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## **Open Collaboration and Digital Technologies in the Context of Environmental Innovations**

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### **Abstract**

Digital technologies are a valuable strategy for finding, identifying, combining and integrating external knowledge, as well as for generating new organizational forms to develop innovative solutions. At the same time, digital technologies are allowing a more active collaboration and interaction among companies, communities of experts, and consumers in order to address environmental-oriented innovation challenges. Environmental innovation refers to the development of new or improved products and the creation of new processes and business models that bring benefits to the natural environment. In that sense, the main objective of this study is to discuss, from a conceptual perspective, how digital technologies promote open collaboration processes to achieve environmental innovations. We analyze crowdsourcing, customer co-development, and R&D alliances as mechanisms to achieve Sustainable Development Goals in general, and environmental-oriented innovations in particular. Our study expands the argument that collaboration with outsiders is a key capability to advance towards environmental innovation and to acquire and provide unique resources and knowledge to facilitate the environmental innovation process.

**Keywords:** environmental innovation; circular economy; open collaboration; stakeholders; sustainability; digital technologies.

## **Introduction**

In order to contribute to sustainable development, companies are required to formulate corporate strategies that deal with the most important today's environmental challenges. According to United Nations, there are many people who still lack access to wastewater management and sanitation facilities. On another hand, the continuous increase in sea levels, extreme weather conditions, greenhouse gases, overfishing, ocean acidification and eutrophication, and the transition towards more sustainable energy systems are also serious environmental challenges requiring an exceptional attention of society (United Nations, 2018). However, the most critical problem of our days is climate change, considering that itself is responsible for the most above-mentioned factors. Climate change is far from being exclusively an environmental problem and also affects the social development and the economic dimension (Silvestre & Țîrcă, 2019).

Thus, how companies can start to think about the environmental effects of their business activities in order to improve their sustainability performance? Due to societal pressures, firms "are searching for ways to do things differently while also seeking opportunities for growth" (Geradts & Bocken, 2019, p.79) which suggests that environmental challenges should be addressed from an innovation-centered approach (Klewitz & Hansen, 2014) with a view to helping businesses transition to environmental sustainability (Adams, Jeanrenaud, Bessant, Denyer, & Overy, 2016). This approach is commonly known as environmental innovation, and it refers to the development of new or improved products and the creation of new processes and business models that bring benefits to the natural environment (Geradts & Bocken, 2019). Environmental innovations, compared with traditional innovations, have a higher degree of complexity, uncertainty and unpredictable financial returns, and require disrupting decisions (Kennedy, Whiteman, & van den Ende, 2017; Kralisch et al., 2018).

Due to the added complex and uncertain character of environmental innovations, many scholars have claimed that collaboration with external players are key mechanisms to identify business opportunities associated with environmental challenges (Kennedy et al., 2017). Indeed, a decade and a half ago, literature has highlighted the importance of going beyond

the conventional boundaries of the firm to foster development of new products through open innovation (Chesbrough, 2003). According to the open innovation paradigm, firms cannot innovate alone. Hence, firms need to collaborate to get the right knowledge that allow them developing new sustainable products, processes or businesses models (Kennedy et al., 2017).

In an attempt to analyze the role of key stakeholders in the eco-innovation process, Carrillo-Hermosilla, Del R o, & K nn l  (2010) assert that a successful environmental innovation requires participation and cooperation among different partners such as academia, public sector, business, consultants, and other stakeholders, in order to find new ideas inside and outside the company. He, Miao, Wong, & Lee (2018) expand this argument claiming that cooperation with outsiders is needed to acquire and provide unique resources, capabilities, and knowledge for facilitating the environmental innovation process.

Through open collaboration firms can obtain valuable knowledge to identify environmental solutions, as well as enhancing the legitimacy and social license to operate. In this context, digital technologies are an important strategy for finding, identifying, combining and integrating external knowledge, as well as generating new organizational forms for the development of innovative solutions. For instance, through digital platforms, a diverse group of entities (e.g. experts, companies, users, universities, R&D centers, etc.) interact in virtual environments in order to transfer and integrate knowledge for solving environmental challenges (IBM Institute for Business Value, 2020).

Thus, digital platforms are mechanisms through which potential "solvers" can generate solutions to important innovative challenges (Abbate, Codini, & Aquilani, 2019). At the same time, digital technologies are allowing more active collaboration and interaction among companies, communities of experts, consumers (Hara, Komatsu, & Shiota, 2018; Rayna & Striukova, 2020) and other external actors through tournaments, open calls and crowdsourcing (Boons & Stam, 2019) or through intermediary platforms (e.g. *InnoCentive*, *IdeaConnection*, or *Innoget*), in order to address environmental innovation challenges (OECD, 2018). In that sense, the main objective of this article is to discuss, from a conceptual

perspective, how digital technologies promote open collaboration processes to achieve environmental innovations.

### **Environmental Innovations**

The transition to a greener economy demands several incremental and radical changes, involving both mature and new emerging sectors (Rosa, Sassanelli, & Terzi, 2019). The best example of environmental innovation are circular economy innovations, which can be understood as an economic model that seeks to reduce the harmful effects of resources consumption, looking for ways to design new materials or systems (Rosa et al., 2019). The circular economy has a clear relation with the United Nations Development Goal 12 of "Responsible Production and Consumption". However, the circular economy have cross-cutting applications to most of the objectives proposed by the United Nations (Demirel & Danisman, 2019).

Circular eco-innovation is a term used to refer to environmental innovations that target resource recirculation in reuse, recycling and renovation loops, and are key to addressing today's major environmental challenges (Demirel & Danisman, 2019). These principles of circular economy innovations are applied at the micro (firm and consumer), meso (eco-industrial parks), and macro (cities, regions, and nations) levels (Demirel & Danisman, 2019). At the same time, innovation trends in the circular economy can be classified in technology push, including strategies such as the production of reusable and longer-life materials, and market pull, such as green consumerism (Demirel & Danisman, 2019).

Varadarajan (2017) emphasizes that at the product level, an environmental innovation consists in the introduction of a new or improved product which environmental impact is significantly lower. At the process level, Klewitz & Hansen (2014) argue that environmental innovation is associated with redesign of operations aiming to produce goods or services using less resources, hazardous materials, and improving the eco-efficiency associated to production activities.

On another hand, organizational environmental innovation generally is associated with formalized management systems such as environmental management systems (e.g. ISO 14001 or EMAS), and tools such as environmental policies, environmental management accounting, stakeholder management, sustainability vision, codes of conduct, employee engagement in sustainability or CSR activities, as well as organizational structures (Klewitz & Hansen, 2014).

### **Open collaboration**

Since the first publication of Chesbrough (2003) a decade and a half ago, the attention of academics, companies, and policy makers on the open collaboration or open innovation paradigm has growing fast (Bogers, Chesbrough, & Moedas, 2018). Open innovation refers to “the use of purposive inflows and outflows of knowledge to accelerate internal innovation” (Chesbrough, 2006, p.1). This knowledge exchange aims to perform successful collaborations with external players such as suppliers, customers, universities, research centers, other companies, and competitors (Guertler, Michailidou, & Lindemann, 2016).

Literature on openness suggests that there are three core modes of open innovation: inbound or outside-in innovation, outbound or inside-out innovation, and coupled innovation (Kessler, 2013). Inbound innovation, refers to the way in which companies can integrate external available knowledge and ideas, aiming to improve their innovativeness capacity (Kessler, 2013), and is based on the enriching of the company’s own knowledge base through the integration of suppliers, customers, and external knowledge sourcing (Enkel, Gassmann, & Chesbrough, 2009).

Acquisition and integration of knowledge also can be fostered by using “rich media, face-to-face meeting, staff exchange and joint supervision of knowledge transfer process, as well as by adopting dedicated ICT systems, promoting videoconferences and providing project management tools” (Natalicchio et al., 2017, p.1369). However, a successful external knowledge integration requires developing a critical level of absorptive capacity to learn effectively from external knowledge sources (Natalicchio et al., 2017).

On the other hand, the outbound innovation or inside-out process refers to the way in which internal knowledge is transferred outside the companies' boundaries (Kessler, 2013). Whereas the inbound process is based on the absorptive capacity, outbound innovation is supported in the desorptive capacity, which implies identifying external opportunities to transfer knowledge to the recipient (Natalicchio et al., 2017; p.1370).

Finally, the coupled open innovation process “deals with the joint use of knowledge by different organizations to innovate, thus concurrently involving inflows and outflows of knowledge” (Natalicchio et al., 2017, p.1370). The coupled process is based on the co-creation with complementary partners through cooperation activities, alliances, and joint ventures, in which success depends of giving and receiving (Enkel et al., 2009; Greco, Grimaldi, & Cricelli, 2015).

Adopting an open approach is not always easy. Prior literature suggests that the main barriers that declare the companies are related to the lack of information about market or the fact that they do not need to innovate (Ricez-Battesti, & Petrella, 2013). Furthermore, the implementation of open innovation is a big challenge for companies since establishing partnerships is a time-consuming issue that represents a transaction cost because of the use of external knowledge sources and intellectual property (Huizingh, 2011).

### **Digital Technologies and Open Collaboration for Environmental Innovation**

Industries are required to improve their environmental efficiency to generate financial and market value (Jakhar, Mangla, Luthra, & Kusi-Sarpong, 2018). In doing so, industries must involve to a set of different primary and secondary stakeholders, as well as economic and social stakeholders, in order to collaborate and work to develop and enable a circular flow of efficient materials and resources (Jakhar et al., 2018).

Collaboration improves workforce flexibility, improves product performance and can lead to the design of efficient waste reduction strategies, while promoting the development of more sustainable business models, thus helping to make societies more sustainable (Witjes &

Lozano, 2016). Some of the most significant modes of collaboration in an environmental innovation context are: crowdsourcing (inbound), customer co-development (coupled mode), and R&D alliances (coupled mode). In this section, we summarize the role of digital technologies in different modes of collaboration in an environmental innovation context (table 1).

### *Crowdsourcing*

In recent years, crowdsourcing has received extensive attention from academics and professionals (Meng, Hang, & Chen, 2019; Ruiz, Brion, & Parmentier, 2020; Simula & Ahola, 2014). The above, considering that the digital age offers a great opportunity for companies to access new knowledge for innovation processes (de Mattos, Kissimoto, & Laurindo, 2018; Han, Sun, Song, Fang, & Liu, 2021; Ruiz et al., 2020). Specifically, in the last decade the use of crowdsourcing and open innovation approaches has increased to involve different actors in solving problems or in developing projects (Acar, 2019; Ruiz et al., 2020; Thompson & Bentzien, 2020). Indeed, previous studies (Vignieri, 2020) define crowdsourcing as a mode of open innovation, in the context of the collaborative economy. In this sense, different crowdsourcing configurations are identified in organizations: internal crowdsourcing; community crowdsourcing; open crowdsourcing; and crowdsourcing via a broker (Simula & Ahola, 2014)

Crowdsourcing allows improving the efficiency of innovation (Li, Bian, Liu, & Wu, 2020), democratize the innovative process, promote creativity and use external knowledge as a response to the challenges of the organization (Forbes, Han, & Schaefer, 2020). Furthermore, crowdsourcing as a new pattern of innovation allows companies to reduce risks and costs (Meng et al., 2019) and generate creative ideas through the interaction of different users (Acar, 2019; Cheng et al., 2020; Forbes et al., 2020; Seltzer & Mahmoudi, 2013).

Currently, crowdsourcing is a mechanism to generate a greater globalization in innovation sourcing, due to the growing competition in innovation and the importance of information technologies (Bakici, 2020). Through collaborative crowdsourcing communities, users become co-creators of new products (Liu, Du, Hong, Fan, & Wu, 2020) and access a set of



relevant knowledge (Pohlisch, 2020). In this regard, crowdsourcing is a topic of great interest in the literature (Campos-Blázquez, Morcillo, & Rubio-Andrada, 2020) and constitutes an open innovation practice widely used by companies (Pohlisch, 2020).

In the environmental innovation context, crowdsourcing is a useful mechanism through which potential "solvers" can generate solutions to important innovative challenges (Abbate et al., 2019). Crowdsourcing can take the form of open calls (Boons and Stam 2019) or can be performed through intermediary platforms (e.g. *InnoCentive*, *IdeaConnection*, or *Innoget*), in order to address environmental-oriented innovation challenges. Crowdsourcing makes it possible to gather opinions, ideas, drafts, suggestions and information from the general public, but it can also be aimed at specific crowds, such as customers. It is a particularly effective process in the early stages of an innovation process, because it allows to generate a large number of ideas (Van de Vrande & Rochemont, 2017)

#### *Customer co-development*

The traditional marketing paradigm, in which the customer assumed a passive role in the development of new products, has been challenged in recent years by a perspective in which customers actively participate in the process (O'Hern & Rindfleisch, 2010). Thus, it is increasingly common for companies to develop products jointly with customers (M Oinonen, Ritala, Jalkala, & Blomqvist, 2018). Consequently, in the context of collaborative innovation, co-creation processes with clients have attracted the attention of academics (Minna Oinonen, 2016) and managers, who must identify the objective of each stakeholder involved to improve co-creation (M Oinonen & Jalkala, 2015).

We use the term co-development or co-creation to refer to way in which organizations seek contact with end customers to test and validate new ideas and prototypes and to bring new ideas together to bring the product to market. Co-development can be perfectly a marketing strategy if managed properly, because it engages customers with their product (Van de Vrande & Rochemont, 2017). For Kazadi et al. (2015) co-development with stakeholders involves "collaborative activities during which multiple interdependent external stakeholders contribute to a firm's innovation process" (p.1).

Co-development is a coupled process of open innovation, initially applied to corporate innovation, with a special emphasis on investigating how it generates business value in the contexts of user-centric innovation and open source projects, virtual communities/platforms and multidisciplinary projects (Silva & Wright, 2019). In the context of environmental innovations, co-development is a way to share, combine and renew resources and capabilities between companies and active users in order to create value through new forms of interaction, and by combining resources, knowledge or ideas to make fundamental environmental changes in companies (Arnold, 2017).

Some activities to implement co-creation in the context of environmental innovation workshops (interactive meetings to generate solutions that result in innovative or incrementally changed products or services); web communities (virtual groups that take the form of social networks or other web applications to interact or improve product sustainability impacts); ideas competition (forums in which people interested in a topic generate creative ideas or concepts regarding a particular sustainability issue); dialogue (a tool to engage people in a serious discussion on a special topic (Arnold, 2017). Co-development processes are especially useful for interactions that take place during different phases of innovation, such as co-production (Lacoste, 2015).

#### *Environmental R&D alliances*

R&D alliances are innovation-based relationships formed by two or more partners who pool their resources in search of a common goal. R&D alliances are also known as cooperative alliances, technology alliances, strategic technology partnerships or technological cooperation agreements (Martínez-noya & Narula, 2018).

Alliances for innovation can be horizontal (between rivals), vertical (with suppliers or customers) or institutional (with universities). In horizontal alliances, usually cooperation is established between companies that carry out the same type of activity. Vertical alliances, generally are established between companies operating in related industries along the same value chain (Martínez-noya & Narula, 2018).

In the context of environmental innovations, an inter-firm alliance can be defined as “a voluntary cooperative agreement between firms aimed at the development, manufacture and/or distribution of green and sustainable products or services in which partners exchange, share or co-develop environmental resources, knowledge or technologies to create economic, environmental and/or knowledge value” (Nielsen et al., 2020, p.4). Environmental alliances, for instance, can be performed with the objective to lower emissions or to solve specific challenges in the energy sector (Jakobsen, Lauvås, & Steinmo, 2019).

Table 1. The role of digital technologies in different modes of collaboration in an environmental innovation context.

<b>Modes of collaboration</b>	<b>Benefits in an environmental innovation lens</b>	<b>Digital technologies</b>
Crowdsourcing (inbound)	<p>Improves the efficiency of innovation (Li et al., 2020)</p> <p>Democratizes the innovative process, promotes creativity and use external knowledge as a response to the challenges of the organization (Forbes et al., 2020)</p> <p>Allows companies to reduce risks and costs (Meng et al., 2019)</p> <p>Allows to generate creative ideas through the interaction of different users (Acar, 2019; Cheng et al., 2020; Forbes et al., 2020; Seltzer &amp; Mahmoudi, 2013)</p> <p>Allows a greater globalization in innovation sourcing (Bakici, 2020)</p> <p>Makes users co-creators of new products (Liu et al., 2020)</p> <p>Allows access a set of relevant knowledge (Pohlisch, 2020)</p>	<p>Crowdsourcing communities</p> <p>Open calls</p> <p>Intermediary platforms</p>
Co-development (coupled mode)	<p>Affects the development of innovative services (Moghadamzadeh et al. 2020)</p> <p>Improves the performance of innovation (Goyal et al., 2020; Lau et al., 2010; Tsou et al., 2019)</p>	<p>Social media platforms</p> <p>Innovation workshops</p> <p>Web communities</p> <p>Ideas competition</p> <p>Dialogue</p>

	Develops radical organizational creativity (Balau et al., 2020b)	
	Develops business intelligence (Fagerstrøm et al., 2020)	
	Allows to share, combine and renew resources and capabilities between companies and active users (Arnold, 2017)	
R&D alliances (coupled mode)	Produces products under the 'brand' of the environmental group	Interchange of resources, knowledge or technologies to create economic, environmental and/or knowledge value enabled by digital technology
	Contributes to specific environmental or fundraising activities	
	Helps to differentiate products and position companies as "green"	
	Develops green and economically viable solutions implements economically viable environmental programs for the greening of business practices investigates environmental scientific and economic issues and propose government policies (Hartman & Stafford, 1997)	

Source: Own elaboration based on literature.

## Conclusion

This chapter has discussed how digital technologies promote open collaboration processes to achieve environmental innovations. As Luers et al. (2020) assert, there are currently two main streams that are conditioning the future of humanity: climate change and digital revolution. Digital platforms, macrodata, and artificial intelligence present important opportunities to drive social transformation and to achieve a secure, climate-smart world. This is due to the great capacity of digital technologies to transform societies, cultures and economies. Digital technologies in the context of sustainability are encouraging environmental attitudes and behaviors, collective climate actions, and changing the way business is done (Luers et al., 2020).

Digital technologies are facilitating collaborative innovation by becoming a means to provide new types of products and services with environmental benefits. For that reason, companies now need to review their inter-firm collaboration and coordination models to meet the expectations of strategic or potential customers. In the context of environmental innovation,

for example, it is much more necessary to establish governance structures and mechanisms capable of reconciling the points of divergence between allies (Q. He, Meadows, Angwin, Gomes, & Child, 2020).

Digital technologies will also make clients more deeply involved in co-creation processes through information and communication technologies. Blockchain, for example, is considered a promising medium for transactions between companies and will therefore improve collaboration between them. Industry 4.0, on the other hand, has great potential to impact global value chains and reduce the use of intermediaries. Likewise, digital transformation will generate new networking possibilities, facilitating cooperation between different actors (Q. He et al., 2020).

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