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Towards a comprehensive framework to analyse the benefits of openness for sustainability-oriented innovation: A systematic literature review

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Abstract

This study systematically reviews the scientific literature on the role of open innovation in addressing current and emerging societal and environmental challenges. To do so, we analysed the *what*, *how*, *who* and *why* of integrating external partners for sustainability purposes. We found a clear predominance of open innovation mechanisms to develop environmental innovations rather than innovations focused on a triple bottom line. We identified at least four mechanisms associated with the *inbound* mode of open innovation (crowdsourcing, lead-user workshops, intermediation, and experiments and discussion sessions) and 10 mechanisms related to the *coupled* mode of open innovation (alliance, business-non-profit engagement, co-creation, joint ventures, cooperation, collaborative innovation contests, coopetition, cross-sector partnerships, joint development projects, and innovation networks). Even though sustainability-oriented innovation promises to be a source of societal transformation and entrepreneurial opportunities, we found that firms can face some tensions when simultaneously addressing financial, environmental and social purposes.

KEYWORDS
collaborative innovation, environmental innovation, open innovation, sustainability-oriented innovation, sustainable business, sustainable innovation

1 | INTRODUCTION

The 2030 Agenda and its 17 Sustainable Development Goals (SDGs) are being adopted by firms in order to help resolve such major societal challenges as poverty, inequality, migration, violence, air pollution, health crises, water scarcity, waste management, and climate change (Adams et al., 2016; Silvestre & Ţîrcă, 2019), to mention just a few examples. Those sustainability issues, due to their high level of complexity (Porter & Birdi, 2018), require system-level changes that may be addressed by firms from an innovation-centred perspective (Klewitz & Hansen, 2014), that is, from the lens of sustainability-oriented innovation (SOI).

SOI consists of developing new or improved products and creating new processes that introduce benefits to the environment and society (Geradts & Bocken, 2019). Compared with most traditional ones, this type of innovation has a higher degree of complexity, uncertainty and unpredictable financial returns for the firms, making the innovation process more challenging (Kennedy et al., 2017; Kralisch et al., 2018).

In that regard, an effective response to the challenges of developing new sustainability-oriented products or processes entails

companies engaging with external partners to co-develop new and viable sustainable solutions. This approach, called open innovation, 'describes a purposive attempt to draw together knowledge from different contributors to develop and exploit innovation' (Ahn et al., 2019, p. 1). For instance, numerous opportunities to create, exchange and capture business value are being facilitated via collaboration and crowdsourcing processes, bringing together firms and industrial actors, policymakers, academicians, scientists, and citizens that are willing to define and apply responses to sustainability issues, such as local climate solutions (Elia et al., 2020).

Collaboration has been a critical mechanism for creating innovative solutions to address such issues as water scarcity management (Porter & Birdi, 2018), climate-smart agricultural production (Yamoah et al., 2020), and the co-identification and co-exploitation of sustainable business opportunities (De Silva & Wright, 2019). The Covid-19 pandemic, for instance, increased the development of joint innovations among large companies, start-ups, governments, universities, and research centres, in the hope of protecting people and saving lives. Innovative approaches against Covid-19 have included, for instance, calls for research proposals, ideation processes, joint development of technological devices, and collaborative research and data sharing (OECD, 2020).

Although the literature on corporate sustainability and innovation management has provided clear evidence that: (1) the relationship between open innovation and SOI is fast becoming a key topic (Ahn et al., 2019; Reficco et al., 2018; Slotegraaf, 2012; Von Geibler et al., 2019); (2) the integration of partners in the innovation process is a crucial capability to advance towards SOI (Hansen & Grosse-Dunker, 2012); (3) firms can benefit from open innovation to obtain the proper knowledge to develop new sustainable products, processes or businesses models (Kennedy et al., 2017); and (4) firms collaborating with external actors are more likely to create new or improved products that achieve market success (Melander, 2017), few studies have identified and summarised the mechanisms that occur in open innovation initiatives oriented towards a sustainability purpose.

Some of the existing systematic reviews summarise the knowledge on multi-sector alliances for sustainability (Gray & Stites, 2012), the motivations to collaborate through environmental alliances (Niesten et al., 2020), the collaboration mechanisms involved in environmental or sustainable supply chain management (Cloutier et al., 2019), the success factors involved in environmental product innovation (Fleith de Medeiros et al., 2014), and the reasons why collaborative innovations sometimes fail (Porter & Birdi, 2018).

We build upon those reviews by analysing the scientific literature on the role of openness in addressing innovations to solve current and emerging societal and environmental challenges. We analysed 35 scientific publications that were carefully selected based on predefined criteria, to explain how a set of open innovation approaches can lead to the achievement of different outcomes in the context of SOI (Ordonez-ponce et al., 2020).

Aligned with the goal of this special issue to provide a better understanding of how systemic changes in our societies may have an impact on sustainability as well as the urgent need to take action to solve societal changes by implementing innovative solutions in every sphere of our society (Zilahy & Dobers, 2021), this paper sheds light on the role of the open innovation model as a conceptual basis to examine the collaborative side of new business solutions that place social and environmental concerns at the core.

In that sense, in this study, we propose a comprehensive conceptual framework to provide clarity on the new solutions aimed at tackling societal challenges and the mechanisms used to collaboratively address sustainability issues, as well as the barriers and success factors, variety of partners, and the reasons and motivations of companies to address the most urgent sustainability-related matters. This study also contributes to the debate on incremental improvements and systemic transformations towards sustainability transitions on the basis that collaborative SOI processes can sometimes lead only to incremental improvements that are not adequate to promote real impacts at the system or society level.

We posed the following research questions to guide this systematic literature review: (1) What sustainability goals are pursued through open innovation approaches? (*the what*) (2) How are partners integrated, that is, what open innovation mechanisms are being considered and discussed in the SOI literature? (*the how*) (3) Which secondary stakeholders are integrated into collaborations to achieve sustainability-oriented innovations? (*the who*) (4) Why do companies and external actors set up collaborations to innovate with a sustainability purpose? (*the why*).

2 | CONCEPTUAL BACKGROUND OF THE STUDY

2.1 | Sustainability-oriented innovation

Sustainability-oriented innovation is an umbrella term often interchangeable with sustainability-driven/related innovation or sustainability/sustainable innovation (Buhl et al., 2019). Research on sustainability-oriented innovation has focused mainly on innovations with a strong emphasis on environmental aspects (Adams et al., 2016) in addition to financial concerns. However, the discourse on sustainability has evolved to include the social and environmental impacts at the same time (Klewitz & Hansen, 2014; Silvestre & Ţîrcă, 2019).

Numerous frameworks have been proposed for the classification of SOI. Research in this field typically establishes typologies considering 'whether an innovation is incremental or radical, whether it focuses on processes or products, and whether it is new to the organisation, or to the industry, or to the world' (Silvestre & Ţîrcă, 2019, p. 326). For instance, Inigo et al. (2020) evaluated two main dimensions of SOI: incremental and radical. The first involves minor variations in innovation processes and is based on marginal changes, such as the improvement of existing products' materials or energy efficiency. In contrast, radical innovation entails transformative changes involving the development of new products, the design of new markets or finding new ways to cater for existing markets (Inigo et al., 2020; Lin, 2019).

Varadarajan (2017) also proposed a framework for SOI consisting of three types of innovation (business model, product-service system, and technological), three sustainability effects (ecological, social, and economic) and three life-cycle-stages (manufacture, use, and end-of-life). Similarly, Klewitz and Hansen (2014) developed an SOI proposal that includes a taxonomy of sustainability strategies (resistant, reactive, anticipatory, innovation-based, and sustainability-rooted) and a set of SOI practices and types of innovation. The study by Adams et al. (2016) is another notable work proposing a conceptual framework to analyse the innovation activities that firms engage in to become more sustainable. In that conceptual model, Adams et al. (2016) distinguish between three stages in the context of SOI: operational optimisation (doing more with less), organisational transformation (doing good by doing new things), and system building (doing good by doing new things with others).

2.2 | Open innovation

Open innovation is a widely used concept in academia, business and innovation policy that has emerged to explain how companies can use internal and external ideas and leverage knowledge inputs and outputs to make innovation processes more successful (Bogers et al., 2018). In addition, open innovation is a crucial perspective for theorising about, analysing and exploring how external partners can provide valuable ideas, knowledge and resources to boost firm innovation (Filiou, 2020).

The literature on open innovation claims that the flow of knowledge between an organisation and external actors may involve innovation activities to benefit from knowledge from external sources (inbound); innovation activities that aim to insert internal ideas into the market (outbound); or a combination of inbound and outbound activities, known as the 'coupled mode,' in which firms and partners jointly develop or commercialise innovations (Flor et al., 2019; Mazzola et al., 2012).

For instance, a typical mechanism of the inbound mode is crowdsourcing, a participative activity in the form of an open call by a company to ask a group of individuals to provide ideas regarding a specific challenge (Porter et al., 2020). The success of crowdsourcing depends on both the number of submitted ideas and the quality thereof (Schäper et al., 2020). Regarding the outbound mode, one usual process is corporate business incubation, which is aimed at 'developing potentially profitable ideas and offering supportive environments for entrepreneurs inside the organisation to identify novel paths to market' (Chesbrough & Brunswicker, 2014, p. 20).

In the coupled mode, innovation networks are one of the most effective collaboration mechanisms, made up of firms and a broad set of partners, such as clients, suppliers, universities, non-profit organisations and communities, among other actors, with the intention being to promote the dissemination and exchange of knowledge in order to address a specific challenge (Peterman et al., 2020).

In the context of sustainability-oriented innovation, Inigo et al. (2020) indicate that the coupled mode of openness is a feasible way to improve SOI since firms can benefit from active partners engagement. However, as Huizingh (2011) suggests, firms need to determine on a first basis with whom and for what purpose they should collaborate. In that regard, previous studies have proposed different ways to classify partners to collaborate. For instance, from the firm's perspective, stakeholders can be categorised as internal and external (Mart et al., 2016). In that sense, for the purposes of this study, external stakeholders are 'those who are outside organisational boundaries (thus excluding employees) and do not have ownership of the firm in any way (thus excluding owners, investors and shareholders)' (Ghassim, 2018, p. 16).

External partners can help generate innovations or exploit the solutions that the company has developed. Those collaborations can be of different lengths, involve varied individuals or organisations, have diverse initiators, and may imply different motivations for partners (Huizingh, 2011). In an open innovation context, each partner must be clear about its role, responsibilities and expectations within the collaboration process (Porter & Birdi, 2018). A successful open innovation process also requires partners to have clear reasons to collaborate.

According to the resource-based view of the firm, organisations collaborate to access their partners' complementary resources, such as information, knowledge, capabilities, technology, or production and distribution capacities, while the resource dependence theory suggests that firms pursue access to those resources to cope with uncertainty and respond faster to changes in industries and markets. Meanwhile, the institutional theory suggests that through collaboration, individuals or organisations gain reputation and legitimacy among their allies. Finally, the transaction cost theory claims that reducing and sharing transaction costs is a strong motivator for inter-organisational collaborations (Niesten et al., 2020).

3 | METHODOLOGY

3.1 | Research design

We performed a systematic literature review (SLR) to address our research questions. An SLR is a research design for synthesising data that is already published, based on a systematic and pre-defined process (Kraus & Dasí-Rodríguez, 2020; Lopes & de Carvalho, 2018). Systematic literature reviews help to consolidate a field of knowledge and allow researchers to take stock of published scientific literature and derive new conceptualisations and future research guidelines (Breslin et al., 2020).

We conducted a descriptive analysis of the articles included in this review. We also performed a content analysis of the studies based on a *what-how-who-why* framework in order to determine the relationship between open innovation and SOI and to establish a conceptual integration of multiple literature streams (Jaakkola, 2020). To systematise the data, we designed a codebook (see Appendix A) to describe each article (e.g., level of analysis, source of information, theoretical perspective, among others), as well as the main categories (see Appendix B) related to our four research questions (the

TABLE 1 Inclusion and exclusion criteria

N°	Criteria	Inclusion	Extended inclusion criteria	Exclusion
1	Time frame	Published between 2000 and 2021.	To cover the last two decades of research.	Any other year.
2	Type of document	Peer-reviewed articles.	Selected peer-reviewed articles because wanted to ensure quality.	Books, book chapters, conference proceedings, reports, editorials, translations, and other types of material.
3	Language	Studies must be in English.	To avoid restrictions related to language.	Any other language.
4	Study type	Empirical studies.	Since we are interested in the empirical evidence around our research topic.	Studies that do not report empirical findings, such as theoretical or conceptual studies.
5	Focal firm	At least one focal firm.	Since we are interested in collaborations that include companies.	No firms involved.
6	Thematic fit	Clear relationship between open innovation and SOI.	Articles must refer to any type or mode of collaboration that leads to an SOI.	Collaboration for SOI is not a central theme. Openness or sustainability terms are used with a different meaning. Articles refer only to the likelihood or propensity of introducing any type of innovation. Articles that do not report an active role of the partners in the collaboration process (e.g., articles only based on patent statistics, or firm alliance data).

sustainability goal, the partners involved, the open innovation mechanisms, and the reasons to collaborate). We followed a deductive logic to reflect collaboration patterns in an SOI context (Jakobsen et al., 2019; Neutzling et al., 2018). In this section, we explain the stages to identify and synthesise our sample of research articles, as proposed by Parmigiani and King (2019).

3.2 | Search

To identify the publications that were analysed in this systematic review, we used the following keyword combinations: ('sustainab* innovation' OR 'innovation for sustainability' OR 'sustainability-oriented innovation' OR 'sustainability-driv* innovation' OR 'sustainability-related innovation' OR 'eco-innovation' OR 'ecological innovation' OR 'environmental innovation' OR 'green innovation') AND ('open innovation' OR 'openness' OR 'collaborat*' OR 'alliance*' OR 'co-innovation' OR 'cooperat*' OR 'partnership*'). Truncation symbols were used to retrieve variant spellings, synonyms and related terms, and word endings. The search was performed in the Web of Science (WoS) — Core Collection database since WoS is considered the most rigorous and comprehensive research publication database (Iñigo & Albareda, 2016; Melander, 2017; Porter & Birdi, 2018). The period of included papers was 2000–2021. The searching process took place in March 2021 and was later updated in January 2022.

Following previous systematic literature reviews, we searched the combination of terms in the publications' titles, abstracts, and keywords. For instance, Klewitz and Hansen (2014), in a systematic literature review (SLR) about sustainability-oriented innovation, searched the literature in the titles, abstracts and keywords of the records to improve the probability of finding relevant studies. A similar strategy was used in previous SLRs developed in the fields of innovation (Cinar et al., 2019; West & Bogers, 2014) and sustainability-oriented labs (McCrory et al., 2020).

3.3 | Eligibility assessment

Studies included in the review fulfilled the attributes described in Table 1.

Based on the search equation, we initially retrieved 569 publications. After applying the timeframe, document type, and language filters, we kept 512 articles which were imported to Mendeley. The next step was to screen the titles, abstracts, and keywords of those articles. At this stage, we aimed to determine whether the documents were related to our research goal or not. Specifically, we analysed whether each study addressed the collaboration between enterprises and external actors for SOI.

Articles for which the reading of these fields did not lead to a conclusive decision were analysed in full text. 139 articles were included in this step. After that, all full-text articles were examined for eligibility in our review. We verified that the articles met all the inclusion criteria in that step. Finally, 35 scientific articles were included in the systematic review. We were very strict in selecting the final sample of articles since we were looking for publications connecting open innovation and SOI. The whole process is shown in Figure 1.

3.4 | Data extraction and synthesis

The 35 articles included in this review were analysed following the procedure used by Klewitz and Hansen (2014) and Govindan et al.

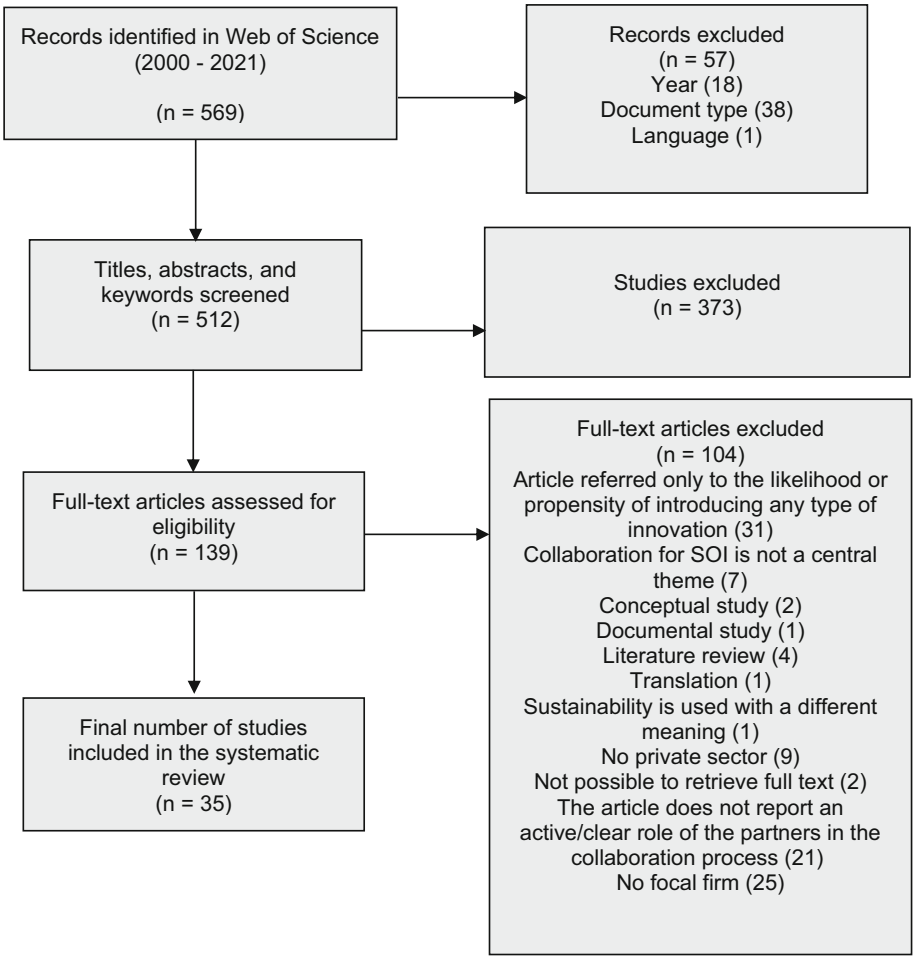

FIGURE 1 Systematic literature review flow diagram.

(2021). First, we conducted a descriptive analysis of the publications. Second, we performed a content analysis of the articles, using categories identified in our background and terminology section, and related to the review questions. To do this, we exported the articles to ATLAS.ti and applied code schemas to analyse each one. The in-depth analysis of the articles made it possible to identify the topics related to our four-dimensional structure (the *what*, *how*, *who* and *why*).

4 | RESULTS

4.1 | Descriptive analysis

In this section, we present an outline of the main features of the articles discussed in this review. We found that 13 of the total articles included in this review are addressed from the perspective of the firm (organisational level of analysis); 11 are focused on the project perspective (intra-organisational level of analysis), while 11 are approached from an inter-organisational level of analysis, including innovation networks, coopetitive relationships, and alliances. Diversity in the levels of analysis and research objects evidence the multilevel nature of SOI.

From a methodological point of view, 34 of the articles analysed are based on qualitative perspectives (22 multiple case studies and 12 single case studies), and only one article used mixed methods. These results are closely related to the findings of Aka (2019), which argues that in research describing processes, qualitative strategies are beneficial for exploring emerging or less understood phenomena. We also identified the main theoretical perspectives or conceptual frameworks on which the analysed studies were based. For instance, we found that the stakeholder theory, the industrial ecology perspective, the network theory, and the absorptive capacity framework are the most widely used perspectives by the authors included in this review.

4.2 | Content analysis

4.2.1 | Sustainability orientation

The studies we analysed deal mainly with the environmental dimension of sustainability (24 articles), while two articles were focused on open innovation processes whose emphasis is only on the social sphere. Nine studies addressed environmental and social sustainability goals, mainly related to collaborative approaches that directly sought both the development of an innovation that simultaneously had social and environmental impacts (Table 2). We found a predominance of open innovation mechanisms to develop environmental innovations. However, authors such as Veleva and Bodkin (2018) argue that it

TABLE 2 Sustainability orientation of the studies

Sustainability orientation	Sustainability innovation goal	Authors
Triple Bottom Line dimension This is the dimension where the foundations are environmental, social, and financial goals (Veleva & Bodkin, 2018).	Eco design and green marketing; new product development for smaller impacts on the environment and new product lines (education and health). New products that have less environmentally harmful inputs and impact and concepts for sustainability communication; health and change management. Development of smart products to improve the quality of living of elderly people. Affordable and comfortable housing for low-income families who want to own their home. Using low carbon emission vehicles to provide micro-entrepreneurship opportunities to the unemployed. Reducing youth unemployment through a new retail business model. Product improves health and safety of employees and other stakeholders. Mobility services aimed to lower greenhouse gas emissions and air pollution, at the time that social value is created in the form of more room for children and outdoor activities, increase of jobs, as well as safer and more enjoyable rides for passengers. Ideation processes to develop circular economy and energy efficiency solutions, social innovation, and sustainable organisational initiatives.	***n* = 9** Lopes et al. (2017); Klewitz (2017); Behnam et al. (2018); Goodman et al. (2017); Juntunen et al. (2019) Watson et al. (2020); Stal et al. (2021); Munten et al. (2021); Greco et al. (2021).
Social dimension The social dimension is about paying attention to human capital development, job creation, and safety issues, among others (Saunila et al., 2018).	Innovations focused on economic development, ecosystems, education, healthcare, and human rights. Development of a non-pharmaceutical method to treat a mental condition that mainly affects children. Delivering medical supplies to remote areas and exploring long-term viable ways to enter those emerging markets.	***n* = 2** Mirvis et al. (2016); Kazadi et al. (2016).
Environmental dimension The environmental dimension encompasses factors such as land use, waste handling, hygiene, and energy and water consumption (Saunila et al., 2018).	New product with components that are not harmful to the environment. Development of products made for more environmentally friendly usage. Sharing of best environmental practices, joint environmental monitoring and production planning. Solve specific challenges in the energy sector and pursue environmental improvements and pollution reduction. New process for product reuse, remanufacturing and waste repurposing. New sustainable product in the field of food; sustainable packaging. Generating clean energy without producing waste, pollution and greenhouse emissions. Gathering and disseminating information to foster eco-innovation. New platforms for the measurement, evaluation and showcasing of eco-innovations. New materials and alternative business models for making improvements to environmental products. New solutions in energy, water technologies, biofuels, and management practices. New organisational forms to firms transitioning towards the circular economy (circular business model innovation).	***n* = 24** Melander and Pazirandeh (2019); Aka (2019); Reficco et al. (2018); Jakobsen et al. (2019); Veleva and Bodkin (2018); Melander (2018); Zimmerling et al. (2017); Arnold (2017); Fliaster and Kolloch (2017); Lee and Kim (2011), Wadin et al. (2017); Neutzling et al. (2018); Rossignoli and Lionzo (2018); Kennedy et al. (2017); Kanda et al. (2018); Bocken et al. (2014); Brown et al. (2019); Pucci et al. (2020); Todeschini et al. (2020); Kanda et al. (2018); Mousavi and Bossink (2020); Pace and Miles (2020); Zucchella et al. (2021); Siltaloppi and Jahi (2021).

needs to be clarified how addressing environmental impacts can be coordinated with social and community impacts.

Another challenge in the study of environmental innovations is that, in some cases, it is difficult to determine the actual impact of those innovations on the sustainability performance of the firm, which in turns prompts the need to develop systems for measuring and monitoring the scope of those innovations in the long term (Goodman et al., 2017). For instance, in terms of impact measurement of environmental benefits, an innovation can be measured based on its outcomes or on the intended environmental impacts of the innovation solutions (the objective or intention) (Kanda et al., 2018).

Silvestre and Ţîrcă (2019) point out that sustainability-oriented innovations should balance environmental, social, and economic purposes. In practise, however, companies appear to have difficulties when simultaneously addressing environmental and social purposes. Also, the problem of clarifying precisely what sustainable innovation means demonstrates that 'the field continues to lack a common theoretical framework that encompasses the distinct aspects of SI' (Iñigo & Albareda, 2016, p. 2).

However, what is evident is that SOI claims for a triple-bottom-line perspective in which sustainability is a core concern of the business model, moving from an instrumental perspective where profit is the dominant motivation to a more integrative approach to sustainability (Munten et al., 2021). Additionally, there is a consensus that SOI cannot be approached by individual actors alone, given that searching for innovative solutions for sustainability challenges requires collaboration within the firms and between the firms and other actors (Munten et al., 2021).

Even though SOI promises to be a source of social transformation and entrepreneurial opportunities, the search for a financial, social, and environmental balance can generate tensions within the firms or unintended negative consequences. For example, according to Munten et al. (2021), some positive outcomes at any given level can negatively affect other levels. It happens, for example, when improvements in a product's eco-efficiency cause an increase in its demand.

In that same vein, Stal et al. (2021) claim that the search for business model innovations for sustainability presents inherent contradictions derived from the efforts of the companies to integrate environmental, social, and economic objectives at the same time. The contradictions arise because those three objectives, despite being interdependent, have different natures: economic value creation seeks to satisfy the market's demands, environmental value is focused on the needs of complex biophysical systems, and social value attends to those human needs that the markets fail to satisfy (Stal et al., 2021).

In cross-sector partnerships for sustainable business model innovation, some challenges and tensions arise because the partners can create value in different ways and prioritise different interests (Stal et al., 2021). For example, some tensions arise because the private sector generally responds to the market logic, while the public sector instead responds to bureaucratic logic. Furthermore, although the market logic tries to align with social and environmental value creation, customers and market efficiency usually are prioritised (Stal et al., 2021).

In the case of mechanisms such as coopetition, referring to the simultaneous pursuit of cooperation and competition between actors in a value network, Munten et al. (2021) reported that this form of collaboration could generate tensions in at least four dimensions: value generation, temporal articulation, relational evolution, and knowledge circulation. For example, in value creation, some tensions can arise because the actors expect to generate sustainable value by considering social and environmental factors whilst they pursue their own economic ambitions (Munten et al., 2021).

The other three categories identified by Munten et al. (2021) are temporal articulation tensions that arise because the actors need separated positions to benefit from SOI in the short term, but at the same time, they must develop an integrative perspective in the long term to promote the impact of SOI on a system level; relational evolution tensions, which emerge principally due to the unequal access to the benefits generated by the exploitation of SOI opportunities; and finally, there are knowledge circulation tensions, caused by the need of the actors to share technical knowledge whilst simultaneously protecting the knowledge they need (Munten et al., 2021). In summary, the role of tensions and paradoxes in the context of SOI could be a relevant research avenue since companies can use that framework to analyse and measure the results of their coopetitive relationships, as well as to identify ways to resolve those tensions (Munten et al., 2021).

4.2.2 | Open innovation mechanisms

This review also explored ways of collaborating for sustainable innovation. The studies analysed in this review mainly describe the inbound or coupled modes. These results are consistent with the traditional literature on open innovation, which points out that the inbound and coupled modes of open innovation are more common in practise and have received privileged treatment among researchers in that field (Culpan, 2014; Dahlander & Piezunka, 2014).

Table 3 shows at least four mechanisms associated with the inbound mode. These include crowdsourcing, a form of public call to collect new ideas or validate existing ones. For example, the study by Zimmerling et al. (2017) describes the use of a public call via different media in order to collectively and collaboratively discuss ideas about new products to improve the quality of living of people with physical limitations. Intermediation was another form of open innovation highlighted in the studies by Kanda et al. (2018) and Kanda et al. (2020). That mechanism is focused on scanning, gathering, and disseminating information, led by cities, technology transfer offices, platforms, architects, industry associations or other innovation ecosystem actors.

Since we selected articles describing collaborative processes in which partners played an active role, we recovered a more significant number of studies focused on the coupled mode. In this form of open innovation based on the creation or joint development of innovations, the most frequent form of collaboration were partnerships and joint development projects. Partnerships are the most traditional form of collaboration and have been addressed by different disciplines, such as management, international business, and innovation (Martínez-noya & Narula, 2018).

Wadin et al. (2017) reveal that competitors sometimes cooperate in alliances to achieve innovation faster and at a lower cost and risk. Moreover, joint development projects are often shorter collaborative programmes aimed at achieving precise, measurable results, which demand a high degree of interaction and commitment between the parties involved (Goodman et al., 2017). A similar mechanism identified in our study, which may imply a lower degree of commitment, was co-creation; co-creation processes are 'collaborative activities during which multiple interdependent external stakeholders contribute to a firm's innovation process' (Kazadi et al., 2016, p. 525). Some stakeholders are included through this mechanism by following a highly selective integration process (Arnold, 2017).

Table 3 also shows, for example, that crowdsourcing is a commonly used mechanism for environmental and triple bottom line contexts. In the same line, we found that other inbound mechanisms such as lead-user workshops, intermediation, experiments, and discussion sessions are associated with open innovation processes that pursue a

TABLE 3 Open innovation mechanisms

Open innovation mode	Mechanisms/practices	Environmental	Social	TBL	Authors
Inbound (sourcing)	Crowdsourcing	√→	√→	√→	Lopes et al. (2017); Zimmerling et al. (2017)
	Lead-user workshops	√→			Zimmerling et al. (2017)
	Intermediation	√→			Kanda et al. (2018); Kanda et al. (2020).
	Experiments and discussion sessions	√→			Bocken et al. (2014).
Coupled (shared activity)	Alliances	√→			Wadin et al. (2017); Kennedy et al. (2017); Veleva and Bodkin (2018); Jakobsen et al. (2019); Pace and Miles (2020).
	Business-nonprofit engagement	√→	√→	√→	Mousavi and Bossink (2020); Watson et al. (2020).
	Co-creation	√→	√→		Mirvis et al. (2016); Arnold (2017); Kazadi et al. (2016); Pucci et al. (2020).
	Collaborative innovation contests			√→	Greco et al. (2021).
	Coopetition			√→	Munten et al. (2021).
	Joint-ventures		√→		Mirvis et al. (2016).
	Cooperation		√→		Mirvis et al. (2016f).
	Cross- sector partnerships	√→		√→	Reficco et al. (2018); Stal et al. (2021).
	Joint development projects	√→		√→	Melander (2018); Behnam et al. (2018); Fliaster and Kolloch (2017); Lee and Kim (2011); Neutzling et al. (2018); Goodman et al. (2017); Todeschini et al. (2020).
	Innovation networks	√→		√→	Aka (2019); Melander and Pazirandeh (2019); Klewitz (2017); Rossignoli and Lionzo (2018); Juntunen et al. (2019); Brown et al. (2019); Zucchella et al. (2021); Siltaloppi and Jahi (2021).

purely environmental purpose. Regarding the coupled mode, we found that alliances, despite being very frequent in the studies analysed, are more approached in the context of environmental innovations. Regarding innovation solutions oriented to solve the three types of sustainability orientations simultaneously (triple bottom line), the most frequent mechanisms are collaborative innovation contests, coopetition, cross-sector partnerships, joint development projects, and innovation networks.

We found that inbound mechanisms such as crowdsourcing are often used with suppliers, customers, and users, while intermediation more commonly involves suppliers, customers, other firms, and industry associations (Table 4). In the coupled mode (Table 5), alliances, for example, usually involve collaborations with other companies, industry associations and higher education institutions, while co-creation, joint development projects and innovation networks are the open innovation mechanisms that involve the widest variety of partners.

4.2.3 | Collaboration partners

The partners identified in this systematic review range from suppliers, commercial research institutes, customers, competitors, other businesses, government, higher education institutions, private non-profit organisations, and communities. In Table 6, we show the number of articles in which firms collaborate with other partners to achieve an environmental, social and/or a triple bottom line goal. We found that in collaborative initiatives that pursue an environmental purpose, it is very common to collaborate with other companies, customers, and suppliers.

Our results coincide with previous studies showing that firms collaborate extensively with customers and suppliers for environmental innovations (Melander & Pazirandeh, 2019). The most frequent partners in collaborative processes oriented towards a purely social purpose are private non-profit organisations. This is not surprising given that NGOs, by nature, are oriented towards social ends and accumulate knowledge about challenges related to social equity. Private non-profit organisations are also important partners in collaborations that pursue both social and environmental goals together with customers and other firms.

In general, few collaborative processes involve key players such as competitors or communities. It is also important to note that most studies address collaborative processes involving a diverse number of actors, showing that partners and stakeholders integrated in different combinations and are not necessarily limited to traditional partners (Juntunen et al., 2019). However, incorporating many partners is not

TABLE 4 Relationship between partners and inbound mechanisms

Type of partner/inbound mechanisms	Crowdsourcing	Lead-user workshops	Experiments and discussion sessions	Intermediation
Suppliers	√→		√→	√→
Customers	√→	√→	√→	√→
Users	√→	√→		
Competitors				
Other firms			√→	√→
Industry associations			√→	√→
Producers				
Professional experts				
Agencies				
Government				
Higher education				
Private non-profit			√→	√→
Community	√→			

always beneficial; companies should establish which allies they should have a close relationship with (Melander & Pazirandeh, 2019).

4.2.4 | Motivations, drivers, barriers and success factors in open innovation processes for SOI

We found in the analysed studies that firms may have motivations related to sustainability, for instance, when they look for future trends and focus areas within environmental sustainability, to gain awareness of sustainability requirements, to acquire an already existing sustainability technology or to use new sustainability technologies (Arnold, 2017; Behnam et al., 2018; Melander & Pazirandeh, 2019; Wadin et al., 2017).

Companies also collaborate for reasons related to human capital, when they want to transfer knowledge, access to other firms' knowledge, gain specialised knowledge or training, or access to the expertise and competencies of their partners with regard to sustainability issues (Brown et al., 2019; Melander & Pazirandeh, 2019; Mousavi & Bossink, 2020; Pace & Miles, 2020; Reficco et al., 2018). A few examples highlight financial motivations, such as the search for financial benefits, potential revenues or access to financial capital (Bocken et al., 2014; Mousavi & Bossink, 2020; Veleva & Bodkin, 2018).

However, the studies mainly reported organisational reasons to collaborate. For example, the full-text analysis of the selected studies showed that companies decide to involve external actors in sustainability collaboration processes to transform new ideas from an external point of view, obtain and test new ideas and technologies, ensure that the product is in line with customers' needs, legitimise corporate responsibility and improve corporate image, exchange and connect with other actors, expand and reach potential customers in new markets, diversify operations, gain status/recognition or jointly develop resources and capabilities (Aka, 2019; Arnold, 2017; Bocken et al., 2014; Brown et al., 2019; Kanda et al., 2020; Kazadi et al., 2016; Kennedy et al., 2017; Klewitz, 2017; Lee & Kim, 2011; Melander & Pazirandeh, 2019; Mousavi & Bossink, 2020; Neutzling et al., 2018; Reficco et al., 2018; Rossignoli & Lionzo, 2018; Wadin et al., 2017).

In the case of collaborative innovation contests (Greco et al., 2021), the primary motivation of companies is to benefit from the knowledge and creativity of solvers for idea creation and novelty processes, idea validation, networking, and to adapt the business to changes in the environment; while the primary motivations of the solvers are related to learning and increase the knowledge base on sustainability issues (Greco et al., 2021). However, the impact of those innovation contests is not always beneficial, since companies often lack the capabilities to adopt the ideas generated externally or because the employees are reluctant to adopt external ideas. One way to extend the results of the challenge is to link one of the participants with the most promising ideas to support the development and validation of the product, provide space for employees to work on the solution, or outsource the development of the challenge to another partner or company (Greco et al., 2021).

We also identified some internal and external drivers that promote open collaboration processes for SOI. We found internal drivers that include organisational sustainability strategies, internal culture, organisational identity, internal policies and capabilities, organisational structures, employee involvement, internal pressures (cost reduction, resource acquisition and risk prevention), technological leadership, leadership skills, the commitment of top management and integrated management systems (Brown et al., 2019; Jakobsen et al., 2019; Kennedy et al., 2017; Lopes et al., 2017; Neutzling et al., 2018; Reficco et al., 2018; Todeschini et al., 2020; Veleva & Bodkin, 2018; Wadin et al., 2017).

Similarly, we identified external drivers that promote open innovation processes for SOI. Those external drivers include stakeholder pressure, increasing demands for sustainable products, government

TABLE 5 Relationship between partners and coupled mechanisms

Type of partner/ coupled mechanisms	Alliances	Business-non-profit engagement	Co-creation	Cooperation	Coopetition	Collaborative innovation contests	Joint ventures	Cross-sector partnerships	Joint development projects	Innovation networks
Suppliers			√→					√→	√→	√→
Customers			√→					√→	√→	√→
Users			√→	√→		√→	√→		√→	√→
Competitors					√→			√→		
Other firms	√→		√→		√→			√→	√→	√→
Industry associations	√→							√→		
Producers									√→	√→
Professional experts	√→		√→			√→		√→	√→	√→
Agencies									√→	√→
Government			√→					√→	√→	√→
Higher education	√→		√→					√→	√→	√→
Private non-profit		√→	√→	√→	√→		√→	√→	√→	√→
Community			√→	√→	√→		√→	√→		√→

TABLE 6 Relationship between type of partners and SOI orientation

Partner/SOI context	Environmental innovation	Social innovation	TBL
Suppliers	14	0	2
Customers	13	0	4
Users	2	1	3
Competitors	1	0	1
Other firms	15	1	6
Industry associations	5	0	0
Producers	1	0	1
Professional experts	1	1	5
Agencies	1	0	2
Government	6	1	4
Higher education	6	0	3
Private non-profit	6	2	4
Community	3	1	1

TABLE 7 Barriers to collaborate for SOI

Barriers	*N*	Authors
Difficulty finding partners to collaborate	5	Todeschini et al. (2020); Arnold (2017); Behnam et al. (2018); Kazadi et al. (2016); Brown et al. (2019).
Lack of customer awareness and market demand	3	Melander and Pazirandeh (2019); Veleva and Bodkin (2018); Todeschini et al. (2020).
Major cultural differences and conflict stemming from stakeholder diversity	3	Wadin et al. (2017); Kazadi et al. (2016); Brown et al. (2019).
Difficulties with contracts and IP agreements	2	Melander and Pazirandeh (2019); Brown et al. (2019).
Low firms' absorptive capacity	2	Jakobsen et al. (2019); Wadin et al. (2017).
Different expectations regarding the timeframe	2	Mousavi and Bossink (2020); Brown et al. (2019).
Lack of financial resources to start something on their own	2	Kazadi et al. (2016); Todeschini et al. (2020).
Limited access to financing	2	Todeschini et al. (2020); Veleva and Bodkin (2018).
Impossibility to build trust-based relationships	2	Behnam et al. (2018); Brown et al. (2019).
Lack of the necessary knowledge and competencies	2	Rossignoli and Lionzo (2018); Brown et al. (2019).
Lack of alignment of skills, capabilities, and resources to collaborate effectively	2	Brown et al. (2019); Veleva and Bodkin (2018).
Conflicting interests and objectives	2	Stal et al. (2021); Munten et al. (2021).
Authority opportunistic behaviours, and power imbalances	2	Stal et al. (2021); Munten et al. (2021).
Low engagement of value partners, suppliers, and customers	1	Zucchella et al. (2021)
Lack of objectives and a clear horizon	1	Jakobsen et al. (2019)
Low ability to be actively involved in the collaboration process	1	Greco et al. (2021)
Time pressures	1	Greco et al. (2021)
Low alignment of solutions with firm capabilities	1	Greco et al. (2021)
Formal procedures (legal rules)	1	Stal et al. (2021)
No clear motivations and goals to collaborate	1	Brown et al. (2019)
Lack of a common language across sectors/life cycle stages	1	Brown et al. (2019)
Lack of commitment to collaboration	1	Brown et al. (2019)
Lack of certifications, standards, tax regulations across life-cycle stages	1	Brown et al. (2019)
Lack of regulation and incentives	1	Veleva and Bodkin (2018)
Lack of data and indicators to measure and communicate impacts	1	Veleva and Bodkin (2018)
Difficulty accessing and integrating knowledge	1	Brown et al. (2019)
Lack of skilled labour	1	Todeschini et al. (2020)

TABLE 8 Success factors in collaboration processes

Success factors	N	References
Effective communication	6	Lee and Kim (2011); Neutzling et al. (2018); Watson et al. (2020); Melander and Pazirandeh (2019); Neutzling et al. (2018); Juntunen et al. (2019).
Building trust-based relationships	5	Behnam et al. (2018); Melander and Pazirandeh (2019); Todeschini et al. (2020); Lee and Kim (2011); Neutzling et al. (2018).
Building long-term relationships	4	Veleva & Bodkin (Veleva & Bodkin, 2018); Melander and Pazirandeh (2019); Reficco et al. (2018); Neutzling et al. (2018).
Sharing common basic knowledge with the firm's partners	2	Jakobsen et al. (2019); Watson et al. (2020).
Large network of companies or cooperation structure	1	Arnold (Arnold, 2017)
Network catalysts	1	Zucchella et al. (2021)
Culture of experimentation and co-experimentation	1	Zucchella et al. (2021)
Learn from leaders and partners	1	Zucchella et al. (2021)
Ability to identify tensions in the collaboration process	1	Munten et al. (2021)
Advance from firm-centric material development to cross-tier collaboration	1	Siltaloppi and Jahi (2021)
Collaboration between challengers and participants	1	Greco et al. (2021)
Proposing challenges according to participants' backgrounds	1	Greco et al. (2021)
Good relationship with external partners	1	Behnam et al. (2018)
Previous experience of collaboration processes	1	Klewitz (2017)
Ability to attract external actors	1	Behnam et al. (2018)
Coordination and alignment with project teams	1	Lee and Kim (2011)
Sharing resources with external stakeholders	1	Kazadi et al. (2016)
Creative skills and environmental knowledge	1	Bocken et al. (2014)
Creating a strong group identity	1	Watson et al. (2020)
Human 'face-to-face' relationships	1	Reficco et al. (2018)
Employee involvement in open innovation activities	1	Lopes et al. (2017)
Increasing partner knowledge	1	Melander and Pazirandeh (2019)
Sharing risks	1	Melander and Pazirandeh (2019)

subventions, customer awareness of the environmental impact of products, digitalisation as an enabler of environmental innovations, and zero waste laws/policies (Bocken et al., 2014; Kanda et al., 2020; Lee & Kim, 2011; Lopes et al., 2017; Melander & Pazirandeh, 2019; Neutzling et al., 2018; Veleva & Bodkin, 2018).

Finally, we identified some barriers that hinder SOI collaboration and a set of factors that make collaboration processes in an SOI context successful (Tables 7 and 8). For example, Jakobsen et al. (2019) argue that the main barriers in collaboration processes between companies and other allies are related to different dominant logic and power imbalances. The former occurs when firms focus strictly on short-term and quick financial returns, while some allies, such as universities, focus on long-term goals and ways to take advantage of research results. Power imbalances arise when one of the actors considers that it does not need the others' knowledge to achieve the established purpose.

The lack of clear goals is a critical barrier to developing successful open innovation processes (Jakobsen et al., 2019). The lack of capabilities to absorb knowledge is another challenge for a collaborative process. Arnold (2017) found that in a co-creation process, for example, sometimes it is not easy to find suitable participants. Other frequent barriers include lack of commitment in the collaboration process, lack of resources to start something independently, and lack of leadership in the collaboration project or initiative.

Regarding success factors, the study by Melander and Pazirandeh (2019), for instance, suggests that in order for a collaborative process to be successful, collaboration must be based on dialogue and the building of trust between all the actors involved. Similarly, Jakobsen

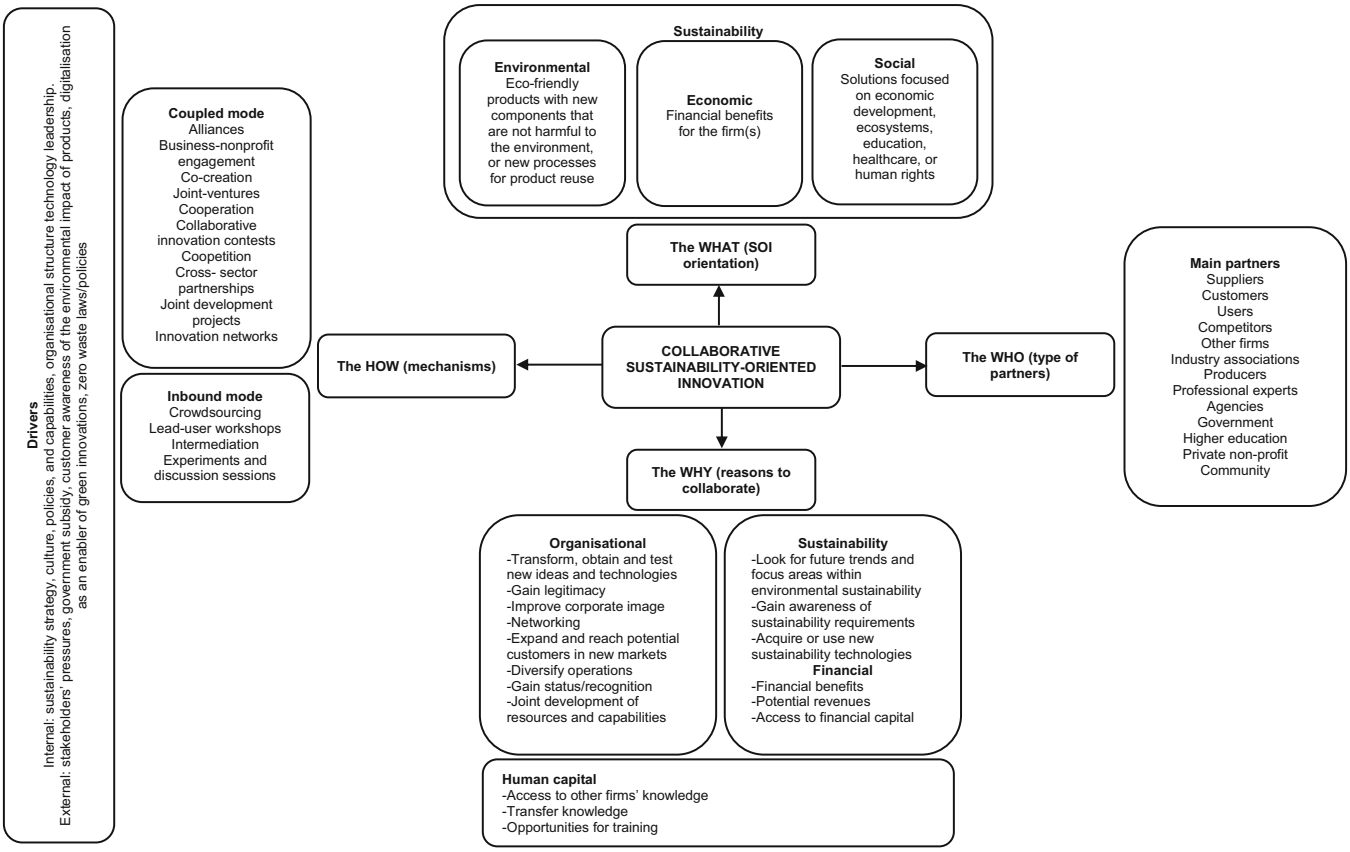

FIGURE 2 Comprehensive conceptual framework.

et al. (2019) point out that previous experience in collaborative processes, sharing common basic knowledge, and the fact that researchers have worked in the industry at some point guarantee a more successful collaboration. In that same regard, Reficco et al. (2018) point out the need to develop human "face-to-face" relationships, while the study by Veleva and Bodkin (2018) on corporate-entrepreneur collaborations for the circular economy highlights the importance of long-term alliances between entrepreneurs and large companies to enable value creation and capture through the establishment of a viable commercial strategy.

5 | CONCLUSIONS

In this systematic literature review we analysed the *what*, *how*, *who and why* of open innovation processes in guiding businesses in their innovation efforts towards sustainability. Based on the results of our content analysis, we produced a comprehensive conceptual framework that synthesises the main findings of this study (Figure 2).

Based on the analysis of the selected scientific articles, we encourage researchers to adopt a temporal and relational perspective to study open innovation for SOI, in order to determine which partners are most important to the firm and at what stage of the innovation process they should be integrated, as suggested by Aka (2019). Further work is requiered to analyse the level of integration of partners and their impact on the sustainability performance of the firms.

There is abundant room for further work in examining how motivations, drivers, barriers, and success factors in open innovation for SOI vary according to contingency factors and the characteristics of the firms. Another area for more extensive research is the difference between the barriers that prevent the establishment of collaboration processes for SOI and the barriers that appear when the collaboration process is happening.

The results of our study could be a source of information to guide the formulation and evaluation of public policies related to technological change and sustainable development. This study could also help to determine and address the fundamental elements, drivers, barriers, and incentives of the sustainability-innovation process. The study also provides essential elements for managers of different business sectors since it identifies and synthesises the main mechanisms to establish collaborative processes that contribute to the sustainability of the planet. We also present an overview of the main factors for successful collaborative processes, helping to reduce the likelihood of failure in collaborations between companies and other actors.

We found, for instance, that digital technologies are critical drivers of collaborations for sustainability purposes as they are a means to provide new types of products and services with societal benefits. Hence, companies now need to review their inter-firm collaboration and coordination methods to meet the expectations of

strategic or potential customers. In the context of environmental innovation, for example, there is a much greater need to establish governance structures and mechanisms capable of reconciling the points of divergence between partners (He et al., 2020).

Another critical point derived from our review is the call for a systemic perspective towards sustainability, given that lacking a systemic view in open innovation processes for SOI can only lead to incremental improvements, which are not adequate to promote real impacts at a system or societal level. Moreover, even those same efforts can hinder a broader system transition since they can stimulate a linear model of production and consumption (Siltaloppi & Jahi, 2021). In that vein, it is necessary to move from a company-centric perspective to cross-tier collaborations, as suggested by Siltaloppi and Jahi (2021). For example, in the context of collaborative innovation for the circular economy, it is important to align technological developments with transformations in business models and the search for changes in regulations and social expectations (Siltaloppi & Jahi, 2021).

Zucchella et al. (2021) also call for a multi-level view of firms' sustainability transition, including entrepreneurial, organisational, and network levels. However, Zucchella et al. (2021) argue that a critical barrier in this process is that established companies tend to think more in terms of supply chains rather than networks or innovation ecosystems, which would allow established firms to partner with different actors, such as innovative start-ups. In that context, a culture of openness and collaboration is crucial driver for the transition towards more circular business models.

We consider that the results of this review contribute to the debate on incremental improvements and systemic transformations, highlighted in previous scientific literature and public guidelines. This review has focused mainly on the role of the private sector in developing innovative solutions and new technologies to meet the most critical challenges facing our planet. However, in line with Ritala (2019), we advocate for a more critical view of sustainable innovation, since many times companies 'tend to incrementally offset negative environmental and societal impacts, rather than eliminate them' (Ritala, 2019, p. 22).

The transition towards new sustainable business models is more difficult for large companies as they face various obstacles in interconnecting the economic, social, and ecological spheres (Ritala, 2019). In that sense, new opportunities for start-ups are emerging in the context of sustainable consumption, for example, through circular business practices (United Nations Environment Programme, 2019), since new ventures can quickly implement radical solutions. Unlike established firms, start-ups from birth can have a high degree of orientation towards developing innovative solutions to solve and mobilise society towards change. However, this cannot be achieved by individual start-ups; they need to be integrated into an ecosystem to benefit from the support and knowledge of other actors while also becoming agents of change within the same innovation ecosystem.

In summary, more integrated and system-based approaches are needed to 'enable cross-linkages to be explored and system-wide effects to be managed, so that policies can effectively support a number of social, economic and environmental goals to support human well-being, ensuring that various preconditions for this well-being are in place' (United Nations Environment Programme, 2019, p. 5). Furthermore, an SOI system perspective is also beneficial to understand that social, environmental, and economic spheres are interconnected; changes in one of those systems affect the other systems, resulting in a coevolutionary development (Ritala, 2019).

For instance, 'environmental issues are closely related to social issues such as hunger, consumption patterns, health, education, inequality, gender gaps, waste and sanitation, refugees, migration, conflicts and intolerance' (United Nations Environment Programme, 2019, p. 9). Incremental improvements are important but not enough since it is challenging to determine if they will have long-term positive and negative impacts. In fact, digital technologies have often created unintended consequences, and for that reason, they can be both a positive or negative driver of environmental change (United Nations Environment Programme, 2019).

We are aware that this study has some limitations. For example, much of our sample of articles is composed of qualitative studies, which reduces the amount of scientific literature covered. However, such a qualitative approach is essential to provide a complete picture to describe how companies are developing open innovation processes for SOI. In addition, the use of only one database and the restrictions in the document types included can also be an important limitation of this study. For instance, we did not search for grey literature, which can help address the problems of time lag (Adams et al., 2016).

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

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APPENDIX A: CODEBOOK FOR SYSTEMATIC LITERATURE REVIEW (DESCRIPTIVE ANALYSIS)

Main categories	Description/examples
Study objective	The main purpose of the study.
Methodological approach	Whether the study is qualitative, quantitative or mixed.
Research design	Whether the study is a single case study, multiple case study, survey-based, etc.
Data collection technique(s)	The techniques used to collect information: in-depth interviews, observation, focus groups, structured questionnaires, secondary databases, etc.
Source of information	Anything that might inform or provide knowledge for data collection.
Level of analysis	Intra-organisational Organisational Extra-organisational Inter-organisational Industry, regional innovation systems, and society
Research object	Individuals, groups/teams, projects, functional areas, business units. Firms, other (non-firm) organisations, strategies, business models. External stakeholders, individuals, communities, organisations. Alliances, networks, ecosystem. Industry development, inter-industry differences, local regions, nations, supra-national institutions, citizens, public policies (Chesbrough & Bogers, 2013) (Bogers et al., 2017)
Sample	Number of observations taken for analysis.
Business sector	Type of business sector of the focal firm(s) (if applicable).
Theoretical lens	Theories or frameworks adopted to explain the phenomenon.
Country	Country in which the study was conducted.

APPENDIX B: CODEBOOK FOR SYSTEMATIC LITERATURE REVIEW (CONTENT ANALYSIS)

Main categories	Subcategories	Description/examples	Source(s)
Sustainability orientation (*the what*)	Triple bottom Line	This is the dimension where the foundations are environmental, social and economic goals.	(Saunila et al., 2018; Veleva & Bodkin, 2018)
	Social	The social dimension is about paying attention to human capital development, job creation and safety issues, among others	Saunila et al. (2018)
	Environmental	The environmental dimension encompasses factors such as land use, waste handling, hygiene, and energy and water consumption (Saunila et al., 2018).	
Collaboration partners (*the who*)	Business enterprises	Suppliers, specialised knowledge services providers and commercial research institutes, customers, competitors or other businesses	OECD/Eurostat (2018)
	Government	Government research institutes, ministries, and agencies	
	Higher education	Universities	
	Private non-profit	Private non-profit research institutes and other private non-profit organisations	
Collaboration mechanisms (*the how*)	Inbound	IP in-licencing Contracting with external R&D service providers Customer relations networks Value-chain networks University research grants Information networking (conferences, conventions) Publicly funded R&D consortia Idea and start-up competitions Crowdsourcing Supplier innovation awards Use of innovation intermediaries Earlier supplier integration Customer co-development External knowledge sourcing and integration	(Chesbrough & Brunswicker, 2014; Enkel et al., 2009; Mazzola et al., 2012; Öberg & Alexander, 2019)
	Outbound	Contracting-out Corporate business incubation Customer relationships Outsourcing alliances Selling of market-ready products IP out-licencing and patent selling Spinoffs Venturing Bringing ideas to market R&D resources made available to third parties Commercialisation of external technologies	
	Coupled	Co-patenting R&D alliances Joint ventures Joint research teams Partnerships Collaborative innovation Industrial districts Industrial relationships Networks Consortia Clusters Communities	

(Continues)

Main categories	Subcategories	Description/examples	Source(s)
Motivations/ reasons to collaborate (*the why*)	Sustainability	Contributing to sustainability goals, to environmental, social or economic, challenges or to community sustainability	(Gray & Stites, 2012; Ordonez-ponce et al., 2020)
	Human capital	Gaining knowledge/learning, gaining expertise, sharing own experiences, improving competencies	
	Organisational	Improving organisations' sustainability, innovation capacity, building new relationships, improving reputation, gaining legitimacy, becoming more influential, gaining access to new markets, marketing opportunities, networking, collaborating with others, engaging with the community, improving relationships.	
	Financial	Improving financial performance, reducing costs, funding opportunities, developing new products/services, creating new businesses, attracting new investors, increasing financial resources	
	Physical	Increasing physical resources, improving processes	
Drivers	Internal	Size, availability of financial resources, organisational complexity, sustainability, innovation management; physical and knowledge capital stock	(Gray & Stites, 2012; Pellegrini et al., 2019)
	External	Social perceptions, expectations and preferences; technological developments; concerns about globalisation; environmental regulations; decline in government efficacy; innovation-oriented industrial relations; market pressures	
Barriers to collaborate	Open codification	Factors that hinder the development of collaborative processes for SOI.	
Success factors	Open codification	The main factors that influence the success of open innovation processes for SOI.	