

## RESEARCH ARTICLE



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# How can the waste management sector contribute to overcoming barriers to the circular economy?

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## Abstract

This paper contributes to an emerging literature stream advocating the multifaceted involvement of the waste management sector in supporting the up-scaling of the circular economy (CE). It explores the role of waste collection and recycling platforms in overcoming various barriers to CE implementation, inductively analyzing the case of postconsumer wood in Italy. Data were collected from multiple sources: interviews with 33 informants, participation in project meetings, site visits, and public and private documents. The case shows how waste collection platforms can perform different activities that can help address cultural, regulatory, market, and technological barriers. First, these platforms can contribute to stimulating demand for postconsumer wood, carrying out information and communication activities, and fostering the development of a positive image of the recovered material. Second, the platforms can contribute to defining and implementing the conditions to enable the activation of recycling processes.

## KEYWORDS

barriers, case study, circular economy, postconsumer wood, waste management platforms

## 1 | INTRODUCTION

In recent years, the circular economy (CE) paradigm has become very popular among a broad range of stakeholders, including policy makers, business organizations, and researchers. The motivation at the basis of this popularity is the aspiration of CE to realize “an industrial economy that is restorative or regenerative by intention and design” (Ellen Macarthur Foundation, 2013), providing a potential solution to achieve sustainable development (Camilleri, 2019, 2020; EU Commission, 2015; Lieder & Rashid, 2016; Murray, Skene, & Haynes, 2017; Urbinati, Chiaroni, & Chiesa, 2017).

Despite the consensus surrounding the concept, implementation of CE principles within business organizations is still fragmented (Lieder & Rashid, 2016), and the shift to CE is hindered by several barriers (De Jesus & Mendonça, 2018; Kirchherr et al., 2018). As a result, the real-world implementation of theoretical CE concepts remains

more episodic than pervasive, with success stories confined to specific organizations, and relevant gaps persist between the vision of a truly circular economy and the large-scale diffusion of this model (Babbitt, Gaustad, Fisher, Chen, & Liu, 2018; Hopkinson, De Angelis, & Zils, 2020).

One of the factors that have attracted growing attention based on its potential to address the issue of fragmentation and foster the up-scaling of CE solutions is the establishment of partnerships with the waste management sector and, in particular, with waste collection and recycling platforms (de Carvalho Araújo et al., 2019; Ghinea & Gavrilescu, 2019; Malinauskaite et al., 2017; Salmenperä, Pitkänen, Kautto, & Saikku, 2021; Singh & Ordoñez, 2016). Waste collection platforms, here denoting organizations that ensure the collection, recycling, and disposal of postconsumer materials, are responsible for many activities, such as management of logistics flows, materials sorting, and materials processing and conversion, which are necessary

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preparatory steps for other possible reactions (recycling, remanufacturing, reuse, etc.).

Traditionally, waste collection platforms have focused on minimizing the cost of collection and disposal to improve the efficiency of the waste management system (Parajuly & Wenzel, 2017) without directly participating in value creation—that is, the transformation of resources into valuable consumer products through innovation, manufacturing, or distribution activities. However, a few papers have started to highlight that waste collection platforms could actively contribute to resource conservation and materials recovery, opening new opportunities for creating value from waste (de Carvalho Araújo et al., 2019; Salmenperä et al., 2021; Singh & Ordoñez, 2016). This could occur via waste prevention, for example, with waste collection platforms helping spread understanding of how to make recycling easier, enhancing the refurbishment and reuse of postconsumer materials, or extracting resources from waste and developing innovative recovery processes (Salmenperä et al., 2021).

Though these papers advocate the multifaceted and proactive involvement of waste collection platforms within the CE paradigm, they do not explain exactly how waste collection platforms could contribute to eliminating or reducing some of the barriers to CE implementation and diffusion. This gap leads to the formulation of our research questions: Which barriers to CE implementation can be addressed by a more proactive role for waste collection platforms? How can waste collection platforms contribute to overcoming these barriers?

To answer these research questions, the paper analyzes the case of recycling platforms for postconsumer wood in Italy. This case is interesting and relevant for different reasons. First, wood is a widely used material in many different industries. In Europe, the so-called forest-based industry (broadly including wood-working industries, pulp-producing industries, paper and other fiber-based product industries, and the furniture industry) accounts for 420,000 enterprises, with a total turnover of over 520 billion euros and approximately 3.5 million workers (Cepi, 2018). As this material is widely used, there is also an enormous quantity of postconsumer wood that may be recycled. The second reason concerns the evolution of regulations on wood recycling. Given that wood is the only major raw material fully reproduced by nature, the EU is setting more stringent recycling targets, calling for new and efficient ways to achieve them. Finally, the case of Italian wood recycling platforms is relevant because Italy is among the most commendable countries in terms of its wood recycling strategy. Compared to some other EU countries where postconsumer wood is mainly used for energy recovery, Italy has made relevant investments to foster postconsumer wood alternative recycling.

The rest of the paper is organized as follows. In Section 2, we analyze the state-of-the-art literature to outline the main barriers to the implementation of the CE paradigm that has emerged from previous studies. In Section 3, we present the research method, with specific reference to how data were collected and analyzed, and we introduce the case studied in this research. In Section 4, we present our empirical material, and based on its analysis, we discuss in Section 5 how the wood recycling platform system is contributing to

overcome barriers to CE. Finally, we conclude in Section 6, addressing the limitations of this research and the path for future studies.

## 2 | LITERATURE REVIEW

Over the last few years, several scholars have analyzed the barriers that can explain the still-limited progress in CE implementation (Agyemang et al., 2019; De Jesus & Mendonça, 2018; Govindan & Hasanagic, 2018; Guldmann & Huulgaard, 2020; Kazancoglu, Kazancoglu, Yarimoglu, & Kahraman, 2020; Kirchherr et al., 2018). The picture emerging from prior literature is heterogeneous and complex. First, researchers have identified a range of barriers that pertain to different domains, including both hard factors, such as technical and economic obstacles, and soft factors, such as social and cultural obstacles (De Jesus & Mendonça, 2018). Second, the existence and relevance of a specific barrier often depend on the roles of different organizations in the CE value chain and even the positions of different individuals within an organization (e.g., different business functions) (Hart, Adams, Giesekam, Tingley, & Pomponi, 2019; Husgafvel, Linkosalmi, Hughes, Kanerva, & Dahl, 2018; Paletta, Leal Filho, Balogun, Foschi, & Bonoli, 2019). Third, the identified barriers are not independent: CE implementation is typically not hindered by just one of them but by a combination of different factors that reinforce one another (Jesus & Mendonça, 2018; Kirchherr et al., 2018; Rizos et al., 2016).

In this paper, to support the analysis of the role of waste collection platforms in overcoming CE barriers, we refer to the taxonomy proposed by Kirchherr et al. (2018), which is comprehensive and quite widespread in the literature (see also Grafström & Aasma, 2021; Paletta et al., 2019). The authors in fact start from four main categories identified by Jesus and Mendonça (2018) and systematize and aggregate the various barriers highlighted in prior studies. As a result of this process, Kirchherr et al. (2018) classify CE barriers as cultural, regulatory, market or technological barriers and provide a list of items generally included in each category.

*Cultural* barriers are related to social and environmental awareness at both the company and consumer levels. They include factors such as a lack of consumer interest, the prevalence of linear systems in the business context, and a lack of willingness to collaborate along the value chain. Recent research points to cultural barriers as the main obstacles to CE implementation due to the need to change individuals' and organizations' habits, which is, in general, challenging (Grafström & Aasma, 2021; Hart et al., 2019; Kirchherr et al., 2018).

*Regulatory* barriers are associated with a lack of regulatory policies to support the transition toward the CE. These barriers include, for instance, obstructive laws and regulations, a lack of incentive systems, and the lack of a global consensus (García-Quevedo, Jové-Llopis, & Martínez-Ros, 2020; Kirchherr et al., 2018). These factors are particularly relevant in connection to the recovery of postconsumer materials because the waste management sector is characterized by the presence of waste management directives that are often not aligned across different countries or even regions within

the same country (Gregson, Crang, Fuller, & Holmes, 2015; Salmenperä et al., 2021).

*Market barriers* are related to circular business models' economic viability, which is influenced, for example, by the low price of virgin materials, high upfront investment costs, limited standardization, etc. (Kirchherr et al., 2018). These factors are even amplified in the context of recovery of postconsumer materials because there is a lack of autonomous customer demand for these materials; rather, demand must be stimulated or even created (Paletta et al., 2019). On the other hand, materials collection and treatment costs are high, and many activities consist of low-value operations, making these processes not very profitable, especially when they are conducted in developed countries (Gregson et al., 2015; Husgafvel et al., 2018; Paletta et al., 2019).

Finally, *technological barriers* are connected to the availability of technologies to implement the CE. Examples of technological barriers include a limited capability of delivering high-quality remanufactured products, limited circular designs, and a lack of data (Kirchherr et al., 2018). Technological barriers are probably the ones that have attracted the most attention in the literature, and they remain a relevant issue. In particular, in the case of recovered materials, technological barriers have a relevant impact on the characteristics of supply. Recovered resources are usually mixed, and their origins and past uses are uncertain; simply collecting materials is not enough to make them usable, and further activities are necessary to ensure that recovered materials actually meet the quality requirements demanded by consumers; this requires the review of activities and processes and development of new technologies.

Finally, it is worth noting that some recent research further confirms the relevance of the above barriers for the specific sector under investigation—that is, postconsumer wood. Husgafvel et al., 2018, in fact, analyze the case of the cascading of recovered wood in Finland and explore the main barriers perceived by different actors involved in the CE. The authors highlight that organizations belonging to different industry sectors report slightly different barriers, even if the most relevant barriers are related to price/cost effectiveness, industrial scale, and quality issues (such as moisture content, cleanliness, and size).

### 3 | MATERIALS AND METHOD

The research method is based on a single *case study* (Yin, 2014) of an Italian consortium of recycling platforms that deal with the collection, recovery, and recycling of postconsumer wood: Rilegno. In particular, we analyze a recent initiative promoted and developed by the consortium and aimed at identifying new potential uses of postconsumer wood in the construction sector.

#### 3.1 | Data collection

Data collection was carried out by triangulating *multiple sources of proof* (Yin, 2014) and including primary and secondary data.

Primary data sources were semistructured interviews with a diversified group of informants. Interviewees included Rilegno personnel (the president, the general manager, the head of communication), two platform operators, three managers of producers of wood particleboard, members of the consortium, two representatives of the wood industry association, and 23 managers of companies competing in the construction industry and not related to the consortium. Informants from the platform operators, wood particleboard producers, and representatives of the wooden industry association were suggested by the president and the general manager of Rilegno based on the informants' familiarity with the technical processes and the opportunities and criticisms connected to the recycling of postconsumer wood. On the other hand, the organizations operating in the construction industry were selected starting from the Aida database, considering firm size and the specific products produced (wooden houses, buildings and structures; construction elements; insulation elements). Then, for each organization, we asked to talk with informants who could evaluate the suitability of postconsumer wood as an input material for their business activity. Table 1 shows the list of the respondents and their background information.

We developed the interview guidelines for each type of informants, identifying the main discussion points and questions, and we used them flexibly to deepen the issues that emerged during the interview (the interview guidelines are shown in Data S1). Concerning the consortium personnel and the platform operators, the interviews aimed to explore the role of the consortium, the articulation of different processes, and the motivations at the basis of the project and the activities related to the project itself. The interviews with wood panel producers and the industry association representatives explored their experience with the usage of postconsumer wood as an input factor in their production processes and how they had overcome barriers and obstacles associated with it. The interviews with construction company managers addressed the feasibility of the usage of postconsumer wood for manufacturing products employed in the construction sector and the possible barriers preventing this use. On average, each interview lasted around 1 hr. Twenty-eight interviews were recorded and transcribed, and five interviews were not recorded, but the interviewer took detailed notes. In addition, after the interviews, all the interviewees received a report and were given the opportunity to verify their accuracy and add comments and changes. Follow-up issues were raised with interviewees to seek additional details or clarifications. Further insights were also collected through direct observation during site visits to the companies' premises, attendance of exhibitions, and direct participation in project activities and meetings.

Secondary data were collected by accessing both publicly available documents (websites, product catalogues, company reports) and privately available documents. Among the data that are not publicly available, we were able to access technical documentation about products and production processes.

The data collected as described above were then summarized and analyzed thematically (Miles & Huberman, 1994). The results emerging from the analyzed data are presented and discussed in the next sections.

**TABLE 1** List of interviewees

Inter.	Organization	Industry sector	Position
1	Rilegno	–	President
2	Rilegno	–	General director
3	Rilegno	–	Head of communication
4	Waste collection platform	–	President
5	Waste collection platform	–	General director
6	Industry association	–	President
7	Industry association	–	Technical expert
8	Company 1	Wood particleboard	CEO
9	Company 2	Wood particleboard	CEO
10	Company 3	Wood particleboard	CEO
11	Company 4	Wooden houses, buildings, and structures	CEO
12	Company 5	Wooden houses, buildings, and structures	CEO
13	Company 6	Wooden houses, buildings, and structures	CEO
14	Company 7	Wooden houses, buildings, and structures	CEO
15	Company 8	Wooden houses, buildings, and structures	CEO
16	Company 9	Wooden houses, buildings, and structures	CEO
21	Company 14	Wooden houses, buildings, and structures	Technical manager
28	Company 21	Wooden houses, buildings, and structures	Commercial manager
29	Company 22	Wooden houses, buildings, and structures	Technical manager
32	Company 25	Wooden houses, buildings, and structures	Technical manager
19	Company 12	Construction elements	Technical manager
17	Company 10	Construction elements	Commercial manager
18	Company 11	Insulation and construction elements	CEO
20	Company 13	Insulation and construction elements	Commercial manager
22	Company 15	Insulation and construction elements	Technical manager
23	Company 16	Insulation and construction elements	Technical manager
24	Company 17	Insulation and construction elements	Technical manager
25	Company 18	Insulation and construction elements	Technical manager
26	Company 19	Insulation and construction elements	Commercial manager
27	Company 20	Insulation and construction elements	Technical manager
30	Company 23	Insulation and construction elements	Technical manager
31	Company 24	Insulation and construction elements	Technical manager
33	Company 26	Insulation and construction elements	Technical manager

### 3.2 | Rilegno ecosystem

Rilegno was founded in 1997 following Legislative Decree No. 22/1997, which introduced a new waste management system based on separate collection and aimed at encouraging materials recovery and recycling in Italy. Specifically, the consortium has the objective of ensuring the achievement of the targets set by law for postconsumer wooden packaging (pallets, crates, boxes, cases, etc.). To this end, Rilegno coordinates two value chains: materials recovery and recycling of wood waste (which is used as an input factor for other production processes) and pallet regeneration. Since its foundation, Rilegno has invested significantly in the construction of the collection infrastructure, which is now extensive and widespread. The

consortium is constituted by 1,986 organizations, including wooden package manufacturers and importers, suppliers and importers of materials used for manufacturing wooden packages, and wooden particleboard producers. It serves 4,541 municipalities,<sup>1</sup> which represent 57% of all Italian municipalities with over 42 million inhabitants—approximately 70% of the Italian population. It coordinates 416 public and private platforms that gather materials derived from municipalities' ecological waste collection areas and directly collect commercial and industrial waste at companies' premises.

Focusing, in particular, on the recovery and recycling value chain, Rilegno has progressively increased its collection capacity (Table 2), leading to growth in the volumes of postconsumer wood that it manages (in 2018, Rilegno collected 1,932,583 tons of wood waste,

representing an increase of 7% over the previous year). The improved capacity, however, has risked saturating demand for the postconsumer wood. Today, approximately 95% of wood waste is absorbed by producers of wood particleboard, a basic element for the furniture industry. The remaining part is used for the production of cellulosic pulp for paper mills, wood–cement blocks for green construction, or other niche applications.

This situation led the consortium to initiate a strategic project aimed at studying the feasibility of alternative applications that could use the material recovered from wood waste as an input factor in their production processes and at understanding which actions and operational changes were needed to make such applications viable. In particular, the project was focused on the building sector as a potential market for products made of postconsumer wood because this sector is characterized by high volumes and a large variety of products currently made of virgin wood (which might be substituted with postconsumer wood) (see also Pomponi & Moncaster, 2017).

## 4 | PROJECT OUTLINE

This section outlines the project carried out by the consortium, with the objective of identifying new potential uses of postconsumer wood in the construction sector. The project was organized into three main phases:

**TABLE 2** Wood waste managed by Rilegno

	Post-consumer wood collected and recycled (tons)	Of which Wood packaging (tons)
2000	60,000	30,000
2001	218,989	106,330
2002	705,021	409,956
2003	1,225,730	690,537
2004	1,417,897	643,482
2005	1,464,915	708,294
2006	1,614,860	829,867
2007	1,814,940	960,205
2008	1,680,341	919,622
2009	1,531,863	789,067
2010	1,851,287	907,063
2011	1,796,822	839,133
2012	1,465,363	693,300
2013	1,402,638	668,839
2014	1,534,204	751,192
2015	1,570,207	789,178
2016	1,627,353	798,754
2017	1,793,748	848,220
2018	1,932,583	925,019
2019	1,967,290	907,431
2020	1,841,065	829,729

1. Technical analysis to identify building components where postconsumer wood is considered fit to replace virgin wood;
2. Strategic analysis to clarify which barriers could prevent construction companies from using postconsumer wood for such components; and
3. Operational benchmarking to reveal whether and how similar barriers are dealt with by current users of postconsumer wood (particleboard producers).

### 4.1 | Technical analysis

The first phase of the project consisted of the identification of products and applications that could be made out of postconsumer wood. This task was carried out by technical experts in construction, and the results of the analysis were discussed with building companies. For this purpose, the main virgin wood elements used in building construction were identified, and the possibility of replacing virgin wood with postconsumer wood was assessed (the results of the technical analysis are illustrated in Arena, Grecchi, & Piantoni, 2020).

For example, structural elements, such as pillars, beams, or plates (or primary supporting structures), made of massive or laminated wood, were excluded from the panel of potential applications because they cannot be produced using postconsumer wood due to its limited technical performance. Then, other nonstructural elements, which are typically made of primary production wood waste (transformed into chips or fibers), were analyzed. This analysis led to the identification of three product families that appeared most promising for the project objective: *thermal insulators*, *acoustic insulators*, and *secondary structures*.

*Thermal insulators* are panels or granules that constitute an essential layer in both the external walls and the roof of a building to reduce energy consumption. Based on the technical analysis, both fibrous panels and granules could be produced using postconsumer wood, yielding technical performance comparable to that of virgin wood. *Acoustic insulators* are panels or granules used in partition walls, ceilings, or floors to reduce noise. They could be produced using postconsumer wood, albeit with more restrictions than those on thermal insulators. In particular, postconsumer wood is not suitable for producing sound-absorbing panels of medium or high density because such levels of density cannot be achieved with this material. Finally, moving to *secondary structures*, postconsumer wood can be used to create particleboards and infills for frame systems. However, postconsumer wood cannot be used for building floors because the chips obtained in this case do not allow sufficient bending strength to be achieved in relation to the thickness.

### 4.2 | Strategic analysis

The second phase of the project consisted of an analysis of the barriers that could prevent building companies from replacing virgin wood with postconsumer wood for the three applications described

above (thermal insulators; selected acoustic insulators; selected components used as secondary structures). Three main sets of issues common to all the applications were identified.

The first barrier consists of the final consumer's *product quality perceptions*. During the interviews, different construction operators highlighted some doubts about how final consumers might perceive a product made of postconsumer wood. The following quote is paradigmatic of these concerns:

“Today, customers who choose to buy a wooden house associate this raw material with the ideal of superior quality. Wood is considered a *valuable* raw material. Post-consumer wood, in the end, is waste: you do not know where the wood comes from, not from a forest, or what it has been used for. This contrasts with the ideal that our customers have of a wooden house.” (CEO, wooden house producer)

Further criticism also emerged in connection to the presence of the glues and resins that are needed to produce panels or granules using postconsumer wood but that are not needed when insulators or lamellar wood components are made of virgin wood.

“There is the problem of glues and resins. Many people appreciate wood because it is natural and it doesn't contain chemicals; but then, if you want to use post-consumer wood for producing a panel or whatever, you must add glues and other materials that are not natural at all.” (Technical Manager, construction operator)

Overall, several interviewees expressed some concerns about the risk that the use of postconsumer wood could in some way undermine the *image* of wood buildings, both because the provenance of post-consumer wood would not be certain and because the material requires the use of chemical additives (glues and resins), leading to a downgrade in the product characteristics.

A second barrier refers to the (perceived) *technical performance of postconsumer wood*. In this case, some companies have expressed doubts about the possibility that this material can guarantee the same performance as virgin wood, particularly concerning water or mould resistance.

“You cannot use post-consumer wood to produce insulants unless you want to face huge problems with water and mould. Post-consumer wood is not water resistant.” (Commercial Manager, wooden house producer)

This point is particularly relevant because this opinion is not shared by the technical experts, who highlighted that both virgin and postconsumer wood should be treated in a similar way to ensure water resistance.

“Water and mould constitute a problem for any type of wood (both virgin and post-consumer). For this reason, you need to treat the material properly to ensure water resistance and avoid mould formation.” (Professor of built environment, technical expert)

A last point is the need to introduce a *certification system*. All the components currently used in the building sector are certified, and certification is a fundamental instrument for demonstrating that a product meets the performance outlined in the technical sheet (for instance, concerning thermal resistance, bending, and compressive strength).

“Certification is fundamental. First, many product certifications are mandatory in our sector. We cannot use products that are not certified because this is a sensitive industry and we are responsible for what we build. Let's think about what could happen in the case of an accident. ... In addition, since we want to position ourselves as a high-quality company, we also have some voluntary certifications. Certification is a way to demonstrate the quality of our product and be competitive against other companies that have lower prices but also lower quality.” (CEO, wooden house producer)

Against this backdrop, the origin and traceability of postconsumer wood are uncertain to date, but as discussed in the next section, some operators have already introduced certification schemes for products made out of postconsumer wood.

### 4.3 | Operational benchmarking

The third phase of the project aimed to explore the experience of particleboard producers that already use postconsumer wood in their production processes to understand if they had faced barriers similar to those that emerged in the interviews with the building sector operators and how these barriers were overcome.

Concerning the *quality perceived by final consumers*, the interviews with particleboard producers partly confirmed the relevance of this issue but also highlighted the possibility of turning the “waste nature” of the material into a strength, thanks to renewed attention to the themes of sustainability and circularity. For instance, one of the interviewees underlined how his company is exploiting the usage of second-hand input material to deliver a more sustainable product to clients.

“We started implementing the idea of a circular economy before it got a name. ... Now that things have changed and governments are pushing companies to be more respectful towards the planet, we have started communicating this message more strongly to our customers. People who choose our products know

that they are choosing not to use virgin trees.” (CEO, particleboard producer)

Similar considerations emerged in all the interviews with the particleboard producers, also highlighting the contribution of the Rilegno consortium in helping people learn the story of postconsumer wood and become acquainted with the idea that wood waste “is a precious resource that cannot be spoiled and needs to be recycled” (CEO, particleboard producer).

Regarding *perceived technical performance*, the particleboard producers were divided. On the one hand, some interviewees confirmed the technical feasibility of the production of the three identified categories of products using postconsumer wood, and they agreed with the evaluation of the technical experts about the technical performance of the input material. One of the interviewees also provided two examples of buildings that have already been constructed using products (insulators and secondary structures) made out of postconsumer wood (a hotel and a service structure). On the other hand, two interviewees were more doubtful. However, they explained their scepticism with company-specific reasons; in particular, the plants that they currently use to produce panels for the furniture sector cannot be used for producing insulators and frame systems for the construction sector due to the maximum dimensions of the panels (in terms of length and thickness). This production would require an ad hoc investment, the feasibility of which is obviously dependent on a plurality of factors.

“The investment would be feasible only if there was enough demand for these products. The costs for developing a new plant are substantial, and there is the risk that a dedicated investment couldn't be repaid.” (CEO, particleboard producer)

Finally, the issue of *product certification* entails two different aspects: certification of the process of cleaning and separating waste wood, resulting in the input material for panel production, and certification of the product itself, in this case, the panel. The former aspect is, in general, the most challenging because it requires certifying how wood waste can be separated from other waste materials (for example, pins and screws) and transformed into a clean secondary material that can be reduced in size and enter the panel production process. Thus, the product certification aims at guaranteeing the characteristics, in terms of different technical performance of the end product.

The interviews with the particleboard producers pinpointed some relevant insights concerning both aspects. First, most of the panels used in the furniture sector are actually subject to a product certification that defines a product's physical and technical characteristics (internal bond, bending strength, modulus of elasticity, thickness swelling, etc.). Furthermore, one of the interviewees pinpointed the existence of a project at a very advanced stage aimed at tracking and certifying the entire process of wood collection and recycling, starting from the recycling platforms to the production of the end product, that is, wood panels. This is a relevant point, as it suggests the

possibility of implementing a similar certification for materials to be used in the construction industry.

## 5 | THE POTENTIAL CONTRIBUTION OF WASTE COLLECTION PLATFORMS IN OVERCOMING CE BARRIERS

The analysis confirms the relevance of *cultural* barriers (see also Kirchherr et al., 2018), which, in this case, are related to the acceptability of postconsumer wood to final consumers and construction companies. Postconsumer wood, being a recycled material, may be perceived as less valuable than virgin wood; therefore, it is potentially less attractive to consumers looking for high-value products. This worry is reflected in the behavior of builders, who fear that the usage of postconsumer wood could damage their image. To address this barrier, the consortium promotes the use of postconsumer wood by leveraging the idea of product sustainability, hence connecting the value of the material to a positive social impact.

These efforts align with what is happening in a range of sectors, where the leitmotiv of sustainability and environmental impact is being leveraged to promote and normalize the usage of recycled materials (Magnier, Mugge, & Schoormans, 2019). In this respect, Rilegno is in a privileged position to enact this type of promotion activity in comparison with other operators in the wood value chain (such as a single company, whether a recycler or a producer). First, it has a consolidated experience with the usage of postconsumer wood as an input factor for other productions, thanks to its long-lasting engagement with particleboard producers. Second, as a consortium that includes different operators, it is used to carrying out research and industry analyses that could benefit a broader range of stakeholders, as it is perceived as more impartial and unbiased than an individual company.

The second type of barrier that emerged from the interviews was *technological*, particularly issues concerning the quality of postconsumer wood. Prior research highlights that one of the main barriers to the engagement of waste platforms within the CE is the actual quality of the waste collected, which can be low due to the limited capacity of waste collection platforms to sort waste materials (Gregson et al., 2015; Milios et al., 2018). The case of postconsumer wood, in this respect, is different. Recycling platforms are potentially capable of selecting the material to ensure high-quality standards. Today, in most cases, this type of selection is not performed because downstream users (i.e., particleboard producers) have integrated the cleaning phases into their manufacturing processes to have better control over the characteristics of the recycled material to be used as an input factor in the respective production processes. However, to support new production, waste collection platforms could carry out some preparation and cleaning activities that are preliminary to the next steps.

The issue of the quality of the material is related not only to technological but also to *regulatory* barriers. In fact, one of the points that emerged frequently from the analysis is the widespread adoption of quality certifications in the construction sector, which are often

required by law. Indeed, the lack of a certification for postconsumer wood was perceived as a relevant obstacle by many interviewees. From this point of view, the establishment of a process certification would represent an important boost for new potential applications of postconsumer wood. Again, this is something that can hardly be promoted by an individual company. Instead, the consortium, with its network of different operators and engagement with industry associations, can take on this role more easily, staying in contact with all the different actors that are or could be involved in different phases of the process.

Last, *market* barriers in this case arise largely from the other barriers, confirming their “nested” nature (Kirchherr et al., 2018). The key point is that in the construction sector, at present, there is no substantial customer demand for the materials produced with postconsumer wood, which is the case for most materials that are collected and recycled through waste collection platforms (Milios et al., 2018). To stimulate or even create such demand, a clear understanding of the usability of recovered materials is necessary alongside the ability to communicate and transfer the potential of these materials to prospective and unaware users (cultural barriers). Even in this regard, the research showed that Rilegno could play a relevant role, promoting studies proving that postconsumer wood has a performance comparable to that of virgin wood for selected applications and communicating the results. Since Rilegno is already active in stimulating wood recycling, it could organize events and training sessions to make operators in other sectors and other supply chains more familiar with this material. Again, the involvement of particleboard producers could reinforce this communication since they already use this recycled material as an input factor in their production.

In conclusion, the case shows that some proactive initiatives are needed to overcome the barriers hindering the exploitation of postconsumer wood, and a multifaceted, more proactive involvement of the consortium that manages waste collection and recycling platforms can contribute to achieving this objective. In fact, if Rilegno had not taken upon itself the exploration of new scenarios for postconsumer wood, no other actor would have started this reflection. None of the other operators involved in the existing supply chain could have an interest in extending the usage of postconsumer wood and increasing its recycling rates. At the same time, if no action is taken, the platform system risks becoming unsustainable due to the increase in the collection capacity and the saturation of potential recycling options. In this respect, the increase in the efficiency and effectiveness of collection processes could become critical if not accompanied by the identification of new recycling paths for the up-scaling of the CE.

## 6 | CONCLUSIONS

This paper investigates how waste collection platforms could contribute to eliminating or reducing some of the barriers to CE implementation and diffusion by analyzing the case of recycling platforms for postconsumer wood in Italy.

This paper contributes to the stream of research that sustains the potential of “postconsumption circular economies” (Gregson et al., 2015; Singh & Ordoñez, 2016). In particular, it supports the idea that the CE paradigm could also be scaled up by leveraging the waste management sector to turn waste into resources. Compared to prior research, the paper attempts to delineate how the waste collection and recycling system could contribute to overcoming some of the cultural, technological, regulatory, and market barriers that affect demand and supply of recycled material.

The actual contribution of waste collection platforms to dismantling CE barriers also depends on a change in the platforms' role: they can carry out some activities not strictly related to the improvement and optimization of the processes of collection and separation of wood waste. In the analyzed case, Rilegno started to proactively explore possible alternative markets for postconsumer wood, which is a task not strictly related to collection and recycling activities. However, the consortium was the only actor interested in finding a new market for this material in response to the increase in collection capacity of the platform network. Similarly, some of the activities in which Rilegno is already engaged (e.g., information, communication, training) as well as some of the possible actions that emerged from the case study (e.g., support for certification development) cannot be considered typical of a waste recycling platform, but as we discussed in the previous section, Rilegno is in a privileged position to engage in them. In this sense, the results of our paper also complement recent research that addresses the role of recycling centers. Milios and Dalhammar (2020), analyzing Swedish recycling centres, highlight a significant potential for increasing reuse operations, stressing the importance of new types of collaborations between recycling centres and other private and public actors. In this respect, Rilegno offers an example of how leveraging the network of actors that constitute the consortium could contribute to overcoming CE barriers.

From a practitioner perspective, the case highlights that recycling platforms can be key allies in supporting the scale-up of the CE. The platform system can contribute to the creation and growth of demand, carrying out information and communication activities, and fostering the development of a positive image of the recovered material. The case clearly highlights that this is a critical issue, particularly in new and emerging sectors where demand is not self-sustaining but needs to be stimulated. The platform system can ensure adequate knowledge about the recovered material and its characteristics, which is fundamental for overcoming the erroneous perceptions that potentially raise barriers. On the supply side, the platform can contribute to defining and implementing the conditions supporting the activation of recycling processes—for instance, ensuring that the material is selected in a way that is coherent with further usage and integrating some of the cleaning phases to be performed by the platforms themselves. All these activities are fundamental in allowing other economic players to develop products and applications using such recycled material if and when economic conditions make it feasible. In this way, the platform system can also contribute to filling the gaps existing between demand and supply of the recovered material in new

supply chains, with relevant implications for the platforms: the up-scaling of circularity can represent a viable path for ensuring the sustainability of the collection system in the long term.

Finally, the research has some limitations that need to be recognized. This paper relies on a qualitative analysis developed in a specific sector, which does not allow systematic generalization of our findings. In addition, this paper focuses specifically on the role of the platform system within the existing wood value chain. Finally, it does not study the interactions between the consortium and policy makers, who, however, could play a significant role in informing the activities carried out by the platform system. In particular, it does not address how policy makers themselves could influence the proactive efforts of the platform system, which could be worth further investigation. As highlighted in the discussion, the project was initiated by the consortium without external pressure from policy makers and in the face of a rather passive attitude of the other actors in the value chain. In this context, it would be interesting to explore the effect of a change in the existing policies or the establishment of a system of incentives for both stimulating the usage of postconsumer material and/or fostering diverse involvement of waste collection platforms in the development of the CE.

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## ENDNOTE

<sup>1</sup> The municipalities are the institutions responsible for the waste management service.

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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