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Cross-industry innovation: A systematic literature review

Antonio Carmona-Lavado [a,*], Elena M. Gimenez-Fernandez [a], Vesna Vlaisavljevic [b], Carmen Cabello-Medina [a]

[a] Universidad Pablo de Olavide, Department of Business Administration and Marketing, Ctra. de Utrera, Km. 1, 41013, Seville, Spain
[b] University of Barcelona, Business Department, John M. Keynes, 1-11, 08034, Barcelona, Spain

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ABSTRACT

This article performs a systematic literature review of cross-industry innovation (CII), which is a specific case of open innovation (OI) that has proved to be especially relevant in a context of increasing digitalization and technological convergence. In spite of its interest, previous research on CII is disperse in studies adopting different perspectives.

A bibliometric analysis and a content analysis were carried out on a sample of 45 articles about CII, published between the year 1997 and the end of 2021. We address five research questions about the conceptualization and types of CII, the main features of CII (types of innovation, industries and actors), the process of CII, its determinants and consequences, and the prevalent methodological trends.

By answering our research questions, we present a comprehensive picture of the state of the art of CII and make valuable contributions. Among them, our research provides a new definition of CII and a delimitation of its types, an integration of the processes of CII described under various approaches, and a network map of the cross-fertilization of knowledge among industries, showing the relationship between source and target industries. By identifying unexplored opportunities in the literature, a research agenda is proposed.

1. Introduction

Since innovation one of the main drivers of economic growth and wealth creation, as well as a source of sustained competitive advantage (Ferreira et al., 2020; Katila and Ahuja, 2002; Teece et al., 1997), firms constantly search for ways to transform and advance their innovation strategies. Among them, the use of external and distant knowledge has been outlined as a key element for successful innovation (Enkel and Gassmann, 2010; Santoro et al., 2020), increasing the importance of the open innovation (OI) paradigm (Obradović et al., 2021). The term open innovation, firstly introduced in 2003 by Henry Chesbrough, emphasizes the change in the way firms conduct their innovative processes, from a closed model to an open innovation model.

Throughout the years, the original conception of open innovation has continuously evolved. New themes have emerged, increasing the nuance and sophistication of the arguments, and broadening this body of research (West et al., 2014). Based on this evolving scope of OI, this research focuses on cross-industry innovation (CII), as a particular case of open innovation that refers to the creative imitation and retranslation of existing solutions with the aim of meeting the needs of other industries (Enkel and Gassmann, 2010; Hahn, 2014). The topic is usually based on the concept of analogy, defined as a cognitive mechanism to identify and use existing knowledge to solve new problems (Herstatt and Kalogerakis, 2005). In cross-industry innovation, the use of analogies implies the transfer of knowledge from one industry to another, where the knowledge acquired can solve a problem.

CII has proved to have special relevance in a number of contexts. Firstly, in highly developed markets, firms aim to extend the range of the functionalities of their products, which requires going beyond their specific domain and looking for knowledge and technologies outside their own industries (Mahnken and Moehrle, 2018). Secondly, CII is also prevalent in business model generation (Enkel and Mezger, 2013), due to the application of the concept of modularity (Aversa et al., 2015) and the emergence of iconic business models (Mikhalkina and Cabantous, 2015). In this sense, many start-ups try to become the Airbnb or the Ikea of their industries. Thirdly, from a regional perspective, CII helps to avoid problems associated to highly specialized regions, which may become too dependent on a single industry, and especially vulnerable to

* Corresponding author.
E-mail addresses: acarlav@upo.es (A. Carmona-Lavado), emgimfer@upo.es (E.M. Gimenez-Fernandez), vesna.savic@ub.edu (V. Vlaisavljevic), mcabmed@upo.es (C. Cabello-Medina).

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disruptions and crises. In those cases, looking for solutions and technologies in other industries may be a relevant mechanism for the renewal of regions (Hauge et al., 2017). Likewise, knowledge and technologies developed in a certain very specialized industry can be reused to create innovation in new sectors (Lyng and Brun, 2018).

In spite of its potential as a trigger to open new perspectives in innovation research, the literature addressing CII is still disperse, with studies focused on different aspects of the topic, together with the need to distinguish it from related and interconnected concepts, such as recombinant innovation (Weitzman, 1998; Keupp and Gassmann, 2013), innovation ecosystems (Yaghmaie and Vanhaverbeke, 2019) and industry convergence (Hacklin et al., 2010). As in the case of OI, those many forms and tastes increase the richness of the concept, although it hinders its theoretical development (Huizingh, 2011). Therefore, it is necessary to organize the current knowledge on CII, delimitate the topic and set the foundations for the development of the CII framework.

To this end, this study poses the following research questions.

- RQ1. How can CII be conceptualized and differentiated from other related topics?
- RQ2. Which relevant features of CII can be identified in the literature (types of innovation, industries and actors)?
- RQ3. What is the process of CII according to different theoretical approaches?
- RQ4. Which are the main determinants and consequences of CII?
- RQ5. Which are the main methodological trends in the research on CII?

We conducted a systematic literature review, and collected and synthesized extant theoretical and empirical research on CII. In particular, we performed a bibliometric and content analysis on a final sample of 45 articles on CII. Firstly, the bibliometric analysis included the number of articles per year, citations, authors, journals, affiliations and countries. Secondly, the content analysis provided the basis for answering our research questions regarding the conceptualization, the characterization, the processes, the determinants and consequences of CII, and the methodological trends in the existing literature.

This paper contributes to the academic research in different ways. Firstly, it provides a comprehensive and organized view of disparate contributions about CII. In particular, we clarify the process of CII through the lens of different theoretical perspectives, such as analogical thinking (Brunswicker and Hutschek, 2010; Enkel and Mezger, 2013; Herstatt and Kalogerakis, 2005), and knowledge and learning approaches (Bader, 2013; Lyng and Brun, 2018, 2020b). Secondly, this study also contributes to the literature by proposing a new definition of CII, making a clear distinction of its types, differentiating CII from other related concepts (Weitzman, 1998; Yaghmaie and Vanhaverbeke, 2019; Bröring et al., 2006). Finally, our study represents a relevant contribution to the OI paradigm (Chesbrough, 2003), pointing out CII as a specific case of OI (Brunswicker and Hutschek, 2010; Horváth and Enkel, 2014).

This systematic literature review is not only helpful to academics and practitioners for gaining a better understanding about the phenomenon, but the gaps identified also inspire a future research agenda that lays the foundations for further development and growth of this body of research.

The paper is organized as follows. It begins with a description of the methodology used in this study. Next, the bibliometric analysis is shown, in order to illustrate the main contributors to the state-of-the-art in CII. The comprehensive content analysis is then presented in detail. Lastly, the main conclusions are discussed and future research lines are proposed.

2. Methodology

In order to comprehensively understand the state-of-the-art in the CII literature, we conducted a systematic literature review process following the three-stage procedure of Tranfield et al. (2003): planning, execution, and reporting. It provides insights on already demonstrated potentials of CII, as well as hints to gaps that have not been addressed in the literature. The process followed is based on previous literature (Vrontis and Christofi, 2021; Chaudhary et al., 2021).

2.1. Search boundaries

Our initial search was limited to papers reported in WOS Core Collection,[1] as it is one of the most comprehensive databases of peer-reviewed journals in the field of social sciences (Crossan and Apaydin, 2010).

2.1.1. Search string

Our aim was to search for articles related to CII. Since not all scholars have referred to this phenomenon using the same terms, we broadened our search by including other terms that reflect the use of knowledge for innovation from one industry into another industry. We used the following search query:

TS = ((cross-industry-innovation) OR (innovation-across-industr*-boundaries) OR (analog* AND innovation AND industry) OR (cross-industry-alliance* AND innovation) OR (cognitive-distance* AND innovation AND industry) OR (cross-industry AND ecosystem) OR (cross-industry AND value-creation) OR (inter-industry AND innovation))

2.1.1.1. Timeframe. The *time span* used was the period from 1900 to 01-01 to 2021-12-31 (including early access), that is, all the years available in the database at the time of the study. The application of the above-mentioned inclusion criteria provided an initial sample of 491 studies.

2.1.1.2. Exclusion criteria. Language: We filtered the records found by languages, selecting only those studies written in English. Therefore, 27 studies written in other languages (e.g., Spanish, Russian, German, etc.) were excluded, obtaining a sample of 464 articles.

Document type: We only considered articles from peer-reviewed journals. Thus, we excluded 124 documents for being proceeding papers, book chapters and review articles, obtaining a sample of 340 articles.

Web of science categories: We limited the search to Business and Management, excluding 172 publications in other fields of knowledge, such as engineering industrial, economics, operations research and management science (ORMS) and regional urban planning.

The search yielded a sample of 168 papers. However, eight of them were wrongly classified as book chapters and four as conference papers, and thus they were excluded, resulting in 156 papers.

2.1.1.3. Relevant article selection. After we obtained the preliminary search results, we subsequently read through the title, abstract, keywords, and full text to identify possible false positives. Our only inclusion criterion for this systematic review was that the papers analyzed the phenomenon of CII as a central topic. Consequently, we excluded 117 articles, since they do not study CII and were not relevant for our research. For example, some of the excluded articles referred to analog vs digital imaging. Therefore, this research effort resulted in 39 valid papers.

Finally, based on the references provided by those 39 papers, we carried out a manual search and citation tracking process to broaden our sample (Calabrò et al., 2019). For this manual process, we maintained the criterion that only articles from peer-reviewed journals could be

[1] Particularly, it includes SCIE (1900-present), SSCI (1956-present), AHCI (1975-present), CPCI–S (1990-present), CPCI-SSH (1990-present), BKCI–S (2005-present), BKCI-SSH (2005-present) and ESCI (2005-present).

Table 1
Ranking of articles on CII by citations in WOS.

Articles	Number of citations in WOS
Hargadon and Sutton (1997)	1449
Dahl and Moreau (2002) [MS]	333
Enkel and Gassmann (2010)	199
Belderbos et al. (2014)	149
Karvonen and Kässi (2013)	117
Bröring et al. (2006)	106
Kalogerakis et al. (2010)	91
Schmidt (2010)	87
Enkel and Heil (2014)	86
Gassmann and Zeschky (2008) [MS]	76
Gassmann et al. (2010)	62
Gassmann et al. (2011)	57
Li and Vanhaverbeke (2009)	55
Brunswicker and Hutschek (2010)	46
Datta and Jessup (2013) [MS]	45
Enkel and Mezger (2013)	44
Dingler and Enkel (2016)	43
Poetz and Prügl (2010)	39
Herstatt and Kalogerakis (2005)	36
Hacklin et al. (2010)	27
Enkel et al. (2018)	24
Enkel and Bader (2016)	22
Streb (2003)	21
Golembiewski et al. (2015)	18
Hauge et al. (2017) [MS]	14
Lee et al. (2016)	14
Zhang and Cantwell (2011)	14
Groβmann et al. (2016)	13
Bader (2013)	12
Galvin et al. (2020)	11
Heil and Enkel (2015)	10
Ciliberti et al. (2016) [MS]	9
Filiou and Massini (2018)	9
Lyng and Brun (2018)	9
Fung (2002)	8
Horváth and Enkel (2014)	8
Mahnken and Moehrle (2018) [MS]	7
Lyng and Brun (2020a)	6
Phillips et al. (2017)	5
Lyng and Brun (2020b)	4
Zhang et al. (2021)	4
Behne et al. (2021)	1
Rhéaume and Tremblay (2017)	1
Choi and Lee (2015)	0
Lyng and Brun [2022]	0

Notes: MS = Manually searched. Lyng and Brun appeared in our list as "early access Dec 2021", although it was finally published in 2022.

included. As a result, six more articles were included, leading to a final sample of 45 articles (see Table 1, where manually searched papers are indicated with [MS]).

Fig. 1 illustrates the applied selection process.

Four researchers coded the articles independently, discussing and reaching consensus when necessary. The research methodology involved a bibliometric analysis and a content analysis; the latter allowed us to find different definitions, types, main features, processes, determinants and consequences of CII. Furthermore, we identified the methodological trends in the research on this topic (unit of analysis, sample size, research strategy, and data analysis technique). Table A1 in Appendix in contains a summary of the 45 publications found. The systematization procedure led to suggesting coherent avenues for future research.

3. Bibliometric analysis

We carried out a bibliometric analysis using SciMAT (Cobo et al., 2012) and VOSviewer (van Eck and Waltman, 2010).

3.1. Number of articles per year, and citations per article

Fig. 2 shows the number of articles on CII per year. As can be observed, 2010 was the most prolific year, with seven articles. Then, five articles were published in 2016, and four in 2013 and 2018. Three articles were published in each of the following four years: 2014, 2015, 2017 and 2020. It should be kept in mind that we closed our search in December 31st' 2021 (including one early access article that was published in 2022). There is an average of 1.8 articles per year (45 articles/25 years), which increased to 3.6 in the last five years (considering the 2022 article within 2021).

Table 1 shows the 45 articles on CII in order, based on the number of citations in WOS, from largest to smallest. Hargadon and Sutton (1997), the oldest article, is, by far, the most cited article, with 1449 citations, followed by Dahl and Moreau (2002), with 333. The third position is for the seminal article by Enkel and Gassmann (2010), with 199 citations. Belderbos et al. (2014), Karvonen and Kässi (2013) and Bröring et al. (2006) have 149, 117,106 citations, respectively. The remaining 39 articles have less than 100 citations in total. The average number of authors per article is 2.4, ranging between one and five.

3.2. Authors

Table 2 presents the ten authors (out of 83) of CII with at least two papers, in descending order, based on their number of articles. Ellen Enkel is the first author, with nine publications. Oliver Gassmann, Eric Christian Brun and Hilda Bo Lyng have four publications and Sebastian Heil three, and there is a group of five authors with two papers (Herstatt, Kalogerakis, Zeschky, Bader and Bröring). The rest of the authors of our sample only appear in one article.

The impact of the authors in terms of citations is not proportional to the number of articles. For example, the nine articles of Enkel accounts for 943 citations and the four articles of Gassmann have 394 citations, while the four articles of Lyng only accumulate 19 citations.

3.3. Journals

Table 3 includes the 23 journals that have published articles on CII. *R&D Management* leads the list with seven articles, followed by *International Journal of Innovation and Technology Management* with six articles, and *International Journal of Innovation Management*, with five articles. *Technovation* is in the fourth position, with four articles. *Technological Forecasting and Social Change* have three articles, and two journals (*Journal of Product Innovation Management* and *Research Policy*) have two articles. Lastly, 16 journals only have one article.

3.4. Affiliations and countries

Authors belongs to 49 different affiliations. Table 4 ranks the affiliations in order, from largest to smallest number of articles, showing the first 18 affiliations. Each article was assigned proportionally depending on the affiliation of all the authors (e.g., if there are three authors, two with affiliation X and one with affiliation Y, then it counts as 2/3 for X and 1/3 for Y). Applying this criterion, Zeppelin University, in Germany, has published the largest number of articles, with almost nine (8.7). The University of Stavanger, in Norway, with four recent publications, is in the second position. The University of St Gallen, in Switzerland, has more than two papers (2.7), holding the third place. The other affiliations have one publication at the most.

Table 5 classifies the 14 countries of the authors' affiliations following the same criterion explained above. Germany is clearly the country that provided the largest research contribution on the topic, with more than 20 articles (20.2, 44.8%). The second country, from a distance, is Norway, with five relatively recent articles (11.1%). The rest of the countries have less than four articles.

If we consider the continents of the countries, Europe represents

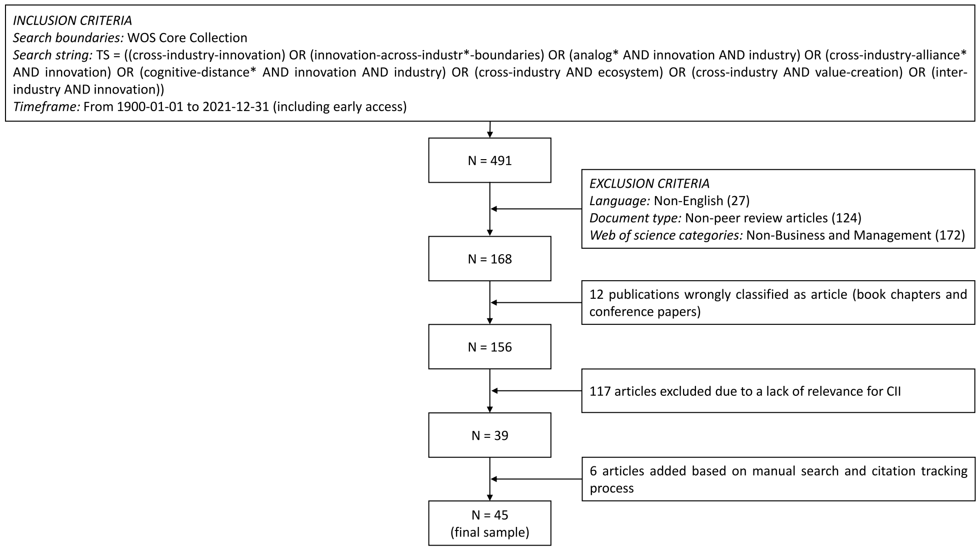

Fig. 1. Applied selection process.

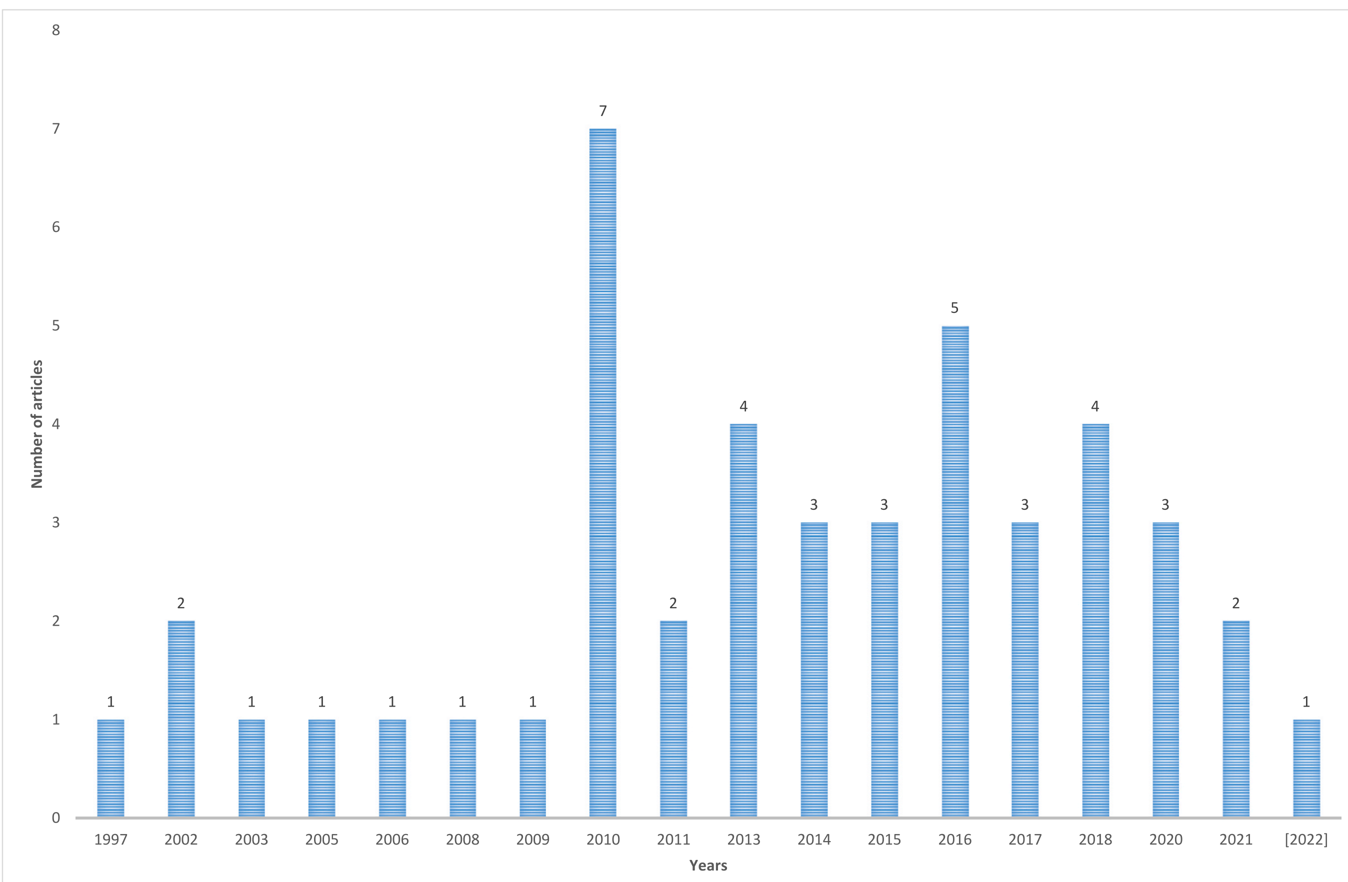

Fig. 2. Number of articles on CII per year.

77.8%, (North) America 11.9%, Asia 9.6% and Oceania 0.7%. None of the articles come from Latin America or Africa.

3.5. Co-citation analysis

The aim of author co-citation is to determine a topic's structure by analyzing the authors that are frequently cited together (Cobo et al., 2011; Secinaro et al., 2022). Using VOSviewer (van Eck and Waltman, 2010), we selected *co-citation* as type of analysis, *cited authors* as unit of analysis, and *full counting* as counting method. Setting 10 as the minimum number of citations of an author, 38 authors were obtained, although two of them were excluded, since they relate to the case study method (Eisenhardt and Yin). Fig. 3 shows the three detected clusters. The green cluster gathers the authors that have explained the process of

Table 2
Ranking of authors by number of articles on CII.

Authors (with more than one article)	Number of articles
Enkel, Ellen	9
Gassmann, Oliver	4
Brun, Eric Christian	4
Lyng, Hilda Bo	4
Heil, Sebastian	3
Bader, Karoline	2
Bröring, Stefanie	2
Herstatt, Cornelius	2
Kalogerakis, Katharina	2
Zeschky, Marco	2

Table 3
Ranking of journals by number of articles on CII.

Journals	Number of articles
R&D Management	7
International Journal of Innovation and Technology Management	6
International Journal of Innovation Management	5
Technovation	4
Technological Forecasting and Social Change	3
Journal of Product Innovation Management	2
Research Policy	2
Industrial and Corporate Change	1
Journal of Technology Transfer	1
European Planning Studies	1
International Food and Agribusiness Management Review	1
International Journal of Innovation and Learning	1
World Patent Information	1
Review of Industrial Organization	1
Managerial And Decision Economics	1
Journal of Marketing Research	1
International Journal of Technology Management	1
Research-Technology Management	1
Long Range Planning	1
Asian Business & Management	1
Technology Innovation Management Review	1
Administrative Science Quarterly	1
Creativity and Innovation Management	1

Table 4
Ranking of affiliations by number of articles on CII.

Affiliation	Number of articles	Proportion of authorship
Zeppelin University (Germany)	8.7	19.2%
University of Stavanger (Norway)	4	8.8%
University of St Gallen (Switzerland)	2.7	5.9%
University of Quebec (Canada)	1.3	2.9%
University of Münster (Germany)	1.3	2.9%
Centre of European Economic Research (ZEW) (Germany)	1	2.2%
Fraunhofer Institute for Industrial Engineering (Germany)	1	2.2%
Hamburg Institute of Technology (Germany)	1	2.2%
Hamburg University of Technology (Germany)	1	2.2%
Lappeenranta University of Technology (Finland)	1	2.2%
Technische Universität Berlin (Germany)	1	2.2%
University of Agder (Norway)	1	2.2%
University of Bremen (Germany)	1	2.2%
KU Leuven (Belgium)	1	2.2%
ETH Zurich (Switzerland)	1	2.2%
University of Heidelberg (Germany)	1	2.2%
Hong Kong Polytechnic University (Hong Kong)	1	2.2%
University of Bonn (Germany)	1	2.2%

Table 5
Ranking of countries by number of articles on CII.

Country	Number of articles	Proportion of authorship
Germany	20.2	44.8%
Norway	5	11.1%
USA	3.5	7.8%
Switzerland	3.3	7.4%
UK (England)	2.7	5.9%
South Korea	2	4.4%
Canada	1.8	4.1%
Belgium	1.5	3.3%
China	1.3	3.0%
Finland	1	2.2%
Denmark	1	2.2%
Hong Kong	1	2.2%
Italy	0.3	0.7%
Australia	0.3	0.7%
TOTAL	45	100%

CII drawing on the identifications of analogies (e.g., Enkel, Gassmann, Kalogerakis, Herstatt). The blue cluster includes authors with seminal articles on sources of innovation (e.g., von Hippel) and analogical thinking applied to creativity or innovation (e.g., Hargadon, Dahl, Gentner). Lastly, the red cluster groups together the rest of authors researching on other topics linked to CII, such as open innovation (e.g., Chesbrough, Laursen), absorptive capacity (e.g., Cohen, Zahra), cognitive distance (e.g., Nooteboom), organizational learning (e.g., March), knowledge (e.g., Kogut), alliances and cooperation (e.g., Mowery) or dynamic capabilities (e.g., Teece).

3.6. Co-keywords analysis

Fig. 4 displays the co-occurrences of keywords on our sample of articles (Secinaro et al., 2022). In VOSviewer (van Eck and Waltman, 2010), we have selected *co-occurrence* as type of analysis, *all keywords* as unit of analysis, and *full counting* as counting method. Setting two as a minimum number of occurrences of a keyword, 66 keywords were obtained, although 24 were excluded, since they did not refer to a research topic (e.g., organization, firms or management). Seven clusters, represented by different colors, were clearly identified. The green cluster contains CII, together with analogical thinking/analogies[2] and absorptive capacity, reflecting the fact that CII has been closely linked to these topics. Even though “open innovation” belongs to the same cluster, it is at a certain distance from CII. This makes sense, given that the OI and CII literatures have followed relatively different pathways. Product innovation is also within this cluster, showing that CII has been focused primarily on this type of innovation. Exploitative and transformative learning are also in the upper left side of this cluster, since organizational learning is another key approach in CII. The blue cluster is mainly related to collaboration, knowledge transfer, transformation or communities, incorporating also distance/proximity and boundary objects. The purple cluster tackles innovation, as well as exploration and exploitation. Interestingly, this cluster includes (industry) convergence and technological convergence, where CII takes place, although they belong to an apparently different stream of research. The red cluster covers very general topics, such as technology, knowledge, alliances, networks, performance and R&D. The latter (R&D) is associated with creation, patents and intellectual property. The yellow cluster gathers capabilities and technological innovation. In addition, ecosystems and spillovers are part of this cluster, which are tangentially associated to CII. The light blue cluster comprises “cognitive distance” and “radical innovation”, as well as “exploratory innovation” and “relational embeddedness”. Lastly, there is a small orange cluster for “creativity”.

To sum up, both co-citation and co-keywords analyses support the

[2] We have joined both keywords because they refer to the same issue.

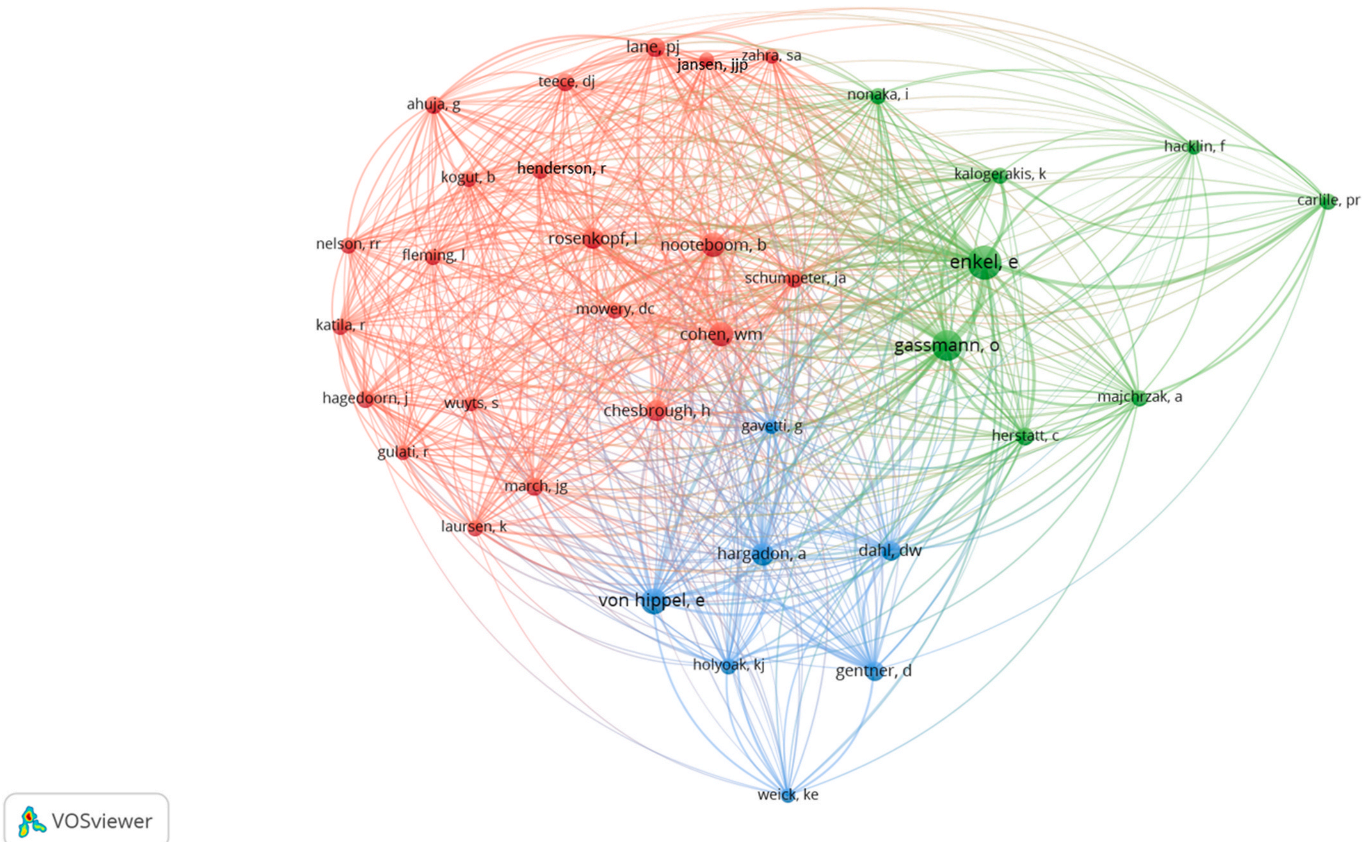

Fig. 3. Co-citation of authors.

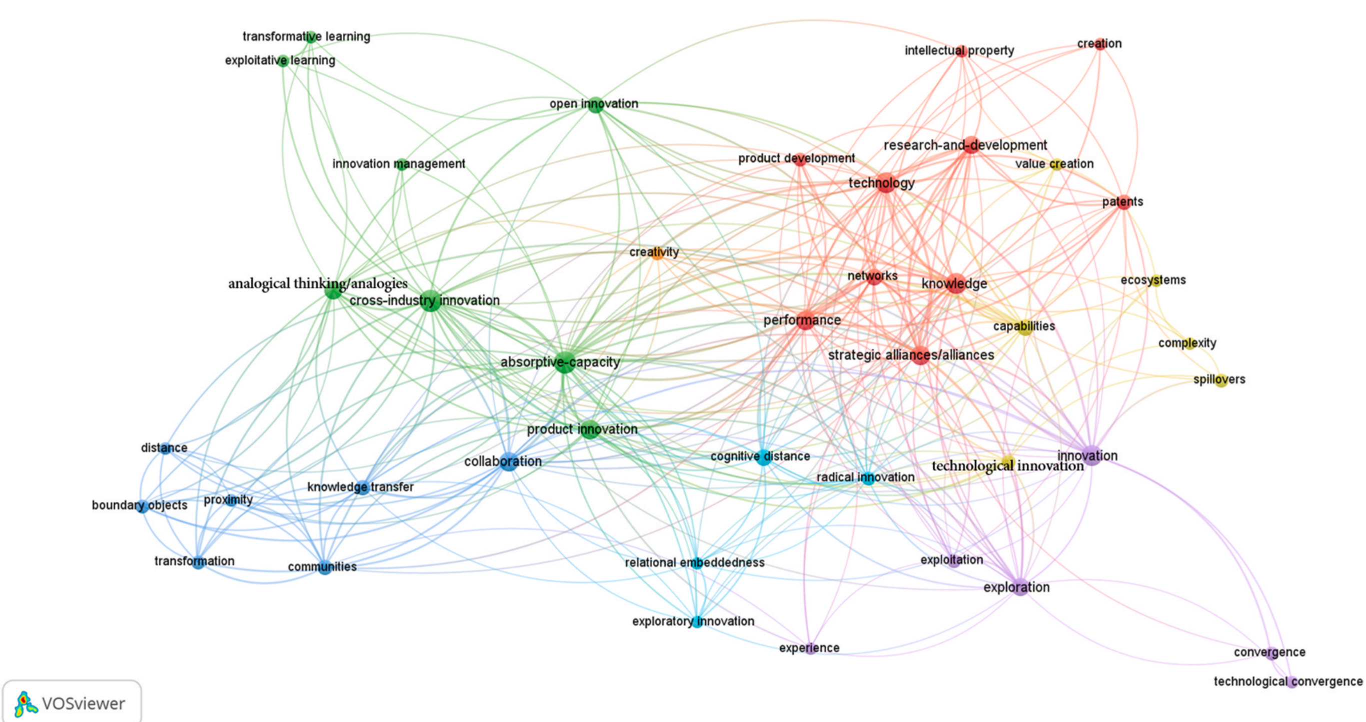

Fig. 4. Co-keywords network.

idea that CII has been connected to a broad variety of topics, leading to a dispersed literature. Moreover, some articles addressing this phenomenon do not explicitly use the term "cross-industry innovation". For example, it does not appear in most of the articles related to (industry) convergence (e.g., Bröring et al., 2006; Hacklin et al., 2010), spillovers (e.g. Lee et al., 2016; Galvin et al., 2020) or other different topics (e.g.,

Table 6
Definitions of cross-industry innovation in the academic literature.

Enkel and Gassmann (2010)	"In cross-industry innovation, already existing solutions from other industries are creatively imitated and retranslated to meet the needs of the company's current market or products. Such solutions can be technologies, patents, specific knowledge, capabilities, business processes, general principles, or whole business models" (p. 256)
Gassmann et al. (2010)	"We refer to the process of exploring and adapting the established technologies of one industry to develop innovative products in another as 'cross-industry innovation'" (p. 640)
Bader (2013)	"Cross-industry innovation defines the ways a firm incorporates external, analogous knowledge across industry boundaries and in what way the firm integrates this more or less distant knowledge within its own innovation processes (Gassmann and Zeschky, 2008; Gassmann et al., 2010)" (p. 1340018-2)
Enkel and Mezger (2013)	"In the field of innovation management, cross-industry analogies represent the creative imitation and adaption of already existing technologies, knowledge, processes or general principles from a source industry to a target industry in order to solve a specific problem (Enkel and Gassmann, 2010; Herstatt and Kalogerakis, 2005)" (p. 1340005-5)
Enkel and Heil (2014)	"the concept of cross-industry innovation … the application of established knowledge or technologies of partners from outside a firm's own value chain (Enkel and Gassmann, 2010; Gassmann et al., 2010; Herstatt and Kalogerakis, 2005)" (p. 243)
	"cross-industry innovation is based on the approach of analogical thinking as an important source of innovation through transfer of an application in one industry to an application in a different industry (Enkel and Gassmann, 2010; Gassmann et al., 2010; Brunswicker and Hutschek, 2010)" (p. 243)
Horváth and Enkel (2014)	"Cross-industry innovation is a specific framework (Brunswicker and Hutschek, 2010) under the open innovation umbrella for accessing external sources from outside a firm's own value chain. It focuses on transferring knowledge from a foreign industry to a firm's own context in order to solve creative problem-solving tasks and to develop innovations" (p. 409)
	"Cross-industry innovation as one framework within the scope of open innovation (Brunswicker and Hutschek, 2010) builds on the creative imitation and retranslation of already existing technologies, knowledge, systems, concepts and general principles developed in foreign industries to own requirements (Herstatt and Engel, 2006; Enkel and Gassmann, 2010). The specificity of cross industry innovation lies in the decisive access of foreign industry knowledge in comparison to working with externals from the same value chain such as customers or suppliers (e.g., Sobrero and Roberts, 2002; Brockhoff, 2003)" (p. 410)
Dingler and Enkel (2016)	"Cross-industry innovation is founded in the imitation, adaption or reuse of already existing solutions from other industries in order to face challenges or fulfill the needs of the organization (Enkel and Gassmann 2010)" (p. 51)
Hauge et al. (2017)	"… cross-industry innovation – the process where "… existing solutions from other industries are creatively imitated and retranslated to meet the need of the company's current market or products" (Enkel and Gassmann, 2010, p. 256, p. 256)" (p. 388)
Lyng and Brun (2020b)	"The concept of cross-industry innovation (CII), which includes the application of knowledge and technologies stemming from organizations outside the firm's own value chain" (pp. 2050050-1, 2050050-2)
Behne et al. (2021)	"Cross-industry innovation (CII) aims to reuse existing solutions by leveraging the innovation power of partners' knowledge from another industry" (p. 2150011-1)
	"… cross-industry innovation (CII) – the transfer of innovative solutions from one industry to another (p. 2150011-2)"
	"The aim of CII is the transfer of innovative solutions from one industry to another. Solutions range from technologies and complementary knowledge to business processes and models (p. 2150011-5)"
Lyng and Brun (2022)	"Cross-industry innovation (CII) is a type of innovation seeking to re-use and recombine knowledge across distant knowledge domains (p. 2150046-2)"
	"In CII, actors in one industry sector adopt and apply knowledge from another industry sector (p. 2150046-7)"

Fung, 2002; Belderbos et al., 2014). This scattering of the literature highlights the need to carry out a systematic literature review on CII.

4. Content analysis

4.1. Conceptualization and types of cross-industry innovation

4.1.1. Analyzing definitions of cross-industry innovation

Table 6 shows 16 definitions of CII provided in 11 academic articles. The first definition is given by Enkel and Gassmann (2010), which has been literally cited (e.g., Hauge et al., 2017) or adapted (e.g., Dingler and Enkel, 2016) by several authors.

A content analysis of these 16 definitions of CII identified 11 attributes, themes or components: term for the concept, action, type of object, moment of the object development, features of the object, source, target, aim, theoretical framework, CII as a process, and CII as a type of innovation (see Table A2 in Appendix). The categories of each attribute cannot be mutually exclusive.

All the definitions used the term "cross-industry innovation" or its abbreviation "CII", except that given by Enkel and Mezger (2013), who refer to it as "cross-industry analogies". Although we have added the term "inter-industry innovation" to the search query, it only appears in Hacklin et al. (2010) and Karvonen and Kässi (2013); however, the authors do not provide any explicit definition of this term. "Creatively imitated/creative imitation" and "transfer" are the most frequent actions in CII definitions. It should be noticed that the most frequent object is "knowledge", present in eleven definitions, rather than "existing solutions". In relation to the features of the object, it is important to stand out the observation by Enkel and Gassmann (2010), who stated that knowledge must be specific. In the case of source, definitions mention one or more foreign industries as the source. Three definitions refer to "outside the firm's own value chain", and one to "across industry boundaries". Lyng and Brun (2022) used the expression "across distant knowledge domains". However, in the same article they clarified that this means "industry sector" domain. Three definitions specified that the source refers to partners or organizations belonging to another industry, rather than the foreign industries as a whole. Although seven definitions used the singular, it is important to underline that more than one industry can serve as a source, especially in the case of coupled CII. For "target", most definitions refer to only one industry as the target. Nevertheless, a definition to cover all the types of CII, especially in the case of outbound CII, should consider multiple industries as target. Moreover, only six definitions mention particular entities in the industry (a company, a firm, an organization or actors), which, in our opinion, should be included in the definition rather than industry in general. Curiously, only half of the reviewed definitions contain the aim of CII. In addition, both definitions by Horváth and Enkel (2014) put CII within the theoretical framework of "open innovation", two articles (Gassmann et al., 2010; Hauge et al., 2017) explicitly say that CII is a process, and for Lyng and Brun (2022) CII is a type of innovation. We take into account these aspects in the definition we propose later.

4.1.2. Distinguishing cross-industry innovation from other innovation-related concepts

Whereas CII can be seen as equivalent to the term "inter-industry innovation" (Hacklin et al., 2010; Karvonen and Kässi, 2013), it is advisable to differentiate it from other overlapping terms of innovation to better delimitate the concept of CII.

Firstly, CII must be distinguished from recombinant or recombinative innovation. According to the economic literature, "recombinant innovation" is the way in which old ideas can be reconfigured into new ways to generate new ideas (Weitzman, 1998; Zhang et al., 2019). Similarly, “recombinative innovation”, a source of innovation, has been described as the outcome of a recombination of existing knowledge elements or novel knowledge elements (Keupp and Gassmann, 2013; Guan and Yan, 2016). In both cases, the combination of ideas or knowledge can take place internally (using only existing ideas or knowledge within the firm) or externally (using ideas or knowledge from outside the firm). However, “externally” could also mean *within* the industry (e.g., competitors, providers or customers as external sources of knowledge). CII specifically implies the adaption of ideas or knowledge coming from outside the firm’s industry boundaries. Therefore, scholars interpret that CII is a more restricted concept than recombinant or recombinative innovation.

Secondly, CII is discussed within open innovation (Brunswicker and Hutschek, 2010), considered a specific framework under the open innovation umbrella or within the scope of open innovation (Horváth and Enkel, 2014), allocated in the field of open innovation (Enkel and Heil, 2014, p. 253), or seen as part of open innovation (Behne et al., 2021). As was explained by Horváth and Enkel (2014, p. 410), “the specificity of cross-industry innovation lies in the decisive access of foreign industry knowledge in comparison to working with externals from the same value chain, such as customers or suppliers”.

Thirdly, CII is different from “innovation ecosystem”, a context favoring open innovation, defined as “various types of actors that collaborate to jointly create value for customers and they capture part of that value in terms of revenues and profits” (Yaghmaie and Vanhaverbeke, 2019, p. 294). Although innovation ecosystems can play a role in CII, they do not rule out actors in the same industry (Amitrano et al., 2017; Granstrand and Holgersson, 2020). For the same reason, CII also differs from the concept of “cross-fertilization”, i.e., the transfer of ideas from one sector to another to develop innovations, since this concept does not exclude competitors, suppliers or customers in the same industry (Rhéaume and Tremblay, 2017).

Fourthly, outbound CII should not be confused with “exaptive innovation”, which is understood as the “process by which technologies developed for one purpose are repurposed for an entirely different role” (Galvin et al., 2020, p. 2). In other words, it is the discovery of unexpected solutions in existing artifacts to completely different problems (e.g., microwave), and thus exaptation is related to serendipity (Andriani et al., 2017). However, CII does not happen by chance, as it requires structured searches to find relevant analogies (Herstatt and Kalogerakis, 2005; Lyng and Brun, 2022).

Finally, CII is also related to “industry convergence”, which is defined as “the blurring of boundaries between industries due to converging value propositions, technologies and markets” (Bröring et al., 2006, p. 488). ICT (Hacklin et al., 2010) or nutraceuticals and functional foods (Bröring et al., 2006) are examples of industry convergence. Following a sequential perspective, Hacklin et al. (2010) distinguish four stages in the industry convergence process: *knowledge convergence*, *technological convergence*, *applicational convergence* and *industrial convergence*. Later, another sequential process was proposed, which includes *science convergence*, *technology convergence*, *market convergence* and *industry convergence* (Golembiewski et al., 2015). The first stage is related to interdisciplinary research, and, in the last stage, a new industry has already emerged. Therefore, CII can arise in the stages of technological convergence and applicational or market convergence. In the process of industry convergence, the three types of CII can take place in the front end of the innovation (Bröring et al., 2006). However, both concepts are different, since CII does not necessarily mean a process of industry convergence, but it can occur occasionally.

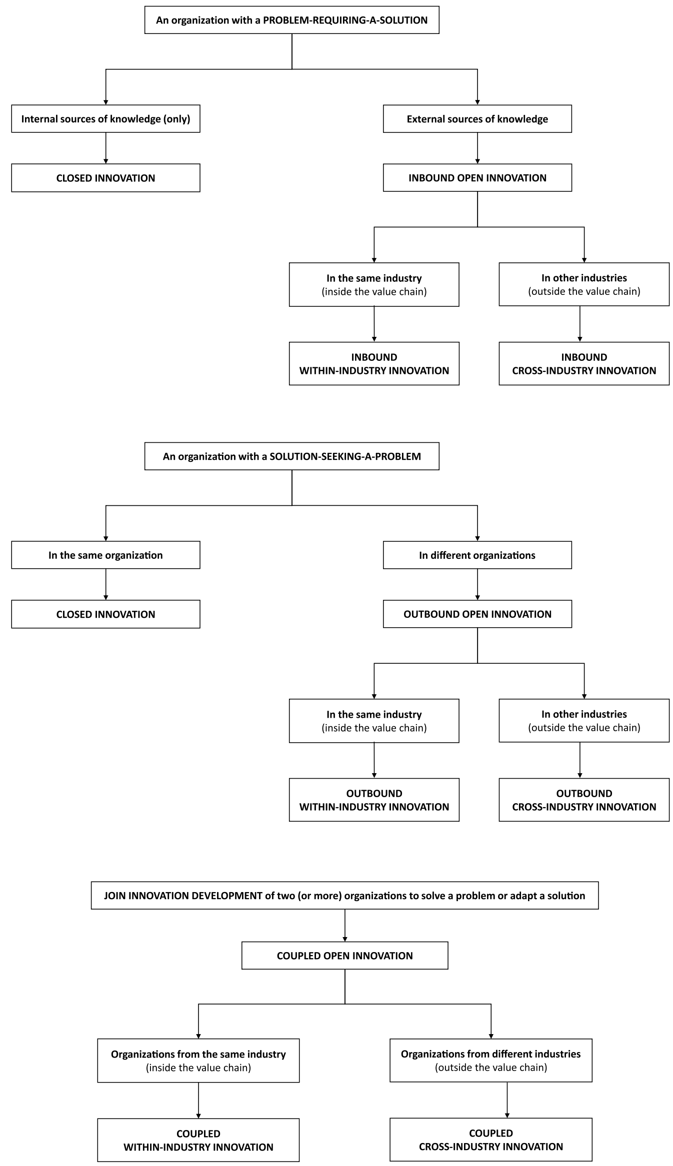

Fig. 5. Types of CII as specific cases of OI.

4.1.3. *A new definition of cross-industry innovation*

Based on the content analysis of literature review (Table A2 in Appendix), we propose the following definition of CII:

CII is a particular type of open innovation characterized by a deliberate process consisting in the creative imitation, retranslation or transfer of specific knowledge, established technologies, existing solutions or business models from some (source) industries to solve problems, to innovate or meet the needs of organizations or end users in other (target) industries.

Indeed, this particular type of OI (Horváth and Enkel, 2014; Lyng and Brun, 2022) does not happen by chance and requires a deliberate process (Gassmann et al., 2010; Herstatt and Kalogerakis, 2005) that involves the adaption of existing solutions to other industries, requiring some degree of creativity, going beyond a simple imitation. “Retranslation” usually follows “creative imitation” in the definitions of CII. Apart from “existing solutions”, we wanted to highlight “specific knowledge”, “technologies” and “business models”, given their relevance. We also consider that patents, capabilities, business processes, systems, concepts and general principles (mentioned by Enkel and Gassmann, 2010; Behne et al., 2021) are some kind of “specific knowledge”. Although the use of analogies to transfer solutions across industries is the most researched process for CII, we do not incorporate it in our definition to avoid ruling out other possibilities. We used the plural for industry (i.e., industries) in order to take into account all three types of CII. Finally, we take into account that CII can also be useful for end users.

4.1.4. Types of cross-industry innovation

Regarding the different types of CII, the distinction is based on two possible forms of analogies: problem in one industry requiring a solution from another industry, and solution-seeking-a-problem in other industries (Gassmann and Zeschky, 2008; Gavetti et al., 2005). As a result, three types of CII can be identified, which, in turn, correspond to the three core process archetypes in open innovation: outside-in processes, inside-in processes, and coupled processes (Gassmann and Enkel, 2004; Enkel et al., 2009). Indeed, the three types or approaches of CII are (Dingler and Enkel, 2016; Behne et al., 2021): *outside-in-process* or *solution-oriented approach* (internalizing knowledge from foreign industries), *inside-out-process* or *market-oriented approach* (externalizing knowledge to foreign industries), and *coupled-process* or *combined approach* (developing new knowledge with partners from different industries). We called them: inbound CII, outbound CII and coupled CII, respectively.

Inbound CII takes place when an organization in one industry (target) has a problem and searches for a solution in other industries with the same or similar problem (source) to reuse it. Outbound CII occurs when an organization in one industry (source) has a solution for a problem and seeks potential users or customers outside the industry with the same or similar problem (target) to offer it. Lastly, coupled CII happens when organizations from different industries (target and/or source) jointly innovate to solve a problem or adapt a solution. Fig. 5 depicts these three types of CII, which are part of open innovation, but different from within-industry innovation (inside the value chain).

Following the aforementioned typology of CII, we classify the articles included in our literature review according to it. A total of 55.6% of the sample exclusively referred to inbound CII; 11.1% to coupled CII; and only one article (2.2%) analyzed exclusively outbound CII. There is a group of articles that analyzed several types of CII at the same time. In particular, 17.8% of the articles analyzed the three types of CII; 8.9% analyzed inbound and outbound CII; and only two articles (4.4%) analyzed outbound and coupled CII.

4.2. Main features of CII

4.2.1. Type of innovation

The Oslo Manual distinguishes four types of innovation: product, process, market, and organizational innovation (OECD, 2005), although not all of them have been studied for CII. We see that research is prevalent for the case of new product development (see Table A1 in Appendix). For example, among the case studies conducted by Kalogerakis et al. (2010), there is the development of a high-quality baby stroller where the disc brakes from mountain biking and the single wheel suspension from vehicle construction were transferred to the baby gear sector. Lyng and Brun (2020a, 2020b) explained 11 and 4 case studies, respectively, that had made use of cross-industry collaborations in order to develop their respective innovations within medical technology, such as products for maintenance treatment of dental implants, or a software for the treatment of elderly people with dementia and chronic diseases. However, the distinction between service and good innovations is not specifically analyzed in the literature of CII, with some exceptions that mention both of them (Poetz and Prügl, 2010; Rhéaumen and Tremblay, 2017).

In addition, most of the analyzed articles demonstrate that companies transfer innovative solutions from other industries in the front-end of the product innovation processes, thus product or process technologies are used in the new product development process (e.g., Behne et al., 2021; Ciliberti et al., 2016; Enkel et al., 2018; Galvin et al., 2020). This means that the goal of the companies is to introduce a new product in the market, but the collaboration could be based on either product or process innovations. Despite the fact that most research does not focus on the distinction between product and process innovation in CII, Ciliberti et al. (2016) evidenced that there are differences on how companies benefit from different external knowledge sources according to the type of innovation. In particular, they concluded that knowledge from suppliers fosters the potential of process innovation, whereas knowledge from customers is relevant for product innovation.

A new tendency in CII is business model innovation (i.e., Enkel and Gassmann, 2010; Bader, 2013; Enkel and Mezger, 2013; Rhéaumen and Tremblay, 2017), although this research is still limited. For example, Enkel and Gassmann (2010) examined 25 cross-industry cases to ascertain the influence of cognitive distance on innovation performance. From those cases, 23 cases referred to product innovations and only two cases referred to business model innovation, although there was no distinction in the analysis between these two categories of innovation. In a similar way, Bader (2013) and Rhéaumen and Tremblay (2017) considered product, process and business model innovations, but their analyses were also general. There is currently only little insight into how CII can be applied to business model innovation efforts of companies. The study of Enkel and Mezger (2013) is an exception, since they explained nine case studies of firms that introduced breakthrough business models by transferring and adapting characteristic business model components of other industries.

4.2.2. Industries

Knowledge differences play a key role in a firm's innovation performance, which might come from different resources, with CII standing out (Li and Vanhaverbeke, 2009). Moreover, understanding the path of knowledge flows between industries is relevant to comprehend the processes of knowledge and innovation diffusion (Semitiel-García and Noguera-Méndez, 2012). The literature review reveals a huge cross-fertilization of ideas, where source and target industries are varied.

To better observe the relationships between source and target industries and the path for inter-industrial diffusion, we have built a network graph to visualize the connections among the different industries based on NACE-codes (see Figure A1 in Appendix), which has been proved to be a satisfactory proxy for knowledge relatedness between firms (Li and Vanhaverbeke, 2009). We used the UCINET 6 software package to build it, since UCINET pays special attention to the graphical representation of networks (Borgatti et al., 2002). In particular, we extracted the industry data from our sample of literature review, distinguishing between source and target industries. Then, we codified the industries according to the two-digit level NACE industry. For those cases in which the CII relationship was not visible at the two-digit level, we disintegrated it to the three- and four-digit level. The data were then aggregated to the industry level and specified by an asymmetric adjacency matrix representing industry relations. The matrix contains zeros and values equal to or greater than one, indicating the presence or absence and strength of a relationship (Borgatti et al., 2002). From that matrix, we created the network graph. Note that not all the articles from our sample could be included to build this network graph, since 15 of the papers tackle CII in a general way, without specifying the source industry, the target industry or both of them, thus we excluded them. Therefore, the network graph was created using a sample of 30 articles, and it had 68 industries (58 source industries and 41 target industries). Figure A1 in Appendix illustrates the network graph, which represents the network as a series of nodes that denote industries connected by arrows, indicating the presence and strength of a relationship. The size of the nodes represents the total times that the industry has been used in the literature review as either source or target industry, while the arrows, reflecting the direction of the CII, are thicker depending on the number of times the relationship occurs. Red arrows are unidirectional (from source to target), while blue arrows are bidirectional. For example, electronic industry knowledge has been used in the chemical industry but not vice-versa, while chemical industry knowledge has been used in the textile industry and vice-versa.

The network graph reveals some interesting points. Firstly, the most mentioned source industries include the automotive industry, metal products, telecommunications, chemicals, and petroleum, and the most mentioned target industries are general machinery and equipment, the automotive industry, chemicals, medical services, electronics, medical equipment, electricity and gas, and lifting equipment (see Table A1 in Appendix). Note that industries can be classified as both source and target industry, as we can see, for example, in the case of the automotive industry and chemicals industry. In general, scholars tend to use samples from well-established companies from various industries (Enkel and Gassmann, 2010; Poetz and Prügl, 2010) or in populations where one could expect high levels of expertise concerning the use of analogies (Kalogerakis et al., 2010), which could assure a knowledge exchange among industries, fostering the cross-innovation processes.

Secondly, companies from the same target industry could search for knowledge in different source industries. For example, the automotive industry, as a target industry, uses, as source industries, telecommunications (Enkel and Mezger, 2013), lifting equipment (Poetz and Prügl, 2010), and medical services (Brunswicker and Hutschek, 2010), among others. The same happens for other industries, such as medical equipment, where source industries are varied, such as electronics (Hargadon and Sutton, 1997), aircraft (Hargadon and Sutton, 1997), boats (Kalogerakis et al., 2010), and food (Enkel and Heil, 2014), among others, or medical services, where source industries are also varied, such as petroleum (Lyng and Brun, 2018, 2020a, 2020b), electronics (Lyng and Brun, 2020a; Phillips et al., 2017), and scientific R&D (Lyng and Brun, 2020a; Phillips et al., 2017), among others.

Thirdly, in a similar way, knowledge from companies of a particular source industry could have applications in several target industries. It is the case, for instance, of the automotive sector, which is used as a source industry for general machinery and equipment (Dingler and Enkel, 2016; Enkel et al., 2018), aircraft (Enkel and Gassmann, 2010; Kalogerakis et al., 2010), sports goods (Enkel and Gassmann, 2010), and construction (Enkel and Mezger, 2013), among others.

4.2.3. Actors

Industries can be distinguished by different factors, such as their actors and knowledge sources, implying a distinct industry-specific innovation system (Bröring et al., 2006). Innovating firms are increasingly generating new knowledge in collaboration with different organizational actors (Li and Vanhaverbeke, 2009). However, the analysis of the types of actors does not seem to have directly attracted the attention of the mainstream of CII literature, or it has been referred to in a general way when describing the case studies, with some exceptions. On this basis, to analyze the different actors that lead the CII process, we need to look at the search strategy that organizations use to search for distant knowledge. For example, it could be described as a broadcast search through the use of databases, the Internet or fairs (Bader, 2013; Enkel and Heil, 2014; Herstatt and Kalogerakis, 2005), or through a direct search for a specific company (Brunswicker and Hutschek, 2010; Enkel and Mezger, 2013; Horváth and Enkel, 2014). In both cases, the role of founders, managers and employees is crucial, since they are in charge of the search for external knowledge according to their own experience and criteria. Bilateral relationships or individual collaborations also emerge in networks composed by firms and other external stakeholders, such as universities or research centers, where the role of project managers is crucial for the development of CII (Lyng and Brun, 2020a, 2020b, 2022). One particular case of networks is business groups (Lee et al., 2016; Zhang and Cantwell, 2011), where the cross-fertilization of ideas can be encouraged by different actors, such as R&D employees, or firms in the upstream and downstream value chain (Lee et al., 2016).

Among the actors in the CII process, the most prevalent is the case of the intermediaries, since some companies trust third parties, such as 'brokers' or consultants, for the search of technologies and solutions (Hargadon and Sutton, 1997; Kalogerakis et al., 2010). On this basis, Gassmann et al. (2011) examined how intermediaries support companies in their innovative activities, bridging the gaps between different industries, and they concluded that there are three different types of intermediaries: the *innovation broadener*, who is able to realize an innovative idea from a very distant context; the *innovation leverager*, who acts within a narrower technological field of expertise but can lead innovation projects further into the adaption phase; and the *innovation multiplier*, who relies on their customers to identify analogies from another industrial ambit.

Moreover, we can also observe the role of lead users (Poetz and Prügl, 2010; Choi and Lee, 2015; Streb, 2003) and experts (Brunswicker and Hutschek, 2010; Enkel and Bader, 2016), who have proved to be a strong source of innovative ideas for CII. For example, Enkel and Bader (2016) show that (external) experts' intention to participate in CII is strongly related to their actual participation, which is explained by the attitude towards CII and the perceived behavioral control regarding CII.

Furthermore, other authors have emphasized the role of suppliers in very different industries as collaborators in the innovation process to provide access to new or complementary knowledge and recombine them into innovations (Golembiewski et al., 2015; Li and Vanhaverbeke, 2009; Phillips et al., 2017; Schmidt, 2010; Streb, 2003). Lastly, the work by Gassmann et al. (2010) broke up with the traditional strategic alliance literature, which has studied partners' complementary resources in vertical R&D alliances, and they examined how a cross-industry alliance with a 'non-supplier' could successfully develop a breakthrough innovation.

4.3. Process of cross-industry innovation

In the OI literature, the interest in the process had been mainly oriented to analyze both the transition from a closed to an open model of innovation, and the stages in OI (the 'how to do it' question) (Huizingh, 2011). For instance, regarding the first issue, Chiaroni et al. (2011) focus on the process of implementing OI, as a deep organizational change. Regarding the second issue, the studies of Fetterhoff and Voelkel (2006) and Wallin and von Krogh (2010) propose stages of the OI process. Fetterhoff and Voelkel (2006), with a clear practical orientation, describes the process followed by Roche Diagnostics, whereas Wallin and von Krogh (2010) focuses on managing knowledge integration. Overall, to our knowledge, very few studies address the OI process.

As a specific case of OI, the literature on CII seems to have overlooked the first question (from a closed to an open model) and focused on the second one, that is, 'how to do' the systematic process that helps firms to explore and adapt solutions of different industries to develop their own innovations. Thus, the literature on CII describes processes of innovation that are 'open' by definition, although incorporating specificities coming from their cross-industry nature (e.g., the use of analogical thinking). These specificities and challenges involved seem to have encouraged researchers to analyze the process of this specific case of OI in greater depth, giving rise to a rich stream of research, which is described below.

The way in which CII research contemplates the process has been mainly determined by the theoretical approaches adopted in the studies. In this sense, analogical thinking and knowledge and learning approaches may be considered the prevalent ones. Moreover, particular aspects in the process of CII could also vary depending on the degree of novelty (radical, breakthrough, incremental), the different types of innovation (product, service, process, or business model) and different types of CII (inbound, outbound, and coupled).

4.3.1. Analogical thinking for explaining the process of CII

Most attempts to explain how the process of CII takes place are based on analogical thinking. Analogies, coming from cognitive psychology, refer to a "cognitive mechanism to retrieve existing knowledge and apply this knowledge to new problems" (Herstatt and Kalogerakis, 2005, p. 332).

To our knowledge, the process of analogies in innovation projects was firstly addressed by Herstatt and Kalogerakis (2005), focusing on

Table 7
Analogical thinking for explaining the process of CII

Based on Herstatt and Kalogerakis (2005), Gassmann and Zeschky (2008); Gassmann et al. (2011); Behne et al. (2021)	Brunswicker and Hutschek (2010) (Integrating the market perspective)	Enkel and Mezger (2013) (Application for Business Model Innovation)
0) Strategic intent: ensure and encourage an open mindset in the organization		
1) Abstraction and problem definition. Analysis and reduction of the problem to its structural issues and functions (technical perspective) and its related customer benefits (contextual perspective); formulation of the requirements for an appropriate solution.	**1) Source selection:**selection of the search field and the target selection. Five steps: • Market trend analysis • Competency analysis Abstraction • Domain selection • Source selection	**1) Abstraction.** Supports the recognition of commercial opportunities and threats and defines intended value proposition for new business models. Mainly supported by exploitative learning processes.
2) Search for analogies (both surface and structural similarities) Use of a number of techniques such as brainstorming sessions, networking and searching in databases. Benefits of using Technology Intelligence (TI), given its capacity to scan, monitor and scout technologies from other industries that are not yet used in one's own industry.		**2) Analogy search and assessment.** Connection of the (abstract) customer problem with a potential solution from another industry; understanding and assessment of the source industry's business model. Mainly supported by transformative learning processes.
3) Verification and evaluation of analogies. Accurate understanding of the analogous solution, identification of its relevant functions and structures, evaluation of what knowledge is valuable and subject to transfer. Crucial role of TI by supporting the decisions, regarding the development, the introduction and the use of a certain technology.	**2) Ideation phase:** conceived for generating ideas. Five steps: • System analysis • Functional analysis • Idea generation • Assessment • Exploitation preparation	
4) Adaptation and integration. Transfer and adaptation of the relevant knowledge.		**3) Adaptation.** Imitation of those specific components of the source business model that are required to implement the new, intended value proposition. Mainly supported by exploitative learning processes.

how analogies can be systematically used in breakthrough innovations. Their proposal, consisting in a process of three phases (problem definition, search for analogies and verification and evaluation of analogies) has become a common starting point for further studies addressing CII processes from the perspective of analogical thinking. Gassmann and Zeschky (2008) analyzed the role of analogical thinking in radical innovation across industries and proposed a similar, though longer process, adding a preliminary stage (strategic intent) and a last stage (adaptation). A subsequent work of Gassmann et al. (2011), focusing on the role of intermediaries in CII, provides a simplified version of the process of analogical thinking in CII (abstraction, analogy and adaptation). Also strongly influenced by the proposals of Herstatt and Kalogerakis (2005) and Gassmann and Zeschky (2008), Behne et al. (2021) set out a structured procedure to be used for product and process innovations in both SMEs and large companies. Mainly focusing on radical innovation, they proposed a process divided into four phases: 1) target definition; 2) search for potential technologies; 3) assessment and decision of a solution; and 4) adaption and integration into one's own company.

Brunswicker and Hutschek (2010) extended and developed the framework proposed by Gassmann and Zeschky (2008) by integrating the market perspective, without focusing on a particular type of innovation (regarding the degree of radicalness). In their proposal, both market trends and future market requirements are the starting point for CII. Their two-staged CII process includes two major phases: source selection (implying the selection of the search field and the target selection) and ideation (conceived for generating and evaluating ideas).

The analogical thinking approach has allowed explaining the process of CII not only for the case of new product development, but also for business model innovation. Enkel and Mezger (2013) combined the framework proposed by Herstatt and Kalogerakis (2005) and Gassmann and Zeschky (2008) (abstraction, analogy identification, adaptation) with the process of business model innovation (recognition of an opportunity or threat, design and implementation), and analyzed how it takes place in nine firms radically innovating in their business models. The study also considers how different learning processes (explorative, exploitative and transformative) are relevant in specific stages of the process of CII.

Some specificities of analogical thinking applied to business model innovation (in comparison with NPD) can be drawn from Enkel and Mezger's research. Overall, interaction between the source and target industries is not always required. Furthermore, although the analyzed firms did not follow an explicit analogical reasoning process, core steps were implicitly applied, adapting them to the nature of this type of innovation. Firstly, abstraction problem is not based on a technological need but on a desired future value proposition (value created for customers). Secondly, analogy identification (search and evaluation) is scarcely applied in a deliberate way. Moreover, the search breadth and the intensity of the evaluation depend on the intended use of the analogy. Lastly, regarding adaptation, an entire business model is not transferred from source to target industry; instead, firms imitate and adapt only those specific components of the source business model that contribute to implementing their intended value proposition.

In sum, analogical thinking has represented a very fruitful approach to analyze the process of CII, mainly for breakthrough innovation. Indeed, analogies have proved to play an important role in innovation projects (Kalogerakis et al., 2010). Furthermore, in the field of innovation, numerous examples of breakthrough innovations are the result of transferring a problem solution from one industry to another (Herstatt and Kalogerakis, 2005). Product innovation is predominant in those studies where the process of CII in business model innovation is only marginal. Moreover, studies based on analogical thinking seem to be mainly concerned with inbound CII, as they are focused on the perspective of the firm trying to "solve" a problem applying existing solutions in other industries.

Table 7 integrates and synthesizes the processes of CII based on analogical thinking.

4.3.2. Knowledge and learning approaches for explaining the process of CII

Knowledge and learning processes are closely connected to the analogical thinking approach and have already been implicitly or explicitly addressed in the works described in the previous section. Studies explained below provide an alternative view of the process taking place in CII by formally adopting knowledge and learning perspectives.

Based on the analysis of the firm, Enkel and Bader (2013) addressed how firms might systematically manage their organizational learning processes (explore, transform, exploit) across industry boundaries for creating radical innovations in product, process, service and business models. The case study describes how the firm scanned distant lead

Table 8
Knowledge and learning approaches for explaining the process of CII.

Based on Bader (2013); Lyng and Brun (2018); Lyng and Brun (2020b)	
1. Exploratory learning and knowledge discovery	Firms seek new knowledge and scan distant lead industries as a source of distant technological solutions.
2. Knowledge transit and assimilation.	Knowledge is transferred from source to destination. Actors in the target domain try to understand the new knowledge.
3. Transformative learning and knowledge integration	Actors in the target domain disseminate the new knowledge throughout the firm and combine it with their prior knowledge, resulting in a more valuable knowledge for their domain context.
4. Exploitative learning	New knowledge is used in the current projects. The discussion of new (cross-industry) concepts and technologies is promoted.

industries (explorative learning) and maintained and disseminated the newly gained knowledge throughout the firm (transformative and exploitative learning).

Lyng and Brun (2018) emphasized the process of knowledge transfer and proximity taking place across two highly distant industries (medicine and petroleum engineering). Their conceptual model of the process of CII is comprised of three stages (knowledge discovery, knowledge transit and knowledge integration), which are characterized by different degrees of proximity (cognitive, technological, geographical, organizational) among actors. In their subsequent work on the same industries, Lyng and Brun (2020b) adopted the absorptive capacity framework and highlighted that actors engaged in CII need to understand how to absorb knowledge from a source domain and how to apply it into a target domain. They proposed a model of knowledge adoption in CII divided into four steps (knowledge acquisition, knowledge assimilation, knowledge transformation and knowledge exploitation). The CII projects analyzed in these studies by Lyng and Brun mainly include product innovation that can be both radical and incremental. These projects aim to solve medical problems by using knowledge developed in the petroleum industry, which represents inbound CII. Moreover, as petroleum companies assume a proactive role developing technologies that may be useful for the medical industry, outbound CII is also present.

Summarizing, studies using knowledge and learning perspectives have been mainly concerned with explaining the process of CII for either radical or incremental product innovation. Some of them go beyond the study of the prevalent inbound CII, and describe some cases of outbound and coupled CII innovation.

Table 8 integrates and synthesizes the processes of CII based on knowledge and learning approaches.

Connections between the analogical thinking perspective and the knowledge and learning approach are easily observable. Searching for analogies clearly implies exploratory learning and knowledge discovery, while the adaptation and integration of analogies would require transformative and exploitative learning.

4.3.3. Other perspectives for explaining the process of CII

The last works highlighted in this section address the process of CII under the umbrella of other perspectives, which bring valuable insights about the decision making process involved in CII, its strategic dimension, and the relevant role played by specific actors.

In the context of industry convergence, Bröring et al. (2006) examined how organizations from different industries and history successfully engage in R&D projects requiring new technology and market competences. Convergence is viewed as a process similar to a decision-making process, comprising two stages: 1) awareness and idea generation, and 2) evaluation and selection. Analyzed firms follow different approaches of this front-end decision making, depending on how they overcome their limited absorptive capacity.

The research by Gassmann et al. (2010) was not explicitly aimed at proposing a systematic process of CII. Instead, from the perspective of R&D alliances, they analyzed how firms can reduce their dependence on their established suppliers, by engaging in inbound cross-industry collaborations to develop radical innovations. Regardless of their particular focus, they provide a detailed description of the process carried out in the BMW/Immersion alliance, as a typical case of cooperation across industries: automotive industry and software industry. Firstly, BMW identified the need for a new component whose technology was not available in its established networks of suppliers; secondly, the company searched for solutions in a different industry; thirdly, they obtained the required technology in the software industry; and, lastly, BMW established a contract with Immersion, with a list of requirements for reassuring the alignment of the new technology to BMW demands. The described process, without the vocation of being a systematic approach, is close to the analogical thinking perspective, as it implicitly entails problem definition, searching for analogies, assessment, and adaptation.

Choi and Lee (2015) emphasized the key role played by lead users in CII, by incorporating expert knowledge from other industries into the new product development process. They developed a four-step conceptual process, named “hetero expert innovation process”. In each stage, both the in-house team and the users assume specific responsibilities. In the first step (navigating for insights), the in-house team navigates cross-industries and select the one from which to seek insights. In the second step (excavating gemstones), the in-house team learns about the selected industry and identifies hetero experts. In the third step (inducing the Medici effect), the in-house team and the hetero experts work together to identify new ideas and concepts. In the last phase (shaping the product idea catalog), the in-house team, together with the potential users, build up and evaluate concepts. The process proposed was applied to a real product development case in the cosmetic industry, in which other distant industries where involved, describing a clear example of inbound CII.

4.4. Determinants of cross-industry innovation

CII, as open innovation, refers to a specific process of innovation applied to a particular type of innovation. Consequently, the direct or indirect determinants of CII correspond to those of the whole process of CII or any of its phases (explained above). Scholars have adopted several approaches to explain the antecedents of the CII process.

4.4.1. Drivers of analogical thinking in CII

There seems to be some agreement in that the identification and use of analogies for innovation is related to the access to broad and diverse knowledge in terms of different industries, technological domains, markets, business models, etc. (Hargadon and Sutton, 1997; Herstatt and Kalogerakis, 2005; Kalogerakis et al., 2010; Enkel and Mezger, 2013).

A number of organizational mechanisms and conditions has been proposed for facilitating CII, which can be divided into three sections.

4.4.1.1. Composition of the NPD, innovation or business development teams. Some authors have suggested widening the range and heterogeneity of the team’s knowledge base for improving the creative recombination by analogies (Kalogerakis et al., 2010). In this sense, researchers recommend fostering interdisciplinary teams within the organization with members from different functional areas or with different industrial and academic backgrounds, experiences or personal interests, avoiding narrow specialization of the employees by working in different industries and technical problems (Hargadon and Sutton, 1997; Kalogerakis et al., 2010; Enkel and Mezger, 2013). Behne et al. (2021) also observed that more analogies are found when workshop members possess different qualifications. However, it should be noted that the diversity or heterogeneity of knowledge bases (cognitive distance) of the development team has shown an inverted U-shaped relationship with innovation performance, which also affects CII (Enkel and Heil, 2014).

4.4.1.2. Internal organizational practices. Apart from the composition of NPD and innovation teams, some other internal brokering routines should be supported among employees within the organization (Hargadon and Sutton, 1997), such as: 1) establishing norms and cultivating a culture of sharing information or (disparate) knowledge; 2) using face-to-face and informal communication among separate groups to facilitate the transfer of tacit knowledge; 3) assigning knowledge brokers (generalists who are familiar with separated domains) to link expert groups (specialists); 4) encouraging frequent movement of employees across teams or working in different projects; 5) adapting motivation and incentive systems to reinforce the effective use of analogies; 6) training in analogical thinking (Herstatt and Kalogerakis, 2005; Hargadon and Sutton, 1997; Kalogerakis et al., 2010; Behne et al., 2021); and 7) the use of analogical mediating objects, linguistically or visually represented, in the early phases of CII (Lyng and Brun, 2022).

4.4.1.3. External organizational practices. In order to favor searching for knowledge outside the organization, the following organizational routines should be highlighted (Kalogerakis et al., 2010; Hargadon and Sutton, 1997; Behne et al., 2021): 1) hiring new employees with relevant knowledge lacking in the firm; 2) promoting contact or access to external sources of knowledge (e.g., other fields or industries), facilitated by knowledge management systems; 3) encouraging the systematic search for solutions in knowledge domains unknown by the NPD team; and 4) broadcasting the problem to be solved to experts from different industries and technology areas (e.g., InnoCentive.com can be a way to distribute problem information to communities of solvers).

4.4.2. Other factors affecting CII

Some studies have focused on variables that help to access external knowledge. Bader (2013) confirmed that *willingness to open up* positively influences organizational learning across industry boundaries (CII). Data from an employees' survey support the sequence willingness to open up-exploratory learning-transformative learning-exploitative learning-CII outcome.

Two articles examined adsorptive capacity (AC) as an antecedent of CII. Heil and Enkel (2015) showed that *inbound CII* is positively influenced by *potential AC*,[3] both directly and indirectly through deliberate *integration mechanisms*.[4] In the same vein, Enkel and Heil (2014) concluded that: "as expected, highly developed potential absorptive capacity allows a firm to pursue cross-industry innovation with external partners at high distance" (Enkel and Heil, 2014, p. 254). Curiously, Schmidt (2010) did not find R&D intensity to have a significant influence on absorptive capacity for inter-industry knowledge.

In relation to collaboration for CII, Dingler and Enkel (2016) argued that *socialization* has positive effects on innovation across industry boundaries (CII), as a mechanism that facilitates knowledge transfer between partners from different industries. Socialization refers to organizational practices/routines such as shared social experiences, common activities/spending time, personal interaction and physical proximity among the collaborating partners. It positively affects all three types of CII.

Several issues also emerged in other two studies (Lyng and Brun, 2020a, 2020b): 1) *legitimacy* (the actor's believe that their partner can fulfill their strategic self-interests); 2) *communication* (knowledge conveyance and convergence), which can be achieved through *retranslation*, a two-stage process in which the actors translate their partner's unfamiliar (epistemic) language into a language they understand, and then the actors translate this external knowledge into their own well-known (epistemic and contextual) language); 3) *use of knowledge brokers or external institutions as intermediaries* (being able to understand both parties and communicate across boundaries), also mentioned by other scholars (Herstatt and Kalogerakis, 2005; Gassmann et al., 2011; Lyng and Brun, 2020a); 4) *prior or previous cross-industry knowledge and experience*, which has also been pointed out by Hauge et al. (2017); and 5) *low level of interdependencies between the involved actors* (decomposition of complexity), observed by Lyng and Brun (2020a).

Hauge et al. (2017) proposed *cross-industry innovation capability (CIIC)* in firms as an important mechanism for cross-industry innovation. CIIC is defined by the authors as: "(1) the firm's ability to continuously transform knowledge and ideas from different industries into new products, processes and systems and/or (2) the ability to adapt existing products, processes and systems to new industries" (p. 390). They identified eight CIIC indicators, which represent practices and processes within the firm that stimulate and reinforce CII: 1) institutionalizing cross-industry innovation as part of a firm's strategy; 2) effective resource management combining different types of competences; 3) learning from different industries; 4) encouraging divergent 'across-border' thinking; 5) organic organizational structure, breaking down barriers and separating different functions and product groups; 6) open and tolerant culture; 7) management of related technologies; and 8) firm's history of cross-industry activities. In turn, regional conditions for innovation and learning, especially diversified vs specialized regions, are drivers of firms' CIIC.

Finally, Zhang et al. (2021), employing patent data from the mobile phone industry (targeted industry of entry), show a positive impact of *technology accumulation different from that of the targeted industry of entry* (T1) (pre-entry knowledge) on the *CII performance*[5] of the new entrants. Moreover, the impact of *the degree of difference between T1 and the targeted industry's technology* is curvilinear (a U-shaped relationship).

4.5. Consequences of cross-industry innovation

Three main consequences of CII can be extracted from the systematic literature review: the benefits associated with the innovation process followed by CII, the degree of innovation novelty resulting from CII, and other outcomes of CII.

4.5.1. Benefits associated with the innovation process followed by CII

Some benefits linked to a reduction in the innovation effort for CII have been highlighted in the academic literature, such as lower development time, cost and risk, or shorter project duration (e.g. Gassmann and Zeschky, 2008; Enkel and Mezger, 2013; Enkel and Heil, 2014; Horváth and Enkel, 2014; Dingler and Enkel, 2016; Behne et al., 2021).

Two survey studies empirically supported these benefits of CII. Heil and Enkel (2015) found that *inbound CII* consistently has the greatest positive effect on *CII performance*, which gauges the efficiency of CII with three items: reduced development cost, shorter development time and shorter project duration. Bader (2013) showed that *organizational learning across industry boundaries* (CII) has a positive impact on *CII outcome*, measured in terms of CII benefits. It assesses the average percentage of CII projects, resulting in reduced development costs, shorter project duration, and other outcomes (during the last three years).

Kalogerakis et al. (2010) provided some empirical evidence that the use of inventive analogies (CII) contributes to reducing the development

[3] "A firm's knowledge processing capability to recognize, assimilate, and maintain potentially valuable external knowledge from other industries" (Heil and Enkel, 2015, p. 1550048-6).

[4] "AC-related mechanisms regarding the development and adoption of distant knowledge from other industries (i.e., abstraction and search for analogical solutions, fostering diversity of existing knowledge bases, reward for exploration of distant knowledge)" (Heil and Enkel, 2015, p. 1550048-17).

[5] Number of forward (mobile phone) patent citations in the newly entered industry. In Zhang et al. (2021), CII performance is a measure of the degree of CII rather than a measure of the consequences of CII.

time (development cost) in the case of near analogies (same product category), as well as in three out of the 10 projects based on medium distance (another product category), where the source and target industries are different. However, in general, analogical distance is negatively related to the reduction of development time. According to the authors, a beneficial effect on project duration is only expected when existing technological solutions and specific functional principles (instead of general knowledge about shapes and design arrangements) are transferred.

Therefore, although some benefits (lower development time/duration, cost and risk) are expected in inbound CII, as it is based on existing solutions, these benefits are likely to be reduced as the cognitive distance between source and target industries increases.

4.5.2. Degree of innovation novelty resulting from CII

The effect of CII on the degree of newness of the generated innovation (often expressed as originality or solution novelty, or as technological or market breakthrough innovation, or radical innovation) is one of its most mentioned consequences (e.g., Herstatt and Kalogerakis, 2005; Poetz and Prügl, 2010; Bader, 2013; Enkel and Mezger, 2013; Dingler and Enkel, 2016; Lyng and Brun, 2020b; Behne et al., 2021). The innovation novelty coming from CII is also present in business models (Enkel and Mezger, 2013).

Some seminal works on analogical thinking in CII have also demonstrated this effect. Dahl and Moreau (2002) revealed that the use of analogies (CII) positively affected the originality of new product designs. Gassmann and Zeschky (2008) reported that, out of the four projects applying analogical thinking, one was radical and three were technological breakthrough. In an analogical thinking study, Kalogerakis et al. (2010) found that all the cases, except two, with source and target from different industries (CII), generated radical innovations.

Other studies on CII further support its relationship with innovation novelty. The case study of Enkel and Gassmann (2010) analyzed 25 CII cases with a large variety of source and target industries. Seven cases were categorized as radical innovation, 13 as technological breakthrough, and five as market breakthrough. Horváth and Enkel (2014), in their multi case study with eight cross-industry projects, found that six of them were radical. Enkel and Heil (2014) also related CII with exploratory (radical) innovation. Datta and Jessup (2013) showed that low levels of breadth of CII and high levels of technology distinctness have a stronger relationship with radicalness. Lastly, Li and Vanhaverbeke (2009) revealed that inbound CII at the firm level had a positive effect on the likelihood of generating pioneering innovation.

To sum up, there is enough empirical evidence for the relationship between CII and the newness of the resulting innovation.

4.5.3. Other consequences of CII

There are other consequences of CII related to a number of outcomes, which have received less attention from researchers.

The effect of CII has also been observed on the perceived value of the new product design (Dahl and Moreau, 2002), on a better serving of existing customer needs, on the access to new customers and markets (items used by Bader, 2013; Heil and Enkel, 2015), and on the development of new business models (item used by Heil and Enkel, 2015). Behne et al. (2021) also refer to knowledge development and increased innovative power.

Several articles based on patents found positive effects of inbound CII on firm's sales per employee (Lee et al., 2016) and on research outputs (Fung, 2002). However, Filiou and Massini (2018) confirmed an inverted U-shaped relationship for the effect of inter-industry alliances or CII (inbound) on firm innovation performance.

Belderbos et al. (2014), at the patent level, revealed that co-patenting with inter-industry partners (coupled CII) increased technological performance (the number of forward citations). At the firm level, it had a positive, but marginally significant effect on financial performance. Finally, Zhang and Cantwell (2011) showed that inter-industry conglomerates facilitated innovation through combinations of knowledge across different industries (coupled CII) or novel applications of knowledge in another industry (outbound CII). Japanese firms strongly linked to these conglomerates experienced a growth of total patenting.

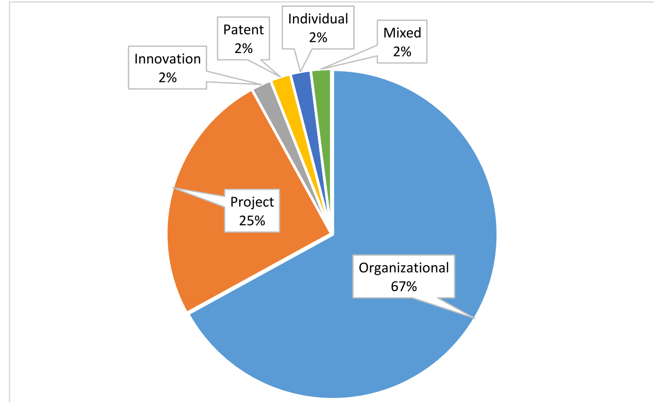

Fig. 6. Unit of analysis from the sample of studies.

4.6. Methodological trends in the research on CII

In order to determine the main methodological trends that were carried out in the research on CII, we analyzed the methods that have been used by previous studies. In this way, we can conclude how the concept of CII is evolving in the existing literature and identify potential methodological improvements and the possible implications for this field of study.

One out of the 45 articles is a theoretical study that does not contain methodological aspects (Herstatt and Kalogerakis, 2005). Therefore, the sample for this part consists of 44 articles (see Table A1 in Appendix for further information).

4.6.1. Unit of analysis

Regarding the unit of analysis (Fig. 6), the sample of our content analysis was divided into 29 articles at the organizational level, 11 at the project level, one at the level of innovation, one at the level of patents, one at the individual level and another study combining the project and organizational levels. At the level of innovation, Galvin et al. (2020) analyzed 98 innovations resulting from DIY laboratories in the bicycle industry, emphasizing the role these labs may play in the creation of CII. At the level of patents, Golembiewski et al. (2015) studied 5333 patent documents and explained the convergence (co-creation) process of bioeconomy. At the individual level, Enkel and Bader (2016) interviewed 35 scientists during innovation workshops to find out motivational factors for their individual participation in and contribution to CII. Studies using either the organization level or the project level share many similarities, especially those studies that applied multiple case study to explain the phenomena of CII, although they also have some differences. For example, the studies of Lyng and Brun (2018, 2020a, 2020b, 2022) addressed only one association (*Pumps and Pipes*), but they examined the knowledge transfer in CII projects including the influence of proximities between actors. Dingler and Enkel (2016) combined the two levels to propose the framework for socialization effects and knowledge development in collaboration with partners across industry boundaries. They studied the innovation activities in detail and systematically on the organizational (six companies) and project (27 projects) levels. Moreover, this accurately illustrates the process and benefits of different parts of CII projects.

4.6.2. Research strategy, data analysis and sample size

As can be observed in Fig. 7, there are 25 qualitative studies, 15

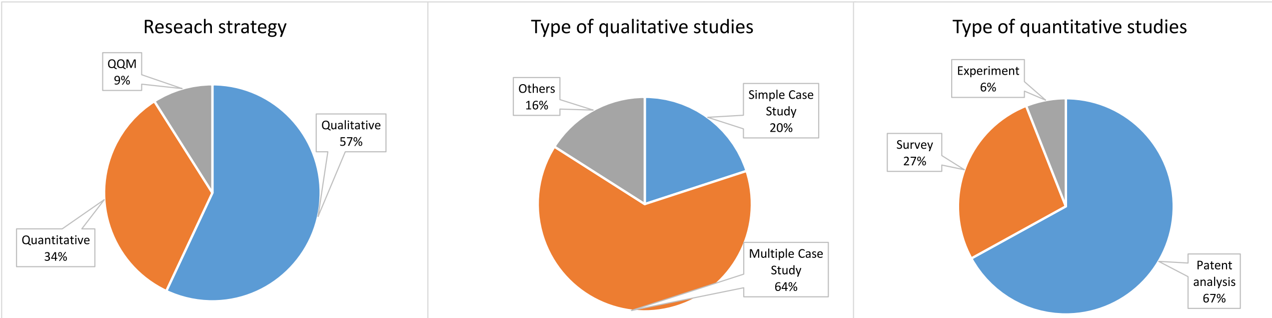

Fig. 7. Research methods used by studies.

quantitative studies and four studies that used a quanti-qualitative methodology (QQM).

Within the qualitative studies, five are simple case studies, 16 are multiple case studies, and four studies used other qualitative methodologies. Specific software for data analysis is rather rarely used. Only the most recent articles did use the NVivo software tool for qualitative research (Lyng and Brun 2018, 2020a, 2020b, 2022). Techniques used for data analysis are mainly related to coding and categorization based on the transcriptions of interviews and, in some cases, triangulated with further primary and secondary data, such as archival documents, technical data and plans, presentations, and press releases. Although rare, there are studies that have used some specific techniques for data analysis, which are *pattern matching logic* in Dingler and Enkel (2016), and content analysis and 'frequency count' in Hauge et al. (2017).

With respect to the four studies using other qualitative methodologies, the oldest research on the topic, Hargadon and Sutton (1997), used *ethnography* by observing the product design firm IDEO and studying their documents to find the implications regarding CII. They are among the first authors to explain how technological brokering of consulting expertise could benefit different industries by enabling inventive combinations for innovation. Later on, in this line, Brunswicker and Hutschek (2010), by using *participatory action research* developed a piloted framework to support the search for external innovation. Poetz and Prügl (2010) applied *Strauss's grounded theory approach* and analyzed the content of 1147 interviews to study the pyramiding search process as a means of crossing domain-specific boundaries to innovate. Recently, Behne et al. (2021) combined expert *interviews*, *literature review and workshops* with management and IT consultants, to develop and validate a holistic CII framework.

A total of 15 studies used pure quantitative research strategy: 10 conducted patent analyses, four performed surveys and one carried out an experiment. However, seven articles used survey data, since three of the studies using QQM included a survey to collect data (Gassmann et al., 2011; Bader, 2013; Enkel and Heil, 2014). In these quantitative studies, the data analysis techniques were structural equation modelling (SEM), variations of probit analysis, weighted OLS regression models or time series analysis.

A last group of four studies used QQM. Enkel and Bader (2016) applied an integrated qualitative-quantitative research design with semi-structured interviews. Qualitative data were transformed into quantitative numbers, which were used to test a SEM model with SPSS AMOS 20. Similarly, Bader (2013), within the best practice case of Henkel, used quantitative data (survey with employees of R&D, innovation, and marketing), qualitative data (semi-structured interviews with top managers) and corporate reports. Partial least squares structural equation modelling (PLS-SEM) was applied to test some hypotheses about the organizational learning process in CII. An importance-performance matrix analysis was also conducted. Gassmann et al. (2011) analyzed survey data from 107 European manufacturing companies and six in-depth case studies, linking different approaches to capabilities of intermediaries required in CII projects. Finally, Enkel and Heil (2014) combined multiple case studies (7) with network analysis of 215 bilateral cross-industry collaborations between 90 firms to examine the relatedness of different industries and evaluate the cognitive distance between firms.

The sample size is usually small, mainly in qualitative studies using case study research, with a maximum of 30 companies (Rhéaume and Tremblay, 2017) and 54 projects (Bröring et al., 2006). However, some quantitative studies were able to access a large number of observations, mainly due to the source of data used in their research (patent databases or institutional surveys). For instance, Mahnken and Moehrle (2018) analyzed 1465 CII patents studying multiple aspects of CII. This paper is of special relevance, as it addresses 35-year windows in the leading market of the USA, finding that Japanese companies are the main players involved in CII, applying for approximately 90% of all multi-CII patents. Another example is Schmidt's (2010) analysis of 1650 companies from the German Innovation Survey, which examined determinants of absorptive capacity for the success of innovation projects with different sources of knowledge.

Therefore, we can conclude that the field of CII is examined mostly by methods that are qualitative in nature. Case studies represent the dominant research strategy, followed by patent analysis, while survey studies are barely used.

5. Discussion and conclusions

In this study, we conducted a systematic literature review of CII, with the aim of providing an accurate picture of the knowledge generated about this topic, and contributing to the growth and development of this body of research. CII, a particular case of open innovation (Brunswicker and Hutschek, 2010; Horváth and Enkel, 2014; Enkel and Heil, 2014; Behne et al., 2021), has drawn the attention of researchers and consultants in the last two decades, given the potential benefits of exploring knowledge and technologies beyond the own industry. This is becoming especially true in an era of increasing technological development and specialization of certain industries (e.g., Mahnken and Moehrle, 2018) and regions (e.g., Hauge et al., 2017), together with the emergence of many cross-industry technologies (such as digitalization, blockchain, AI, robotics, data science, etc.).

Our bibliometric analysis on a final sample of 45 articles revealed that the research stream of CII started in 1997, with an average of 1.8 articles per year, being 3.6 in the last five years. Hargadon and Sutton (1997) is the article with the largest number of citations (1449), although the most prolific and prominent author is Enkel, with 9 articles and 943 citations. Other recognized authors, with at least two articles and more than 100 citations, are Zeschky, Bröring and Heil. The journal, the affiliation and the country with more articles are R&D Management, Zeppelin University and Germany, respectively. The majority of the research on CII has been conducted by European scholars, especially German scholars. Thus, this topic seems to draw less attention from researchers in other continents, with no articles being published in Africa or Latin America.

The content analysis was guided by five research questions, which provide valuable insights about its conceptualization and main features, the process under different theoretical approaches, its main determinants and consequences and the main methodological trends in the research conducted about CII.

RQ1. How can CII be conceptualized and differentiated from other related topics?

We have analyzed the 16 definitions found in the CII literature and identified 11 attributes, which give us an in-depth view about this term. Although CII can be seen as a synonym of "inter-industry innovation", there are other close and related innovation concepts, but different from CII. From the analysis, we were able to delimitate the concept of CII by establishing its differences from recombinant or recombinative innovation, open innovation, innovation ecosystem, cross-fertilization, exaptive innovation, and industry convergence. This has allowed us to propose a new definition of CII based on our analysis, which aimed to integrate the different perspectives.

Furthermore, three types of CII can be identified in the literature, inbound, outbound and coupled, similar to those proposed for open innovation (Gassmann and Enkel, 2004; Enkel et al., 2009), although previous studies have hardly explicitly differentiated among these types. Based on our analysis and the definitions provided by Dingler and Enkel (2016) and Behne et al. (2021), we have delineated the three conditions when CII is applied. In addition, these three types of CII have been included within the OI framework as specific cases (Fig. 5).

We found that the research has been mainly focused on inbound CII. Open innovation literature has claimed that inbound activities have been more thoroughly explored than outbound activities (Obradović et al., 2021), and our study reveals the same conclusion for CII.

RQ2. Which relevant features of CII can be identified in the literature (types of innovation, industries and actors)?

Firstly, we have observed that CII has been mainly applied to product innovation, although there is recent interest for business model innovation (Enkel and Mezger, 2013). We did not find any evidence of the application of CII to marketing innovations. It is surprising that research on the marketing area has paid little attention to the topic, considering that CII is a very common practice in marketing strategies.

Secondly, the analysis of the industries allows understanding the inter-industrial structures in the diffusion of knowledge and innovation (Semitiel-García and Noguera-Méndez, 2012). This literature review shows a cross-fertilization of ideas among industries, where source and target industries are highly varied. The general machinery and equipment, automotive and chemical industries are among the most active industries that search for solutions in distant industries. In the same way, the automotive and metal industries and telecommunications are commonly used as sources of knowledge. The network graph also shows the sectors where CII has been analyzed to a lower degree or has not been analyzed, such as the tobacco industry, financial services, accounting activities, warehousing, and education.

Thirdly, the main actors in CII are the members of the innovation development teams belonging to both the source and target industries. Moreover, the literature has pointed out the role of knowledge intermediaries (Hargadon and Sutton, 1997; Kalogerakis et al., 2010; Gassmann et al., 2011), connecting a broad set of perspectives and heterogeneous knowledge. The literature has argued that the potential contribution of the different actors to the different types of innovation could be dependent on the type of industry (Ciliberti et al., 2016), but our analysis did not reveal a clear link between types of actors and industries. Moreover, the relevance of certain actors seems to be associated with the type of CII; for example, internal actors are more prevalent for outbound CII, while external actors play a more relevant role for inbound CII, with both internal and external actors being key for coupled CII (Bröring et al., 2006). We also found different types of CII in studies where there is a network of firms (e.g., Lyng and Brun 2018, 2022) or where the role of intermediaries is highlighted (e.g., Hargadon and Sutton, 1997; Kalogerakis et al., 2010; Gassmann et al., 2011).

RQ3: What is the process of CII according to different theoretical approaches?

In comparison to the OI process, the CII process is more complex, as it incorporates some specificities derived from its cross-industry nature. Analogical thinking has been the predominant framework for explaining the process of CII (Herstatt and Kalogerakis, 2005; Gassmann and Zeschky, 2008; Brunswicker and Hutschek, 2010; Gassmann et al., 2011; Enkel and Mezger, 2013; Behne et al., 2021). It makes sense, given that analogies represent a core concept in this field. The relevance of knowledge and learning processes to understand how CII takes places has inspired theoretical approaches based on knowledge management and organizational learning to describe the process of CII (Bader, 2013; Lyng and Brun, 2018, 2020b). Both groups of theoretical approaches are not disconnected, as analogical thinking cannot take place without learning process and knowledge transfer.

Alternative perspectives have allowed connecting CII to the decision making process (Bröring et al., 2006), strategic issues, such as reducing dependence (Gassmann et al., 2010), and to other hot topics in the field of open innovation, such us user-centered innovation (Choi and Lee, 2015). This variety of approaches, although limited, informs about the richness and potential of the topic that has not yet been fully exploited from a theoretical and practical point of view.

We had expected that the different ways of describing the process of CII would reflect specific features of the research, such as the type of innovation (e.g., radical, breakthrough, incremental; product, process, business model, and so on) or the type of CII (e.g. inbound, outbound or coupled). Nevertheless, we could not find such a clear correspondence in the reviewed studies. Regardless of the theoretical approach, there is a predominance of studies addressing the process of CII for breakthrough product innovation and inbound CII.

Indeed, the outbound CII process is theoretically underdeveloped. The process of searching other industries with a common problem and adapting a novel solution to them (outbound) could be different from the process of seeking existing solutions in foreign industries to a given problem in the own industry (inbound). Consequently, the difficulties and capabilities needed in inbound and outbound CII are likely to be different.

Coupled CII would also demand more in-depth analyses. The aim of the co-creation that takes place in this type of CII can be diverse, depending on whether the problem to be solved belongs to only one of the industries or is a common problem to both industries, or even a problem of a third industry (the same consideration applies to the solution to be adapted). The variety and complexity of possibilities would increase in the case of multi-coupled CII.

RQ4. Which are the main determinants and consequences of CII?

With respect to determinants, the success of CII depends on the diversity or heterogeneity of knowledge bases of the development team with a broad background and experience in different functional areas, domains, industries, markets and business models (Hargadon and Sutton, 1997; Herstatt and Kalogerakis, 2005; Kalogerakis et al., 2010; Enkel and Mezger, 2013). This improves the absorptive capacity and facilitates the learning process, leading to the accomplishment of CII. We have identified some organizational mechanisms and conditions that are drivers of analogical thinking and CII, related to the composition of the NPD, innovation or business development teams, and internal and external organizational practices. Other determinants of CII are willingness to open up, potential adsorptive capacity, socialization, legitimacy, communication and retranslation, use of knowledge brokers or

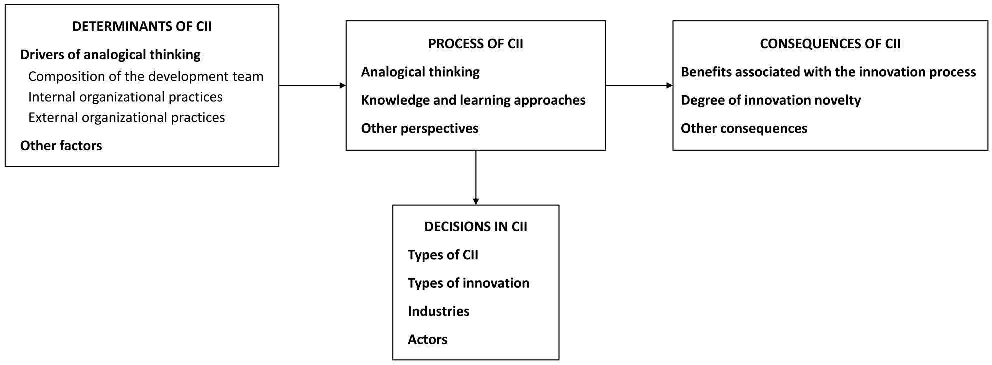

Fig. 8. Integrated framework of CII derived from our content analysis of extant literature.

external institutions such as intermediaries, prior cross-industry knowledge and experience, low level of interdependencies between the involved actors, cross-industry innovation capability, or pre-entry knowledge in the targeted industry.

The clearest consequence of CII is that it increases the resultant (product or business model) innovation degree of newness, with abundant empirical evidence supporting this relationship (e.g., Dahl and Moreau, 2002; Enkel and Gassmann, 2010; Horváth and Enkel, 2014; Li and Vanhaverbeke, 2009). The impact of CII in terms of lower development time, cost, risk and project duration has been widely emphasized in the academic literature (e.g., Gassmann and Zeschky, 2008; Enkel and Mezger, 2013; Bader, 2013). There are also some other consequences, such as the development of new business models (e.g., Heil and Enkel, 2015), firm's sales per employee (e.g. Lee et al., 2016), and patent forward citations (e.g., Belderbos et al., 2014).

RQ5. Which are the main methodological trends in the research on CII?

CII research has mostly relied on qualitative methods based on case studies (single-case and, mostly, multi-case studies) and quantitative methods based on patent analyses. Studies have been mainly conducted at the organizational level with a relatively small number of cases. Moreover, interviews with main stakeholders are a common technique for data collection, while the use of surveys based either on primary or secondary data is scarce. Furthermore, we observed that the studies from our sample did not employ emerging research methods linked to the digitalization of businesses and other crowdsourcing events, such as netnography (Bertello et al., 2022). Thus, it is clear that this research topic is still at its early stage, and that much remains to be done empirically to evolve as a relevant field of research.

We also found that, in most cases, studies did not provide clear operational definitions of variables. The lack of validated measurement scales restrains the development of quantitative studies with surveys. Common techniques for data analysis allowing replicability, especially in qualitative studies (frequency count, text mining, and pattern matching logic, among others), are still missing. A more in-depth explanation of the methodological issues (variables, data collection, triangulation and so on) would be beneficial for the consolidation of this field of research.

5.1. Theoretical contributions

The theoretical implications of this paper can be organized around three main contributions. Firstly, we provide a structured overview of the current state of the art on CII, which facilitates the development of this body of research. The integration of previous literature and the relationships between the different elements of CII can be clearly understood from Fig. 8. Furthermore, we identify some predominant theoretical perspectives analyzing the process of CII: analogical thinking, and knowledge and learning approaches. We provide, on the one hand, an integration of studies using analogical thinking (Table 7), and, on the other hand, studies based on knowledge and learning approaches (Table 8). Connections between both of them are also suggested. Moreover, our study brings together different research streams that address the phenomenon of CII, which have been relatively disconnected; this has been shown by the clusters resulting from our co-citation and co-keywords analyses. For example, studies on industry convergence, innovation ecosystems and spillovers are usually not framed within analogical thinking and knowledge and learning approaches. This is also the case for scholars using patent data (Karvonen and Kässi, 2013; Belderbos et al., 2014). Our study complements the systematic literature review carried out by Mahnken (2020), who analyzed the literature based on semantic similarity analyses, whereas, in the present study, we conducted a bibliometric and content analysis, which led to new conclusions and prominent areas for future research.

Secondly, we propose a new and more accurate definition of CII, which integrates the main contributions of previous studies and makes a clear distinction from other related concepts of innovation. We explicitly differentiate the types of CII, inbound, outbound, and coupled, as has been also done in the OI literature. This is of particular interest, since the proposed definition helps to specify the construct domain of CII, improving the content validity for future measurement scales, as well as its discriminant validity regarding other similar constructs. Moreover, this will also facilitate a well-articulated development of this body of research.

Finally, our study represents a relevant contribution to the OI paradigm. Despite the fact that CII is a specific case of OI, it has been poorly addressed by the literature on OI, with some exceptions (Li and Vanhaverbeke, 2009; Brunswicker and Hutschek, 2010; Horváth and Enkel, 2014; Enkel and Heil, 2014; Behne et al., 2021). Our literature review organizes the knowledge generated about a specific case of OI, that is, when knowledge flows take place among organizations across different industries beyond their own value chain. In Fig. 5, we place CII within the OI framework for inbound, outbound and coupled CII. In particular, we differentiate CII from within-industry innovation in each type of OI. This may invigorate the research on the phenomenon of CII as a subfield of the OI framework.

5.2. Practical implications

The research is also valuable from the managerial and policy makers' perspectives. For managers, our research provides insight about opportunities coming from knowledge exchanges with other industries, which may be overlooked in some industries and firms where knowledge exchange is not a common practice. In particular, our network map (Figure A1 in Appendix), which shows clear interactions between industries (differentiating source and target ones), could help managers when they search for ideas to satisfy their needs, by providing them with a picture about where they may find potential solutions and markets for their technologies. It is clear that the industries analyzed so far in the literature about CII are, in some cases, sufficiently validated to represent either a suitable source or target to a particular industry (from automotive to other machinery, from petroleum to medical services, from food to chemicals and vice versa, among others). Knowing these ties makes it easier for practitioners to explore beyond their industry boundaries.

Firms that aim to differentiate themselves from their competitors by means of radical innovation could apply CII, not only occasionally to solve a specific problem (inbound CII) or to open a new market (outbound CII), but as part of a deliberate innovation strategy. Managers that want to institutionalize a CII strategy should know and understand the process involved, as well as the specific organizational practices (such as cultural changes) to be implemented in this context. Those firms should create interdisciplinary teams with members from diverse backgrounds that improve the needed absorptive capacity to assimilate the knowledge from other industries.

Policy makers can also draw lessons from our research. Firstly, we highlight the relevance of promoting interactions among industries, not only as a way of growth for emergent and established industries, but also as a strategy to renew industries and regions in crisis (Hauge et al., 2017). Secondly, our analysis of the determinants of CII can lay the foundation for designing mechanisms to promote it, such us knowledge intermediaries connecting organizations across industries, and incentives to interdisciplinary research and education, where universities can play a crucial role. Finally, our research also provides a view of industries usually playing as targets or sources, together with industries with a poor role in a CII scenario, which can be a base for designing policies oriented to identify and address unexploited opportunities.

Finally, this paper can be of interest for actors in innovation ecosystems in general, as it provides the theoretical basis for the design of platforms that connect organizations from different industries with an innovative goal. For instance, it helps to improve open innovation challenge programs, usually as part of corporate innovation strategies, given that the most innovative solutions usually come from organizations from outside the value chain. The insights from our research could also inspire developers to launch new tools and platforms in order to ease the links between potential collaborators, with the aim of finding inter-industry solutions that could benefit society in general.

Table 9
Research agenda for CII.

Theme	Research opportunities and recommendations
Types of CII	Make a clear distinction and explicit explanation of the types of CII under study Conduct more studies addressing outbound and coupled CII to find its potential differences with respect to inbound CII Conduct more studies addressing cases of multi-inbound CII • Can the new solution for the problem of an industry come from combining knowledge from several foreign industries? • How can firms coordinate the CII process when there is more than one participating source industry?
Types of innovation	Make a clear distinction and explicit explanation of the type of innovation under study Which specific elements are creatively imitated in cross-industry business model innovation? How much does CII affect each specific element of the business model? Conduct more studies addressing CII in marketing innovation (in which CII seems to be very useful and frequently used) Analyze cross-industry service innovation
The process of CII	Which are the specific stages of the process for each type of CII? Could it be possible to have an integrated framework of the process of CII? Which are the capabilities needed for each stage of the process depending on the type of CII?
Actors	Which are the main actors facilitating CII? Which is the role of different actors in every type of CII? Which is the role of actors in each stage of the process of CII? Which is the role of intermediary actors such as accelerator programs in the cross-industry business model innovation of start-ups?
Determinants	Which are the determinants of each type of CII? How can HRM practices (selection process, training, incentives, etc.) foster CII?
Consequences	Which are the consequences of each type of CII? Compare studies with and without CII, to determine their differentiated benefits (in terms of lower development costs, time and risk, etc.) What is the impact of CII on commercial and financial performance of the firm depending on the type of CII?
Methodological	Develop and validate multi-dimensional measurement scales for the types of CII, benefits of CII and performance of CII Conduct more quantitative (even longitudinal) studies of CII apart from those based on patents Use quanti-qualitative methods as a more comprehensive approach to address the complexity of the phenomenon of CII Use emergent methods of research that are more strongly connected with the digital environment
Others	Explore connections between innovation ecosystems and CII • How do innovation ecosystems encourage the three types of CII? • Compare the type and differentiated role of actors involved in innovation ecosystems and in CII Apply CII to sustainable innovation and circular economy Compare OI in the same industry (within-industry innovation) and CII in terms of firm performance Determine the conditions under which it is better to innovate using external sources within the value chain or sources outside the industry Explore CII between industries that have not been studied or scarcely studied in previous empirical research (e.g., financial services, warehousing, education and tourism, among others)

5.3. Limitations

Some limitations of our research should be pointed out. Firstly, our systematic literature review is based on the WOS Core Collection. Although we included other relevant articles not reported by our search strategy, we should not ignore the fact that some papers on the topic could have been missed. Secondly, our review was focused on articles in the English language, overlooking potential contributions from authors writing in other languages, especially German. Finally, since the reviewed literature has not explicitly explained the type of CII or innovation addressed, some classifications provided in our research are based on the criteria of the authors.

6. Research agenda

This literature review has revealed the increasing importance of CII for academia and practitioners. However, numerous questions remain unanswered about this topic. Therefore, we bring a research agenda for future studies (Table 9).

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APPENDIX 1

Table A1
Summary of analyzed studies

Authors	Year	Type of CII	Type of Innovation	Source Industry	Target Industry	Actors	Unit of analysis	Sample size	Type of study	Research strategy	Data analysis technique
Hargadon and Sutton	1997	Inbound and outbound	Product	Personal care; Computer; Typewriters; Defense; CAD; Consumer products; Slide projector; Toy; Vacuum cleaner; Sailing; Fans; Airplane; Office tools; Medical equipment; Videogames; Garage door; Steel; Biology; Videocassette; Automotive; Tool and die; Station wagon; Electronic; Biking; Housing technologies; Towel dispensers; Typewriter; Drafting boards; Disk-drive	Beverages; Medical equipment; Computer; Mechanical whale; Vacuum cleaner; Toy; Videogames; Cosmetic; Biking accessories; Label marker; Mechanics; Desk lamp; Office chair; Automotive; Waste paper collector; Paper handling; Printing	Consultants	Organizational	1 company	QUAL	Ethnography	Interviews & data triangulation
Dahl and Moreau	2002	Inbound	Product	Airplane, medical equipment, food, catering trade	Automotive	Students	Organizational	4 pairs of NPD practitioners, 106 and 119 students	QNT	Experiment	Observations
Fung	2002	Inbound	–	–	Chemical; Computer; Electric and Electronic	–	Organizational	224 firms	QNT	Patent analysis and other secondary data	Regressions
Streb	2003	Outbound	Product	Plastic	Chemical; Textile; Machinery; Motor vehicles; Furniture	Suppliers and customers	Organizational	1 company	QUAL	Case study	Data triangulation
Herstatt and Kalogerakis	2005	Inbound	Product	–	Medical equipment	Employees					
Bröring et al.	2006	Inbound, outbound, and coupled	Product	Food, pharmaceutical	Nutraceuticals	Managers, employees, researchers, supplier, customers	Project	54 R&D projects	QUAL	Multiple case study	Interviews & data triangulation
Gassmann and Zeschky	2008	Inbound	Product	Bowed instruments; Computer; Irrigation	Sports equipment; Aluminium; Textile machinery; Piping systems	Employees and technology suppliers	Project	4 companies	QUAL	Multiple case study	Interviews & data triangulation
Li and Vanhaverbeke	2009	Inbound	Product	–	–	Suppliers	Organizational	595 innovations	QNT	Survey	Binary logistic regression
Brunswicker and Hutschek	2010	Inbound	Product	Medical equipment	Automotive	Managers or employees and experts	Organizational	1 company	QUAL	Participatory action	Planning, acting, and reflection of actions
Enkel and Gassmann	2010	Inbound	Product and business model	Printing; Steel; Sports; Automotive; easyInternet, easyMoney, easyBus, easyCar, easyCinema, easyMobile, easyWatch, easyHotel, easy4men,	Packing; Automotive; Elevators; Sports; Aircraft; Airline; Textiles; ICT; Sewing machines; Food; Sanitary;	R&D leaders and employees	Organizational	25 companies	QUAL	Multiple case study	Interviews & data triangulation

(*continued on next page*)

Table A1 (*continued*)

Authors	Year	Type of CII	Type of Innovation	Source Industry	Target Industry	Actors	Unit of analysis	Sample size	Type of study	Research strategy	Data analysis technique
				easyPizza, easyMusic; Medical care; Mobile phones; Electronics; Chemical; Music; ICT; Electric power installation; Games; Oven; Personal care	Construction tools; Chemical						
Gassmann et al.	2010	Inbound	Product	Dynamic software	Automotive	Non-supplier	Project	1 project	QUAL	Case study	Interviews & data triangulation
Hacklin et al.	2010	Inbound, outbound, and coupled	Product, service, business models, and process	–	ICT	–	Organizational	26 firms	QUAL	Multiple case study	Interviews & data triangulation
Kalogerakis et al.	2010	Inbound and outbound	Product	Automotive; Stone age tools; Nature (animals); Lighting; Audio equipment; ICT; Sports; Waste; Medical equipment; Furniture; Television and audio equipment; Boats	Sound studio; Tools; Commercial vehicles; Medical equipment; Aircraft; Sports; ICT; Baby gear; Promotion; Furniture; Mobile communication	Consultants	Project	18 companies	QUAL	Multiple case study	Interviews & data triangulation
Poetz and Prüg	2010	Inbound	Product	Industrial machinery, Sailboats, Computer simulation; Conveyor belts, Ropeways, Mining; Elevators, Doors and gates; Biotechnology, PET bottles, Toy; Event technology, Model making, Bike racks; Veterinary medicine, Entrepreneurship, Care of the elderly; Cinema, Power plants, Aerospace industry; Pharmacy, Home improvement, Barkeeping	Lifting, loading and handling systems; Escalators and elevators; Automotive; Beverages; Baby care; Electronics; Food	Lead users	Project	1147 interviews	QUAL	Strauss's grounded theory	Interviews & data triangulation
Schmidt	2010	Inbound	Product and process	–	–	Employees, customers, suppliers, and researchers	Organizational	1650 companies	QNT	Survey	Probit and Triprobit estimation models
Gassmann et al.	2011	Inbound and outbound	Product	Power plants; IT hardware; Laboratory equipment; Food packaging; Automotive	Civil construction; Home appliances; Outdoor clothing; Automotive; Medical technology	Intermediaries	Project	107 companies	QQM	Survey and Multiple CS	Content analysis, Interviews & data triangulation
Zhang and Cantwell	2011	Coupled and outbound	Product and process	–	–	Business group members	Organizational	127 firms	QNT	Patent analysis	Regressions
Bader	2013	Inbound	Product and business models	Food and beverages, plastic materials, textiles, pharmaceuticals,	Laundry and home care	Employees	Organizational	1 company	QQM	Survey and Case study	PLS-SEM, importance–performance matrix, Interviews & data triangulation

(*continued on next page*)

Table A1 (*continued*)

Authors	Year	Type of CII	Type of Innovation	Source Industry	Target Industry	Actors	Unit of analysis	Sample size	Type of study	Research strategy	Data analysis technique
				medical engineering, printing, electronics, electronic devices, and robotics							
Datta and Jessup	2013	Inbound	Product	–	Information Technology	–	Organizational	69 firms, 192,070 patents, 2,000,000 citations	QNT	Patent analysis	SEM
Enkel and Mezger	2013	Inbound	Business model	Newspapers, Journals; online retailing (clothes, food); Automotive; Mobile phones; One-way bike rental; Music; Online games; Online advertising	Clothes retailing; Food retailing; Construction/ Building equipment; Lighting equipment; Automotive; Sewing machines; Online betting; Loyalty programs	Founders and managers	Organizational	9 companies	QUAL	Multiple case study	Interviews & data triangulation
Karvonen and Kässi	2013	Inbound, outbound, and coupled	Product, process, and business model	Computer technology, audio-visual technology, semiconductors, and optics	Electronics; Paper	–	Organizational	84 companies	QNT	Patent analysis	Cluster analysis
Belderbos et al.	2014	Coupled	–	–	–	–	Organizational	164 firms	QNT	Patent analysis	Regressions
Enkel and Heil	2014	Inbound	–	Automotive; Chemical; Electronics; Rubber and plastics; ICT; Mechanical engineering; Construction; Energy; Glass and Ceramics; Food; Pharmaceuticals; Textiles	Textiles; Mechanical engineering; Personal and home care; Chemical	Employees, crowd, experts, intermediaries	Organizational	90 companies	QQM	Survey and Multiple CS	Network analysis, Interviews & data triangulation
Horváth and Enkel	2014	Inbound	Product	Home accessories, plastics, food	Dynamic consumer goods (laundry and home care)	R&D managers and employees	Project	8 projects	QUAL	Multiple case study	Interviews & data triangulation
Choi and Lee	2015	Inbound	Product	Forestry and logging, silk-type weaving, restaurants, fish farming, and medical/surgical equipment manufacturing	Cosmetic	User experts	Organizational	1 company	QUAL	Case study	Interviews & data triangulation
Golembiewski et al.	2015	Coupled	Product and process	Agriculture; Energy	Bioenergy	Supplier	Patents	5333 patent documents	QNT	Patent analysis	Patent counts, content analysis
Heil and Enkel	2015	Inbound	–	–	–	Managers, employees, and experts	Organizational	125 companies	QNT	Survey	SEM
Ciliberti et al.	2016	Inbound	Product and process	–	Food	–	Organizational	703 companies	QNT	Survey	Probit model
Dingler and Enkel	2016						Org & Proj		QUAL		Pattern matching logic

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Table A1 (*continued*)

Authors	Year	Type of CII	Type of Innovation	Source Industry	Target Industry	Actors	Unit of analysis	Sample size	Type of study	Research strategy	Data analysis technique
		Inbound, outbound, and coupled	Product, service, and process	Automotive; ICT; Public authorities; Textile; Mining; Chemical; Mechanical engineering; Turbine; Container; Racing; Medical; Pipeline; Wind energy; Food; Aerospace; Electronics; Film; Industrial drives	Mechanical engineering	Managers, founders, employees, customers, brokers		6 companies/ 27 projects		Multiple case study	
Enkel and Bader	2016	Inbound	Product	Biotechnology, organic chemistry, marine biology, oceanography, nutrition technology, bionics, and renewable primary products	Chemical	Experts	Individual	35 scientists	QQM	Workshops	SEM & interviews
Groβmann et al.	2016	Inbound and outbound	Product	ICT	Automotive	Employees	Organizational	3 companies	QUAL	Multiple case study	Interviews & data triangulation
Lee et al.	2016	Inbound	–	–	–	Employees, buyers, sellers	Organizational	79 groups and 417 affiliated firms	QNT	Patent analysis and other secondary data	Regressions
Hauge et al.	2017	Inbound	Process	Construction and energy, estate and consulting, trade, health and social services, industry, ICT/ Telecom, culture and NGO, oil, gas and mining, primary production, shipping, transport and tourism	Oil and gas	Employees	Organizational	15 companies	QUAL	Multiple case study	Interviews, content analysis & frequency count
Phillips et al.	2017	Coupled	Product	Biology, micro-electronics, flexible electronics, new neural interfaces, energy harvesting, and new control algorithms; Mobile technologies, cloud computing, and artificial intelligence (AI) technology	Healthcare and medical technologies	Managers, firms leaders, employees, stakeholders	Organizational	5 companies	QUAL	Multiple case study	Interviews & data triangulation
Rhéaume and Tremblay	2017	Inbound	Product, service, business models, and process	–	Videogames	Managers, customers, suppliers, academia, incubator an accelerator managers, consultants,	Organizational	30 organizations	QUAL	Multiple case study	Interviews & data triangulation

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Table A1 (*continued*)

Authors	Year	Type of CII	Type of Innovation	Source Industry	Target Industry	Actors	Unit of analysis	Sample size	Type of study	Research strategy	Data analysis technique
						researchers, venture capitalists, professional associations members, government					
Enkel et al.	2018	Coupled	Process and product	Film; Food; ICT; Medical; Pipeline; Public management; Textile; Turbine; Wind energy; Automotive; Aerospace; Chemical; Racing	Automotive; Industrial drives; Mechanical engineering; Mining; Container	Team members	Project	26 companies	QUAL	Multiple case study	Interviews & data triangulation
Filiou and Massini	2018	Inbound	Product, and process	Bio-pharmaceutical	–	–	Organizational	110 firms	QNT	Patent analysis and other secondary data	Negative binominal regression
Lyng and Brun	2018	Inbound, outbound, and coupled	Product	Petroleum, aerospace	Medical	Project managers	Project	1 association	QUAL	Case study	Nvivo, content analysis, Interviews & data triangulation
Mahnke and Moerhle	2018	Coupled	Product	–	Mobility, electronics, fossil fuels, medicine (top ten)	Network members	Organizational	1465 patents	QNT	Patent & time series analysis	Patstat, Orbis & Excel
Galvin et al.	2020	Inbound	Product and process	Racing, Chemical; Aerospace; Automotive; Mechanical engineering; Medical equipment; Basic metals	Bicycle	Founders and employees	Innovation	98 innovations	QUAL	Multiple case study	Analytically structured history; Interviews & data triangulation
Lyng and Brun	2020a	Inbound, outbound, and coupled	Product	Petroleum; Sensors; ICT; Material technology; Academia; Sterilization; Clinical research; Real estate; Process control; Automation	Medical	Project managers	Organizational	11 companies	QUAL	Multiple Case study	Nvivo, Interviews & data triangulation
Lyng and Brun	2020b	Inbound, outbound, and coupled	Product	Petroleum	Medical	Project managers	Project	7 projects	QUAL	Multiple Case study	Nvivo, content analysis, Interviews & data triangulation
Behne et al.	2021	Outbound and coupled	Product and process	Automotive	Various areas (e.g. production, logistic)	Consultants	Organizational	8 experts	QUAL	SRL & Workshop	Interviews & data triangulation
Zhang et al.	2021	Inbound	Product	Patents in other technology fields	Mobile phone	–	Organizational	109 companies	QNT	Patent analysis	OLS model & regressions
Lyng and Brun	2022	Inbound, outbound, and coupled	Product	Petroleum; Aerospace; Image; Sensors; Robotics	Medical	Project managers	Project	1 association	QUAL	Case study	Nvivo, content analysis, Interviews & data triangulation

Table A2
Content analysis of the definitions of CII

Term for the concept	Action	Object (type)	Object (moment of development)	Object (features)	Source	Target	Aim	Theoretical framework	CII as a process	CII as a type of innovation
15/16: Cross-industry innovation/CII 1/16: Cross industry analogies 0/16: NA	4/16: Creatively imitated/creative imitation 4/16: Transfer 3/16: Retranslate/retranslation 3/16: Adapt/Adaption 3/16: Application/apply 3/16: Re-use/reuse 1/16: Imitation 1/16: Adopt 1/16: Incorporate 1/16: Explore 1/16: Access 1/16: Recombine 1/16: Leverage (the innovation power) 0/16: NA	11/16: Knowledge 7/16: Technologies 6/16: Solutions 3/16: (Business) processes 3/16: General principles 2/16: Business models 1/16: Patents 1/16: Systems 1/16: Concepts 1/16: Applications 1/16: Capabilities 0/16: NA	5/16: (already) Existing 2/16: Established 9/16: NA	1/16: Specific 1/16: External 1/16: Analogous 1/16: (more or less) Distant 1/16: Complementary 12/16: NA	7/16: One/another/foreign/a source industry (sector) 4/16: Other/foreign industries 1/16: Across industry boundaries 1/16: Across distant knowledge domains 1/16: External sources from outside a firm's own value chain 1/16: Organizations outside the firm's own value chain 1/16: Partners from outside a firm's own value chain 1/16: Partners … from another industry (3/16: Outside a firm's own value chain) 0/16: NA	6/16: One/another/different/target industry (sector) 2/16: Company 2/16: Firm 1/16: Organization 1/16: Actors in one industry sector 5/16: NA	3/16: to innovate 2/16: to meet the needs of the company's current market or products 2/16: to fulfill the needs of the organization/to own requirements 2/16: to solve problems 1/16: to face challenges 8/16: NA	2/16: Open innovation 1/16: Innovation management 1/16: Analogical thinking 12/16: NA	2/16: Yes 14/16: NA	1/16: Yes 15/16: NA

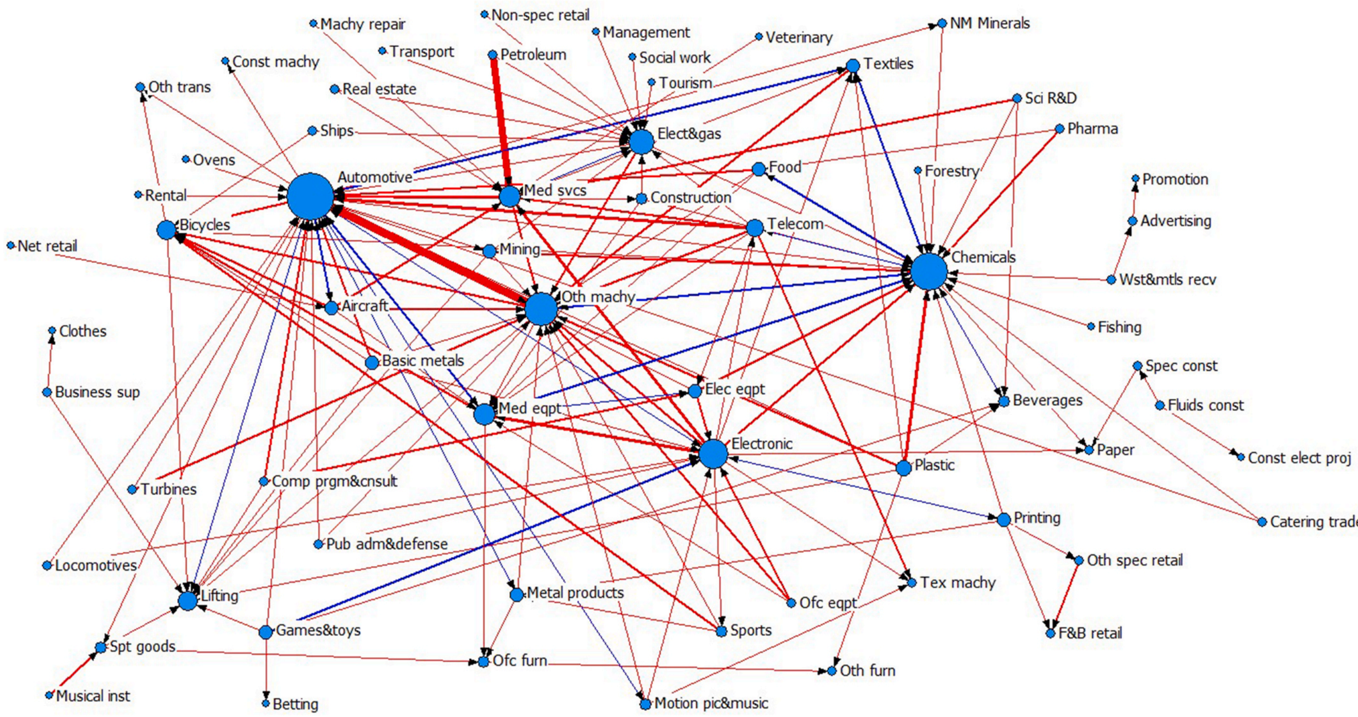

Figure A1. Network of CII relationships

NOTES: 1) This figure was produced by Ucinet's visualization module, NetDraw (Borgatti, 2002).2) NM Minerals: Non-metallic minerals; Elect eqpt: Electrical equipment; Ofc eqpt: Office equipment; Oth machy: Other machinery; Const machy: Construction machinery; Tex machy: Textile machinery; Oth trans: Other transport; Ofc furn: Office furniture; Oth furn: Other furniture; Musical inst: Musical instruments; Med eqpt: Medical equipment; Machy repair: Machinery repair; Elect&gas: Electricity and gas; Wst&mtls recv: Waste and materials recovery; Const elect proj: Construction of electricity projects; Fluids const: Fluids construction; Spec const: Specialized construction; Non-spec retail: Non-specialized retail; F&B retail: Food and beverage retail; Oth spec retail: Other specialized retail; Net retail: Internet retail; Motion pic&music: Motion pictures and music; Info svcs: Information services; Comp prgm&cnsult: Computer programming and consultancy; Sci R&D: Scientific R&D; Business sup: Business support; Pub adm&defense: Public administration and defense; Med svcs: Medical services.

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Antonio Carmona-Lavado is Associate Professor in the Business Organization and Marketing Department at Universidad Pablo de Olavide (Seville, Spain). He teaches Entrepreneurship and Innovation Management and Business Administration to undergraduate students and Survey Methodology to postgraduate ones. His main research area of radical innovation, service innovation, open innovation, business model innovation, and startup accelerators. Currently, he is leading a national project about innovation in startups funded by the Spanish Ministry of Science and Innovation. His research has been published in academic journals such as *Industrial Marketing Management*, *Technological Forecasting and Social Change*, *R&D Management*, *Journal of Business Research*, *British Journal of Management*, *Business Research Quarterly, Industry and Innovation, Technology Analysis and Strategic Management or Creativity and Innovation Management*.

Elena M. Gimenez-Fernandez, PhD in Business Administration, is an Assistant Professor in the Business Organization and Marketing Department at Universidad Pablo de Olavide (Seville, Spain). She has been a visitor student at Garwood Corporate Innovation Center. Her research focuses on open innovation and entrepreneurship. Her research has been published in academic journals such as *Research Policy, Industry and Innovation, International Small Business Journal*, and *Creativity and Innovation Management*, among others.

Vesna Vlaisavljevic is an Assistant Professor in the Business Department at the University of Barcelona, Spain. She holds PhD with International Mention in Business Administration and Management from Pablo de Olavide University (Seville, Spain). She has been a visiting scholar at KU Leuven, the MSI department, several times and she is still closely collaborating with INCENTIM (Research division of KU Leuven R&D). Member of several national and international research projects. With diverse research interests including innovation processes, knowledge, cooperative strategies, networks, technology clusters and regional innovation systems, has presented manuscripts at various international conferences. Her research has been published in *Technological Forecasting and Social Change, British Journal of Management and R&D Management*.

Carmen Cabello-Medina is Full Professor in the Business Organization and Marketing Department at Universidad Pablo de Olavide (Seville, Spain). She has a Ph.D. in Business Administration. She teaches Organizational Theory, Innovation Management and Abilities for the Bachelor and Master Thesis. Her research focuses on innovation management, cooperation for innovation and open innovation. Currently, she is leading a project about the role of accelerator programs on the innovation in startups, funded by the Government of Andalusia. The results of her research are published in international journals as *R&D Management*, *Technological Forecasting and Social Change*, *Industrial Marketing Management*, *Journal of Business Research*, and *British Journal of Management*, among others.