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Fostering the transition towards circular economy through collaborations: An open innovation perspective in the building industry

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The current linear economy has led to environmental pollution and resource depletion. To tackle these issues, a new economy model has emerged, namely the circular economy. Being a new economic model, the transition to a circular economy is particularly challenging for existing companies that have designed their business models and collaborations in a linear fashion. This aspect holds particularly true in resource-intensive industries characterized by long value chains. Among these industries, the building one stands out as characterized by high resource consumption and complex value chains. We argue that in such an industry, the transition to circular economy calls for establishing collaborations between the different players involved to access external competences and engage in a new way the whole value chain. Open innovation enables to access these external competences and fosters collaboration throughout the whole value chain. Taking the façade of a building as a unit of analysis, we aimed at investigating how companies exploit open innovation to implement circular economy initiatives. To address this issue, we leverage the original open innovation framework developed by West & Bogers (2014) adapting it to the peculiarities of the circular economy transition. By applying the action research methodology to analyse the interplay between circular economy and open innovation in the building façade industry, we get evidence that open innovation plays a key role in enabling the transition towards circular economy in a façade-as-a-service model. The need for external knowledge sources in circular product design is reported in order not to have mismatches throughout the product useful life. Besides, we point out the relevance of collaborations in circular economy transition to jointly design products and business models according to the circular economy principles.

KEYWORDS
action research, building, circular economy, collaboration, external knowledge sources, façade, open innovation, product design, product-service system

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1 | INTRODUCTION

The mainstream economy model is the so-called "take-make-dispose". It is based on the extraction of virgin raw materials, which are used to make products. Customers purchase these products and dispose of them at the end of their useful life. This economy model is a linear one because resources are taken from the environment, processed and then disposed of. The linear economy model has led to negative outcomes, such as environmental pollution and resource depletion. Recently, an alternative economy model has emerged, which goes under the name of circular economy. Conversely to the linear one, the circular economy model aims to keep products in use as long as possible and preserve the value of natural resources. Circular economy "closes-the-loop" through different practices, either biological or technological (Figge, Stevenson, & Gutberlet, 2023; Kirchherr, Yang, Schulze-Spüntrup, Heerink, & Hartley, 2023).

The transition from a linear to a circular economy is still far from being completed and different barriers remain to be solved (Franzò, Urbinati, Chiaroni, & Chiesa, 2021). This transition is particularly challenging in industries characterized by a high environmental impact (Leising, Quist, & Bocken, 2018) and a complex value chain (Charef, Lu, & Hall, 2022). Indeed, the high environmental impact offers more possibility to reduce resources, energy consumption and emissions and waste production compared to industries characterized by lower environmental impact (Pomponi & Moncaster, 2017). Besides, a complex value chain is characterized by information biases and a lack of transparency among the several players involved (Charef et al., 2022). Accordingly, the players operate with a silo approach, rather than with a holistic perspective and focus on short-term objectives, rather than long-term and innovative ones (Chen, Feng, & Garcia de Soto, 2022; Dewagoda, Ng, & Chen, 2022; Leising et al., 2018). However, the implementation of the circular economy principles in these industries could unfold economic and environmental benefits and fully exploit circular economy potentialities (e.g., tackling resource depletion by extending product useful life and valuing resources) (Franzò et al., 2021; Leising et al., 2018; Mignacca & Locatelli, 2021; Urbinati, Franzò, & Chiaroni, 2021).

Among these industries, the building one stands out as it is resource-intensive, energy-intensive and characterized by high greenhouse gas emissions (Dewagoda et al., 2022; Ness & Xing, 2017; Norouzi, Chàfer, Cabeza, Jiménez, & Boer, 2021; Soto-Paz, Arroyo, Torres-Guevara, Parra-Orobio, & Casallas-Ojeda, 2023). In addition, the building industry is fragmented, and it is characterized by a long value chain involving heterogeneous players (Dewagoda et al., 2022; Harala, Alkki, Aarikka-Stenroos, Al-Najjar, & Malmqvist, 2023). To undergo the transition from a linear to a circular economy in such an industry, the players involved in this industry need to be aligned with the circular economy principles, to ensure not to have mismatches among the different phases of the long and fragmented value chain. Therefore, implementing a circular economy in the building industry is challenging and calls for collaborations between all the players involved in its value chain (Ghafoor, Hosseini, Kocaturk, Weiss, & Barnett, 2023; Giorgi et al., 2022; Khitous et al., 2022; Köhler, Sönnichsen, & Beske-Jansen, 2022). Indeed, to overcome the issues characterizing this industry (e.g., long and fragmented value chain), all the companies belonging to the whole value chain have to engage themselves in the transition from linear to circular economy (Genovese, Acquaye, Figueroa, & Koh, 2017; Ghisellini, Cialani, & Ulgiati, 2016; Harala et al., 2023; Ossio, Salinas, & Hernández, 2023; Seuring & Müller, 2008).

Current literature on the intersection between circular economy and the building industry focuses on (i) design strategies and/or tools for designing circular buildings (Antwi-Afari, Ng, & Chen, 2022; van Stijn & Gruis, 2020), (ii) level of application of circular principles in the building industry (Giorgi et al., 2022), (iii) circular strategies that could be adopted (Charef et al., 2022; Chen et al., 2022; Dewagoda et al., 2022) and (iv) Life Cycle Assessment (LCA) analysis (Antwi-Afari et al., 2022). All these perspectives contribute to enlarge the scientific contribution of circular economy studies focusing on the building industry and to improve the understanding of the transition towards circularity in such a context. In addition, scholars have noted that collaborations are at the core of the circular economy transition, particularly because of the radicalness of the transition and problems extending beyond individual organizational boundaries (Brown, Bocken, & Balkenende, 2019). In this research context, the adoption of an open innovation approach can be an opportunity for promoting collaboration between stakeholders, thus (i) resolving environmental problems, (ii) implementing the strategies of reuse, reduce and recycle, (iii) encouraging consumers' participation and (iv) creating a culture of sustainable consumption (Jesus & Jugend, 2023).

However, to the best of our knowledge, the interplay between the circular economy, the building industry and the open innovation approach is still an under-researched management issue and an emerging research field. The perspective of open and collaborative innovation in the context of buildings' transition towards circular economy merits additional academic research. Buildings are complex products and the circular economy principles can more easily be implemented in building external elements (Hartwell, Macmillan, & Overend, 2021; Pomponi & Moncaster, 2017; Wouterszoon Jansen, van Stijn, Eberhardt, van Bortel, & Gruis, 2022). Indeed, these elements are easier to access, maintain and repaired (Giovanardi, Konstantinou, Pollo, & Klein, 2023). The building façade stands out among the main building external elements. Accordingly, the unit of analysis of this paper is represented by the building façade for three main reasons: (i) it is characterized by a high environmental impact, (ii) it is easily accessible and (iii) it is characterized by a fragmented value chain. First, the building façade is responsible for 10% to 20% of the total embodied carbon emissions of the building. Second, it is more easily accessible and, therefore, easier to repair and remanufacture according to the circular economy principles. Third, the building façade, similarly to the building industry, is characterized by a fragmented value chain with a large set of players involved, each one contributing with specific competences and skills, and a resulting lack of information sharing and reliability among the involved players. Therefore, environmental, economic and value chain benefits could be potentially achieved in the transition towards circularity of the building façade (Giovanardi et al., 2023). For instance, the exploitation of an open innovation approach to collaborate and to achieve circularity

is relevant to overcome mismatches among subsequent phases of the value chain and of the product useful life, thus enabling companies to access to complementary skills, information and resources (Köhler et al., 2022; Triguero, Cuerva, & Sáez-Martínez, 2022).

Based on the premise above, and taking the building façade as unit of analysis, we aim to address the following research question: "*How do companies operating in the building industry exploit the open innovation approach to implement the circular economy principles?*"

By addressing this question, we aim to further the academic debate at the intersection between circular economy and open innovation in the building industry and provide useful insights to managers. From an academic standpoint, we point out that (i) the players involved in the building industry need to be engaged and collaborate to implement the circular economy principles and (ii) the open innovation approach could facilitate the transition towards circular economy in the building industry. From a managerial standpoint, managers could grasp (i) the typology of players involved in a circular value chain and (ii) the role performed by each player in a circular economy model rather than a linear, traditional one.

The remainder of this article is organized as follows. Section 2 presents the theoretical background with reference to circular economy and open innovation in the building industry. Section 3 reports the rationale of the methodology adopted in this research. Findings are presented and discussed in Section 4. Finally, Section 5 draws conclusions, contributions and limitations and acknowledges avenues for future research.

2 | THEORETICAL BACKGROUND

The implementation of the circular economy principles and open innovation approaches in the building industry is at length described in this Section. In Section 2.1, we present the traditional building industry according to the linear economy model and we present the key concepts characterizing the transition towards circularity in this industry. In Section 2.2, we introduce the concept of open innovation, we identify the main benefits of its application in the transition towards circularity and describe the framework proposed by West and Bogers (2014), used as guidance for our empirical analysis.

2.1 | From linear to circular economy in the building industry: key concepts and elements

The conventional building industry follows the linear economy model, the so-called "take-make-dispose". In the linear building industry, natural resources are first extracted from the environment. Thereafter these materials are processed to produce building materials and elements. Buildings are then constructed with the manufactured materials and elements. Given the huge diversity of materials and elements used, buildings result in complex products (Illankoon & Vithanage, 2023). Accordingly, a building can be typically referred to as "a complex 'object' with several layers, such as the facade […] each having their own time frame for operation" (Leising et al., 2018, p. 977). Finally, as the building useful life comes to an end, demolition activities are performed. Materials and elements are disposed of and generate a high volume of demolition waste (Illankoon & Vithanage, 2023). Therefore, the linear building industry is characterized by resource-intensity and leads to resource depletion (Norouzi et al., 2021; Ossio et al., 2023; Soto-Paz et al., 2023). The linear building industry is energy-intensive and therefore characterized by high emissions. According to the International Energy Agency (IEA), emissions from the building industry (considering both constructions and operations) accounted for more than 12 $GtCO_2$ at the worldwide level in 2022. Therefore, the building industry accounted for more than one-third of global energy-related emissions (International Energy Agency, 2023). Several players are involved in the different phases of the value chain (see e.g., Charef et al., 2022). Each player belonging to this industry operates in a specific phase of the value chain and, rarely, collaborates with each other (Chen et al., 2022; Ghafoor et al., 2023). Consequently, short-term objectives prevail over long-term ones (Charef et al., 2022; Chen et al., 2022; Ghafoor et al., 2023; Khitous et al., 2022; Ossio et al., 2023). Accordingly, the linear building industry results in a long, complex and fragmented value chain (Dewagoda et al., 2022; Giorgi et al., 2022). Multiple players operate in each phase of the building useful life, involving not only main contractors but also sub-contractors for each phase (Chen et al., 2022; Pomponi & Moncaster, 2017).

The transition from a linear to a circular economy in such an industry would require a shared effort of as many as possible players (Khitous et al., 2022). Indeed, the players involved in the building value chain need to be engaged to jointly implement the circular economy principles. Given the complexity of both the final products of this industry (i.e., buildings) and the value chain, the circular economy principles need to be simultaneously implemented by the several players involved in the building value chain (Ghafoor et al., 2023; Harala et al., 2023). The objective of this joint implementation is to avoid mismatches among the different phases of the building value chain and useful life (Charef et al., 2022). The joint implementation ultimately aims to turn linear buildings into circular ones (Eberhardt, Birkved, & Birgisdottir, 2022; Ghafoor et al., 2023; Munaro, Freitas, Tavares, & Bragança, 2021).

We reviewed the existing academic literature on the intersection between the circular economy and the building industry with a narrative literature review methodology (Fan, Breslin, Callahan, & Iszatt-White, 2022). We started from a small number of contributions (e.g., Leising et al., 2018; Pomponi & Moncaster, 2017) and applied the backward and forward snowball sampling approach to enlarge our theoretical base until an incremental knowledge expansion was saturated. A circular building has been recently defined as a building that integrates "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). Two keywords could be highlighted from this definition: (i) design and (ii) ownership model. First, buildings are designed according to the circular economy principles. The implementation of circular product design practices requires collaboration among the players involved in the circular product useful life. Circular buildings need to be designed

considering the whole lifespan of buildings, even the end-of-life phase. Therefore, the several players involved in each phase of the building lifespan need to be involved in the design phase (Aguiar & Jugend, 2022; N. Bocken, de Pauw, Bakker, & van der Grinten, 2016; Konietzko, Bocken, & Hultink, 2020). Second, circular buildings call for new ownership models. The objective of these new ownership models consists of keeping the building elements in use as long as possible and valuing resources. Central to the concept of circular economy is the shift from ownership to access, which consists of allowing the customers to use a product as long as possible while letting the product return to the producer and start a new life cycle. Accordingly, customers turn into users and the product ownership is retained by the producer companies. Ultimately, products are turned into services. The literature identifies a set of circular-oriented managerial practices to implement this transition. For example, the implementation of a Product-Service System (PSS) goes in this direction, and it calls for the involvement of several players in the value chain (Centobelli, Cerchione, Chiaroni, Del Vecchio, & Urbinati, 2020; Charef et al., 2022).

Buildings are very complex products composed of several subproducts, namely elements or components. Among these components and elements, especially the external elements of a building have been identified among the most suitable for addressing the circular economy principles. In particular, the façade of building is characterized by ease of accessibility and maintenance and by a high environmental impact. These characteristics make the façade element suitable for the implementation of a circular economy (Giovanardi et al., 2023; Hartwell et al., 2021; Wouterszoon Jansen et al., 2022). Therefore, the façade element of a building could be designed according to the circular economy principles. Besides, this element could be offered to the final users (i.e., the occupants of a building) with new ownership models. On the one side, several circular product design practices (e.g., design for disassembly, design for modularity) could be jointly implemented by the players involved in the building façade value chain. On the other side, a PSS could be designed to turn the façade from being considered a service rather than a product. Both design and ownership models need the engagement of the players involved in the different phases of the building façade value chain and useful life. These players are required to collaborate to jointly implement the circular economy principles and to avoid subsequent mismatches.

This paper takes the façade element of the building as unit of analysis, whose characteristics make it one of the most suitable building element for implementing a circular economy. We especially investigate how companies operating in the building façade industry engage with each other and exploit the open innovation approach to turn a linear façade into a circular façade.

2.2 | Open innovation fostering circular economy in the building industry

The concept of open innovation has been defined as "a distributed innovation process based on purposively managed knowledge flows across organizational boundaries" (Chesbrough & Bogers, 2014, p. 1). Thanks to an open innovation approach, the innovation process becomes distributed. Open innovation is particularly relevant when dealing with profound changes, which require unusual ways to approach a process. The transition towards circular economy requires profound changes and collaborations among the several players involved in the value chain are key to implementing coherently the circular economy principles (Aarikka-Stenroos, Chiaroni, Kaipainen, & Urbinati, 2022). The players involved in the building industry are required to collaborate to undergo the transition from a linear to a circular economy (Brown et al., 2019). In other words, the transition towards circularity in the building industry calls for collaborations, and the open innovation approach represents an opportunity for promoting collaborations between the several players operating in such an industry (N. Bocken & Ritala, 2022; Jesus & Jugend, 2023; Köhler et al., 2022).

Two main characteristics of open innovation could be beneficial for the transition towards a circular economy. First, open innovation leverages not only internal but also external knowledge sources. This is particularly relevant to grasp relevant information, competences and skills, which are outside the boundaries of the single company. In addition, external knowledge sources give the possibility for higher visibility on the overall useful life of the products and on the whole value chain. External knowledge sources could be a relevant lever to implement both circular product design practices and circular ownership models (N. Bocken et al., 2016; Genovese et al., 2017). Second, open innovation calls for collaboration. Indeed, open innovation adopts a value chain perspective that goes beyond the perspective of a single company (Aarikka-Stenroos et al., 2022; Ghisellini et al., 2016). Collaborations can be referred to "as joint activities between the company and the other actors for circularity" (Aarikka-Stenroos et al., 2022, p. 323) and are of paramount importance for the transition of industries towards circular economy. Indeed, collaborations enable the concurrent implementation of the circular economy principles by the players involved in its whole value chain and prevent subsequent mismatches along the useful life of products. Accordingly, open innovation represents an effective approach to investigate how collaborations among several players involved in a specific value chain, such as the one represented by the building industry, enable the transition towards a circular economy. This notwithstanding, academic research at the intersection between circular economy and open innovation is still nascent and deserves further research efforts (N. Bocken & Ritala, 2022; Brown, Von Daniels, Bocken, & Balkenende, 2021), as also highlighted by several *Special Issue – Calls for Papers* at this intersection (N. Bocken et al., 2023; Herstatt, Dlugoborskyte, & Damberg, 2023). The implementation of open innovation approaches could promote and foster the implementation of the circular economy principles in the building industry as (i) it is an industry characterized by a long, fragmented value chain, in which each company operates "in silos" and focuses on a particular phase of the value chain and of the product useful life (Dewagoda et al., 2022), (ii) it is an industry characterized by multiple interruptions of information, resources, materials flows (Chen et al., 2022), (iii) it is an industry characterized by complex and durable final products (Pomponi & Moncaster, 2017). Open innovation could especially foster the

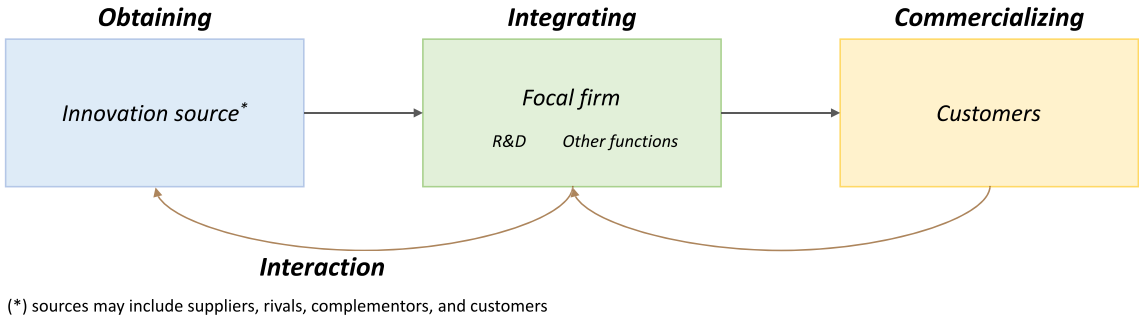

FIGURE 1 Overview of the four-phases open innovation framework readapted from West and Bogers (2014). [Colour figure can be viewed at wileyonlinelibrary.com]

implementation of the circular economy principles in the building industry for two main reasons. First, the open innovation approaches enable to consider the whole product useful life by promoting collaboration among the different companies operating in the specific phases of the product useful life (Leising et al., 2018). Therefore, circular product design can be properly implemented, and its full benefits can be achieved. These benefits include, for instance, the possibility to consider all at once the information, materials and resource flows, previously interrupted several times along the product useful life. Second, the open innovation approaches enable theimplementation of PSS (Jesus & Jugend, 2023). Open innovation could be useful to proactively engage not only the companies involved in the building value chain but also the end users, which turn from customers to users, therefore, from a passive to an active role.

We reviewed the existing academic literature on the open innovation approaches with a narrative literature review methodology – the same methodology was deployed to review literature at the intersection between the circular economy and the building industry (Fan et al., 2022). We started from a small number of contributions on open innovation approaches (e.g., seminal contributions by Chesbrough and Bogers) and we applied the backward and forward snowball sampling approach to enlarge our theoretical base until an incremental knowledge expansion was saturated. Different perspectives, measurement procedures and frameworks are available in the existing scientific research (Carrasco-Carvajal, Castillo-Vergara, & García-Pérez-de-Lema, 2023). Among the ones proposed by several authors, the contribution provided by West and Bogers (2014) proposed a four-phases framework, which takes the perspective of a focal firm, and identifies the different phases required to implement the open Innovation approach. Here, collaborations and knowledge sharing happen through distinct phases.

The first phase refers to obtaining innovations from external knowledge sources and it is thus named "obtaining". It is the base ground of the innovation process and enables the focal firm to access skills, knowledge sources and competences, which it does not have internally. The second phase refers to the integration of the external knowledge sources and it is thus named "integration". Once the external knowledge sources are obtained, the focal firm needs to internalize and assimilate the collected knowledge. The third phase refers to the commercialization of innovations, and it is thus named "commercializing". It considers the business standpoint, and it aims to profit from the innovation with a proper business model. The fourth phase refers to the interactions among the distinct phases of the framework and it is thus named "interaction". Open innovation involves several players (e.g., suppliers, customers) who interact with each other in different ways (e.g., feedback loops, cocreation) throughout the different phases of the framework. The first three phases follow an "unidirectional linear path" (i.e., they are subsequent phases). Whereas, the last phase enables to implement bidirectional flows among the previous phases (West & Bogers, 2014). Figure 1 reports the four-phases open innovation framework developed by West and Bogers (2014). Table 1 reports a brief overview of main the characteristics of each phase.

We believe that this framework is particularly suitable to tackle our research question. In particular, the framework provided by West and Bogers (2014) is suitable for the purpose of this paper for three main reasons. First, the framework captures the main phases required to leverage external innovation sources and to jointly develop and commercialize an innovation through collaborations and interactions.

TABLE 1 Description of the four-phases open innovation framework readapted from West and Bogers (2014).

Phases of the open innovation framework developed by West and Bogers (2014)	Brief description of each phase
Obtaining	Access to external sources of innovation (e.g., skills, competences) from different players, such as suppliers, rivals, complementors and customers.
Integrating	The focal firm internalizes and assimilates the obtained external sources of innovation.
Commercializing	The innovation is commercialized with a proper business model Directed to the targeted customers with the final objective to profit from the innovation.
Interaction	Communication activities such as feedback loops and cocreation activities are performed to enable interaction among the involved players during the other phases of the framework.

Second, we argue that this framework fits also the context of the circular economy transition, which requires collaborations to jointly develop and commercialize a new circular service. Third, this framework could be particularly helpful in the building industry characterized by a long and fragmented value chain to clearly identify the players that should be involved, the phases in which they should be involved, and the role that each company should play with the final objective to achieve circularity. This last point especially enables us to compare the players involved and their roles in the distinct phases between the linear context and the circular context. Overall, the framework by West and Bogers (2014) provides a theoretical structure suitable to investigate the implementation of the circular economy principles fostered by collaboration in the building industry with an open innovation perspective. Accordingly, we leverage this framework as a theoretical guidance in our empirical analysis to tackle our research question.

3 | ACTION RESEARCH METHODOLOGY

The empirical base for our research has been provided through an action research approach, i.e., "an approach to research that aims both at taking action and creating knowledge or theory about that action" (Coughlan & Coghlan, 2002, p. 220). In an action research approach, researchers and practitioners are actively involved in a real-world research process, from research design to the identification of evidence and findings, aiming to advance both academic and practical knowledge (Checkland & Holwell, 1998; Whyte, 1991). Action research methodology has already been applied in the building industry, enabling close collaboration between practitioners operating in the building industry and researchers to advance both theory and practice (see, e.g., Eriksson, 2010). Action research has also been successfully applied in the context of the circular economy (see, e.g., N. M. P. Bocken, Schuit, & Kraaijenhagen, 2018; Christensen, 2021). Additionally, action research has been acknowledged as a methodology suitable to be implemented when coupled with innovation (Ollila & Yström, 2020). Accordingly, this methodology is particularly suitable for answering our research question, already highlighted in the Introduction, i.e., "*How do companies operating in the building industry exploit the open innovation approach to implement the circular economy principles?*". The three main steps identified by the seminal contribution by Coughlan and Coghlan (2002) were followed. The three main steps included are pre-step, main steps and meta-step.

To begin with, the ***pre-step*** aims to set the context and purpose. Action research methodology has been selected because the transition towards circularity in the building industry is still far from being completed and action research represents a suitable methodology to investigate this subject matter. Action research enables one to (i) dive into this industry and participate in a real-world project, (ii) interact multiple times with the players involved and (iii) understand, from the perspective of the players involved, the peculiarities and sought benefits of circular economy transition (e.g., not to shift the burden among subsequent phases of the product useful life). Arup, a global company active in the built environment has been selected as a suitable context due to its experience in the building industry and its commitment towards the achievement of the circular economy principles. Two authors of this paper approached the company to explore potential collaborations with a positive outcome. A research project – the so-called "Envelope for Service – Phase II" – was just starting and the two researchers were invited to join the project. The role of the researchers was contractualized to actively involve them in the multidisciplinary research team, participate in data collection, analysis, evaluation and reporting activities and contribute with their methodological skills and expertise in the circular economy field. Therefore, the researchers leveraged active participation in the "Envelope for Service – Phase II" project to implement action research and access to first-hand empirical data about the implementation of the circular economy principles in a complex and fragmented industry, such as the building façade industry. "Envelope for Service – Phase II" is the sequel of "Envelope for Service – Phase I" research project (Andaloro, Juaristi, Avesani, Santoro, & Orlandi, 2022). "Envelope for Service – Phase I" was shortlisted among all the projects participating in the Arup's Global Research Challenge, which aimed to rethink the current design of the built environment to reach economic, environmental and social benefits through collaboration. Among the several projects participating in Arup's Global Research Challenge in 2019, "Envelope for Service – Phase I" was shortlisted. The main objective of "Envelope for Service – Phase I" was to analyse the current value chain of the façade element. Then, Arup decided to further develop the outcomes of "Envelope for Service – Phase I" with "Envelope for Service – Phase II". Both "Envelope for Service – Phase I" and "Envelope for Service – Phase II" were funded with their own capital by Arup. The main objective of the "Envelope for Service – Phase II" project was to design a circular model, according to the product-as-a-service principle, to be applied in the building façade industry. The research project involved other three partners: an applied research institution, and two universities. The research team involved three practitioners and six researchers, and it was multidisciplinary. The practitioners contributed with their competences and expertise in the building façade industry, four researchers contributed with technical knowledge in the building façade industry, and two researchers contributed with scientific knowledge of circular economy. The research project lasted 2 years (2020 and 2021), and it was characterized by collaborative relationships among the research team members. Project meetings were arranged to be recurrent to share current activities, discuss next steps and favour knowledge transfer among the research team members. Confidential progress reporting was carried out to track the project advancements and collect contributions from the team members.

Thereafter, the ***main-steps*** were followed. Data collection, feedback and analysis lasted approximately 16 months and action planning, implementation and execution lasted approximately for the subsequent 8 months. The whole multidisciplinary team was involved in the steps in both formal and informal collaborative settings. The data collection aimed to gather relevant data and information considering both academic and grey literature (e.g., sectorial and consultancy reports). On the one hand, a narrative literature review methodology

was deployed to review academic literature. This methodology is suitable for investigating the interplay between different domains and it is characterized by an incremental knowledge expansion through a snowball sampling approach (Fan et al., 2022). On the other hand, professional databases, such as LexisNexis, were used to collect relevant grey literature. The multidisciplinary team triangulated and validated the collected data and conducted semi-structured interviews to further validate the collected data. Semi-interviews were selected because they are characterized by a flexible setting which enhances the collection of nuanced information and data based on the interviewee's peculiarities (DiCicco-Bloom & Crabtree, 2006). An interview protocol (reported in Appendix 1) was structured to focus on two main topics: (i) the companies involved in the building façade value chain and (ii) their role in implementing the circular economy principles. Eight semi-structured interviews were conducted with two façade manufacturers, a facility management company, an integrated design consultancy company, a general contractor and three Energy Service Companies (which operate in the built environment value chain to implement energy efficiency measures with a servitization approach (Yi, Lee, & Kim, 2017)). The interviews were conducted in Italian and online (given the pandemic outbreak) and they lasted approximately between 45 and 60 minutes. A content analysis was performed on the data and information collected (Weber, 1990). Data and information triangulation was performed by the multidisciplinary team to identify the players involved in the linear and circular façade context together with their roles. Afterwards, the action planning, implementation and evaluation were performed though a demo-case study, i.e., a real word Italian testing project. This case study refers to the retrofitting of an existing building through the adoption of an innovative way to deliver building façades. As far as the building characteristics of the testing project are concerned, it is a residential social housing condominium, almost forty years old and located in central Italy, with four floors and more than 10 flats. This residential social housing condominium has over eight hundred square meters of walkable heated floor and over three hundred and fifty square meters of roof. The overall façade surface of the residential social housing condominium totals one thousand and one hundred square meters. Almost 40 rooms have at least one external wall. Almost 70% of rooms with at least one external wall refer to living rooms, South-East oriented. The remaining over 30% refers to bedrooms, North-West oriented.

At last, the ***meta-step*** was performed to implement continuous monitoring of the research project advancements and to implement feedback loops. The objective of this step was to learn from the gathered data, information and insights. A three-fold reflection was implemented to reflect on the issues encountered (i.e., content reflection), on the action planning, strategies and outcomes (i.e., process reflection), and on the unstated assumptions, informally gathered, to constructively criticise them (i.e., premise reflection) (Coughlan & Coghlan, 2016). Figure 2 presents briefly the steps followed to deploy action research methodology.

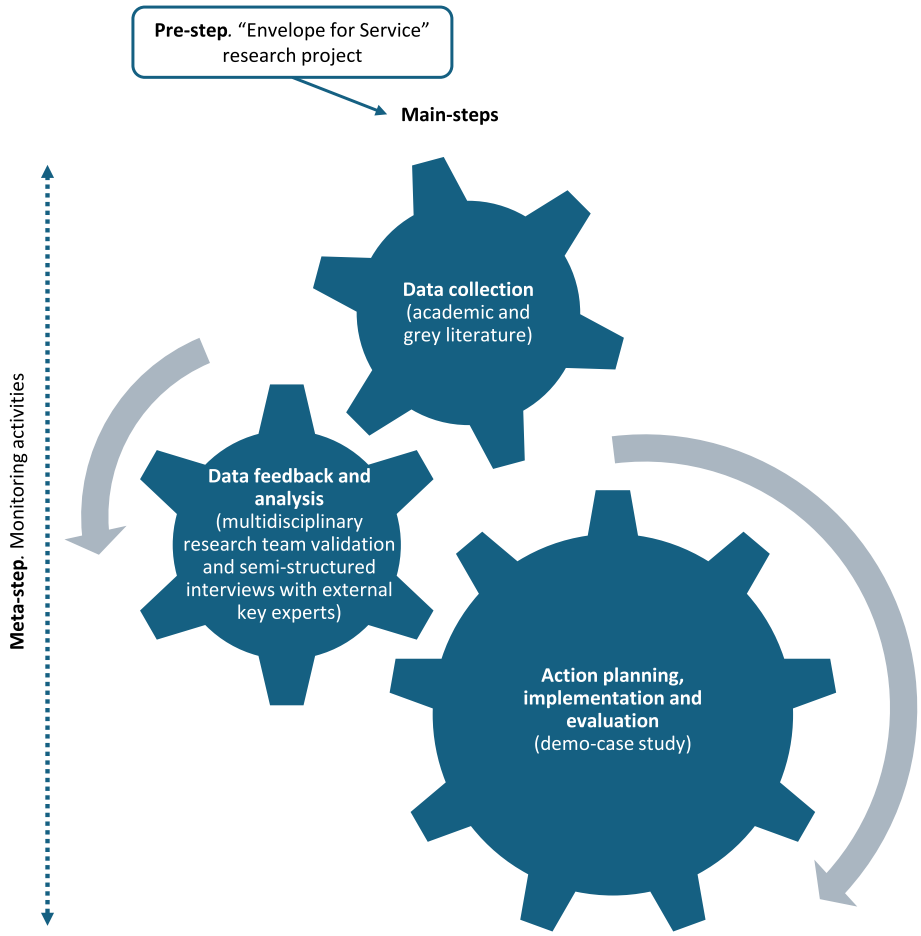

FIGURE 2 Action research methodology steps (adapted from Coughlan & Coghlan, 2002) applied to the "Envelope for Service – Phase II" research project. [Colour figure can be viewed at wileyonlinelibrary.com]

Overall, we adopted an abductive approach, which enables researchers to combine both theoretical and empirical evidence in an iterative process as action research activities advance (Dubois & Gadde, 2002; Han, Konietzko, Dijk, & Bocken, 2023). For instance, the data, information and unstated assumptions collected through semi-structured interviews validated and enriched the data collected through academic and grey literature. Through the abductive approach and in accordance with previous contributions (see e.g., Aarikka-Stenroos et al., 2022), we were able to modify and tailor the starting framework by West and Bogers (2014), reported in Figure 1, with additional empirical and theoretical evidence gathered iteratively during the advancement of the action research activities (Dubois & Gadde, 2002), as presented in Figures 3 and 4 and Table 2.

We believe that the overall steps implemented enabled us to meet the quality criteria of action research, i.e., rigorousness, reflectiveness and relevance (Coughlan & Coghlan, 2016). First, the purpose, context, the multidisciplinary team, the collaborative setting and the role of the researchers are presented. Second, the methodologies deployed to collect data and information and generate reflection and feedback cycles (e.g., thanks to the information gathered through semi-structured interviews and the implementation of the demo-case study) are described. Third, both intended and unintended (e.g., referring to economic unfeasibility) outcomes are reported in Section 4.

4 | FINDINGS

First, we describe at length the "Envelope for Service" project in Section 4.1. Briefly, it refers to an interdisciplinary project aimed at turning the façade from a linear to a circular element and, thus, developing a façade-as-a-service model. Thereafter, we investigate the collaborations among the several players involved in the façade value chain by using the framework presented in Figure 1 and adapted from West and Bogers (2014). In Section 4.2, we focus on the linear façade context and report on the open innovation framework developed by West and Bogers (2014). In Section 4.3, we focus on the circular façade-as-a-service context, and we report the framework in the circular façade-as-a-service context, identifying the roles of the players involved in each phase and providing an overview of the roles of the players throughout the whole phases. The findings highlight the difference between the linear and the circular context. The linear context is characterized by subsequent phases with limited interactions. Conversely, continuous collaborations throughout the full set of players involved in the façade-as-a-service context are needed to jointly develop a circular model for this building element.

4.1 | The envelope for service project

The Envelope for Service project is divided into two subsequent phases, i.e., phase I and phase II. "Envelope for Service – Phase I" aims to set the context: (i) perform a market analysis to understand the peculiarities and criticalities of the current value chain of the building façade, (ii) identify the building façade element suitable for the implementation of the circular economy principles and (iii) design a proper circular model, involving the several players operating in the building façade value chain. "Envelope for Service – Phase II" aims to provide practical evidence on the Envelope for Service performance. In particular, "Envelope for Service – Phase II" aims to: (i) identify the implementation of the circular economy principles in the building façade value chain, (ii) complete and better define a circular model for the façade element, considering both the dimensions of generating and capturing value from the façade-as-a-service model, (iii) apply the Envelope for Service concept in a demo-case building façade.

The already mentioned collaborative environment of the project allowed us to identify: (i) the several players belonging to the building façade value chain and (ii) the distinct roles played by each player to foster the façade-as-a-service model in the building façade value chain. Players involved in the building façade value chain were jointly classified by the project's partners as follows: integrated design consultancy company, façade manufacturer, service provider, facility manager and asset owner. The integrated design consultancy company is involved in the design of both the components of the building (e.g., building façade) and of the entire building. The façade manufacturer operates in the manufacturing of the building façade. The service provider provides strategic and managerial guidance in the implementation of the circular economy principles, and it is in charge to offer the circular building façade to the final users. The facility manager is involved in activities to ensure the proper maintenance of the building and its proper operations. The asset owner owns the building and its components.

The building façades in the Envelope for Service project are modular and composed of controllable blinds, a decentralized ventilation machine and a building-integrated photovoltaic system. Moreover, these façades are embedded with digital technologies. The digital technologies enable the monitoring of performances and therefore optimize daylight control and thermal heat transfer and, consequently, energy consumption and comfort perceived by the building occupants. Lastly, the building integrated photovoltaic system enables it to produce electric energy and to, partly, self-consume it. The façades in the Envelope for Service project look promising to be adopted in residential buildings generating both qualitative (i.e., improved comfort) and quantitative benefits (i.e., energy consumption reduction), even if at the current stage of development, the investment cost difference is relevant, and the benefits achieved by reducing the energy consumption, are not enough to make it fully economically sustainable. Regardless of the unintended negative outcome on economic feasibility, the competences and knowledge gathered during the research project enabled Arup to establish a competence centre on circular economy and thus further the implementation of the circular economy principles in such a company operating at a global scale.

4.2 | The context of the linear façade

The players of the traditional linear façade context, jointly identified by the "Envelope for Service – Phase II" project partners, are involved

in the different phases according to their peculiarities. The focal company in the linear façade context is mostly represented by the façade manufacturer. It is the bridging point between the product design and the customers, who will ultimately own the façade. *"We (the façade manufacturer company) are the ones selling the product (i.e., the building façade) to the customers. The value chain relies on us to get access to the customers (a manager)"*. The façade manufacturer does not have inside its boundaries all the skills and competences to develop an innovative façade. Therefore, the façade manufacturer leverages on the external knowledge sources provided by the integrated design consultancy company to design an innovative façade. The integrated design consultancy company provides the latest trends and technical innovations. It develops an innovative façade concept design. *"Our objective (the objective of the integrated design consultancy company) is to be always up to date with the most innovative technological trends. We attend specialized fairs and conferences (a technician)"*. Then, the façade manufacturer integrates the external sources collected. The Research and Development (R&D) business unit of the façade manufacturer absorbs and assimilates the external knowledge. The façade manufacturer is therefore able to produce an innovative façade. The innovative façade leverages on externally provided hints and knowledge, but it is aligned with the façade manufacturer's internal R&D skills and production process. Afterwards, the innovative façade is commercialized. The façade manufacturer commercializes the innovative façade maintaining its traditional business model. The final customer of the innovative façade is typically represented by the asset owner, namely the owner of the building over which the façade will be installed. The asset owner owns the façade, which is sold by the façade manufacturer eventually by means of intermediaries and installers. Limited interactions are established to design and commercialize the innovative façade. The main interaction identified is the one between the façade manufacturer and the integrated design consultancy company. These two companies establish feedback loops in order not to have mismatches among the design and the manufacturing phases of the façade. *"We (the integrated design consultancy company) provide them (the façade manufacturer) innovative design. They come back to us to refine or modify the design if they do not have the required skills and machinery to manufacture it (a technician)"*. The linear façade context is thus characterized by the focal company that leverages on limited external knowledge sources with limited interactions. Moreover, the focal company commercializes the innovative façade by selling it to the final customers. Figure 3 highlights this process.

4.3 | The context of the circular façade

The players of the façade-as-a-service context, jointly identified by the "Envelope for Service – Phase II" project partners, are different from the ones involved in the linear façade context and are involved in different phases. First, the focal company is represented here by the service provider. It should be mentioned that this company is not already involved in the traditional façade context, therefore, it is a new player needs to be involved in the transition from the linear to the circular context. The focal role of the service provider has been identified by the multidisciplinary team involved in the "Envelope for Service – Phase II" thanks also to the semi-structured interviews with external key informants. Particularly, the interviewed Energy Service Companies already implement servitization principles which could similarly be applied by the service provider in the context of the circular façade-as-a-service.

The service provider acts as the central hub in this context. The service provider leverages several external knowledge sources. The façade manufacturer, the integrated design consultancy company and the end users are involved to gather all the relevant sources of information, knowledge, competences and skills required to implement the circular economy principles in the façade context. These players provide different and complementary information. Indeed, in the circular economy context, products must be designed by having in mind from the beginning of the last phase of the product useful life. The involvement of several players from the beginning is indeed crucial to design a product whose useful life could be extended as long as possible. The ultimate objective of involving these players is to avoid mismatches among the subsequent phases of the façade's useful life. The service provider is then called to integrate all the knowledge collected. The service provider acts like a technical merging point and ultimately develops the circular innovative façade. This façade is used by the final users, who do not definitely own the circular façade. The circular façade is offered to the final users in a product-as-a-service way. A proper circular model is applied by the service provider, which retains the ownership of the circular façade. *"We (the Energy Service Company) retain the ownership of our products and the users only get access to it without owning it (a manager)"*. To commercialize the circular façade, the service provider involves the asset owner and the facility manager. These two players are crucial not to sell a product but to offer mostly a service to the final users. Indeed, they support the service provider in managing the façade installed at the end user's

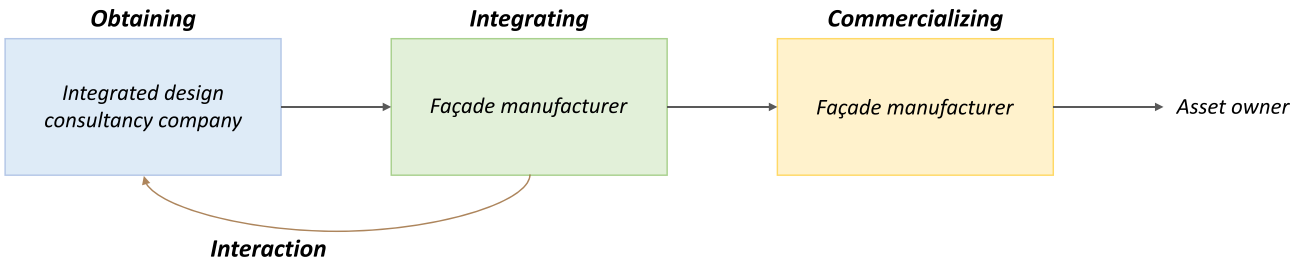

FIGURE 3 The four-phases open innovation framework readapted from West and Bogers (2014) and applied to the context of the linear façade. [Colour figure can be viewed at wileyonlinelibrary.com]

premises and guarantee the proper façade performance. The digital technologies embedded in the building façade enable to monitor performance, detect changes and consequently call for interventions to restore performance to guaranteed levels. *"Digital technologies are fundamental for us (the Energy Service Company) to enable pay-per-performance contracts. Through remote monitoring, we detect problems and directly send our technicians to restore normal operations and the guaranteed performance (a manager)"*. Continuous interactions are required to allow for the effectiveness of the innovative circular façade. The service provider acts like a technical and a managerial hub. This player interacts with the several players involved in the distinct phases to jointly design and commercialize – as a service – the circular façade. On the one side, interactions are needed to design the façade according to the circular economy principles and not to have mismatches among subsequent phases of the façade useful life. On the other side, interactions are needed to commercialize the circular façade in a product-as-a-service way. Figure 4 highlights this process.

In the next sub-section, a deep dive into the context of the circular façade is presented. The role of the players involved in each phase of the four-phases open innovation framework developed by West and Bogers (2014) is reported. We provide a final overview of the role of the players throughout the whole four-phases in the last sub-section.

4.3.1 | Obtaining phase: the players involved and their role

The service provider identifies and gathers several external knowledge sources. These external knowledge sources provide complementary information, needs, skills and competences for the development of an innovative product-as-a-service model for the façade element. In particular, the external knowledge sources involved are the following: the integrated design consultancy company, the façade manufacturer and the final users.

The integrated design consultancy company provides strategic guidance on the whole design process, enabling the early identification of issues and threats. This company has the complete set of skills and competences needed to design not only the circular product but also to consider and anticipate all the product requirements along its circular useful life. The integrated design consultancy company has thus to address circular product design practices and to consider the needs of the several players involved and the façade requirements needed by the final users. Besides, this company supports the service provider in defining the Key Performance Indicators (KPIs) to be monitored to guarantee the effectiveness of the façade's performance. Remote performance monitoring is enabled by the integration of digital technologies, such as sensors, in the building façade. The integrated design consultancy company designs the building façade with integrated digital technologies enabling the service provider to monitor the façade's performance.

The façade manufacturer has full visibility and knowledge of the façade production process. The manufacturer can modify, in advance, the façade production process in order not to incur mismatches along the phases of the circular product useful life. The involvement of the façade manufacturer is crucial to prevent the risk of mismatches among the design, the manufacturing, the installation and the post-usage (i.e., recycling) phases. Besides, the façade manufacturer leads the development of manufacturing activities according to circular product design practices. For instance, the product needs to be not only manufactured but also remanufactured by the façade manufacturer, who needs to be able to disassemble the façade and repair it. *"We (the façade manufacturer) have full control over the production process. Any changes in design must be agreed with us. If restoration activities are to be done, we need to account for them right from the start (i.e., the production) (a technician)"*. Finally, another external knowledge source is represented by the final users. Indeed, they provide the desiderata of the product to be met.

4.3.2 | Integrating phase: the players involved and their role

One of the main antecedents to the circular economy transition is the managerial commitment (Centobelli et al., 2020). The managerial culture of a company needs to be aligned with the circular economy principles to have the managers on board in the transition towards circularity. Therefore, the involved companies should have an adequate managerial culture. The focal company, represented here by the service provider, needs to be willing to cooperate and it needs to be committed to turn a product into a circular service.

The service provider needs also to have the suitable skills and competences to integrate the technical contribution provided by the external knowledge sources. The service provider acts as the technical hub. It gathers all the relevant knowledge and information

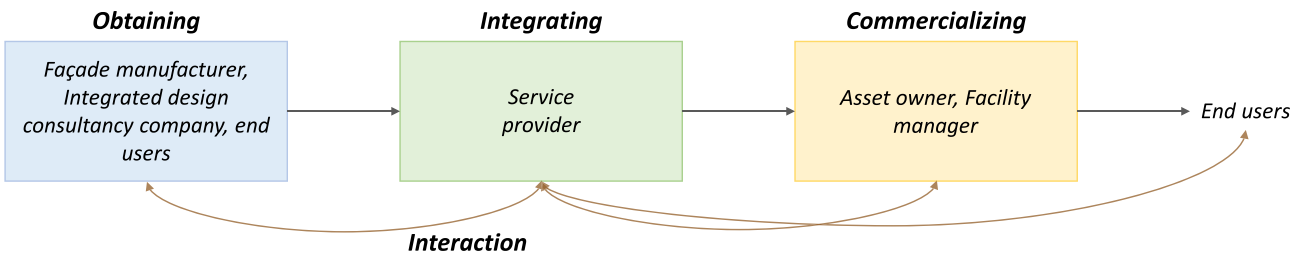

FIGURE 4 The four-phases open innovation framework readapted from West and Bogers (2014) and applied to the context of the circular façade. [Colour figure can be viewed at wileyonlinelibrary.com]

(e.g., requirements needed by the final user). It internalizes and absorbs the external knowledge, and it accordingly designs the circular façade. *"We (the Energy Service Company) need to talk the same language of the other players involved in the design process; therefore, it is fundamental that our team masters technical skills and competences (a manager)."*

4.3.3 | Commercializing phase: the players involved and their role

A key step in the transition towards circular economy is to design a proper circular model, describing how value is created, transferred to the customers and ultimately captured by the upstream players. Value creation is the base ground for a circular transition in the building façade industry. It implies the design of the circular façade, and it leverages on the external knowledge provided by the integrated design consultancy company, the façade manufacturer and the final users. However, once the circular façade has been designed, it must be commercialized, namely the created value must be transferred to the final users and captured by the upstream players.

The service provider is the focal company also in the commercialization of the circular façade. The service provider designs a circular model, through which the circular façade can be offered into the market as a product-as-a-service with a guaranteed performance level.

The asset owner and the facility management closely collaborate with the service provider to design and implement the circular model of the building facade. The asset owner relies on the service provider, who must ensure the agreed façade's performance. The facility manager supports the service provider in the monitoring and maintenance activities, and it ensures the adequacy of the façade's performance. *"We (the facility management companies) are in charge of ensuring proper operations and contribute to achieving the guaranteed performance level (a manager)"*. The product-as-a-service offering is enabled not only by collaboration but also by the digital technologies embedded in the building façade. Indeed, digital technologies enable the remote monitoring of performance and, therefore, enable to detect performance changes and be able to meet the guaranteed performances. The target customers are represented by the final users, who do not definitely own the façade but benefit from the guaranteed façade's performance.

4.3.4 | Interaction phase: the players involved and their role

Feedback and cocreation are very relevant to design and commercialize the façade element of a building as a product-as-a-service. The whole value chain needs to be aligned with the product-as-a-service requirements. The companies involved in the different phases of the circular product useful life need to be aligned in order not to have mismatches among subsequent phases of the circular product useful life. For instance, maintenance requirements need to be considered from the design phase to design the product according to the principles of design for disassembly, which enables the repair of the product whenever needed.

The service provider acts both as technical and managerial guidance. It ensures feedback and cocreation interactive activities among the players involved in the four-phase open innovation framework. The continuous feedback loops and cocreation allow the several players involved in the circular façade context to jointly design and commercialize a product-as-as-service model for the façade element. *"A pay-per-performance contract needs system thinking to be successfully implemented. Different players need to smoothly interact and provide their skills and expertise. Our guidance and coordination are key factors to be considered and ensured (an Energy Service Company manager)"*.

4.3.5 | Overview of the players' involved in the context of the circular façade

Table 2 presents an overview of the role played by each player involved in each of the phases of the open innovation framework. For

TABLE 2 Players' role in the four-phases open innovation framework readapted from West and Bogers (2014) and applied to the context of the circular façade.

Phase	Players involved	Main role
Obtaining	Integrated design consultancy company	It provides a strategic guidance throughout the whole design process.
	Façade manufacturer	It prevents the risk of mismatches among the design, the manufacturing, the installation and the post-usage.
	Final users	They provide the desiderata of product to be met.
Integrating	Service provider	It acts as the technical hub. It gathers the knowledge and information, internalizes it and accordingly designs the circular façade.
Commercializing	Asset owner	It relies on the service provider, who must ensure the agreed façade's performances.
	Facility management	Supports the service provider in the monitoring and maintenance activities.
Interaction	All players	The players involved in the whole framework jointly develop a circular product to be offered as-a-service. All the players are involved in the feedback loops and co-creation. The service provider provides both technical and managerial guidance.

each phase, the players that provide external knowledge sources, as well as the main role of each one, are reported.

5 | CONCLUSIONS

This article contributes to further advance the academic and managerial debate about circular economy in the building industry. We point out the relevance of adopting an open innovation approach in the circular economy studies to deepen the role of collaborations fostering the transition of companies towards circular economy. The open innovation approach allows to leverage external and internal knowledge sources and, above all, collaborations to enhance the transition towards circular economy. External knowledge sources are relevant to consider the needs of the full set of players involved in the value chain and the desiderata of the final users. Collaborations are key to achieving circularity without drawbacks. Indeed, collaborations are needed to jointly consider the overall product useful life. Therefore, mismatches among subsequent phases of the product useful life are avoided through collaborations among the players involved in each phase. The transition towards circular economy requires a systemic shift that does not involve a single company but the whole value chain. We posit that open innovation is a relevant approach to be used in circular economy studies as it allows us to reflect in terms of a systemic implementation of the circular economy principles. It should be mentioned the central role of the service provider, which becomes the focal company in the circular context. The service provider oversees managerial and coordination activities to ensure that the circular economy principles are coherently implemented throughout the whole product useful life by all the players involved in the value chain. We believe that our contributions could be also applied to other industries with the same characteristics of the building industry (i.e., long, and fragmented value chain; complex and durable products; multiple interruptions of information, materials and resources flows). These industries could promote the transition towards circularity with an open innovation approach and the centrale role of the service provider, which acts as the focal company and, for instance, orchestrates all the information, materials and resource flows. Therefore, we posit the focal role of the service provider and we identify open innovation as a proper lever on which fragmented industries could act to achieve the transition towards circular ecosystems (Aarikka-Stenroos, Ritala, & Thomas, 2021).

5.1 | Theoretical, managerial and policy implications

From a theoretical standpoint, this article contributes to further advance both circular economy and open innovation literature. To fully achieve circular economy benefits, it is necessary to innovate multiple elements (e.g., product design, service offering, production processes, organizational settings). This innovation process has to be open and rooted in collaborative aspects to involve different players, each one with its own specific skills and expertise. We confirm and strengthen the need for collaborations to undergo the transition towards circular economy (see, e.g., Aarikka-Stenroos et al., 2022; Zucchella & Previtali, 2019). Besides, we posit how the interactions are of paramount relevance in the circular economy. Indeed, in a circular model, interactions take place both in the upstream and downstream phases of the value chain, conversely to what happens in a linear, traditional model (coherently to, e.g., Dewagoda et al., 2022; Farooque, Zhang, Thürer, Qu, & Huisingh, 2019). By leveraging the open innovation framework developed by West and Bogers (2014), we show that interactions in circular economy take place not only from the upstream to downstream phases (one way only) but also from the downstream to upstream ones (double way). Accordingly, shifting from a linear to a circular model requires the focal firm to take a new managerial and coordination role in a circular model. In this case, the interactions among the several players involved change and take place in both directions along the chain to jointly co-develop a circular service. This evidence contributes to further advance literature on open innovation with specific reference to how companies interact with each other while implementing the circular economy principles. Lastly, we posit that digital technologies are a key lever in the transition towards circular economy. The enabling role of digital technologies is acknowledged by academic literature, which still lacks empirical evidence (Ertz & Gasteau, 2023; Huynh, 2022). We provide theoretical insights based on an interdisciplinary research project, in which digital technologies enable the offering of a product-as-a-service, i.e., façade-as-a-service (in accordance with, e.g., Toth-Peter, Torres de Oliveira, Mathews, Barner, & Figueira, 2023). Digital technologies together with collaboration and open innovation approaches could foster the transition towards circularity, a transition which seems more difficult as time passes by (Circle Economy Foundation, 2024). Overall, we posit the relevant role of four elements in enabling the transition towards circular economy: (i) open innovation approaches to innovate multiple aspects according to the circular economy principles (e.g., product design), (ii) collaboration to involve and engage multiple players with diverse skills and expertise useful and complementary to undergo the transition, (iii) double-way interactions to facilitate knowledge flow from the upstream to downstream and vice versa, (iv) digital technologies to smooth and enhance the implementation of the circular economy principles (e.g., servitization). Figure 5 visualizes these four elements.

From a managerial standpoint, the key role of collaborations among all the players involved in the value chain of the building industry is reported. The transition towards circularity requires companies to jointly design products and business models according to the circular economy principles to avoid mismatches throughout the products' useful life. We posit the relevant role of the service provider, a new company to be included in the circular façade context, to provide strategic and managerial guidance and to act as the user's single point of contact. By leveraging existing literature, as well as an empirical analysis of an interdisciplinary research project, we developed an ad hoc four-step open innovation framework (readapted from the one proposed by West & Bogers, 2014), which reconceptualizes how the open innovation approach can be exploited in a circular economy context to allow for the effectiveness of collaborations in a circularity

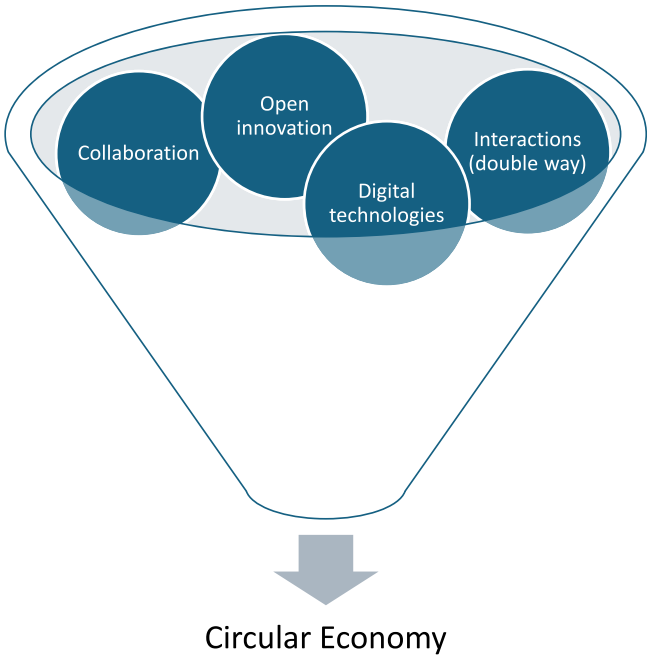

FIGURE 5 The four elements enabling the transition towards circular economy. [Colour figure can be viewed at wileyonlinelibrary.com]

transition (reported in Figure 4). In the proposed framework the interactions and collaborations are different with respect to a linear, traditional economy (reported in Figure 3). Managers could thus use this "refined" framework as a tool to identify the interactions and collaborations needed to undergo the transition towards circular economy, especially in the building façade industry and, eventually, broadly applicable to other building elements, and by considering the involvement of additional players, whenever needed.

From a policy maker standpoint, we emphasize the role of collaborations and interactions to foster the circular economy transition. Accordingly, the policy makers could set a regulatory framework that promotes collaborations to support the transition towards circularity in the building industry (and not only). Support schemes could be set to push players to collaborate and jointly implement the circular economy principles. The policy makers are called to foster collaborations among players even tough not already involved in a specific industry. Therefore, industry boundaries shall not be placed on collaborations among several players.

5.2 | Limitations and future research avenues

This research presents some limitations that could represent the starting point for future research avenues. Action research is tightly linked to a real-world research process that limits the generalization of its results (Checkland & Holwell, 1998). This aspect means that the generalization of results can be made for theory building, also known as "analytical generalization", but not to explain the entire population, i.e., "statistical generalization" (Baškarada, 2014; Yin, 2009; Zittoun, 2017), with the limited possibility to favour their "transferability" to other similar cases (Gomm, Hammersley, & Foster, 2000). Additionally, we adopted a step-by-step approach with not only researchers but also practitioners to unfold context-specific and relevant contributions to the academic debate (Checkland & Holwell, 1998; Ollila & Yström, 2020). Therefore, we hope that our study, and especially the framework elaborated in Figure 4, could be useful for analysing other cases in the same, similar or different industry.

Our empirical evidence refers to the "Envelope for Service – Phase II" project, which focuses on the Italian context. Accordingly, an avenue for further research could be represented by an extension of the geographical scope of the empirical analysis to consider other geographical areas. Besides, the project was focused on the building façade industry. Therefore, another avenue for further research could be represented by the investigation of the intersection of circular economy and open innovation in other industries.

Finally, we suggest four other avenues for future research not specifically related to the analysed project. First, further research could focus on the economic feasibility of the façade-as-a-service project to assess if the circular economy generates not only environmental improvements but also allow for effective economic performances of this transition (see, e.g., Zerbino, 2022). Second, a broader perspective could be investigated. Indeed, the analysis could not be limited to the players directly involved in the transition towards circularity. The analysis could consider the whole business ecosystem which needs to jointly adopt the circular economy principles and therefore develop into a circular ecosystem (recently defined by Aarikka-Stenroos et al., 2021). Accordingly, further research could explore the intersection between circular ecosystems and open innovation, given the need for the transition towards a circular economy at the ecosystem level, and the open innovation approach could enhance collaborations and interactions, key factors to achieve this transition. Third, the environmental benefits achieved through the implementation of the circular economy principles in the building façade could be assessed though, e.g., a Life Cycle Assessment (LCA) analysis. Fourth and lastly, an economic assessment could be performed to compare the economic performance of the traditional business ecosystem and the economic performance of the circular ecosystem.

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DATA AVAILABILITY STATEMENT

Research data are not shared.

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APPENDIX 1: Details of the interview protocol that was used for the conduction of the semi-structured interviews

Introduction	◦ Role, expertise, and competences of the respondent/s ◦ General description of the firm (turnover, employees, etc.)
Firm main activities	◦ Do you offer a product or a service? ◦ What are your main activities required to offer it? ◦ How is the company structured?
Linear façade context	◦ Which are the companies involved in the traditional building façade value chain? ◦ Which is the role of each company? ◦ Which company plays a focal role in this value chain? ◦ Do the companies involved in this value chain interact? ◦ If yes, how do they collaborate and interact?
Circular façade context	◦ Which are the companies involved in the circular building façade value chain? ◦ Which is the role of each company? ◦ Which company plays a focal role in this value chain? ◦ Do the companies involved in this value chain interact? ◦ If yes, how do they collaborate and interact?