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Open Innovation as Fuel for the Circular Economy: an Analysis of the Italian Context

Luigi Sergianni[1], Alessandra De Chiara[2], and Sofia Mauro[3]

[1]University Institute of Higher Studies of Pavia (IUSS) - Operating Address: University of Naples L'Orientale, Largo S. Giovanni Maggiore, 30, Naples, Italy | *luigi.sergianni@iusspavia.it*
[2]Department of Human and Social Sciences, University of Naples L'Orientale, Largo San Giovanni Maggiore, 30, Naples, Italy | *adechiara@unior.it*
[3]University of Naples L'Orientale" Largo S. Giovanni Maggiore, 30, Naples, Italy | *s.mauro1@unior.it*

Abstract

In recent years the circular economy (CE) has gained considerable interest in the academic debate as a tool for achieving sustainable development. The implementation of the circular economy model requires innovation to overcome technological, economic, environmental, social, and regulatory barriers. However, companies do not always have the means to innovate due to lack of information, limited technical skills and financial constraints; as a result, innovation remains a fragmented phenomenon. Open Innovation (OI) is a tool identified in the literature as useful for overcoming this problem and thus for the development of the CE, as it accelerates the exchange of knowledge and the realisation of the necessary innovations. Despite this, the relationship between CE and OI, and particularly the influence of OI on CE, has been little investigated. In line with this, the paper aims to explore this relationship by analysing the process through which OI supports the development of the CE, focusing on the knowledge exchange aimed at circular innovation, and categorising the actors contributing to this process and their roles. The study adopts a qualitative approach and uses methods of descriptive analysis and case studies. The sample consists of 240 Italian circular organisations that support circularity in different ways. The results made it possible to classify the main actors involved and their contributions to the CE through OI practices, revealing unseen circular activities that support classical circular activities (slowing, closing, and narrowing of material and energy circuits) and are identified in services, technology or research. As a theoretical contribution, the research provides a framework describing the actions and relationships among the actors involved in the CE initiatives, with a focus on the Living Lab practices.

Keywords: Circular Economy; Open Innovation; Collaboration; Living Lab; Italian Firms; Circular Innovation.

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1 Introduction

The circular economy (CE) is a new paradigm, aimed at achieving sustainable development, that in recent years, given the urgency of climate change, has received considerable interest in the academic debate (Bakker et al., 2021; Korhonen et al., 2018). Its principles represent a guide for an economic model that aims at maximum efficiency of production and consumption, achieving the decoupling of environmental pressure from economic growth, operating at the micro (firms, consumers), meso (industrial symbiosis networks, eco-industrial parks), and macro (cities, regions, national or global governments) levels (Ghisellini et al., 2016). The CE emerges as opposed to

the linear economic model (extract, produce, consume) by replacing the concept of 'end-of-life' with 'reduce, reuse, and recycle' (3R paradigm) (Jesus and Jugend, 2023). In the work of Bocken et al. (2016), the CE's actions on material and energy circuits are identified: slowing, closing, and narrowing. In detail, circuit narrowing refers to efficiency in design and production processes, circuit closing refers to post-consumer material reuse (recycling) and slowing refers to product life extension. At the enterprise level, the work of Vinante et al. (2021) proposes a reinterpretation of Porter's value chain into a circular value chain in which they schematise the 23 circular categories of the value chain useful in understanding the depth at which the CE changes the enterprise's strategy and functions. Finally, the CE has been defined as a tool for achieving social sustainability through employment opportunities, education and outreach, health and safety, and government involvement (Mies and Gold, 2021).

However, the adoption of the CE requires overcoming certain obstacles such as technological, economic, environmental, social, and legislative barriers (Jesus and Jugend, 2023). The innovations that the CE requires are complicated to develop and implement, and companies do not always have the possibility to realise them due to a lack of information, low technical skills, and financial barriers; therefore, innovation remains a fragmented phenomenon (De Jesus and Mendonça, 2018). A solution to some of the limitations above is identified in the literature as open innovation (OI), which accelerates the innovation process and increases the benefits produced by innovation by fostering collaboration and knowledge exchange, building on complementary capabilities, and accelerating the commercialisation of innovation (Elmquist et al., 2009; Ovuakporie et al., 2021). By opening up innovation beyond company walls, Open Innovation (OI) enables the pooling of resources and capabilities from various companies and organisations of all kinds. This pooling accelerates the innovation process necessary for the Circular Economy (CE). Some authors, from an ecosystem point of view, propose possible coordination within the different types of these circular innovations represented by sustainable Living Lab (Burbridge et al., 2017), considering Living Lab open innovation networks (Leminen et al., 2012) are the context where OI most supports CE development. The actors involved in living labs collaborate to find innovative solutions to complex social issues involving different stakeholders (Følstad, 2008; Kviselius, 2009).

However, although OI has been described as a key weapon for the development of the CE, the integration of these two issues, and especially the question of how OI could contribute to a more sustainable economy, remains little investigated (Jesus and Jugend, 2023). Furthermore, the role that Living Lab can play in generating fundamental knowledge about complex user interaction and sustainable solutions remains overlooked (Burbridge et al., 2017). Finally, although works such as that of Bocken and Ritala (2021) contribute to the understanding of the different actions that can be adopted for the development of the CE by exploiting the openness of innovation, a complete picture of the innovative actors that, through OI, contribute to the development of the CE seems to have not yet been developed.

The purpose of this paper is to understand the processes and actors that support the CE through OI, by analysing the actors that shape this process in the Italian market. Therefore, two research questions can be identified: (1) Who are the innovative actors that support CE through OI? (2): How do these actors lean on OI to support CE?

The study concludes with the elaboration of a framework describing the actions and relationships that different actors can assume by conceptualising the circular innovation process in a Living Lab. However, this paper does not examine Living Lab empirically. Rather, these represent, from a systemic point of view, an evolution of the relationship between OI and the CE, towards which the results of this study direct the final discussions and implications.

The paper is structured as follows: Section 2 represents a review of the literature on circular innovation, section 3 provides a preliminary explanation of the methodology adopted, section 4 shows the results of the analysis carried out on 240 Italian circular organisations, section 5 presents the Circular Living Lab framework, and section 6 highlights the conclusions of this work.

2 Circular Innovation

Several studies emphasise the need for multiple types of innovation to support the development of the CE; these include technological innovation (Khan et al., 2022; Bocken et al., 2014), business model innovation (Bocken et al., 2014), circular design (Dokter et al., 2023; Mesa and González-Quiroga, 2023), and the innovative contribution of consulting services (Pereira and Vence, 2021). Indeed, CE require innovators and intermediaries helping to overcome these barriers (Ghisellini et al., 2016; Golinska et al., 2015). Innovations of products and processes, as well as value proposition innovations, are necessary for the realisation of a CE (Geissdoerfer et al., 2017).

For example, Ranta et al. (2020) describe the four logics of innovation in the value proposition in the CE, namely: resurrect, share, optimise, and replace value, which respectively refer to (1) resurrecting the diminished value of resources and returning it to the market, (2) sharing the value of a single resource among several customers, (3) optimising the value of a resource for a single customer, and (4) replacing traditional resources with new higher-value resources. Conversely, Bocken et al. (2014) investigate innovation in circular business models by classifying them into technological, social, and organisational innovation, from which they derive eight circular business model archetypes.

Rather than innovation as a process, it is clear how we refer to innovation as an outcome (Crossan and Apaydin, 2010) such that the CE needs to be implemented. This paper considers these needs jointly, as product or service innovation from a circular perspective requiring innovation from different fields emphasises the need for longitudinal research approaches (Pieroni et al., 2019). OI, as mentioned above, is a valuable tool for making up for the lack of innovative competences that companies might suffer but also a way to coordinate such innovations, e.g., in the form of a circular Living Lab (Cantù et al., 2021).

2.1 Circular Open Innovation

In contrast to the traditional concept of innovation developed within companies, open innovation (OI) represents a new approach to innovation involving ideas, knowledge, and technologies from both inside and outside the company (Chesbrough, 2006). Knowledge flows in OI can be divided into three categories: outside-in, inside-out, and coupled. Outside-in (or inbound) knowledge flow is concerned with the acquisition of external knowledge to enrich internal resources, thereby improving the firm's innovativeness (Chesbrough, 2017; Enkel et al., 2009). Inside-out (or outbound) knowledge flow represents the reverse, i.e., the sharing of corporate knowledge with the outside world, e.g., through technology licensing or the creation of start-ups and spin-offs, allowing the company to take advantage of otherwise underutilised resources (Barham et al., 2020). Finally, OI coupled implies the simultaneous presence of outside-in and inside-out knowledge flows (Enkel et al., 2009).

Innovation can be considered a driver into the transition to circular economy (De Jesus and Mendonça, 2018), which goes beyond mere sustainability, promoting the reuse, recycling, and renewal of resources, known as 'eco-innovation' (Sáez-Martínez et al., 2016).

This eco-innovation expands traditional view on innovation to include waste prevention, sharing, repair, and recovery, as well as involving the product design and use phases (EIO, 2016). It is a

distributed innovation process that manages the flow of knowledge between organisations aiming at meeting present needs without compromising those of future generations (Bogers et al., 2020, Brundtland 1987). However, its realisation is hindered by the dispersion of skills and infrastructure among the various market actors (Blomsma, 2018).

Among the main barriers to the adoption of the CE, the literature has highlighted the lack of knowledge and technology. Therefore, OI practices have been described as a useful tool for overcoming these shortcomings (Jesus and Jugend, 2023). To develop CE, multiple actors at each stage of the product life cycle must collaborate by coordinating innovation activities to understand how to adapt or create new systems to generate circularity (Brown et al., 2020). OI is the fundamental approach to achieve this (Jesus and Jugend, 2023), as innovation is achieved precisely through collaboration. Bocken and Ritala (2021), intersecting two strategic choices to be made by the circular enterprise, namely the innovation strategy (open or closed) and the impact on resources (slowing down, closing or shrinking), derive six archetypes that reflect the strategic alternatives available to the enterprise to be circular, to which the authors add possible scenarios in which it might be useful to adopt one choice rather than the other, confirming the concrete contribution that OI can give to the development of CE.

In this context, collaboration and knowledge management assume a key role; each stage of the product life cycle and each actor involved must adopt shared agendas with partners to innovate together and find solutions that promote circularity (Brown et al., 2020). The adoption of a multilevel cooperative approach between public institutions, companies, and communities is essential to the success of the circular economy, and such cooperation must be supported by appropriate environmental regulations and policies (Prasad et al., 2023), as well as tools such as Living Lab, which provide an environment that brings together different actors to contribute to sustainable development (Hossain et al., 2019).

2.2 Living Lab and the Circular Economy

Although discussed in many previous studies, the definition of "Living Lab" is still unclear due to multiple views and domains (Westerlund et al., 2018). Living Lab are based on the philosophy of the Open Innovation (OI) paradigm. Indeed, organisations involved in this process collaborate and share resources to develop new innovations in various forms, including products, processes, or technologies (Leminen and Westerlund, 2012; Følstad, 2008; Kviselius, 2009). The European Network of Living Lab (ENoLL), an umbrella organisation for Living Lab around the world, defines them as ecosystems of open innovation in real-life environments (https://enoll.org/about-us), but, also, the literature defines them as testbeds for presenting applications to users (Guzmán et al., 2013) or as a form of open innovation (Westerlund and Leminen, 2011). In this paper, we consider Living Lab as open innovation networks (Nyström et al., 2014; Leminen et al., 2012). Living Lab rely on external sources for innovation by facilitating collaboration and helping to develop new products and services (Bergvall-Kåreborn et al., 2009). Central elements in the Living Lab are co-creation, co-production, an experimental environment, real life, users, and producers (Franz, 2015). From a sustainability perspective, Living Lab offer important support for the coordination of innovative processes (Burbridge et al., 2017), though the use of these as a tool for sustainable development has been little investigated (Hossain et al., 2019). Finally, other studies (Nyström et al., 2014; Leminen et al., 2021) Investigate how Living Lab improve environmental and social sustainability in cities by improving the innovation process.

3 Methodology

The study adopts a qualitative approach and uses methods of descriptive analysis and case studies, the main expected contributions are theoretical (Eisenhardt and Graebner, 2007). From the perspective of a deductive approach, the aim is to achieve a holistic representation of complex issues (Yin, 2018), such as the contribution of OI to the circular economy in Italian organisations. In particular, the analysis is carried out on 240 Italian circular organisations (profit, non-profit, research organisation, public organisation), namely organisations that support circularity in any way. This work starts from such a broad view of actors supporting circularity to examine every possible contribution to the development of the circular economic model.

To select the organization to be analysed, the authors consider the database of Italian circular firms provided by the Italian Atlas of the Circular Economy, a web platform, introduced in 2017 and regularly updated. Its objective is to identify, map, organize, and support Italian businesses committed to embracing the principles of the circular economy. The Atlas is designed and created by the CDCA - Documentation Center on Environmental Conflicts of A Sud Association (www.asud.net) with the support of Erion and born from the experiences of two Italian consortia RAEE (waste from electrical and electronic equipment) (www.economiacircolare.com); the scientific committee involves the Poliedra Consortium - Polytechnic of Milan. To be included in the Atlas, organisations must fill in a form which will undergo an evaluation by the scientific committee, through a series of indicators that take into account all phases of the production process: (i. g. the raw materials used, energy efficiency in logistics, waste management, the creation of shared social value, territorial valorization, and the analysis of the whole supply chain.

Furthermore, the Atlas provides a set of data for each organization: industrial sector, location, web address, type of organization (profit, non-profit, research organisation, public organisation), target (B2C, B2B), number of employees, year of birth, and year of reconversion to the circularity. In addition, the Atlas shows how each organization is pursuing circularity by providing information about the innovation processes implemented, if any, and any external innovators involved in the process.

Research process

To perform the empirical research, all the information provided were considered (Table 1). The literature review allowed the identification of a set of elements upon which the authors defined a framework for data interpretation adopted to classify the circular activities and the OI approach of the selected organisations. In particular, the analysis took into account the types of circular activity (closing, shrinking, slowing down) (Bocken et al., 2016) and the mode of openness to innovation, focusing on the direction of knowledge flows (outside-in, inside-out, coupled) (Chesbrough, 2017; Enkel et al., 2009). The research process was developed in four steps. First, the collection of data on the organisations from the atlas and company websites. Then, the analysis of data through the lens of the elements emerged from the literature review; performed individually by the authors to avoid mutual influences. The set of data obtained from the Atlas was improved through the consultation of organization websites, to collect further useful information (e.g., posts, documents and video), hence achieving a joint evaluation of multiple data. The data was collected in September 2023.

The adoption of different methods allowed a triangulation, since the authors combined scholars perspectives, data from multiple sources and/or different types of data to mitigate biases and enhance reliability and validity (Jick 1979; Eisenhart 1989; Yin 1994). The case studies analysis allowed to make an inventory of the circular economy activities, and then to cross-reference this

categorization with the OI approach in order to derive the dynamics within which OI supports the circular economy.

In general, the study focuses on the role of the analysed organisations in the development of the circular economy. To this end, it categorises the contribution to the CE and the ways in which they are open to innovation, focusing on the direction of knowledge flows (outside-in, inside-out and coupled). The aim is to classify the actors and understand their relationships.

Table 1. Elements of investigation

Industrial business	Food / Furnishings / Stationery - Stationery - Printing / Household Goods - Hygiene - Cosmetics / Commerce - Second-hand markets / Culture - Art - Sport / Building and Renovation / Education - Information - Consultancy / Electronics / Packaging - Packaging / Secondary Raw Materials / Mobility - Transport - Logistics / Sharing and Exchange Platforms - Mobile Apps / Energy Production and Distribution / Waste Collection and Management / Textiles - Clothing - Accessories / Agriculture and Animal Husbandry / Tourism - Events - Catering
Type of organisation	Profit / Non profit / Research organisation / Public
Part of Italy	Northern / Central / Southern
Target	B2C / B2B
Number of employees	0 - 14/ 15 - 49/ 50 - 249/ $>$ 250
Age of approach to circularity	since birth / 1- 5/ 6 - 10/ 11 - 15/ 16 - 20/ 21 - 25/ 26 - 30/ more than 30
CE activity	Slowing / Narrowing / Closing
Open innovation approach	Outside-in / Inside-out / Coupled

4 Results

The analysis of the circular practices adopted by the organisations comprising the dataset revealed that these can be divided into two categories. The first category is activities that could be defined as direct, whose effect is to slow, close, or narrow material and energy circuits, while the second category could be defined as indirect, including all those activities that, while not acting directly on material and energy circuits, support this purpose and, in fact, enable, facilitate, or incentivise the implementation of the direct activities.

Direct circular activities have thus been recognised as all those activities that aim to *slow*, *close*, or *narrow* material and energy circuits and thereby promote the realisation of a circular product and the adoption of a process or strategy that acts sustainably on the use of resources by achieving the decoupling of environmental pressure from economic growth. Most of the activities found in the analysis refer to direct circular activities.

Activities that this paper defines as indirect circular activities include the provision of services, technologies, or research that support direct activities in the pursuit of circularity. Table 2 shows examples found during the analysis of circular practices that clarify the support of indirect circular activities to direct ones.

Table 2 Examples of support for direct circular activities

Direct Circular Activities	Indirect Circular Activities		
	Service	Technology	Research
Closing	Closing service e.g., organisations that facilitate the matching of supply and demand for waste, flea markets, etc.	Closing technology e.g., waste treatment machinery, waste re-use technologies, etc.	Closing research e.g., new recycling process, new recyclable material, etc.
Slowing	Slowing service e.g., advice on durability of materials, ecodesign, etc.	Slowing technology e.g., more precise machinery, etc.	Slowing research e.g., new, more durable materials, etc.
Narrowing	Narrowing service e.g., consulting on resource optimisation, ecodesign, etc.	Narrowing technology e.g., more efficient machinery, technologies to monitor waste, etc.	Narrowing research e.g., new, more optimised work process, better performing materials, etc.

4.1 Direct Circular Activities

Direct circular activities are those promoting the *slowing*, *closing*, or *narrowing* of material or energy circuits. These actions take the form of producing a product with recycled, reused, or more sustainable material, thus making it more durable, recyclable, or less impactful, or adopting a circular production model that does not involve a material modification of the product, though through the reorganization of production and/or marketing strategies (e.g., sharing economy), environmental impacts are optimized by placing maximum attention on the provenance, quality, and use of resources with a view toward sustainability, while also providing for the reuse of one's own waste or its proper disposal. These practices create circular value in that they concretely decrease environmental impact by adopting the logic of the circular economy. The theoretical debate has devoted ample space to this type of activity.

Following are some examples from the dataset: Exseat, a company that produces bags and accessories using regenerated fabrics from disused car upholstery and seat belts; Lessmore, which produces and markets a collection of furniture and accessories designed according to circular economy criteria using various materials, first and foremost cardboard, wood, and methacrylate that are often already recycled or FSC-certified; Mella Verde, an exclusive retailer of plantable, recyclable, and compostable paper in Italy; and The Circle, which aims to produce quality food through aquaponics technology.

These circular practices are adopted by 52% of the analysed organisations. In particular, these practices are very present in organisations operating in the textile, furniture, and food sectors, mainly for-profit organisations, but also in about 17% of nonprofits. The target is both B2B and B2C, although slightly in favour of B2B, and with a number of employees that, for about 70%, is between 1 and 14. The latter result is expected given the strong presence of micro and small businesses in this sample (66%). Among the organisations adopting this circular approach, about 43% practice OI with more than half coupled as 100% Campania, the network for sustainable packaging in which organisations, operating mainly in the paper supply chain, cooperate to develop innovative and sustainable products from the waste obtained from recycling. Finally, more than 55% adopt circular practices from birth, while 20% did so before the age of 10.

4.2 Indirect Circular Activities

To better understand this category, the three indirect actions of Circular Service, Circular Technology, and Circular Research are explored.

Circular service

A circular service is a service that enables or encourages circular practices for companies or citizens, thus incentivising the use of circular products or the reuse of old products without their being manipulated, facilitating the matching of supply and demand for waste, spreading circular values, and providing education about purchasing and consumption. This first category of support therefore encapsulates all those services that were born or have evolved to support the spread of the circular economy by encouraging the creation or dissemination of circular products or products made using the circular production model. Some examples taken from the dataset analysed in this paper are EcodesignLab, an environmental design and consulting company offering integrated eco-design and eco-innovation services for the development and realisation of innovative and sustainable products through a wide range of activities, from design to communication to engineering and prototyping support; Mercatino S.r.l., which deals with the recovery of used objects and their remission into the virtuous circle of reuse through one of their 187 points of sale; and Progetto B.A.R.E.G.A., an open source initiative for the sharing of knowledge in green building. The project's goal is to show, through popular workshops led by professionals in the field, that there are techniques and technologies to build in green building with natural materials, locally sourced, at very low economic, environmental, and energy-related cost.

These circular practices are offered by 35% of the entities in the dataset, making it the largest category of the three indirect circular activities; this is also due to the wide range of practices tracing back to circular services. These practices are particularly prevalent in companies or organisations involved in organising flea markets, in the food sector, and in the waste collection and management sector. Additionally, the entities that offer circular services are almost half non-profit entities, whose target audience is in favour of B2C, and with a number of employees that, in most cases, is less than 15. The organisations that adopt this circular approach practice OI in about 47% of cases, of which more than half adopt the coupled type. An example is Circularity, a platform that connects companies in Italy to nurture a sustainable industrial economy by offering consulting, training, and certification services in support of companies seeking to integrate the circular economy into their business model. Thanks to its team of professionals, who are experts on sustainability and materials engineering issues, and its network of qualified partners, Circularity can accompany companies on the path to integrating the circular economy within their business models, providing companies with the necessary know-how.

Finally, it is recorded that more than 70% of service providers contribute to circularity from inception. This is the highest percentage in the indirect circular activity category. Meanwhile, 15% began doing so before the age of 10.

Circular technology

Circular technology is a new technology that helps reduce the environmental impact of a product or production process by facilitating its inclusion in a circular economic model. It can comprise a new piece of machinery or the modification of an old one to allow companies to optimize the use of raw materials or energy or to recycle waste. Some examples of the analysed organisations include Bimora, which sells, installs, and programs automated waste collectors by sorting incoming light and bulky packaging such as PET bottles, aluminum cans, and glass and by rejecting unsuitable, harmful, or hazardous waste materials; and TS Asfalti s.r.l., which markets equipment

and machinery for road maintenance, has invested in an innovative machine that recycles the milled asphalt on site and reuses it without the need for prior treatment in another regeneration plant, as is the case with almost all construction waste.

This technological support for circularity is offered by 3% of the organisations in the dataset, making it the least numerous indirect category. These are technologies and machinery which specifically entail reprocessing waste into secondary raw material. Here, the totality of the entities is for-profit, with a target audience that is mainly B2B, and with a higher number of employees, on average, than the other categories. About 43% of organisations that adopt this circular approach practice OI, of which 70% are inside-out and the remainder coupled. One example is Ecocentro Environmental Technologies, which designs, builds and operates innovative, fully automated plants for processing waste from road sweeping and sanding. The company can transform waste into differentiated, quality raw materials that are CE-certified and compliant with European Union regulations. The company also collaborates and innovates with various associations, such as Assorem material recovery, the Foundation for Sustainable Development, and the Marevivo association.

Lastly, 57% have maintained circular practices from birth, while 14% started doing so before the age of 10. The same percentage did so between 11 and 30 and over 30.

Circular research

A research project that promotes the advancement of knowledge in various scientific-disciplinary fields with a specific focus on the CE, enabling the transfer of knowledge to companies, institutions and citizens and opening up new ways to achieve circularity. Some examples taken from the dataset under analysis are: Atlante Inerti Project, a organisation of researchers, planners, and designers collaborating for one goal, i.e., to contribute to closing the production cycle of building materials for the benefit of the environment and local communities; and the Eco-friendly Polymeric Materials Laboratory, a young start-up whose mission, given its established scientific and technological background, is aimed at research and development of materials, processes, and technologies in the field of polymeric materials and semi-finished and finished eco-friendly manufactured products, using as leverage the approach of technology transfer of know-how to industry, with particular reference to product and process innovation in the circular economy and sustainability.

This category includes 7% of the organisations analysed. Most of them are research institutions and thus part of the education sector. The target audience is mainly B2B, with a larger average number of employees than the other categories. About 65% of organisations that adopt this circular approach practice OI of which most are coupled. Examples include: RISE (Research & Innovation for Smart Enterprises) is a research laboratory of the Department of Mechanical and Industrial Engineering of the University of Brescia that, starting from the production of new ideas and knowledge, contributes to the innovation of processes, products, and business models, thereby helping companies become more competitive; and the POR-FESR Emilia Romagna 2014-2020 project "Sostenibilità e innovazione nella Filiera Vitivinicola" by Biogest-Siteia, which counts among its objectives the development of an integrated strategy for the recovery of by-products from the vineyard and from the winemaking and distillation processes, to reduce their environmental impact and obtain high-value-added derivatives, with potential profit for companies in the wine sector; it collaborates with several universities, such as the University of Bologna and Parma, for this and other projects.

Finally, the age at which circular practices are adopted is, on average, the highest among the categories of indirect activities.

5 Discussion

Many scholars discussed circular economy practices, focusing on their extent (Ghisellini et al., 2016), on the value created (Ranta et al., 2020), and on the business model to which they refer (Bocken et al., 2014). However, little attention has been focused on indirect ones, i.e., those activities that, through the OI, support companies, consumers, and public entities in being circular. The results of the analysis of the 240 Italian entities on the the Italian Atlas of the Circular Economy platform show that the presence of indirect circular activities, i.e., educational and advisory services, technology provision, and advancement in knowledge, is very high. Therefore, they must be considered as circular value-producing actors. While not directly contributing to the *slowing*, *closing*, or *narrowing* of material and energy circuits, indirect circular activities are shown to be necessary for the diffusion of the circular economy, especially in a scenario in which the market is populated by small firms with resource, knowledge, and relationship constraints that alone cannot cope with the transition to a circular economy. In this context, OI supports the whole process of circular economy expansion.

The results of the analysis show that in indirect circular activities, inside-out practices are more present. The contrary is the case for direct ones – a sign that knowledge transfer mainly has a direction from indirect to direct activities, though in many cases knowledge transfer remains bidirectional. This highlights the continuous collaboration between the parties for coordinated and targeted innovation. Moreover, the difference in size, assessed on the basis of the number of employees of the analysed organisations, shows that technological innovations and research projects are, on average, carried out by larger organisations – a sign that this function can be supported only by organisations with more resources. It can be deduced that OI is a key process for small organisations in improving CE practices.

Results also show that the age of the organisations affects the choice of implementing CE initiatives. For example, organisations that provide technology or knowledge (research projects) start contributing to circularity at a later stage. Conversely, organisations engaged in direct circular activities are usually born circular. This highlights that an organisation committed to slowing, closing or narrowing material and energy circuits is much more likely to have been born with these objectives and not to have adopted them at a later stage. This points to a lower propensity of mature organisations to perform a transition process and adopt direct circular actions. This shows the need to support indirect circular activities, in particular circular services where education and advice offer, through OI, a new way forward for companies anchored in the linear economy.

The results also show the difference in type: for-profit for direct circular activities, many non-profits for services, research organisations for research, and large for-profit companies for technology. This shows a relationship between organisational type and circular objectives.

In addition, the results provide an overview of the actors and their contributions to the circular economy, as well as the flows and directions of knowledge, effectively describing an innovative context in which the network of innovators work together to contribute to the development of the CE. This allowed the authors to identify the categories of actors and their respective roles involved in circular innovation.

This general framework leads the work to the conceptualization of a framework describing how an innovative and circular context based on OI, a Living Lab, functions. Figure 1 is a graphical representation of this framework.

Figure 1 highlights the network of collaborators/innovators that support the three circular activities directed at energy and materials circuits. The indirect circular activities are not uniquely aimed at supporting the direct circular actions, but they also support each other pre-

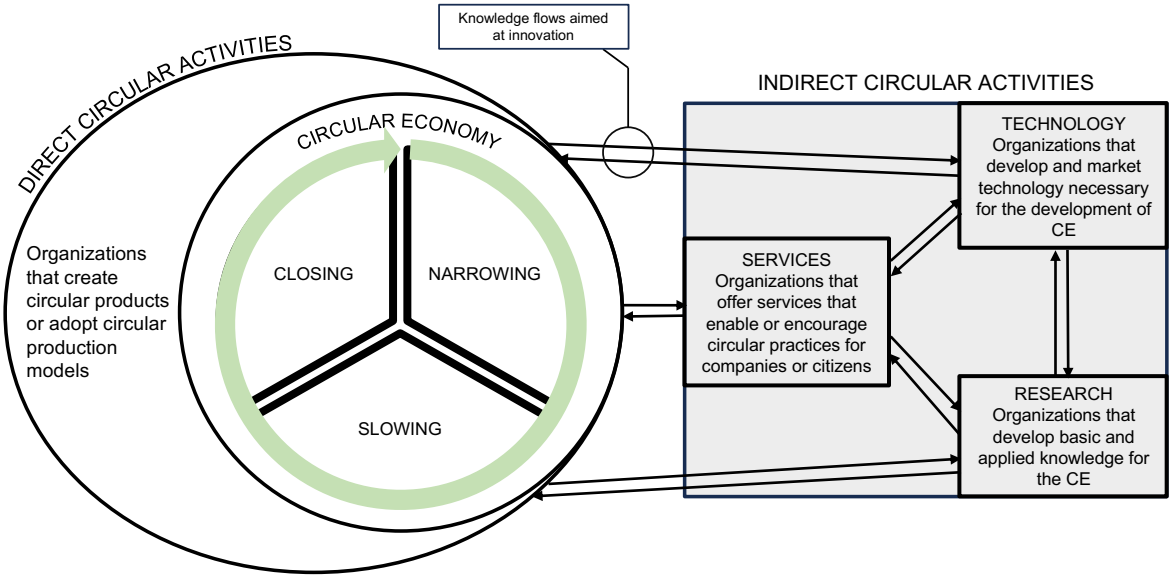

Figure 1. Circular Living Lab. Authors' elaboration

emptively or contextually to make a more robust contribution to the direct circular activities. This conceptualization of Circular Living Lab summarizes and schematizes the relationships among the innovators that emerged from the findings of this study and that, through the OI paradigm, contribute to the development of the CE.

6 Implications and Conclusions

This paper contributes to the literature on the relationship between the CE and OI by studying 240 Italian circular organisations. In particular the analysis centred on the categories of actors and knowledge processes enabling this process. By focusing on the contribution of individual organisations to circularity, their choice to adopt OI practices, and their role on the OI process, the study highlights how the transition process of an Italian company to a circular economy hardly depends on the latter's strengths and capabilities alone and the existence of two type of circular activities: direct and indirect circular activities. It emerges that the CE is supported by organisations that offer specialized consulting services, non-profit entities that spread its values, and research organisations or tech organisations that develop knowledge and technologies useful in the transformation of the linear economic model to circular. These activities are considered indirect circular activities. This work thus shapes an identity to the different categories of actors contributing to innovation found in studies on sustainable Living Lab (e.g. Leminen, et al, 2021).

The innovation necessary to implement the process of transforming the linear economy into the circular economy is heterogeneous and complex, and OI plays a key role in Italy by allowing the burden of innovation to be spread over multiple actors playing different roles. This work conceptualizes an example of a Living Lab that explains the different categories of innovators. Thus, it offers a starting point in the analysis of an innovative system useful in the development of the CE. This point of view highlights the important role of the actors that indirectly support the CE by creating circular value, even if they are not yet considered in the literature in the logic of circular value creation (i.e., Ranta et al., 2020). Advances in research along these lines can help the systemic view of the transition process by identifying key activities enabling the CE. Possible

future research could be carried out by comparing the results of this study with a study carried out in a different geographical context, as well as by considering the results companies would have achieved throughout time to contrast the effectiveness of OI to CE.

Finally, this work serves not only as an impetus for new research on an OI devoted to the CE from an ecosystem perspective but also as a reminder to delve individually into the role of the different innovators involved. It also outlines possible new categories of circular activities within those identified in this study. For example, the service-providing entities are very heterogeneous, including consulting firms, material exchange platforms, and support of various kinds. This represents fertile ground for further investigation.

From a managerial point of view, this study emphasises the importance of adopting an open innovation approach for the development of the circular economy. The proposed Circular Living Lab could be the right solution for a company that wants to use company resources to implement CE processes. Using the Living Lab to support the circular economy can be an useful tool for companies wishing to innovate, collaborate, and improve their performance. In addition, it is important to note the breadth of business opportunities that the circular business model offers and the possibility of precisely fitting into the vacancies that this initial phase of transition provides.

The findings also present interesting implications for policy makers. The categories of innovators that this paper outlines highlight the importance of specific policy actions to support the formation of Circular Living Lab, enhancing the role of actors with indirect circular activities and investing in the CE to reduce the cost of innovation for each individual actor. Ultimately, the use of the Living Lab to support the circular economy can be an useful tool for policy makers who wish to create a policy environment conducive to innovation, support collaboration and favor the transition to a more sustainable economy.

7 Limitations

The main limitation of this work is the use of secondary data. Another limit is represented by the organisations being analysed coming from a single source that encompasses them all; while this ensures uniformity of information for each organisation, it also represents a limitation as one is filtered by the concept of circularity of the platform used. Another limitation is that the authors have not directly analysed Living Lab, but only the forms of collaborative innovation for CE, so the conceptualisation of Living Lab is partial.

In addition, this analysis does not consider the magnitude of innovation flows and thus the impact that organisations have on circular innovation. Regarding the stakeholders of Living Lab, this work does not analyse the contribution of consumers, as consumer participation was not found in any company. Nevertheless, it is clear that consumer contribution is an important element of Living Lab, as well as the impact of Living Lab governance on the circular innovation process. Therefore, this representation of circular Living Lab is considered only partial, as a warning to future analyses exploring these aspects in more detail.

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Figure : Elaborazione degli autori

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9 Appendix

Part of Italy	
North	49%
Centre	27%
South	21%
Industrial Business	
Food	10%
Furniture	13%
Stationery - Stationery - Printing	4%
Household goods - Hygiene - Cosmetics	4%
Trade - flea markets	8%
Culture - Art - Sport	4%
Building and Renovation	7%
Education - Information - Advice	5%
Electronics	3%
Packaging - Packaging	4%
Raw Material - Secondary	8%
Mobility - Transport - Logistics	0%
Sharing and Exchange Platforms - Mobile Apps	3%
Energy Production and Distribution	0%
Waste Collection and Management	8%
Textiles - Clothing - Accessories	11%
Agriculture and Livestock	3%
Tourism - Events - Catering	3%
Type of Organisation	
Profit	67%
Non-profit	25%
Research organisation	3%
Public	2%

Direct Circular Activities	
Circular production model	22%
Circular product	31%
Indirect Circular Activities	
Circular service	34%
Circular technology	3%
Circular Research	7%
Target	
B2B	26%
B2C	16%
B2C B2B	55%
Number of employees	
0-14	66%
15-49	14%
50-249	10%
>250	7%
Open Innovation Approach	
OI	45%
outside-in	5%
inside-out	16%
coupled	24%
Age of approach to circularity	
at birth	58%
less than 10	18%
less than 30	13%
more than 30	8%

Biographies

Luigi Sergianni. PhD student in Sustainable Development and Climate Change at the University School for Advanced Studies IUSS Pavia, Cycle XXXVIII. Lecturer in accounting and reporting at the University L'Orientale of Naples. His research is based on circular economy and his most recent works focus on circular value creation logics, industrial symbiosis and social capital, entrepreneur personality in companies adopting circular economy, relationship between Open Innovation and Circular Economy. Recently, he has participated in national and international conferences focused on knowledge management for sustainability, as well as on local roots and interactions in management.

ORCID: https://orcid.org/0000-0003-2417-4091

CRediT Statement: Conceptualization, Methodology, Writing – Original Draft.

Alessandra De Chiara. Alessandra De Chiara is full professor of Business Management and lecturer of Corporate Social Responsibility at the University of Naples "L'Orientale" (Italy). Her scientific activity is aimed at deepening the issues of sustainability and corporate social responsibility, also with reference to the units of investigation of the supply chains, clusters and local systems. The topics of stakeholder engagement for sustainability strategies, of CSR disclosure and standards, of new consumption models in the circular economy are investigated with a focus on food, jewelry and apparel industries. She is Coordinator of Master degree in International Relation and Rector's Delegate for the development of sustainability at the University L'Orientale.

ORCID: https://orcid.org/0000-0002-8254-4372

CRediT Statement: Supervision, Writing - Review & Editing

Sofia Mauro. Sofia Mauro is a PhD Student in International Studies at University of Naples L'Orientale", Italy. Her main research areas are Sustainability, Circular Economy and Circular entrepreneurship.

ORCID: https://orcid.org/0009-0002-4571-6419

CRediT Statement: Writing - Review & Editing