered on R&D, stakeholders' wellbeing, and harnessing their capabilities (Bocken et al., 2014). The internationalization increases the ongoing learning of these companies from new markets, while their certifications offer a competitive advantage. These four CE champions leverage a collaboration-oriented approach inside and outside their group based on trust, transparency, and ambitious goals (Sodagar & Fieldson, 2008).

Table 1: Cross-case comparison.

Company / Building Block	Company A	Company B	Company C	Company D
Creation of shared circular vision	• Reach customers worldwide • Human resources are central • Green philosophy	• Adopt green practices • Be a benchmark	• Harmony between humankind and environment • Continuous innovation	• Ecology and harmony between mankind and nature • Be a benchmark • Continuous development and innovation
Collaboration	• Internationalization • Scientific support • Loyalty & transparency	• Collaborate with compliant partners • Technological support for CE	• Verticalization • Long-term collaboration underpinned by trust • Internationalization	• Collaboration is central • Trust and information sharing
CBM and design activities	• Technical support starting from design • Repair while preserving quality • Eco-sustainable and durable products • Scaling-up the offering	• Green products with aesthetic look • Internalize 4.0 technologies • Renewable support	• New concepts of office system • High quality panels from recycled wood • Cascading use of wood	• Personalization of offerings and customer support • Application of CE principle • Communication • Verticalization
Implementation	• Environmental compliance • Virtual applications for clients' support	• Environmental compliance • Extending offer using virtual applications	• New process for using recycled wood • Environmental compliance	• Kitchen configuration systems and 3D models • Environmental compliance
Long term alliance for closing the loop	• Cradle-to-cradle products and packaging • Credits with sustainable projects	• Return materials to loop • Cradle-to-cradle products	• Take-back schemes for wood • Cascading use of wood	• Free take-back schemes • Modular design • Anti-waste wood projects
Ongoing learning	• Intense R&D • Leverage collaborations • Continuous training and advice to stakeholders • Green certification	• Support educational institutions • Increase awareness at different levels • Continuous training • Green certification	• R&D for wood use and building sector • Certification	• R&D focused on CE • Sustainability and innovation driven approach • Research of partners • Design is focal

5. Conclusion, limitations, and directions for future research

This research aimed to highlight how companies operating in the building industry, design a circular business model (CBM), and how collaborative relationships across the building supply chain enforce their CBM. Accordingly, first, this research presents a step-by-step research framework, which highlights the phases and procedures that companies operating in the building sector can follow and implement for a successful CBM, as well as the role of collaboration relationships among the supply chain actors to increase their degree of circularity. Second, the research tests the framework leveraging the historical analysis of the activities of four Italian companies considered as circular economy (CE) champions.

- *Theoretical implications*

The analysis shows that a collaborative vision based on CE principles is the first step for companies operating in the building sector to undertake the transition towards CE. The collaboration affects the business models, design activities, and their implementation, and allows overcoming the barriers and triggering the CE drivers. These collaboration activities are centered on corporate social responsibility (CSR), CE awareness, and involving stakeholders since the design phase, ongoing learning, and virtual implementations.

The analysis also uncovers the crucial role of technologies in the shift towards CE. The cases show that a cascading use of materials is conditioned by investing in manufacturing technologies, efficient material use, and automatization through upgrading in-house technologies. The virtual implementations allow for design and built before the physical realization, while support service and high personalized offer are facilitated by virtual applications. Finally, the findings further confirm that sustainability issues should be tackled throughout business model innovation (BMI), based on technological, social, and organizational innovation.

- *Managerial implications*

This research provides managers operating in building sector, with a framework for closing the loop. This framework outlines the fundamental steps, the possible prioritization of procedures, and the sequence of the managerial practices to be implemented.

Additionally, these findings uncover how leveraging collaboration could lead to knowledge improvement regarding communication and social purposes, business performance, recognition by stakeholders as a sustainable company.

The study also highlights the paramount importance of take-back schemes and design in enabling reuse or recycling of the collected materials.

- *Implications for policymakers*

The results suggest that politicians might foster the adoption of CE in the building sector, throughout encouraging collaboration between firms in the building supply chain (e.g., symbiosis). Politicians might also encourage CE related certifications and digital technologies throughout regulation and incentives schemes (e.g., for access to public markets), in addition to encouraging research focused on clean technologies.

- *Limitations and avenues for further research*

This study has several research limitations. First, the number of selected cases used to validate the framework. Second, the data collection that could be enhanced using an interview protocol and primary sources of information. Finally, the generalization of results is limited to the specific context (i.e., industry and geography) in which the study was conducted. Nevertheless, this research highlights potential avenues for further investigating the implementation of CE in the building industry. Examples include researching the impact of the specific characteristics of firms (e.g., size) on CE implementation and collaborations, investigating the impact of cultural biases or geographical differences either by replicating the study in other countries, or by running a quantitative study to test the dimensions of the proposed research framework. Finally, the role of some specific technologies (i.e., virtual implementation) in a CBM transition should deserve further attention from scholars.

References

Albino, V. and Berardi, U., (2012). Green buildings and organizational changes in Italian case studies. Business Strategy and the Environment, 21(6), pp.387-400.

Antikainen, M., and Valkokari, K., (2016). A Framework for Sustainable Circular Business Model Innovation. Technology Innovation Management Review.

Associazione Nazionale Costruttori Edili (ANCE), 2012. Osservatorio congiunturale sull'industria delle costruzioni. http://www.ance.it/docs/docDownload.aspx?id=6739

Beltramello, A., Haie-Fayle, L. and Pilat, D., (2013). Why new business models matter for green growth.

Bocken, N.M., de Pauw, I., Bakker, C. and van der Grinten, B., (2016). Product design and business model strategies for a circular economy. Journal of Industrial and Production Engineering, 33(5), 308-320.

Bocken, N.M., Short, S.W., Rana, P. and Evans, S., (2014). A literature and practice review to develop sustainable business model archetypes. Journal of Cleaner Production, 65, 42-56.

Boons, F. and Lüdeke-Freund, F., (2013). Business models for sustainable innovation: state-of-the-art and steps towards a research agenda. Journal of Cleaner production, 45, 9-19.

Brown, S. L., & Eisenhardt, K. M. (1997). The Art of Continuous Change: Linking Complexity Theory and Time-Paced Evolution in Relentlessly Shifting Organizations. Administrative Science Quarterly, 42(1), 1.

Carra, G. and Magdani, N., (2017). Circular Business Models for the Built Environment. Arup, https://www.arup.com/publications/research/section/circular-business-models-for-the-built-environment [Accessed 22/08/2018].

Centobelli, P., Cerchione, R., Chiaroni, D., Del Vecchio, P., & Urbinati, A. (2020). Designing business models in circular economy: A systematic literature review and research agenda. *Business Strategy and the Environment*, bse.2466.

Chiesa, V. and Frattini, F. (2011). Commercializing technological innovation: Learning from failures in high-tech markets. Journal of Product Innovation Management, 28, 437-454.

Ellen MacArthur Foundation (EMF), (2013). Towards the Circular Economy: Economic and business rationale for an accelerated transition.

Ellen MacArthur Foundation (EMF), (2014). Towards the Circular Economy: Accelerating the Scale-up Across Global Supply Chains.

European Environment Agency , (2018). The circular economy and the bioeconomy: Partners in

sustainability. doi: 10.2800/02937.

Genovese, A., Acquaye, A.A., Figueroa, A. and Koh, L., (2017) Sustainable supply chain management and the transition towards a circular economy: Evidence and some applications. Omega, 66, 344-357.

Geissdoerfer, M., Morioka, S.N., de Carvalho, M.M. and Evans, S., (2018). Business models and supply chains for the circular economy. Journal of Cleaner Production, 190, 712-721.

Green, K., Randles, S., (2006). Industrial Ecology and Spaces of Innovation. Edward Elgar Publishing, London.

Gottschalk, L.R. (1969). Understanding History: A Primer of Historical Method. Knopf, New York

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. Journal of Cleaner Production, 114, 11-32.

Guide, V. D. R., and Van Wassenhove, L. N. (2002). The reverse supply chain: smart manufacturers are designing efficient processes for reusing their products. Harvard Business Review, 80, 25-26.

Häkkinen, T., and Belloni, K. (2011). Barriers and drivers for sustainable building. Building Research & Information, 39(3), 239-255.

Kok, L., Wurpel, G., and Ten Wolde, A. (2013). Unleashing the power of the circular economy. Report by IMSA Amsterdam for Circle Economy.

Lai, K.H., Cheng, T.C.E. and Tang, A.K., (2010). Green retailing: factors for success. California Management Review, 52(2), 6-31.

Leising, E., Quist, J. and Bocken, N., (2018). Circular Economy in the building sector: Three cases and a collaboration tool. Journal of Cleaner Production, 176, 976-989.

Legambiente (2017). Ecosistema Urbano, Rapporto sulle performance ambientali delle città. URL: https://www.legambiente.it/sites/default/files/docs/ecosistema_urbano_2017_dossier.pdf

Lewandowski, M. (2016). Designing the business models for circular economy—Towards the conceptual framework. Sustainability, 8(1), 43.

Linder, M., and Williander, M. (2017). Circular business model innovation: inherent uncertainties. Business Strategy and the Environment, 26(2), 182-196.

Oghazi, P., and Mostaghel, R. (2018). Circular Business Model Challenges and Lessons Learned—An Industrial Perspective. Sustainability, 10(3), 739.

Planing, P. (2015). Business Model Innovation in a Circular Economy Reasons for Non-Acceptance of Circular Business Models. Open Journal of Business Model Innovation.

Nußholz, J. L. (2017). Circular business models: Defining a concept and framing an emerging research field. Sustainability, 9(10), 1810.

Richardson, J., (2008). The business model: an integrative framework for strategy execution. Strategic Change, 17(5-6), 133-144.

Saunders, M., Lewis, P. and Thornhill, A., (2009). Research methods for business students. Pearson Education.

Sodagar, B. and Fieldson, R. (2008) Towards a sustainable construction practice. Construction Information Quarterly, 10(3), 101-108.

Stahel, W.R. (2016). The circular economy. Nature, 531(7595), 435e438.

Teece, D.J., (2010). Business models, business strategy and innovation. Long Range Planning, 43(2-3), 172-194.

Ünal, E., Urbinati, A. and Chiaroni, D., Manzini, R. (2019). Value Creation in Circular Business Models: The case of a US small medium enterprise in the building sector. Resources, Conservation & Recycling, 146, 291-307.

Urbinati, A., Chiaroni, D. and Chiesa, V. (2017). Towards a new taxonomy of circular economy business models. Journal of Cleaner Production, 168, 487-498.

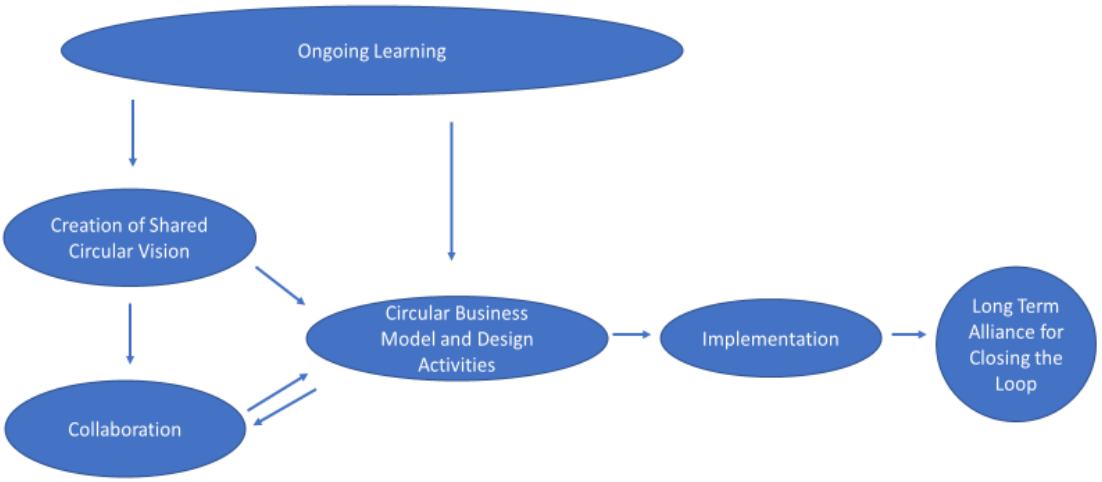

Figure 1: The collaboration framework for closing the loop

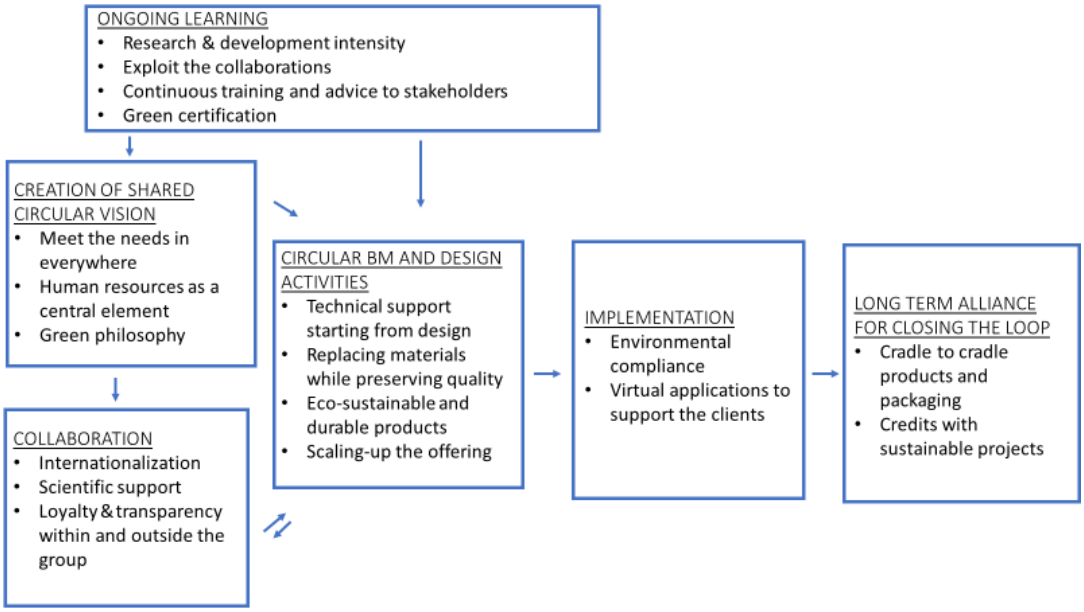

Figure 2: The collaboration framework for closing the loop at Company A

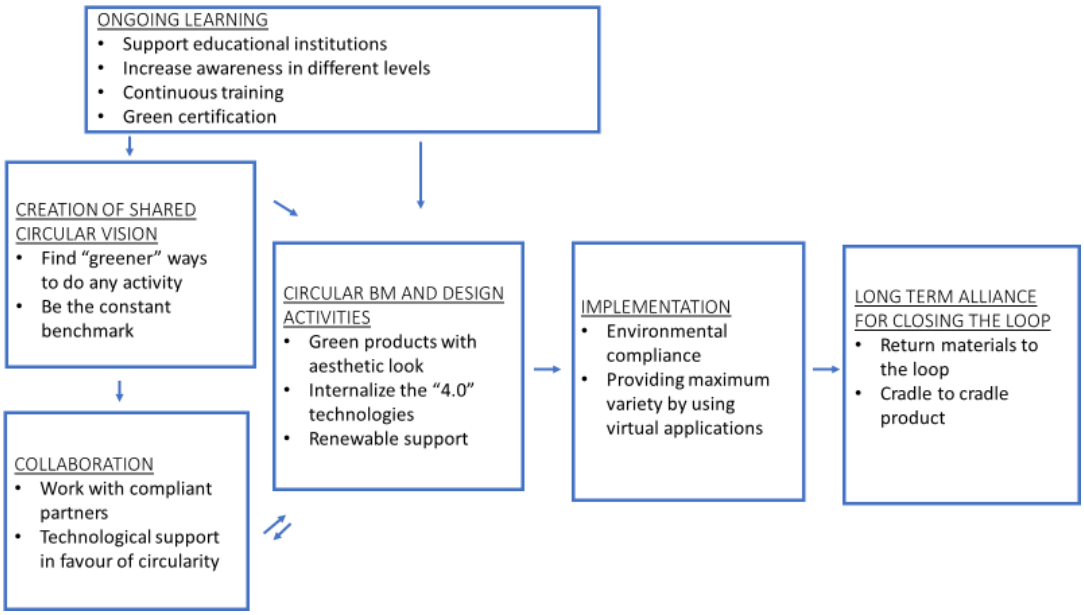

Figure 3: The collaboration framework for closing the loop at Company B

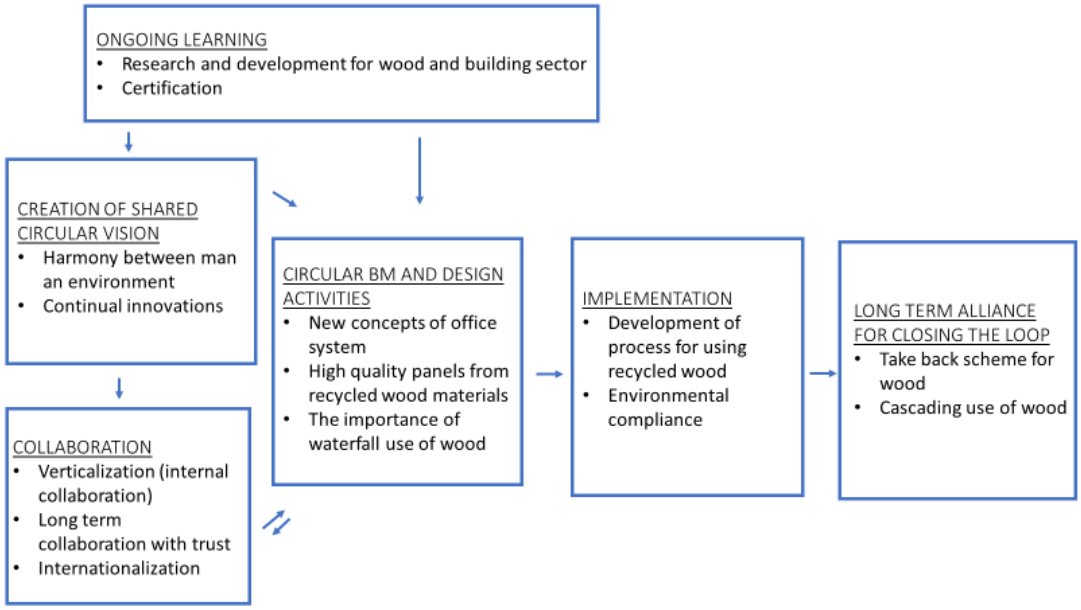

Figure 4: The collaboration framework for closing the loop at Company C.

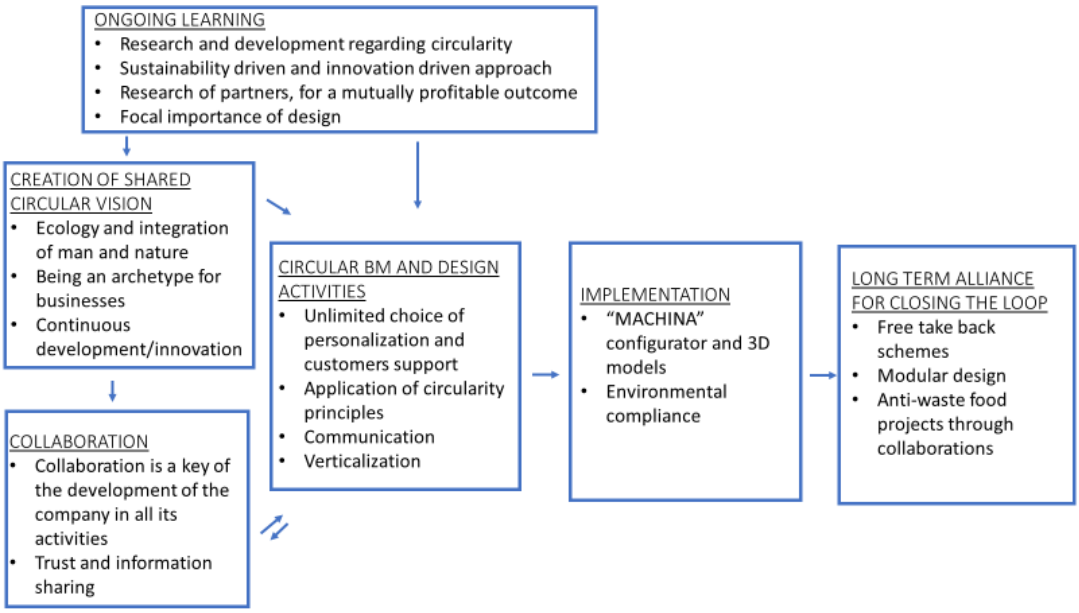

Figure 5: The collaboration framework for closing the loop at Company D.