



Open social innovation: A systematic literature review and future research agenda

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ABSTRACT

Open Social Innovation (OSI) has garnered significant attention in recent years as a collaborative approach to addressing societal challenges. However, the field remains fragmented, with divergent definitions, methods, and theoretical underpinnings across disciplines. Through bibliometric and multi-level content analysis, we analyze 115 studies to address these tensions and propose a systems-based framework that bridges conceptual and practical divides. We map the intellectual structure and synthesize OSI research's antecedents, processes, relationships, and outcomes. Unlike prior reviews focused on particular OSI initiatives (e.g., Living Labs) or single levels of analysis, our study integrates dispersed knowledge to highlight actionable insights for practitioners and policymakers. Finally, our review establishes a thematic agenda for future research, targeting multi-level investigations into OSI drivers, mechanisms, and impacts.

1. Introduction

The need for innovative approaches to tackling complex societal challenges has never been greater, as highlighted by the Sustainable Development Goals Report (United Nations, 2023). Open Social Innovation (OSI) has emerged as a promising approach for answering this call, building on the principles of Open Innovation (Chesbrough, 2003) and Social Innovation (Holmes and Smart, 2009; Murray et al., 2010). By harnessing the collective knowledge, resources, and creativity of diverse stakeholders, OSI provides novel perspectives for tackling societal challenges (Chesbrough and Di Minin, 2014; Gegenhuber and Mair, 2024). However, despite its potential, OSI remains fragmented, where conceptual proliferation obstructs theoretical cohesion and the field lacks a cohesive framework to integrate its research domain.

Beyond this fragmentation, OSI remains under-theorized, lacking a well-developed framework. Indeed, similar to Open Innovation (Bogers et al., 2017), OSI could be considered more of an emerging phenomenon than a mature area of research, marked by a lack of cohesive study and understanding. The research on OSI, drawing from diverse perspectives, has resulted in fragmented insights and explanations, obstructing the synthesis of findings and the accumulation of knowledge. In addition, there have been multiple definitions of OSI proposed by scholars, each

with its own focus. This has led to a proliferation of terminology and a lack of cohesion between studies, making it difficult to evaluate and compare findings from different sources.

Previous reviews on OSI have focused on specific social issues, levels of analysis, or initiatives, such as Living Labs (Edwards-Schachter et al., 2012), Do-It-Yourself (DIY) Labs (Dzandu and Pathak, 2021), crowdfunding processes (Cillo et al., 2023), urban-regional open initiatives (Anthony, 2023; Appio et al., 2019), collaborative public service relationships (Merlin-Brogniart et al., 2022), or environmental/sustainability issues (Kimpimäki et al., 2022; Melander, 2017; Urbinati et al., 2023). These studies show that unlike Open Innovation's traditional focus on firm-centric strategies for knowledge inflows and outflows (Bogers et al., 2017), OSI transcends organizational boundaries, prioritizing collective action for societal change.

Similar to Stanko et al.'s (2017) conceptualization of open innovation as an umbrella term, we regard OSI as a broader concept encompassing pre-existing research areas (e.g., participatory governance, open eco-innovation, or community-driven innovation) at the intersection of openness and social innovation. This inclusive perspective addresses a critical gap: the lack of integration of management-driven practices of open innovation into a broader social application (Bogers et al., 2017). Building on prior research, this paper conducts a systematic literature

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review (SLR) to comprehensively analyze OSI research. To this end, we answer the following research question: *What key themes, conceptual frameworks, and factors (i.e., antecedents, processes, and consequences) shape and constitute the emerging paradigm of Open Social Innovation?*

In pursuit of this aim, we retrieve data from 115 articles published in top-tier journals. Our approach combines quantitative bibliometric techniques, including co-citation analysis, with qualitative multi-level content analysis. By systematically gathering and synthesizing findings from various studies (Tranfield et al., 2003), we focus on influential journals, leading scholars, and research methods (Martin, 2012). This allows us to map the existing knowledge landscape and identify evolving trends in OSI.

Our contributions are fourfold. First, we synthesize dispersed OSI literature into a coherent intellectual map, revealing overlooked connections between theories and concepts. This synthesis aims to contribute to the development of theoretical frameworks that could enhance research foundations and potentially support the implementation of more effective OSI initiatives. Second, we extend the open innovation approach by providing evidence of the relationship between these practices and societal impact across stakeholders beyond private firms. Third, we provide an ecosystem-based framework that could stimulate future research by facilitating knowledge integration and pattern recognition while enabling comparative analysis of similar methods across the OSI process. Finally, by addressing the gaps identified in the literature, we propose a research agenda to advance OSI principles and their practical application.

The remainder of the article is structured as follows. Section 2 summarizes the key definitions related to OSI. Section 3 outlines the methodological approach employed in this SLR. Section 4 presents the SLR results and Section 5 proposes an integrative conceptual framework. Section 6 discusses the theoretical and managerial implications. Section 7 outlines a future research agenda for OSI. Finally, Section 8 concludes the review by highlighting the main study's implications, limitations, and future research avenues.

2. Definitions and scope

Open Innovation emerged as a paradigm shift from closed, firm-centric R&D strategies to collaborative models. According to Chesbrough and Bogers (2014), it is defined as "a distributed innovation process based on purposively managed knowledge flows across organizational boundaries" (p. 17). At its core, open innovation emphasizes boundary-spanning practices to accelerate value creation and capture. Concurrently, social innovation has evolved as a multidisciplinary field with various definitions (Edwards-Schachter and Wallace, 2017; van der Have and Rubalcaba, 2016), but can be conceptually delineated through its emphasis on "a novel solution to a social problem that is more effective, efficient, sustainable, or just than existing solutions" (Phills et al., 2008, p. 38). These innovation concepts demonstrate an evolution from linear processes confined to single organizational responsibility toward dynamic, multi-actor interactions across micro (individual/single community), meso (organizational/alliances), and macro (systemic/policy) levels. This evolution reflects broader theoretical shifts toward approaches like innovation ecosystems (Adner, 2006; Carayannis et al., 2018), where diverse stakeholders (entrepreneurs, activists, policy-makers, etc.) co-evolve resources and capabilities around common objectives.

Over recent years, the integration of these innovation approaches into practice is illustrated by organizations such as Ashoka and Open-IDEO, as well as public participation initiatives like the City of Birmingham in the United Kingdom, which have implemented OSI frameworks (Chesbrough and Di Minin, 2014; Fayard, 2023). However, it was during the COVID-19 pandemic that OSI garnered increased academic interest, leading to several studies that empirically examined and described its initiatives (e.g., Bertello et al., 2022; Mair and Gegenhuber, 2021). The urgent need for innovation and adaptability

brought about by the pandemic accelerated the adoption of the OSI approach, fostering extensive collaboration among various entities to develop community-driven solutions. These projects have provided empirical evidence (e.g., Mair et al., 2023) that enhances our understanding of OSI applications, showcasing its potential in crises across diverse domains (Chesbrough, 2020; Scheidgen et al., 2021).

OSI research has taken different paths depending on the authors' initial theoretical approaches and conceptual background. From one perspective, some scholars have proposed OSI based on the frameworks of Open Innovation, aiming to apply aspects of crowdsourcing, collaboration, and knowledge sharing to address social problems (e.g., Bertello et al., 2022). Alternatively, scholars rooted in Social Innovation approaches have advocated for incorporating dimensions of openness, inclusivity, and co-creation derived from open practices (e.g., Edwards-Schachter and Wallace, 2017). Furthermore, given that these innovations emerge within contexts characterized by interconnected economic, cultural, and environmental dimensions (Baker and Mehmmood, 2015; Cajaiba-Santana, 2014), different organizational models have been proposed that aim to advance social change while simultaneously achieving financial sustainability and generating social and environmental impact (Battilana and Lee, 2014; Doherty et al., 2014). Similarly, a stream of literature has emerged that particularly focuses on the application of open innovation to environmental and sustainability challenges in organizations (Bogers et al., 2020; Chistov et al., 2021), complementing the broader OSI approach by highlighting its potential to tackle environmental issues.

Overall, the concept of OSI has evolved markedly over the past decade (see Table 1), reflecting a dynamic shift in approaches to social problem-solving. Initially, Chalmers (2013) distinguished OSI from traditional social innovation models by emphasizing collaborative and inclusive strategies. Chesbrough and Di Minin (2014) further define the concept, framing it as the application of inbound and outbound open innovation strategies to social challenges. In recent years, Mair and Gegenhuber (2021) expanded on this by describing OSI as a participatory approach. Gegenhuber et al. (2023) detailed OSI by focusing on the process involving multiple actors, enhancing the understanding of stakeholder interactions within OSI. Ultimately, Gegenhuber and Mair (2024) described OSI as a structured, multi-stakeholder process spanning various sectors to address complex social issues.

Table 1
Definitions of the OSI concept.

Authors	Open Social Innovation is defined or distinguished as:
Chalmers (2013, p. 29)	"Differs from some traditional social innovation processes in that it repudiates the heroic individual approach to social innovation and identifies collaborative organizational structures and behaviors required to systematically tackle social problems."
Chesbrough and Di Minin (2014, p. 170)	"The application of either inbound or outbound open innovation strategies, along with innovations in the associated business model of the organization, to social challenge."
Mair and Gegenhuber (2021, p. 28)	"An open and participatory approach to social innovation based on collective action expedited by the power of digital technology."
Gegenhuber et al., (2023, p. 1)	"Participatory approach and process involving multiple stakeholders (citizens, organized civil society, and the public and private sectors) in the idea generation process of developing and scaling solutions to make progress on such challenges."
Gegenhuber and Mair (2024, p. 1)	"A concerted effort undertaken by multiple stakeholders from various sectors throughout the social innovation process, from diagnosing societal challenges, to developing ideas for how to solve problems, creating solutions, effectively scaling solutions and generating impact."

3. Methodology

As mentioned earlier, we conducted a systematic literature review that integrates bibliometric and content analysis techniques to investigate and consolidate the findings. Bibliometric reviews provide a quantitative examination of publication patterns and are valuable for visualizing a research domain (Zupic and Cater, 2015). Moreover, scholars in innovation and entrepreneurship find bibliometrics and author citation analysis useful for quantitative assessment (Landström et al., 2012; Shafique, 2013). To examine the manuscripts using bibliometric techniques, we used the bibliometrix R package developed by Aria and Cuccurullo (2017). Specifically, the mapping of co-cited references helps to display connections between groundbreaking studies, while cluster analysis illustrates research focal points (Van Eck and Waltman, 2007). Following the bibliometric analysis, we conducted a content analysis, proceeding with a thematic review that uncovered patterns in the antecedents, processes, and consequences of OSI, as outlined by Zahra et al. (2006). We systematically extracted data from selected studies into a structured template, capturing details such as the authors, publication year, objectives, methodologies, social issues, and key findings.

We incorporated key elements of the PRISMA guidelines into our SLR. These guidelines assist authors in transparently documenting their review process (Page et al., 2021). Before the review, a protocol was established that outlined the scope, inclusion/exclusion criteria, search strategies, and analysis methods (Moher et al., 2015). To ensure access to one of the most up-to-date and reliable sources of scientific literature for our review, we used the WoS Core Collection database (Visser et al., 2021). This is due to several key factors. First, WoS is known for its selective indexing approach, which focuses on high-quality and impactful journals (Pranckuté, 2021). Second, WoS provides robust metadata that is suitable for conducting bibliometric analyses (Gaviria-Marin et al., 2019). Third, WoS offers access to interdisciplinary information, making it well-suited for innovation reviews (Schmitz et al., 2017).

Nevertheless, our initial search using the keywords “Open Social Innovation” returned only 18 articles in WoS. Tuckerman et al. (2023) address this scarcity, revealing that “openness” in OSI exists on a spectrum rather than a simple open/closed dichotomy. Moreover, as an emergent approach, OSI arguably remains under-theorized in areas of research, like some open innovation topics from years ago (Bogers et al., 2010). Therefore, in line with Randhawa et al. (2016) social innovation review, we added more search terms related to OSI.

To enhance our keyword selection method for SLR, we compiled an extensive set of keywords from highly cited articles in the Web of Science (WoS) Core Collection database, focusing on innovation-related concepts. We began by extracting keywords from the 100 most cited articles on “Social Innovation” and “Open Innovation”, as well as from the 18 available articles on “Open Social Innovation”. This initial step amassed a vast array of keywords, from which we systematically removed duplicates to ensure a streamlined dataset. Our evaluation and selection process distilled the initial list to a curated set: 159 keywords for Social Innovation, 266 for Open Innovation, and 58 for Open Social Innovation. Following this, we undertook a classification stage, organizing these keywords into categories reflective of synonyms, sub-themes, stakeholders, processes, or others. Finally, the selection of search terms was based on their relevance and criticality in representing the landscape of the respective innovation paradigms, ensuring the final collection of terms offered a comprehensive and nuanced semantic network (see Table 2).

Data were collected from the WoS Core Collection database, including documents indexed up to August 1, 2024. No specific time frame restrictions were applied to the search. We searched for the terms listed in Table 2 in the title, abstract, and keywords of the articles. The terms listed were combined using boolean operators (AND OR), proximity operators (NEAR/X or W/X), and the wildcard character (*) for

Table 2
Selected search terms.

Search terms	Keyword sources
<i>Open Social Innovation</i>	
Hackathons	Gegenhuber et al. (2023)
Fab lab / makerspaces	Rayna and Striukova (2019)
Participatory	Gegenhuber et al. (2023)
<i>Social Innovation</i>	
Civil Society	Seyfang and Haxeltine (2012)
Co-creation	Voorberg et al. (2015)
Cooperative	Hewitt et al. (2019)
Citizens	Koirala et al. (2018)
Ecology	Winans et al. (2017)
Grassroot	Seyfang and Haxeltine (2012)
Eco-innovation	Ghisetti et al. (2015)
Nonprofit / non-profit	Westley et al. (2014)
Philanthropy	Dees (2012)
Responsible	Bock (2012)
Societal	Avelino et al. (2019)
Socio-	Baker and Mehmod (2015)
Sustainable	Boons and Lüdeke-Freund (2013)
Sustainability	McPhearson et al. (2015)
Transformative	Avelino et al. (2019)
<i>Open Innovation</i>	
Collaborative	Baldwin and von Hippel (2011)
Collaboration	Schaffers et al. (2011)
Collective	Zhao and Zhu (2014)
Community	Franzoni and Sauermann (2014)
Crowd	Franzoni and Sauermann (2014)
Crowdsourcing	Bogers et al. (2017)
Co-creation	Schaffers et al. (2011)
Distributed	Boudreau (2012)
Ecosystems	Bogers et al. (2017)
External	Mina et al. (2014)
Living labs	Schaffers et al. (2011)
Network	Lee et al. (2010)
Openness	Dahlander and Gann (2010)
Platforms	Bogers et al. (2017)
Tournaments	Majchrzak and Malhotra (2013)

retrieving plurals and different spellings (Castaneda et al., 2018; Khare and Jain, 2022). As a result, we obtained 3229 documents using the following search query:

TS = ((Open OR Collaborat* OR Collective* OR Communit* OR Crowd* OR Co-creation OR Distributed OR Ecosystem* OR External OR “Living lab”* OR Network* OR Openness* OR Platform* OR Tournament* OR Hackathon* OR “Fab lab”* OR Makerspace* OR Participat*) NEAR/3 (Social OR Civil OR Societ* OR Co-creation OR Cooperative* OR Citizen* OR Ecolog* OR Grassroot* OR eco-innovation* OR Nonprofit* OR non-profit* OR Philanthrop* OR Responsible OR Societal OR socio-* OR Sustainabl* OR Transformative) NEAR/3 (Innovation*)).

Following that, the search was restricted to articles, review articles, or early access as the document types, while also limiting the language to English (Merigó et al., 2016). Working papers, book reviews, and conference proceedings (often referred to as gray literature) were omitted (Kraus et al., 2020). To be consistent with the content analysis objective of this review, we focused our search on the following WoS categories: management, business, economics, and public administration (Chesbrough et al., 2014). To identify high-quality journals, we only considered those with a 5-year Journal Impact Factor (JIF) of either Q1 or Q2, based on Journal Citation Reports (JCR) for 2023. Subsequently, we screened 626 abstracts using the inclusion and exclusion criteria outlined in Table 3, followed by a full-text review for those that appeared to be relevant. Ultimately, a sample of 115 articles was selected (see Fig. 1).

To examine the conceptual foundations of OSI, we conducted a co-citation network analysis. This approach, based on WoS bibliometric data, maps the frequency with which certain articles are cited together

Table 3

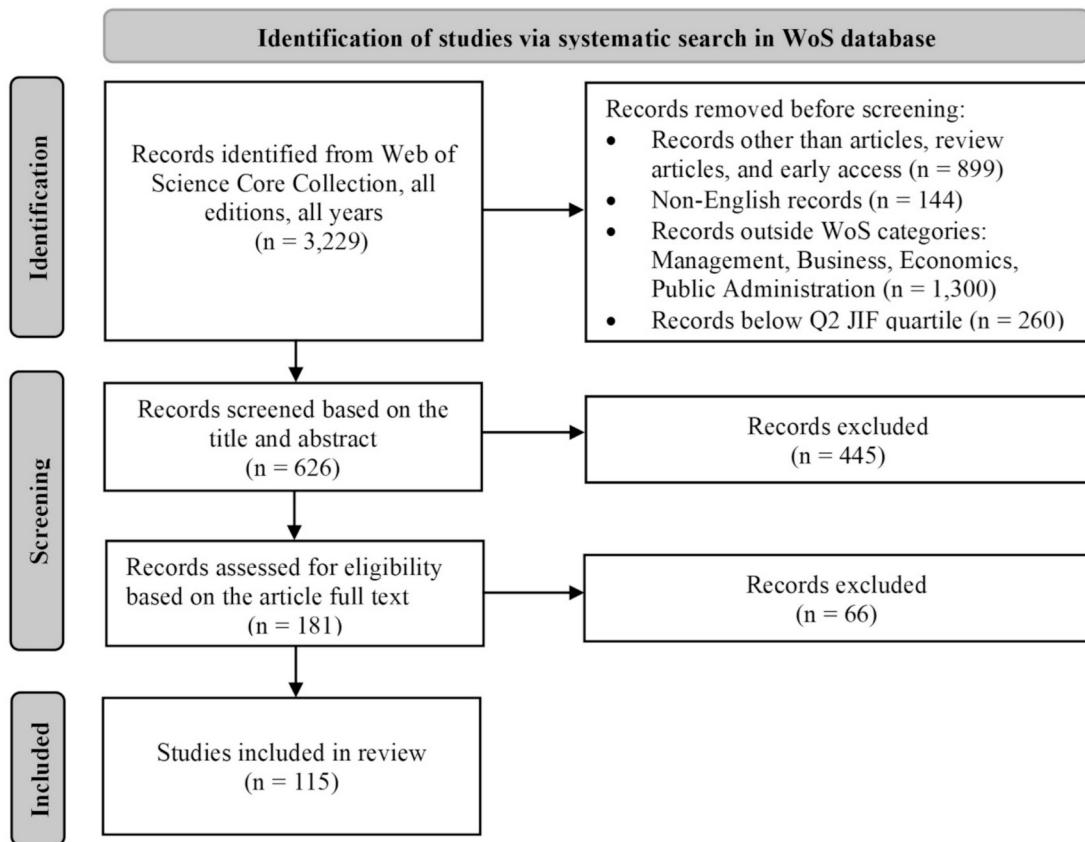
Inclusion and exclusion criteria.

(A) Inclusion criteria

1. Document type: Peer-reviewed journal articles, literature reviews, and early access.
2. Language: Only articles published in English.
3. Web of Science Category: Management, business, economics, and public administration.
4. Studies within the domain of social innovation: focus on social challenges, create social value, environmental sustainability, or similar.
5. Studies within the domain of open innovation: participatory, collaboration, engagement of multiple stakeholders, co-creation, or similar.
6. Empirical and conceptual studies.

(B) Exclusion criteria

1. Studies not primarily oriented toward social innovation and open innovation domains.
2. Book chapters, editorials, seminal papers, and conference proceedings (gray literature).
3. Articles that are unavailable electronically or by other reasonable means.
4. Articles published in any language other than English.
5. Articles published in journals ranked in the third (Q3) or fourth (Q4) quartiles according to the 5-year Journal Impact Factor in the 2023 Journal Citation Reports.
6. Articles published in journals that are not in the Core Collection database of WoS.

**Fig. 1.** Data collection process based on PRISMA flow diagram (adapted from [Page et al. \(2021\)](#)).

within the literature, revealing intellectual linkages and thematic relationships between works (Gmür, 2003). By applying the following criteria—requiring a minimum of 2 edges and removing isolated nodes—we used the Louvain clustering algorithm to investigate network modularity (Zupic and Cater, 2015). This method allows for the identification of clusters of interconnected publications, which can then be categorized based on their thematic focus. In the resulting network, the relative size of each node indicates its co-citation frequency, highlighting the most frequently co-cited articles.

In addition, to examine the conceptual structure of OSI, we conducted a co-occurrence network analysis of authors' keywords. This approach maps the frequency with which the most common keywords appear together in the literature, revealing thematic relationships and

conceptual linkages in the field (Boyack and Klavans, 2010). Applying the Louvain clustering algorithm, we used the same criteria of co-citation analysis: requiring a minimum of 2 edges and removing isolated nodes. In the resulting network, the relative size of each node indicates its co-occurrence frequency, highlighting the most frequently used keywords. The thickness of links between keywords shows their frequency of simultaneous use by authors.

Finally, to examine the findings of our content analysis, we adopt a systems theory analytical approach (Bertalanffy, 1968). A system is a set of interacting elements with a specific purpose (Ackoff, 1971; Flood and Jackson, 1991). When we mention an element, it could be an individual, an organization, a government agency, or any other relevant entity. A relationship involves two elements interacting for a specific purpose,

exchanging resources or information. By employing a systems perspective, we align with recent calls for a more comprehensive understanding of the ecosystem, bridging micro, *meso*, and macro levels of analysis (Bogers et al., 2017; Gegenhuber and Mair, 2024). To operationalize this systems approach, we organize our content analysis into four analytical themes: (i) antecedents, (ii) processes, (iii) relationships, and (iv) consequences. These themes encompass the fundamental components and dynamics of OSI initiatives, allowing for a methodical exploration of the phenomenon.

4. Results

4.1. Descriptive analysis

In our final sample, we included 115 relevant articles from 54 different journals that delved into the field of OSI. Our analysis reveals that a majority (52.2 %) of these articles were published within the last three years (2022–2024), as shown in Table 4. This increase in publications provides evidence of the growing importance of OSI research, which can be partly attributed to case studies focusing on collaborative initiatives addressing the challenges posed by the COVID-19 pandemic (Di Minin et al., 2021; Vermicelli et al., 2021).

The study of OSI has emerged in recent decades, with the earliest article published in 2006. This signifies the emergence of an expanding area of interest, highlighting the rapid development and current significance of OSI studies. In terms of journal productivity, Technological Forecasting and Social Change, as well as Business Strategy and the Environment contribute most publications, accounting for 15.7 % of the articles (18 out of 115).

To assess the articles' impact, we analyzed their total citation counts on WoS. Table 5 highlights the top ten cited articles. The three most cited articles focus on open sustainability approaches in the business landscape. The clear frontrunner is Ghisetti et al. (2015), garnering 318 citations for their exploration of knowledge sourcing's influence on firms' environmental innovations. In second place, Fabrizi et al. (2018) examine the impact of regulation policies and research network policies on environmental innovation. In third place, Watson et al. (2018) conducted a systematic review on stakeholder engagement as a dynamic capability for firms to co-create sustainable solutions.

Overall, 311 distinct authors contributed to the 115 articles reviewed, averaging 2.83 authors per article. Gallouj F. was the author with the highest number of publications, contributing four articles.

Table 5
Most cited articles.

Paper	Total citations
Ghisetti et al. (2015)	318
Fabrizi et al. (2018)	208
Watson et al. (2018)	182
Edwards-Schachter et al. (2012)	145
Ornetzeder and Rohracher (2006)	120
Melander (2017)	118
Nesti (2018)	90
González-Moreno et al. (2019)	79
Alves (2013)	78
Oskam et al. (2021)	75
Chalmers (2013)	73
Windrum et al. (2016)	73

Following in terms of academic impact, Triguero A. and De Silva M. received significant attention with 96 and 94 total citations, respectively. Table 6 provides details of authors with two or more articles and their respective WoS total global citation counts.

Most papers (80.9 %, 93 out of 115) are based on empirical research, with qualitative methods being the most commonly used (68.8 %, 64 out of 93). This aligns with the exploratory nature of the OSI approach, where case studies serve as a valuable tool for examining novel phenomena (Eisenhardt, 1989). In terms of the social research issue, our analysis revealed that 64.3 % (74) of the studies are broad-spectrum, meaning they do not focus on a particular social issue. Table 7

Table 6
Most frequent authors and total citations.

Authors	Articles	Total citations
Gallouj F.	4	113
Triguero A.	2	96
De Silva M.	2	94
Rubalcaba L.	2	84
Schartinger D.	2	78
Windrum P.	2	78
Adomako S.	2	38
Desmarchelier B.	2	31
Djellal F.	2	31
Fuglsang L.	2	20
Scupola A.	2	20
Gegenhuber T.	2	11
Mair J.	2	11

Table 4
Journals and published articles per year.

Journal	Total	2006	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Technological Forecasting and Social Change	9				1					1	2		4	1	
Business Strategy and the Environment	9						1			2	1	1	3	1	
R & D Management	6							5						1	
European Journal of Innovation Management	6					1	1				1			3	
Industry and Innovation	5					1			1		1			1	1
Journal of Business Research	5						1			1		2	1		
Public Money & Management	4											4			
Corporate Social Responsibility and Environmental Mgmt.	4									1	1			2	
Journal of Responsible Innovation	4										1		2	1	
Journal of the Knowledge Economy	3													1	2
Research Policy	3						1			1		1			
Management Decision	3								1					1	
IEEE Transactions on Engineering Management	3										1	1	1		
Journal of Product Innovation Management	3									1	2				
Technology Analysis & Strategic Management	3						1					1			
Other journals	45	1	2	2	1	2	1	1	2	3	4	1	8	12	5
TOTAL	115	1	2	2	2	6	3	2	6	13	12	6	22	25	13

Table 7

Overview methodological procedures by social issue classification.

Document types (methodology)	Literature review	Conceptual	Empirical			Total empirical	Total
			Mixed methods	Qualitative	Quantitative		
Social issues							
Broad-spectrum	7	10	5	45	7	57	74
Environmental	3		1	5	16	22	25
Social integration and cohesion		1		5		5	6
Social development and well-being		1		3		3	4
Health				4		4	4
Poverty and inequality				2		2	2
Total	10	12	6	64	23	93	115

provides an overview of the number of articles considering the social issue for each type of methodology used. Among the studies that focus on a specific social issue, environmental issues stand out at 21.7 % (25). Furthermore, the majority of articles in these studies are quantitative (16 out of 22) and primarily focus on examining how to reduce the environmental impact of firms.

Fig. 2 shows the bibliographic network based on co-citation analysis of the top 100 most frequently cited references, classified into three main clusters: Cluster 1: Empirical Insights: Firms, Environment, and Open Innovation; Cluster 2: Theoretical Foundations: Open Innovation and Social Innovation; and Cluster 3: Qualitative Approach: Case Studies. These clusters demonstrate thematic complementarity rather than domination, where the central theoretical frameworks (Open Innovation and Social Innovation) mediate between empirical applications and different complementary frameworks, as synthesized in Table 8.

4.1.1. Cluster 1. Empirical insights: Firms, environment, and open innovation (left)

This cluster reveals a fundamental knowledge base centered on organizational innovation practices. The co-citation patterns demonstrate theoretical linkages between open innovation performance metrics (Laursen and Salter, 2006) and environmental innovation frameworks (Horbach, 2008). The cluster's structure indicates a distinctive theoretical foundation where environmental and open innovation concepts have been systematically integrated, particularly in for-profit contexts organizations (e.g., Cainelli et al., 2012). Notably, works like De Marchi (2012) and Rennings (2000) anchor this cluster's

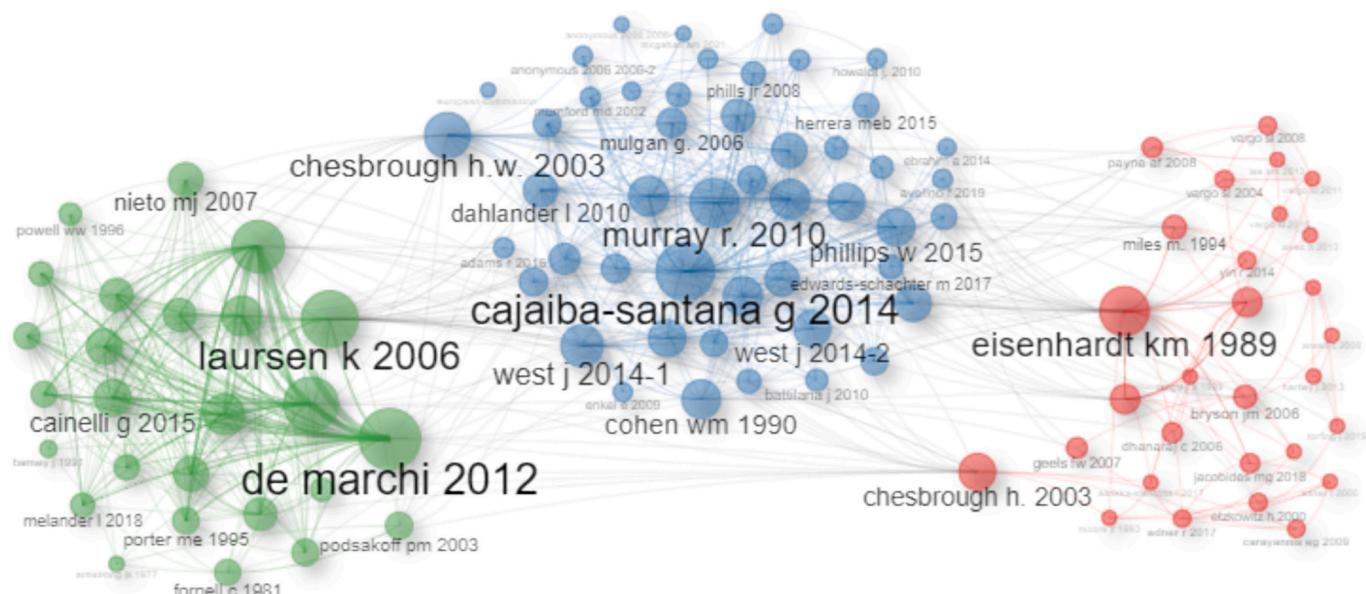
focus on sustainability-oriented collaboration mechanisms, aligning with broader scholarly constructs such as 'sustainable open innovation' (Bogers et al., 2020). This cluster provides practical frameworks for organizations to optimize their open collaboration processes while actively contributing to environmental sustainability.

4.1.2. Cluster 2. Theoretical foundations: Open innovation and social innovation (center)

This cluster represents the central theoretical domain within OSI, characterized by dense co-citation patterns between foundational social innovation conceptualizations (e.g., Cajaiba-Santana, 2014; Mulgan, 2006; Murray et al., 2010) and open innovation (Chesbrough, 2003; West and Bogers, 2014). The network structure reveals theoretical integration with alternative approaches, including local innovation (Moulaert and Nussbaumer, 2005), user innovation by von Hippel (1988), and co-creation processes (Voorberg et al., 2015). Moreover, the presence of the absorptive capacity framework (Cohen and Levinthal, 1990) within this cluster suggests its theoretical relevance within the knowledge integration processes in OSI. This cluster shows that organizations and communities can implement strategies combining openness benefits with social impact to effectively address urgent social challenges through cross-sector knowledge flows.

4.1.3. Cluster 3. Qualitative approach: Case studies (right)

This cluster highlights a significant knowledge base grounded in qualitative research frameworks, founded upon case study methodology (Eisenhardt, 1989). It includes influential works that contribute theoretical frameworks from qualitative evidence, as exemplified by Gioia

**Fig. 2.** References' co-citation network of OSI research.

Source: Biblioshiny, based on the WoS dataset.

Table 8
Prevailing theoretical perspectives analysis by cluster.

Cluster	Theoretical perspectives
Cluster 1: Empirical Insights - Firms, Environment, and Open Innovation	<ul style="list-style-type: none"> Sustainable development literature exhibits co-citation patterns with innovation management papers. External knowledge sourcing studies appear connected to environmental innovation papers. Innovation adoption research clusters with sustainability-oriented literature.
Cluster 2: Theoretical Foundations - Open Innovation and Social Innovation	<ul style="list-style-type: none"> Open innovation literature forms a central node within the overall co-citation network. Social entrepreneurship papers co-occur frequently with open innovation literature. Multi-stakeholder collaboration studies position themselves between traditional and social innovation literature. Public sector innovation research appears in conjunction with business innovation literature.
Cluster 3: Qualitative Approach - Case Studies	<ul style="list-style-type: none"> Service-dominant logic papers form connections with both innovation and social value literature. Papers on ecosystem approaches occupy positions linking theoretical and empirical research. Papers on resource orchestration cluster together with firm boundary literature. Value co-creation literature appears frequently in co-citation relationships across different research traditions. Knowledge flow frameworks form a visible subgroup within the broader empirical cluster.

et al. (2013), Miles and Huberman (1994), and Yin (2004). Furthermore, the co-citation patterns reveal theoretical frameworks operating at broader analytical levels, including innovation ecosystems (Adner, 2006), the triple helix model (Etzkowitz and Leydesdorff, 2000), and cross-sector collaboration works in the domain of public administration (e.g., Bryson et al., 2006; Hartley et al., 2013). This cluster establishes case studies as a fundamental approach to capture and analyze the complex dynamics of multi-actor collaboration in OSI initiatives.

Finally, the co-occurrence network categorizes the top 50 most frequently used keywords into five clusters, excluding 26 isolated keywords. The results are presented in Fig. 3. The analysis shows that 'social innovation' and 'open innovation' are central nodes with limited direct connectivity between them. However, this weak inter-nodal connection is counterbalanced by complementary frameworks and practices emerging around each node. Within the social innovation node, links connect to terms like 'co-creation', 'entrepreneurship', 'ecosystem', and 'networks', indicating a focus on creating collaborative and participatory structures. The open innovation node, meanwhile, shows connections to 'corporate social responsibility' and 'sustainable', revealing a more formalized and business-oriented approach to OSI.

The co-occurrence analysis uncovers that different mechanisms aim to address societal issues. The social innovation cluster emphasizes bottom-up, community-driven broader approaches, while the open innovation cluster integrates open practices within sustainability and corporate social contexts. Moreover, the prominence of the 'sustainable development' node indicates that sustainability is a key driver in OSI studies, pointing to the field's potential responsiveness to global issues. Notably, the smaller 'open social innovation' node suggests that this concept is still developing, presenting opportunities for further exploration of the interconnectedness of these research areas.

4.2. Content analysis

Drawing upon the methodology and structure of analysis employed in prior literature reviews in the fields of innovation and entrepreneurship (Urbano et al., 2019; Urbano et al., 2022; Zahoor and Al-Tabbaa, 2020; Zahra et al., 2006), we synthesize our findings into four analytical themes: (i) antecedents, (ii) processes, (iii) relationships and (iv) consequences. The antecedents explore the determinants and drivers moderating OSI initiatives' emergence across individual, organizational, and ecosystem levels. The relationships investigate the interconnections and interactions among actors for resource exchange and value co-creation. The process theme examines how OSI initiatives unfold, encompassing practices, routines, and mechanisms for collaboration, coordination, co-creation and similar. The consequences analyze OSI initiatives' outcomes and implications. Fig. 4 provides an overview of the analysis, and each theme is further discussed in the following subsections.

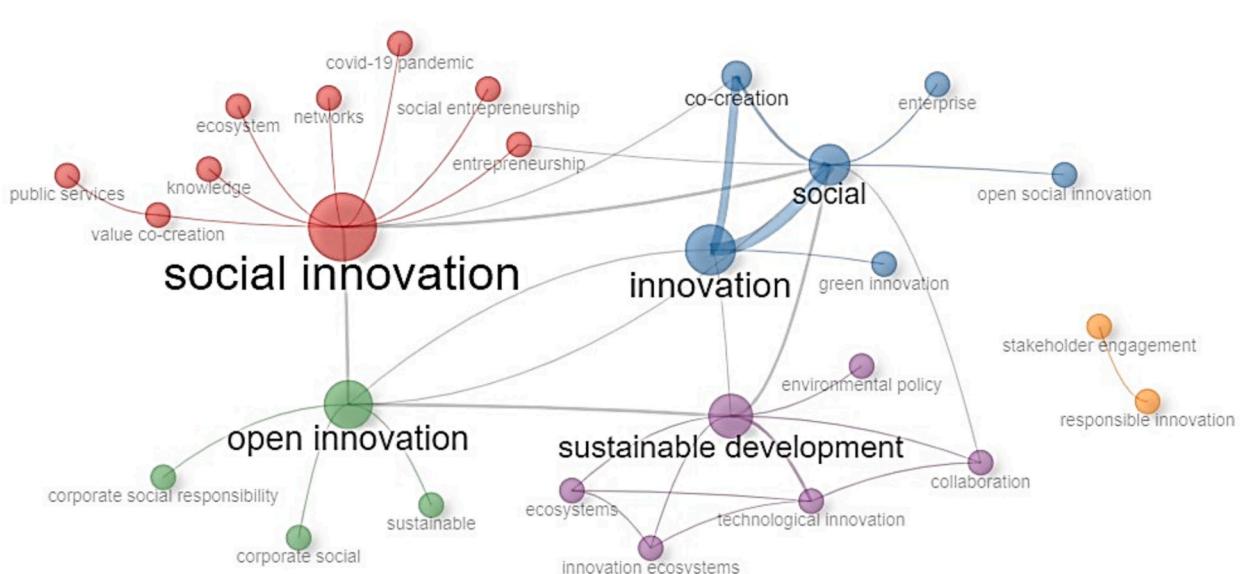


Fig. 3. Conceptual structure of OSI research.
Source: Biblioshiny, based on the WoS dataset.

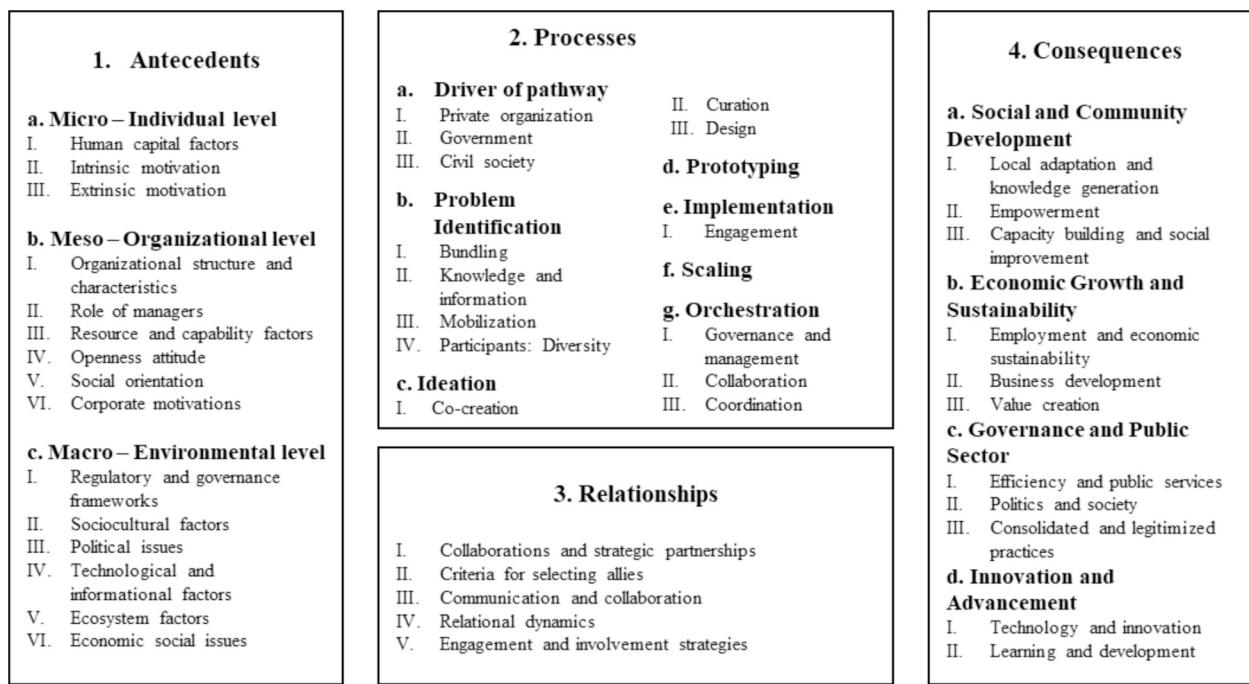


Fig. 4. Overview of themes and dimensions identified through content analysis.

4.2.1. Antecedents

4.2.1.1. Micro – Individual level. Human capital factors emerge as determinants of OSI. Leadership skills help individuals guide and inspire others toward innovative objectives (Grama-Vigouroux et al., 2024), while knowledge acquisition across various domains provides the foundation for ideation and problem-solving processes (Kimpimäki et al., 2022; Kobarg et al., 2020). An entrepreneurial orientation, characterized by creative and ambitious thinking, is conducive to OSI (De Silva and Wright, 2019). In addition, the propensity of individuals to take risks plays a role in their decision to participate in community initiatives (Hardyman et al., 2022).

Motivation, both intrinsic and extrinsic, emerges as a recurring theme in OSI initiatives (e.g., Akasaka et al., 2023; Nesti, 2018). Intrinsic motivation, such as the entrepreneurial ambition to found ventures, drives innovation activities (Dzandu and Pathak, 2021). Extrinsic motivators, including monetary rewards, recognition, and other incentives, are also effective in encouraging engagement in OSI (Allal-Cherif et al., 2022; Fait et al., 2023; Schmidhuber et al., 2019).

4.2.1.2. Meso – Organizational level. Organizational factors influence OSI (e.g., Gibbon and Rutter, 2022; Melander, 2017). The structure and shared values within an organization are crucial determinants of its engagement in OSI initiatives (Altuna et al., 2015; Palakshappa et al., 2024). Additionally, credibility and open networks facilitate OSI efforts by providing access to resources and enhancing organizational reputation (van Geenhuijen and Ye, 2014). Moreover, resilience (Vendrell-Herrero et al., 2023) and adaptive capacity (Smolka and Bösch, 2023) are important for overcoming OSI challenges.

Openness to knowledge exchange, encompassing acquisition and dissemination, is fundamental for OSI, as external sources enhance social innovation performance (Hagedoorn et al., 2023). For example, Allal-Cherif et al. (2022) emphasize that OSI thrives on collaboration among diverse stakeholders, with multifunctional teams enabling exceptional performance and stronger partnerships. Furthermore, diversity in top management teams, especially gender diversity, enhances OSI performance by incorporating varied perspectives and approaches, as suggested by Ten Holter (2022).

The accessibility of resources is essential for OSI initiatives (Alcalde-Heras and Carrillo, 2023; Rey-García et al., 2019; Shaheen et al., 2023). Factors such as dedicated time for innovation, R&D investments, and knowledge capabilities have been identified as pivotal for OSI (Watson et al., 2018). Moreover, organizational attributes such as size (Moreno-Mondéjar et al., 2020), age (Kher et al., 2023), absorptive capacity (Ghisetti et al., 2015), and dynamic capabilities (Rey-García et al., 2019) play a significant role in shaping OSI potential. Notably, attributes like dynamic capabilities have been evaluated in contexts such as green innovation, contributing to sustainable practices (Khan et al., 2023). Regarding early-stage organizations, OSI initiatives, such as social accelerators, not only offer financial support but also provide business expertise, networking opportunities, and mentorship (van Geenhuijen and Ye, 2014).

Corporate social responsibility (Cai et al., 2023; Dionisio and de Vargas, 2022; Roszkowska-Menkes, 2018) and environmental sustainability (Khan et al., 2023) align organizations with OSI principles. Firms' motivations, such as enhancing competitive positioning, improving corporate image, and accessing lower-end markets, drive OSI initiatives (Babu et al., 2020). In response to societal demands, community pressure (Hofman et al., 2020) often drives organizations to adopt OSI, while power dynamics within communities influence the direction and focus of these initiatives (Cabrera-Fierro et al., 2024).

4.2.1.3. Macro – Environmental level. Multiple environmental elements at the macro level shape OSI. Regulatory and governance aspects, such as bureaucracy (Grama-Vigouroux et al., 2024), normative institutions (Sweeting et al., 2022), and regulatory laws (Fabrizi et al., 2018) influence the OSI ecosystem. In parallel, sociocultural elements, including values, legitimacy, and community attitudes, are integral to OSI regional practices (Cabrera-Fierro et al., 2024; Ricciardelli et al., 2020).

The development of OSI in the public sector is shaped by factors such as political agendas, centralization, paternalism, open government practices, and local disputes (Randhawa et al., 2019; Sarma and Sunny, 2017; Sweeting et al., 2022). For example, the degree of centralization and paternalism in government affects resource distribution and decision-making processes, thereby influencing OSI's dynamics and scope (Sweeting et al., 2022). Furthermore, the relationship between

political factors and OSI in society is emphasized by the importance of government transparency and openness (Colovic and Schruoffeneger, 2021).

The technological landscape and informational factors influence OSI (Gegenhuber et al., 2023), as evidenced by the role of digital technologies and data sharing in OSI initiatives. These include aspects like open data availability, which promotes transparency and accessibility, facilitating scalability (Cabra-Fierro et al., 2024; Colovic et al., 2022). These technological advancements facilitate novel approaches to collaboration and innovation management across various contexts, such as smart communities and smart cities (Ciasullo et al., 2020; Sarma and Sunny, 2017). Among these technological developments, emerging technologies are transforming how social issues are constructed and addressed (Hong and Lee, 2023; Leite, 2022; Xin et al., 2023).

Finally, the development of a favorable ecosystem for OSI is influenced by macro factors, such as social economy models (Catala et al., 2023). Globalization, on the other hand, presents both opportunities and challenges for internationalization and collaboration scaling (Lee and Restrepo, 2015). Within its ecosystem, OSI operates alongside unmet social demands (Galdini and De Nardis, 2023; Vendrell-Herrero et al., 2023) and is supported by economic resources such as philanthropic funding (Cai et al., 2023; Chalmers, 2013) and impact investing (Christopoulos et al., 2023).

4.2.2. Processes

The process theme in OSI involves stages that range from problem identification to scaling solutions for societal challenges. Problem identification involves recognizing and framing societal issues to invite innovative solutions, necessitating a deep understanding of the problem's roots to create collective awareness (Hansen et al., 2022). Ideation follows a bottom-up approach, empowering those affected by the problem to contribute ideas and solutions, distinguishing OSI from top-down models (Kruse et al., 2019). In addition to this, co-creation enables dynamic knowledge exchange and the development of capabilities to co-create value in innovative ways (Hardyman et al., 2022).

The iterative nature of OSI is underscored in studies by Jamieson and Martin (2022) and Kruse et al. (2019). However, the trajectory of these initiatives varies based on the leading stakeholders addressing the issue, particularly those external to the public sector (Hansen et al., 2022). While the literature proposes horizontal (Allal-Cherif et al., 2022) or multi-level governance models (Cabra-Fierro et al., 2024; Catala et al., 2023), it is observed that a primary organization or sector may take the lead in driving these initiatives. For instance, when private companies take the lead, the research focus often includes topics such as sustainable development solutions (Chang, 2019), corporate social responsibility (Altuna et al., 2015), and legitimization (Verleye et al., 2019). On the other hand, government-led projects emphasize citizen participation (Sarma and Sunny, 2017) and improving public services (Alves, 2013), with the aim of achieving broad, long-term systemic changes (Eseonu, 2022). Meanwhile, civil society organizations prioritize citizen empowerment initiatives (Sweeting et al., 2022), socially embedded actions (Christopoulos et al., 2023), and addressing local issues (Dzandu and Pathak, 2021).

In addition to the traditional stages of the innovation process, OSI goes beyond by incorporating practices and mechanisms that facilitate collaboration, coordination, and orchestration of activities (Jarmai and Vogel-Pöschl, 2020; Oskam et al., 2021; Ricciardelli et al., 2020). Collaboration involves bringing together diverse stakeholders with unique skills and perspectives, enriching the innovation process and establishing a supportive network (Adomako and Nguyen, 2024; Rey-García et al., 2019). These innovation networks benefit from clear aims and appropriate compositions to facilitate such exchanges (Sarasini, 2015).

Effective coordination is crucial for tackling collaborative approaches like OSI. This involves aligning objectives (Oskam et al., 2021) and establishing clear communication (Olsson et al., 2021).

Additionally, it is essential to ensure that stakeholders work toward a shared vision (Cutler White, 2014) and address challenges such as the scarcity of resources, including time (Kallio and Lappalainen, 2015). In this context, leaders of OSI initiatives, also known as orchestrators, perform various activities. From a functional perspective, Wegner et al. (2023) identify key orchestrating activities, including designing, organizing, integrating, monitoring, bridging, legitimizing, and adapting. Complementing this, Gegenhuber and Mair (2024) propose a process-oriented approach that outlines four phases: mobilizing stakeholders, bundling ideas, curating solutions, and scaling initiatives.

4.2.3. Relationships

OSI is influenced by the extensive network linkages within the process (Barrett and Dooley, 2024). These linkages contribute to resource exchange and the co-creation of value (Babu et al., 2020), encouraging novel forms of interaction among diverse stakeholders (Citroni, 2015). Trust plays an essential role in the success of these collaborations (Jarmai and Vogel-Pöschl, 2020) as it influences their stability and effectiveness (Sarasini, 2015). Additionally, community engagement is another key aspect of OSI (Dezi et al., 2018). For instance, involving citizens in the process can enhance legitimacy and align innovations with public interest, thereby facilitating smoother implementation (Häikiö, 2012).

Research has identified several factors that contribute to these relationships and the impact of innovations. For example, forming alliances with large companies can provide access to extensive resources, broader market reach, and valuable expertise (van Geenhuizen and Ye, 2014). Additionally, collaborations with top strategic partners, who are leaders in their fields, can offer critical insights, resources, and support (De Silva et al., 2020).

4.2.4. Consequences

Studies have shown that OSI may generate various types of social value and yield sustainable social impact (De Silva and Wright, 2019; Fayard, 2023). This is because OSI focuses on collaborating with stakeholders to co-create solutions that are tailored to local needs, thereby enhancing their practicality and sustainability (Bentzen, 2022; Rayna and Striukova, 2019; Svensson and Hambrick, 2019). OSI initiatives, such as DIY labs and Living Labs, align technological advancements with societal needs through citizen participation (Lhoste, 2020), potentially yielding innovations that address community challenges more effectively (Edwards-Schachter et al., 2012). Consequently, these co-created solutions are more accepted by the community and exhibit greater long-term viability due to the involvement of multiple stakeholders (Windrum et al., 2016). In addition, this approach enhances social innovation performance, especially when there is strong institutional support and high levels of social legitimacy (Adomako and Nguyen, 2024).

From an economic perspective, OSI makes contributions to employment and economic sustainability. According to Kher et al. (2023) OSI initiatives, like social accelerators, have a positive impact on financing, revenues, and employment in ventures. Additionally, studies by Juusola et al. (2024) have shown that these initiatives enhance the capacity of social enterprises to generate value in underserved markets. Furthermore, OSI facilitates the creation of value by endorsing solutions that are economically viable and socially beneficial, as evidenced by Lippolis et al. (2023) in environmentally sustainable initiatives.

OSI also promotes the empowerment of individuals and communities (Nesti, 2018; Windrum et al., 2018). It achieves this by involving diverse stakeholders, including citizens, lead users, and social entrepreneurs, in the innovation process (Battisti, 2019). This collaborative approach fosters a sense of ownership and shared responsibility among stakeholders, leading to a more engaged and proactive ecosystem capable of sustaining positive change (Palakshappa et al., 2024). Furthermore, OSI initiatives facilitate legitimacy establishment through inter-organizational, multi-level, and external building blocks (Verleye

et al., 2019).

In terms of community impact, OSI also enhances community well-being through mechanisms such as knowledge transfer. OSI facilitates short-lag societal impact, as evidenced by Olsson et al. (2021), who emphasize that aspects such as continuity and co-creation in collaborative research contribute to tangible community benefits. OSI encourages continuous learning, experimentation, and adaptation, fostering a culture of lifelong learning and empowering individuals and communities to tackle complex challenges (Svensson and Hambrick, 2019). Additionally, the study conducted by Rashid et al. (2023) indicates how knowledge transfer through social innovation, involving multiple stakeholders, can lead to improved living standards, enhanced community competitiveness, and the creation of sustainable economic opportunities.

Lastly, OSI initiatives enable public organizations to respond effectively to complex issues by fostering the generation of new solutions (Alves, 2013). This aligns with novel public service management practices that support collective learning of strategic importance in addressing complex societal challenges (Kallio and Lappalainen, 2015). Additionally, by adopting an ecosystems perspective, OSI initiatives may enhance understanding of experimentation and value co-creation in public services (Hardyman et al., 2022). Moreover, these collaborative approaches give rise to innovative governance models that position local governments as creators, facilitators, and gatekeepers of systems (Cabrera-Fierro et al., 2024). In these systems, various stakeholders, including citizens, actively participate in decision-making processes. Through collaboration with policymakers, community leaders, and citizens, OSI enhances governance structures, making them more inclusive and adaptable to societal challenges (Merlin-Brogniart et al., 2022).

5. Toward an integrative conceptual framework

In this section, we introduce an integrated framework that combines insights from Social Innovation (Murray et al., 2010), Open Innovation (Chesbrough, 2003), and the findings from the SLR. The purpose of this framework is to capture the essential components and dynamics that describe OSI. We define OSI as a cross-collaborative, ecosystem-based approach to tackling social problems. It serves as a framework for the diverse models of initiatives that facilitate the orchestration of synergies and collective action to empower actors (such as communities, firms, NGOs, entrepreneurs, etc.) for transformative social change. OSI promotes distributed and participatory processes throughout the different

social innovation stages. Table 9 provides a comparative overview of the key principles, characteristics, and practices of OSI.

The proposed conceptual framework adopts a system approach (Bertalanffy, 1968), unveiling the complex, multi-dimensional nature of OSI. Based on this framework, OSI is observed through actors interacting and exchanging resources, both tangible and intangible, over time for a specific purpose. While traditional models may limit actors to sector-based roles, innovation ecosystems, as conceptualized by Carayannis et al. (2018), promote dynamic, multi-level interactions across sectors. Consequently, our framework places emphasis on the definition of essential roles that actors assume, based on their actions and the dynamic value they bring to the OSI process (see Table 10). This approach is premised on the understanding that a single actor may assume multiple roles within the OSI process. For instance, the entrepreneurial university approach expands the traditional role of universities as generators of knowledge (Etzkowitz, 2003), enabling them to also facilitate inter-relationships and linkages among several external organizations through incubators and other support programs (Guerrero et al., 2016).

The OSI process has emerged through various models that promote collaboration, co-creation, and collective action. These models engage diverse stakeholders and leverage their knowledge, resources, and capabilities to address social challenges. The process is orchestrated

Table 10
Overview of key roles of OSI process.

Role	Description	Organizational examples
Activists	These are the actors who identify and seek to transform a social issue.	Community-based organizations, city councils, community leaders, or similar.
Affected communities	These actors are directly influenced or benefited by the problematic situation.	Migrant communities, polluting companies, low-income neighborhoods, or similar.
Knowledge communities	These are groups of actors who provide relevant information or knowledge (technical-scientific, contextual-traditional knowledge, etc.).	Research centers, local knowledge holders, community leaders, think tanks, or similar.
Orchestrators-design team	These actors lead the process by facilitating collaboration among stakeholders and promoting the transformation of ideas into tangible societal innovations.	Social incubators, collaborative networks, crowdsourcing projects, public-private partnerships, living labs, or similar.
Entrepreneurs	These actors materialize ideas into products, services, practices, or management models in the affected communities.	Intrapreneurs in city councils, social entrepreneurs, cooperatives, or similar.
Promoters	These actors make innovations visible and disseminate them within and outside the ecosystem to support their scalability in other similar contexts.	Organizers of awards and recognitions, platforms, media, and journalists, or similar.
Enablers	These actors provide all kinds of tools and resources, monetary or in-kind, such as training, talent, consultancy, financial resources, infrastructure, and spaces in the OSI process.	Impact investors, philanthropic foundations, government agencies, coworking spaces, or similar.
Regulators	These actors define the formal institutions (norms, laws, and regulations) that influence the development and interactions of the ecosystem.	National government, local authorities, international institutions, policymakers, or similar.

Table 9
Overview of comparative key aspects of OSI.

Key aspect	Open Social Innovation	Traditional social welfare approaches
Principles	Emphasize openness, diversity, synergy, and collaboration.	Emphasize social mission, efficiency, and outcome control.
Actors involved	Multiple stakeholders, including affected communities, the private sector, government, academia, and civil society.	Driven primarily by non-profit organizations and government.
Sources of ideas and knowledge	Collective intelligence, co-creation, and diverse perspectives.	Internal experience and specialized knowledge.
Innovation process	Effectuation: Iterative, adaptive and based on experimentation.	Causation: Linear, planned and based on implementation.
Resources and capabilities	Mobilizing diverse and complementary resources through connections, networks, and partnerships.	Dependence on one's own resources, grants, or government funding.
Governance and decision-making	Participatory, transparent and based on collaboration between multiple stakeholders.	Hierarchical, centralized and based on the authority of the leading organization.

through a series of initiatives, also referred to as projects, which may vary in terms of their specific objectives, expected outcomes, or temporal boundaries. Table 11 provides a concise overview of the main examples of OSI initiatives, which have been categorized into four quadrants based on the social innovation process stages (Murray et al., 2010) and scalability (local or regional). These quadrants include: (i) multi-stakeholder issue analysis, (ii) scalable social impact initiatives, (iii) community-driven problem framing, and (iv) contextualized social innovations (see Fig. 5). Furthermore, the OSI models can be distinguished into two primary groups depending on their main emphasis: exploration-oriented initiatives, which prioritize the initial stages of the innovation process, and empowerment-oriented initiatives, which concentrate on implementation and scaling in later stages.

Exploration-oriented OSI initiatives target the early stages of the innovation process, such as problem identification and ideation. Examples include hackathons, which gather individuals with diverse skills to develop solutions collaboratively (Lara and Lockwood, 2016), and crowdsourcing campaigns that use digital platforms to engage many people in contributing ideas, resources, or labor (Hossain and Kauranen, 2015). Living labs also belong to this category, offering real-life environments for users and innovators to co-create solutions iteratively (Hossain et al., 2019). On the other hand, empowerment-oriented OSI initiatives prioritize the later stages, placing emphasis on the implementation and scaling of social innovations. Social entrepreneurship accelerators are a good example in this category, providing structured support, mentorship, and resources to help social ventures expand their impact (Crișan et al., 2021; Hallen et al., 2020).

A comprehensive approach to OSI requires the strategic integration and customization of diverse initiatives, tailored to address the unique context and objectives of each social challenge. This strategy may involve, for instance, launching a broad crowdsourcing campaign, then advancing selected ideas into a specialized social incubator. By strategically merging and coordinating these initiatives across the innovation process, OSI practitioners may unlock powerful synergies and maximize the transformative impact of their efforts.

6. Discussion and implications

The rapid growth in OSI-related publications, particularly following the COVID-19 pandemic, reflects increasing recognition of its potential for tackling multifaceted problems that single organizations cannot effectively address alone. Our analysis further reveals OSI's distinctive nature as more than a simple application of open innovation principles to social contexts. It represents a fundamental shift in how multiple

Table 11
Summary OSI main initiatives.

OSI Initiative	Description
Crowdsourcing platforms.	Online spaces where a diverse community is invited to propose ideas and solutions to a specific problem or opportunity, leveraging collective intelligence.
Ideathons, Hackathons, and Contests.	Intensive events, programs, or competitions in which participants collaborate to develop innovative solutions for specified challenges.
Public Innovation Labs.	Public sector units that provide opportunities to experiment with new approaches, co-create solution prototypes with citizens, and test innovations before larger-scale implementation.
Living Labs, Fab Labs, and Makerspaces.	Spaces that foster collaboration and enable the community to design, prototype, and manufacture solutions using a variety of tools and equipment.
Social Incubators and Accelerators.	Programs that provide training, mentorship, networking, or funding to social ventures in order to facilitate their growth, acquire traction, and achieve greater impact.
Smart Cities Initiatives.	Initiatives aimed at improving urban services and quality of life in cities by applying digital technologies, data, and intelligent systems.

stakeholders collectively address societal challenges through distributed processes that emphasize inclusivity, co-creation, and social change.

The conceptual framework we propose views OSI through an ecosystem lens where actors assume distinct functional roles based on their contributions rather than their sectoral origins. This perspective highlights how OSI orchestration initiatives can be strategically deployed across different innovation phases. By emphasizing both exploration-oriented initiatives and empowerment-oriented models, our framework provides a comprehensive understanding of OSI's dynamic processes. This study has both theoretical and managerial implications.

6.1. Theoretical implications

Our review clarifies the conceptual foundations of OSI by synthesizing fragmented literature and identifying distinct intellectual clusters that shape this field. By mapping the connections between open innovation and social innovation, we provide a coherent framework that addresses the current theoretical gaps. The co-citation patterns reveal the dominance of organization-centric perspectives stemming from seminal open innovation works, while simultaneously showing emerging ecosystem approaches that represent a critical evolutionary point in OSI's theoretical development. Additionally, our role-based typology extends the innovation ecosystem models beyond the triple helix and sector-based classifications, offering a more nuanced understanding of the diverse actors involved in developing an idea into real-world change. Furthermore, our categorization of OSI initiatives by orientation (exploration/empowerment) and scale (local/regional) enables complexity decomposition, allowing researchers to conduct more rigorous comparative analyses of diverse OSI approaches.

6.2. Managerial implications

Several managerial implications can be derived from this study. First, the literature has presented OSI initiatives as distinct approaches (like living labs, hackathons, or social accelerators) without providing practitioners with clear guidance on their strategic selection and integration. This has led to fragmented implementation where organizations often adopt a single model without considering its fit within broader innovation processes (for example, what happens with the awarded idea?). By classifying these initiatives based on orientation (exploration/empowerment) and scale (local/regional), our framework enables practitioners to envision and integrate appropriate approaches based on specific objectives, resources, and innovation phases rather than following trends. Second, our role-based perspective helps practitioners transcend traditional sector-based thinking when forming collaborations. Instead of assuming fixed roles based on organizational type (business, government, civil society), stakeholders can strategically adopt functions that leverage their unique capabilities and resources, potentially assuming multiple roles throughout the innovation process. This flexible approach enhances resource mobilization and knowledge integration across boundaries. Third, for public sector innovators, our findings highlight how OSI approaches can enhance service delivery through citizen participation without requiring complete organizational transformation. By strategically implementing OSI initiatives that complement existing operations, public administrators can gradually build collaborative capabilities while generating tangible social value. This incremental approach reduces resistance and implementation risks. Lastly, for social funders and sponsors, our review suggests the need to shift from financing isolated projects toward supporting ecosystem development. By investing in platforms, shared infrastructure, and orchestration capabilities, funders can create enabling environments that stimulate multiple innovations rather than depending on single interventions. This systemic approach yields more sustainable impact by building collaborative capacity across stakeholders rather than creating dependency on continuous funding.

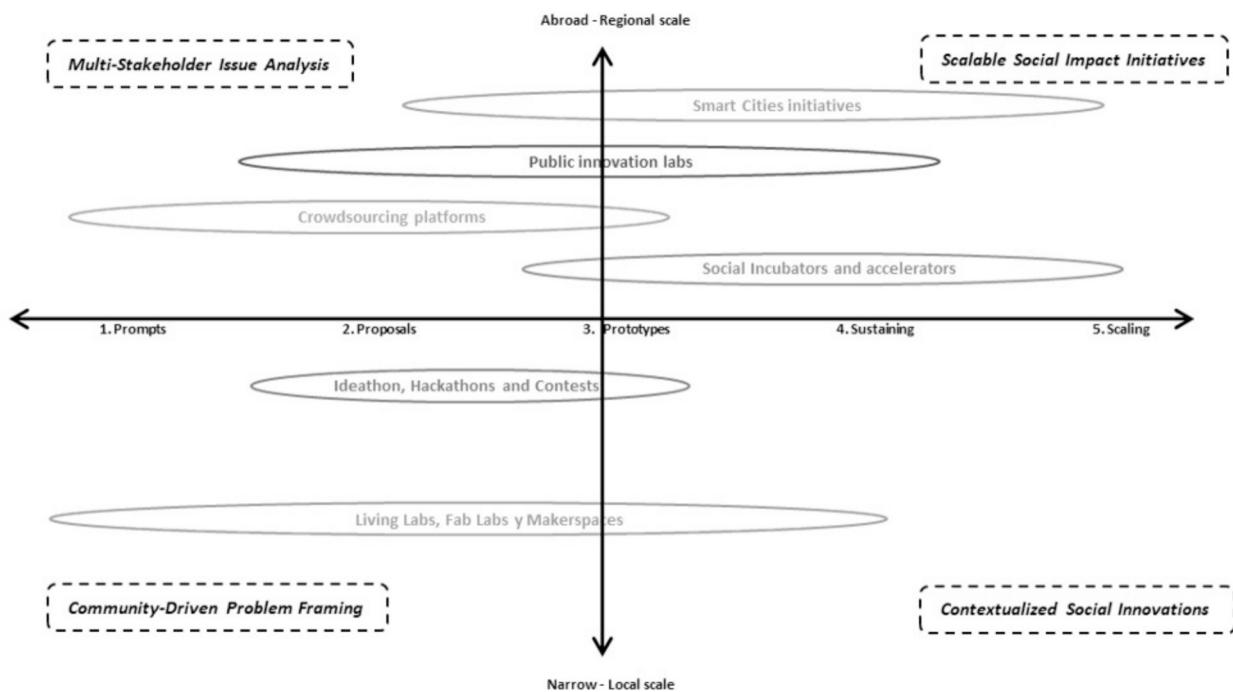


Fig. 5. OSI orchestration initiatives.

7. Research agenda

Our systematic review of 115 articles reveals significant opportunities for advancing OSI research. The analysis demonstrates that while descriptive studies have proliferated, a more integrated theoretical understanding of OSI as a cross-collaborative, ecosystem-based approach to tackling social problems remains underdeveloped. Nevertheless, to break down and understand this dynamic process in which actors interact and exchange resources over time, it may be useful to employ multi-level approaches (e.g., Bogers et al., 2017), and multi-initiative frameworks. The research agenda for OSI should prioritize the exploration of complex relationships among initiatives, stakeholders, and the broader socio-economic context within which they operate. Such insights can guide the design and implementation of more effective OSI initiatives. Similar to our framework for analyzing the results, we propose four research themes that warrant scholarly attention: (i) antecedents; (ii) process and relationships; (iii) consequences; and (iv) methodological considerations. Table 12 presents a set of potential research questions derived from the future work suggestions identified in the analyzed studies, along with guiding theoretical frameworks that align with these research themes based on our analysis, rather than representing an exhaustive theoretical assessment.

7.1. Research theme 1: Multi-level antecedents of OSI

Our analysis suggests that while organizational factors influencing OSI have received considerable attention, significant gaps persist in understanding the interplay of OSI with individual-level factors (e.g., individual agency) and macro-level elements (e.g., institutional contexts and societal structures). Further research in these areas could enhance our comprehension of OSI dynamics and effectiveness across different contextual settings.

At the micro level, future research could explore the socio-psychological underpinnings that drive sustained participation in OSI initiatives. Current literature has begun to examine how intrinsic motivational factors influence user contributions (Schmidhuber et al., 2019), which presents opportunities for further theoretical development. Studies examining individual-level antecedents could benefit

from greater engagement with established psychological frameworks, creating opportunities to integrate theories such as Self-Determination Theory (Deci and Ryan, 2000) to examine how individual values intersect with organizational commitments and participation patterns.

At the *meso* level, we identify opportunities to examine how organizational commitments and structures shape OSI development. Current research provides valuable descriptive insights into how corporate social responsibility, eco-innovation, and shared value creation influence OSI initiatives across sectors (Cai et al., 2023; Kobarg et al., 2020). Building on this foundation, future research could develop frameworks that explain these relationships in different contexts. Additionally, while studies have identified organizational considerations such as institutional adaptation, intellectual property approaches, and resource allocation (Colovic et al., 2022; De Silva and Wright, 2019), there remain opportunities to develop frameworks that explain how organizations navigate these considerations. Additionally, analyzing OSI's impact on business activities in organizations of varying sizes and product diversification may yield valuable insights into its organizational implications (Altuna et al., 2015). Future research could develop and test theoretical models that connect organizational characteristics to OSI implementation effectiveness.

At the macro level, there are promising opportunities for researching OSI's societal impacts, integrating theoretical frameworks with practical implementations (De Silva and Wright, 2019; Kruse et al., 2019; Windrum et al., 2016). This area of inquiry connects with discussions in innovation ecosystems research regarding governance approaches (Dedehayir et al., 2018). On the other hand, it may be useful to integrate theoretical frameworks widely discussed in academic disciplines, such as the institutional approach (North, 1990), to contrast the influence of formal and informal factors that facilitate the creation of an environment conducive to social innovation through openness and sustainability (Fabrizi et al., 2018; Gramma-Vigouroux et al., 2024). These connections create opportunities for scholars to investigate the dynamic interplay between macro factors and OSI ecosystem development (Gegenhuber and Mair, 2024; Trischler et al., 2020).

Table 12
Examples of research questions in OSI.

Theme	Area /Level	Potential research questions (RQs)	Theoretical perspectives that can be applied	Dominant references
Antecedents	Micro (Individual)	<ul style="list-style-type: none"> • How do principles of responsibility in innovation processes affect the initiation and development of OSI, especially regarding ethical, social, and environmental considerations? • How do different types of motivation, for example, green individual motives, influence the quality and nature of users' contributions in OSI initiatives? • What distinctive personal values drive individuals' continuous participation and engagement in OSI initiatives compared to other forms of volunteering or innovation? • How do individual competencies and self-efficacy, as conceptualized in goal-setting theory, influence the successful implementation of empowerment-oriented OSI initiatives? • To what extent does human capital mediate the relationship between collaborative models and innovation outcomes in OSI initiatives? • How do human capital factors interact with organizational absorptive capacity to affect knowledge transfer efficacy in cross-sector OSI partnerships? 	<ul style="list-style-type: none"> • Self-Determination • Goal-Setting • Human Capital • Personal Responsibility • Social Exchange 	(Chang, 2019; Fait et al., 2023; Hong and Lee, 2023; Randhawa et al., 2019; Schmidhuber et al., 2019; Smolka and Bösch, 2023; Ten Holter, 2022; Urbinati et al., 2023; Wu, 2023)
		<ul style="list-style-type: none"> • To what extent does corporate social responsibility influence the initiation and development of OSI initiatives across different industries and cultural contexts? • To what extent do resource constraints in social organizations impact the choice and effectiveness of OSI approaches across different sectors? • What are the key organizational dynamic capabilities required for effective implementation of OSI strategies across different social issues? • How do organizational learning processes contribute to the evolution and sustainability of OSI initiatives over time? • What organizational culture and governance styles influence participation in OSI initiatives? 	<ul style="list-style-type: none"> • Dynamic Capabilities • Absorptive Capacity • Resource-Based View • Resource Dependency • Organizational Knowledge Management 	(Altuna et al., 2015; Cai et al., 2023; Colovic et al., 2022; Cutler White, 2014; De Silva et al., 2020; Dionisio and de Vargas, 2022; Fait et al., 2023; Hong and Lee, 2023; Kobarg et al., 2020; Rey-García et al., 2019; Roszkowska-Menkes, 2018; Watson et al., 2018)
		<ul style="list-style-type: none"> • What factors influence how OSI impacts mainstream activities in organizations of different sizes and levels of product diversification? • How do organizational resources and capabilities influence the formation and governance of OSI initiatives? 		
		<ul style="list-style-type: none"> • What role do policy interventions play in shaping cross-sector OSI collaborations for scaling impactful solutions? • How does the interplay between local and national innovation policies affect the diffusion of user-driven OSI initiatives? • How do national regulatory frameworks influence the formation and scaling of OSI initiatives focused on sustainable development goals? • What ecosystem structural factors enable the development of transformative and economically sustainable OSI initiatives? • Which local processes are generalizable for cooperating on OSI initiatives, and which are culturally specific? 	<ul style="list-style-type: none"> • Institutional Approach • Ecosystem Approach • Innovation Systems • Complex Adaptive Systems 	(Babu et al., 2020; Caridà et al., 2022; Català et al., 2023; Christopoulos et al., 2023; Desmarchelier et al., 2021; Fabrizi et al., 2018; Gramma-Vigouroux et al., 2024; Hansen et al., 2022; Kher et al., 2023; Sarasini, 2015; Trischler et al., 2020; Vendrell-Herrero et al., 2023; Windrum et al., 2018)
		<ul style="list-style-type: none"> • What problem framing and bounding strategies are most effective for engaging diverse stakeholders in OSI? • What co-creation processes and methods are most effective for absorbing and integrating knowledge from diverse stakeholders to create new solutions? • What collaborative approaches are most effective for transforming collective ideas (exploration) into real solutions (empowerment)? • How do the temporal dynamics of scaling (e.g., pace, timing) influence the resilience and adaptability of OSI initiatives? 	<ul style="list-style-type: none"> • Stakeholder Approach • Service-Dominant Logic • Organizational Resilience • Collective Action 	(Akasaka et al., 2023; Hagedoorn et al., 2023; Wegner et al., 2023)
	Problem identification & ideation			
	Implementation & scaling			

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Table 12 (continued)

Theme	Area /Level	Potential research questions (RQs)	Theoretical perspectives that can be applied	Dominant references
	Orchestration	<ul style="list-style-type: none"> • How do orchestrators adapt their governance approaches when scaling OSI initiatives from local to global levels? • What are the key practices that enable orchestrators to effectively manage resource constraints while fostering disruptive innovations for societal benefit? • How do orchestrators in OSI initiatives adapt their governance strategies to different stages of the innovation process (exploration-oriented vs. empowerment-oriented)? 	<ul style="list-style-type: none"> • Adaptive Governance • Resource Orchestration 	(Christopoulos et al., 2023; Fayard, 2023; Gegenhuber et al., 2023; Kruse et al., 2019; Oskam et al., 2021; Wegner et al., 2023)
	Legitimation dynamics	<ul style="list-style-type: none"> • How do legitimation dynamics in OSI ecosystems influence the advancement of well-being objectives beyond local networks? • What are the effects of conflicting institutional logics on specific legitimacy establishment processes in OSI initiatives? • How do conflicting tensions influence the legitimation activities used to establish the legitimacy of OSI in collaborative governance contexts? 	<ul style="list-style-type: none"> • Shared Value • Institutional Legitimacy 	(Häikiö, 2012; Oskam et al., 2021; Verleye et al., 2019)
	Stakeholders' engagement	<ul style="list-style-type: none"> • How can inclusive participation mechanisms effectively engage marginalized groups typically excluded from large-scale OSI processes? • What engagement strategies are most effective for sustaining stakeholder commitment throughout the implementation of OSI initiatives? 	<ul style="list-style-type: none"> • Social Inclusion • Social Justice • Social Exchange 	(Barrett and Dooley, 2024; Bentzen, 2022; Hardyman et al., 2022; Marschalek et al., 2022; Oskam et al., 2021)
	Governance of innovation networks	<ul style="list-style-type: none"> • What is the optimal structure of OSI networks based on the roles of stakeholders, allocation of resources, social issues, and decision-making processes? • How do different governance structures within cross-sector partnerships impact the sustainability of OSI initiatives? • To what extent do different governance models shape the centrality patterns of actors in multi-sectoral OSI networks? • What strategies do effective stakeholders employ to navigate power asymmetries across different levels (micro, meso, and macro) within network structures to ensure equitable participation in OSI initiatives? • How do mechanisms of informal influence and power distribution affect decision-making processes and resource allocation in OSI initiatives? • How does the integration of digital tools in OSI processes affect the scaling strategies of social enterprises compared to traditional non-profit organizations? 	<ul style="list-style-type: none"> • Structural Contingency • Power Dependency 	(Callagher et al., 2022; Desmarchelier et al., 2021; Herrera, 2016; Hong and Lee, 2023; Kimpimäki et al., 2022; Logue and Grimes, 2022; Merlin-Brognart et al., 2022; Oskam et al., 2021; Randhawa et al., 2019; Rey-García et al., 2019; Sarasini, 2015; Wegner et al., 2023)
	Digital technologies	<ul style="list-style-type: none"> • How are social media platforms enabling and scaling OSI initiatives? • To what extent do digital platforms enable or constrain the inclusion and empowerment of marginalized stakeholders in OSI processes? • How do digital technologies mediate the relationship between corporate social responsibility initiatives and OSI across for-profit organizations of varying sectors? • How are disruptive technologies and innovations transforming OSI initiatives? 	<ul style="list-style-type: none"> • Digital Divide Approach • Technology Mediation • Digital Inclusion 	(Cambra-Fierro et al., 2024; Carayannis et al., 2021; Caridà et al., 2022; Cosimato et al., 2022; Dezi et al., 2018; Gegenhuber et al., 2023)
Consequences	Longitudinal effects	<ul style="list-style-type: none"> • To what extent do “innovation mindsets” fostered by OSI initiatives persist in communities in the long term? • How do stakeholder engagement, adaptability, and business model robustness influence the persistence of impact on OSI? • How do OSI initiatives contribute to community resilience and adaptability in different socio-cultural contexts? • What unintended consequences can emerge from OSI initiatives in the long run? 	<ul style="list-style-type: none"> • Transformative Learning • Social Capital • Social Impact Assessment 	(Citroni, 2015; De Silva and Wright, 2019; Fayard, 2023; Hagedoorn et al., 2023; Hardyman et al., 2022; Oskam et al., 2021)
	Assessment of OSI engagement	<ul style="list-style-type: none"> • What comprehensive frameworks can be created to evaluate the breadth and depth of participation in OSI? 	<ul style="list-style-type: none"> • Participatory Evaluation 	(Bentzen, 2022; De Silva and Wright, 2019; Desmarchelier et al., 2021; Martínez-Martínez

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Table 12 (continued)

Theme	Area /Level	Potential research questions (RQs)	Theoretical perspectives that can be applied	Dominant references
Quantifying impact		<ul style="list-style-type: none"> • How do socio-economic and cultural contexts (e.g., developed versus developing countries) influence the long-term engagement in OSI among social organizations? • How does partner diversity influence sustainability outcomes in OSI? • What frameworks can compare the degree of collaboration in different OSI initiatives? • How does the involvement of for-profit organizations impact the direction and outcomes of OSI initiatives? • What organizational learning processes and mechanisms enable the building of innovation capabilities through participation in OSI? • How do regional and national innovation systems impact the performance and diffusion of OSI across different sectors and geographies? • What effect does diverse stakeholder participation in OSI have on the replicability of successful initiatives? 	<ul style="list-style-type: none"> • Cultural Dimensions • Hybrid Organizing • Organizational Learning 	<p>et al., 2023; Smolka and Bösch, 2023; van Geenhuijen and Ye, 2014; Windrum et al., 2016)</p> <p>(Altuna et al., 2015; Barrett and Dooley, 2024; Cai et al., 2023; Cassetta et al., 2023; Desmarchelier et al., 2020; Hofman et al., 2020; Kallio and Lappalainen, 2015; Kruse et al., 2019; Rayna and Striukova, 2019; Wegner et al., 2023)</p>

7.2. Research theme 2: Process dynamics and stakeholder relationships

Our review highlights opportunities for expanding our understanding of the processes and relationships underpinning OSI initiatives. This theme encompasses four research opportunities that invite deeper investigation. First, current research has begun to address the complex leadership models and collaboration dynamics that drive OSI processes. While studies have begun examining legitimization dynamics and their broader societal impacts (Verleye et al., 2019), the analysis of how different leadership approaches affect OSI outcomes remains underdeveloped. This creates opportunities for scholars to contrast leadership models with OSI to advance understanding beyond descriptive accounts.

Second, the governance of OSI initiatives presents opportunities for future research, with a focus on optimizing network structure and function for greater impact (Sarasini, 2015). This includes scrutinizing stakeholder roles, power dynamics, resource distribution, and decision-making processes (Logue and Grimes, 2022). Further empirical validation across diverse welfare regimes could enhance these frameworks (Merlin-Brognart et al., 2022). In this context, analyzing the dynamics of OSI at various levels and their impact on sustainability goals may enable researchers to develop and test new collaboration models that address complex sustainability challenges (Kimpimäki et al., 2022).

Third, the role of orchestrators in multi-stakeholder collaborations deserves attention. Researchers should identify the competencies, behaviors, and strategies of effective facilitators, as well as the challenges they face and the support needed for success (Wegner et al., 2023). To build on this foundation, scholars might consider systemic frameworks, such as Complex Adaptive Systems (Schneider and Somers, 2006), to examine the emergent properties and non-linear interactions within multi-stakeholder networks. This approach could reveal how collaborative structures evolve and self-organize, particularly when examining OSI implementation across diverse community contexts with varying resource constraints and societal impact objectives. Finally, the influence of digital technologies on OSI warrants considerable attention (Cosimato et al., 2022). Future studies should explore the specific capabilities of technologies like social media and crowdsourcing tools, the challenges, and opportunities they present, and their use by various actors in the innovation ecosystem.

7.3. Research theme 3: Longitudinal consequences and impact assessment

Our review highlights the limited number of longitudinal studies that have investigated the long-term effects of OSI initiatives. This research

theme encompasses three key opportunities for development. First, longitudinal research designs could reveal important insights about OSI's potential to address complex societal challenges (e.g., Fayard, 2023). While current cross-sectional and case-based studies provide valuable insights, longitudinal approaches could enhance our understanding of how OSI initiatives evolve and adapt over time. This area connects with discussions in ecosystem metrics research regarding contextual considerations in performance assessment (Leendertse et al., 2022). Scholars could employ longitudinal designs to examine factors contributing to OSI scalability (Rayna and Striukova, 2019), including stakeholder engagement persistence, adaptation mechanisms, and business model resilience.

Assessing the extent of OSI engagement within social ecosystems presents a complex challenge (Wegner et al., 2023). Current assessment approaches provide various valuable perspectives that could be further integrated. Future research could develop comprehensive frameworks that conceptualize various dimensions of engagement, including participation breadth and depth, stakeholder diversity, and collaboration intensity (Windrum et al., 2016). Such frameworks would enable systematic comparison across different OSI initiatives and contexts.

Finally, future studies should examine the impact of OSI initiatives adopting various organizational models, such as hybrid organizations, and the roles of different actors in social innovation ecosystems (Carayannis et al., 2021). Current research provides valuable descriptive insights into these relationships, creating opportunities for more comprehensive conceptual development. For example, scholars might investigate the application of social business models in digital social innovation ecosystems, specifically in the context of smart cities.

7.4. Research theme 4: Methodological considerations for advancing OSI research

OSI studies have benefited from case study approaches that provide rich contextual understanding. To further advance the field, mixed-method approaches could contribute to theoretical development by combining the contextual richness of qualitative methods with the comparative insights of quantitative approaches. This methodological integration could support robust theory building and testing, particularly for complex multi-level phenomena characteristic of OSI. Such approaches could include alternative research designs like social network analysis (Shipilov and Gawer, 2020) to examine interorganizational networks and clusters; or agent-based modeling and simulation (Wu et al., 2010) to reveal emergent properties in OSI ecosystems.

8. Conclusion

This SLR of OSI, encompassing 115 articles from leading journals, offers an integrated perspective on the evolution and current state of OSI research. As an emerging field, OSI is a young concept in academic literature, with research in this area gaining momentum in recent years. Our analysis, rooted in content analysis and bibliometric approaches, reveals the multi-faceted nature of OSI, underpinned by diverse theoretical frameworks and methodologies. The review highlights the growing interest in OSI, especially in response to complex social challenges such as the COVID-19 pandemic. This interest is reflected in the increasing volume of publications and the expanding scope of OSI in the last two years, demonstrating increased recognition of the potential of this approach to address complex societal issues.

Advancing OSI research has significant implications from both theoretical and practical point of view. From a theoretical perspective, the review has the potential to enhance our understanding of distributed innovation processes, particularly in social and sustainability-oriented initiatives. Additionally, it can contribute to the development of new theoretical models and refine existing ones. This includes frameworks related to stakeholder engagement, value co-creation, and the role of institutions in shaping innovation. From a practical standpoint, research on OSI may provide valuable insights for designing and implementing more effective initiatives to address pressing societal challenges. It can offer guidance on how communities and organizations can foster a culture of openness, collaboration, and social responsibility. Furthermore, it can serve as a resource for policymakers in creating an environment conducive to OSI.

Despite the comprehensive nature of this SLR, our study acknowledges limitations that warrant consideration. First, while focusing on major journals in specific fields ensured the inclusion of high-quality, peer-reviewed research, this approach may have inadvertently excluded relevant OSI studies published in other disciplines or disseminated through alternative formats. Second, although citation or co-citation analysis provides valuable insights into the impact and influence of scholarly works, it has inherent limitations. This method does not fully capture the nuanced intentions behind each citation, as researchers may cite work for various reasons beyond its direct relevance or discussion. Additionally, as this review primarily stems from a management disciplinary perspective, valuable perspectives and trans-disciplinary knowledge from other social science domains could contribute to a richer understanding of complex social phenomena like OSI. Lastly, the swiftly developing nature of the OSI field presents an ongoing challenge for literature reviews. As new research emerges and theoretical perspectives shift, the findings and conclusions of this SLR may require continual updating to maintain their relevance and applicability.

Future research on OSI presents numerous opportunities for in-depth exploration, as it is an emerging approach that can be examined from various perspectives and applied across different models of implementation. One valuable direction for subsequent research involves a deeper examination of how OSI advances, challenges, or transforms theoretical frameworks both within management studies and across adjacent disciplines. The dynamic nature of OSI, shaped by evolving societal needs and technological advancements, necessitates innovative, multidisciplinary, and collaborative research approaches. By integrating OSI with fields such as organizational creativity, strategic management, and entrepreneurship, we can enhance our understanding of its impact and the factors that influence it. As research and applications of the OSI approach continue to expand, exploring these intersections and synergies may generate novel insights and research directions. Ultimately, by bridging the gap between theory and practice, OSI research has the potential to drive positive social change and contribute to the development of more inclusive, sustainable, and resilient societies.

CRediT authorship contribution statement

Jose Nicolas Pacheco: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Andreu Turro:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **David Urbano:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

None.

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Data availability

Data will be made available on request.

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