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Systems dynamics research in management and organization studies: Overview and research agenda

Canio Forliano[a,*], Paola De Bernardi[a], Zoltan Rozsa[b,c], Alberto Bertello[a]

[a] Department of Management, University of Turin, Italy
[b] Faculty of Social and Economic Relations, Alexander Dubcek University of Trencin, Slovak Republic
[c] European Centre for Business Research, Pan-European University, Prague, Czechia

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ABSTRACT

This paper presents a bibliometric analysis of the systems dynamics (SD) research landscape, drawing on 2,091 documents from Scopus and Web of Science. This research employs bibliometric techniques to explore the evolution of the scientific community over the past 50 years and assess research productivity and impact. Through network analysis, the study further reveals the field's social and conceptual structures. This approach revealed four pivotal thematic clusters, which were discussed based on content analysis: (1) operations research and strategy formulation, (2) behavioral studies and collaborative approaches, (3) dynamic performance management, and (4) systems thinking for sustainable development. The findings reveal a diverse and interdisciplinary trajectory of SD research, reflecting its integration into a broad array of fields and its potential to inform both theoretical and practical applications. The paper concludes by providing targeted recommendations for future SD research, with a particular emphasis on enhancing management and organizational studies through the incorporation of SD methodologies. This includes the potential for SD to influence the design of adaptive strategies, the use of SD in participatory policymaking, and the application of SD tools in promoting organizational learning and sustainability.

Introduction

In today's rapidly changing world, where technological, market, and environmental complexities increasingly challenge organizations, the adoption of advanced analytical tools has become indispensable (Bresciani et al., 2022; Forliano et al., 2022). Systems dynamics (SD), which is rooted in the broader discipline of systems thinking, offers a powerful lens through which to understand and navigate these complexities. Unlike traditional econometric models, which often rely on linear assumptions and static relationships, SD excels in modeling dynamic systems characterized by feedback loops, time delays, and nonlinear interactions (Woodside, 2013). In response to these analytical shortcomings, there has been a discernible shift toward complexity theories and asymmetrical techniques that better accommodate the intricate dynamics of organizational systems (Misangyi et al., 2017; Kumar et al., 2022).

As a foundational component of SD, systems thinking promotes an understanding of organizations and their environments as interconnected wholes, rather than as collections of isolated parts (Ricciardi et al., 2020). This holistic approach is critical for addressing the multifaceted challenges faced by modern organizations, which are often systemic and cannot be effectively understood through reductionist methods (Dentoni et al., 2021; Mair & Seelos, 2021). SD, as an extension of systems thinking, enable the exploration of how various elements within an organization interact over time, thereby providing insights into potential future behaviors and outcomes.

SD uniquely combines qualitative and quantitative methods to enhance the modeling and analysis of complex systems (Sterman, 2000; Bianchi, 2016). Qualitatively, causal loop diagrams help elucidate the relationships and feedback mechanisms within systems, offering insights into the underlying structures and potential behavior patterns. Quantitatively, stock and flow diagrams provide a means to numerically simulate these dynamics, allowing for detailed scenario planning and decision analysis. This integration of qualitative and quantitative dimensions enables a more comprehensive exploration of system dynamics than is possible with traditional methods that rely on static linear

* Corresponding author.
E-mail address: canio.forliano@unito.it (C. Forliano).

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assumptions to estimate net effects (Aminullah, 2024; Hasegan et al., 2018). These capabilities make SD particularly effective in environments where traditional statistical models fail to capture the essence of dynamic interactions. For these reasons, the adoption of SD has become increasingly prominent among scholars and practitioners and has proven to be crucial in decision-making across both the public and private sectors (Borgonovi et al., 2018; Cosenz & Bivona, 2020; Forliano et al., 2020). In our contemporary society, where complex systemic issues underpin major societal challenges, SD is recognized as an indispensable tool for addressing “wicked problems”—challenges characterized by complexity and resistance to straightforward solutions (Wasieleski et al., 2021). SD provides a powerful analytical framework capable of revealing and managing the dynamic and complex interrelations that these problems present. The inherent complexity of such issues necessitates innovative approaches that surpass traditional linear analytical models, advocating for a systemic perspective that is intrinsic to SD (Grewatsch et al., 2023). This approach has been applied across a wide spectrum of domains, effectively addressing persistent issues such as poverty and inequality (Tey et al., 2020), environmental sustainability (Ding et al., 2018), resources and energy management (Del Vecchio et al., 2019; Sun et al., 2017), enhancing public health systems (Darabi & Hosseinichimeh, 2020), improving safety and reducing crime (Xavier & Bianchi, 2020), and catalyzing educational reforms (Maruccia et al., 2020). The broad application of SD and systems thinking in providing insightful analyses and fostering collaborative efforts toward sustainable solutions (Ricciardi et al., 2020) underscores the need for comprehensive research to explore how these perspectives are implemented across diverse fields, thus contributing to the academic discourse and practical applications of systems dynamics.

Second, as highlighted by Grewatsch et al. (2023), systems thinking and SD have been conceptualized in various forms over the years. They have been seen as a comprehensive theory aiming for a general understanding of social sciences (Von Bertalanffy, 2010), a paradigm shift from mechanistic or reductionist worldviews to an integrative, systemic approach (Gladwin et al., 1995), a belief system for mindset change (Senge, 1990), a perspective for theory−practice engagement (Lewis, 1991), or a methodological approach for multilevel, complex problem analysis (Forrester, 1994; Sterman, 1994). This conceptual diversity underscores the necessity of synthesizing these various applications and implications, thereby providing clarity and direction for future research within management and organization studies. To capture and illustrate the increasing trend of SD publications in this domain, numerous articles have attempted to systematize SD research. However, these efforts have often been confined to specific fields, such as strategic management (Cosenz & Noto, 2016) or performance management (Oladimeji et al., 2020); specific contexts, such as healthcare (Darabi & Hosseinichimeh, 2020) or tourism planning (Sedarati et al., 2019); or specialized journals, such as the *System Dynamics Review* (Torres, 2019). This work aims to broaden this perspective by providing a comprehensive and inclusive overview of prior work using SD in management and organization studies. By conducting a bibliometric analysis combined with science mapping techniques, we seek to answer the following pivotal research questions:

RQ1. What trends characterize scientific publications on systems thinking and SD as retrievable in management and organization research areas?

RQ2. What social and conceptual structures characterize the scientific debate on systems thinking and SD in management and organization research areas?

RQ3. How can future research on systems thinking and SD be developed in management and organization research areas?

By answering these research questions, this paper contributes to the research by offering a broad and comprehensive systematization of studies on SD as retrievable in management and organization studies, pointing a way forward for future research directions. In addition, practitioners and decision-makers may find a useful blueprint to promote the adoption and development of SD models and tools in organizational and community-level contexts, here considering their managerial and organizational implications.

The remainder of the present article is organized as follows: Section 2 systematically describes the research design and the methods employed. Section 3 presents the descriptive results of the bibliometric analysis. Section 4 presents the results of the network analysis and the different thematic clusters that emerged. Based on the previous discussions, Section 5 offers possible future research streams based on several propositions and possible research questions. Finally, Section 6 highlights the paper’s implications, limitations, and further developments.

Research design

In this work, a bibliometric approach was adopted to investigate the scientific production related to SD, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol, as in other systematic literature reviews in the business and management research fields (Bertello et al., 2023; Kraus et al., 2022). Bibliometrics, which represents a subbranch of informetrics, consists of statistical techniques aimed at measuring both the productivity and impact of scientific research (Cuccurullo et al., 2016; Merigó et al., 2015). By adopting bibliometric methods, more articles than traditional literature reviews could be investigated, ensuring high levels of rigor, transparency, and replicability (Daim et al., 2006; Rey-Martí et al., 2016). In the current study, bibliometrics was used to uncover the underlying structure of research related to the application of SD principles and tools, focusing attention on the business and management domains. Moreover, as in other bibliometric works (Forliano et al., 2021; Secinaro & Calandra, 2020), a network analysis aimed at depicting the underlying structures (i.e., conceptual and social) characterizing the research field was performed.

Data collection and extraction

After defining the study’s research questions, the second step of a bibliometric study is to determine which keywords must be used to collect raw data. Consistent with previous studies related to the SD topic (Darabi & Hosseinichimeh, 2020; Oladimeji et al., 2020; Sedarati et al., 2019) and the broad investigation aim of this study (Chen & Xiao, 2016), high-level keywords related to systems thinking, SD, and related methods such as causal loops and stock and flow diagrams were used.

Third, the database to be investigated to collect the necessary metadata related to publications on SD had to be selected. In the social sciences, the two largest and most reliable databases are Clarivate Analytics’ Web of Science (WoS) and Elsevier’s Scopus (Forliano et al., 2021). Therefore, according to the syntax of the two databases, the string was developed using wildcards to truncate the keywords and capture singular and plural variants of the search terms, while it was possible to search for alternatives through the Boolean operator “OR.” The search was conducted in January 2023 to search for documents’ titles, abstracts, and keywords, returning 37,605 results to WoS and 55,241 results to Scopus. As shown in Fig. 1, different exclusion criteria were applied, excluding studies not written in English or that passed through a peer-review process. To answer the research questions of this study, all articles that were not classified in the “Business” or “Management” domain were further excluded (Massaro et al., 2016; Tranfield et al., 2003). Although representing a possible limitation of this study, applying these selection criteria also allowed us to perform a more accurate comparison of different productivity and relevance metrics. Indeed, other relevant subdomains concern “STEM” disciplines (i.e., science, technology, engineering, and

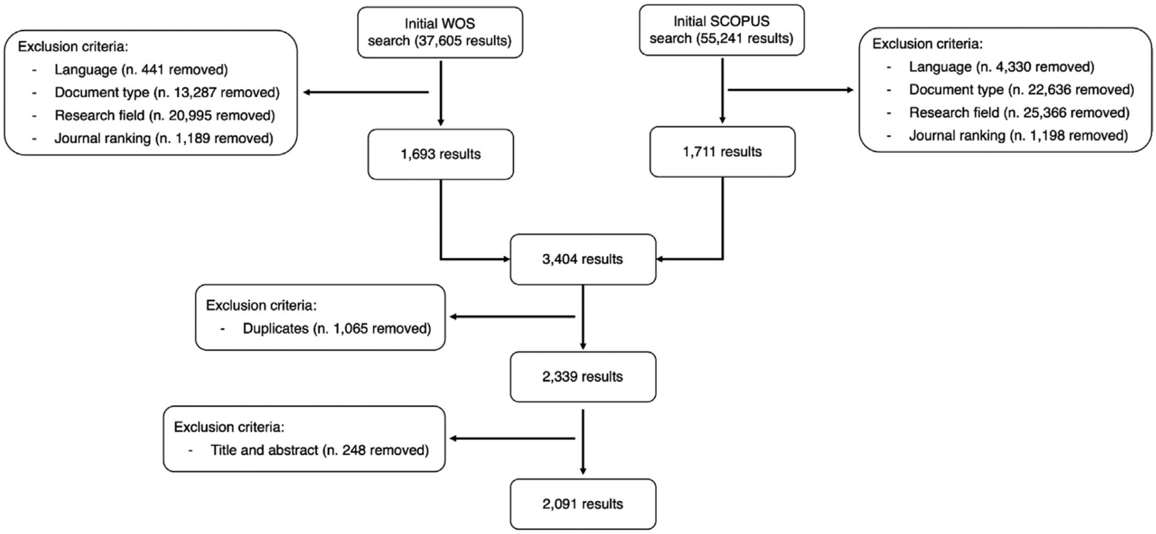

Fig. 1. PRISMA flow diagram showing the different phases of data extraction activity.

mathematics) or medicine, whose productivity and relevance metrics are completely different from those of the social sciences. Finally, as in previous systematic literature reviews (Battisti et al., 2021; Zheng et al., 2022), the search was restricted to only articles published in journals ranked 2 or above in the 2021 Academic Journal Guide (formerly the Chartered Association of Business Schools, ABS). In this way, the most relevant and rigorous articles could be collected and analyzed. Hence, after the two databases were merged, 3404 articles were identified, of which 1065 duplicates were removed. Finally, by analyzing the articles' titles and abstracts while maintaining a broad perspective, it was possible to restrict the data collection to a final sample of 2091 records.

Bibliometric analysis

The final sample of 2091 articles was analyzed through bibliometric analysis. Thus, open-source *RStudio* software (RStudio Team, 2016) was used for conducting a performance analysis of the scientific literature related to the topic, especially the *Bibliometrix* package (Aria & Cuccurullo, 2017), which has been increasingly adopted by researchers in similar studies (Forliano et al., 2021; Secinaro & Calandra, 2020) because it enables the creation of a normalized matrix comprising all records extracted from Scopus and the performance of a bibliometric analysis. A performance analysis of studies related to SD was completed by leveraging several indicators built on metadata related to articles, scholars, countries, and journals (Massaro et al., 2016). In this sense, both their productivity and impact on the scientific community could be captured by evaluating general trends characterizing this research field in the business and management domains.

Network analysis

Another widely used technique in bibliometric studies is network analysis, which maps the underlying structures characterizing a given research field and their evolution over time (Cobo et al., 2012). This analysis is crucial for identifying research trends and gaps in a given field. Thus, the social and conceptual structures of studies on SD were reconstructed. Notably, the former was analyzed by considering the authors' coauthorships. Conversely, assuming that keywords used together refer to themes that are relevant to each other and can be combined into a thematic cluster (Van Eck & Waltman, 2009), the latter was analyzed by investigating keywords' co-occurrences. In particular, both the authors' keywords and index keywords were used. However, to do so, the original sample of 6343 different authors' keywords (out of 10,120 in total) and 7108 different index keywords (out of 16,044 in total) had to be normalized. Indeed, keywords written in different ways but referring to the same term because of singular/plural forms, upper or lowercase letters, British/American English variants, acronyms, hyphens, and similarities had to be reconciled. This analysis was conducted using *OpenRefine (ver. 3.3)*, an open-source tool originally developed by Google for managing and cleaning big data, and successfully utilized in several similar studies (e.g., Montoya et al., 2016). Considering the size of the database, the different specific algorithms embedded in the software and designated for data reconciliation enabled us to obtain more rigorous and replicable results than manual analysis. At the end of the data cleaning phase, 5627 authors' keywords and 6512 index keywords were retained. Thus, the refined dataset was processed in *VOSviewer (ver. 1.6.13)*, which is a powerful tool for visualizing the structure and dynamics of large networks. Indeed, *VOSviewer* creates distance-based maps of networks based on the similarity measure of the nodes (Van Eck & Waltman, 2010).

Descriptive results of the bibliometric analysis

This section presents the results of the performance analysis, which was conducted by analyzing articles, authors, countries, and journals as units of analysis. In this way, it is possible to answer RQ1 of this study.

The evolution of articles over time

Studies on SD started in the late 1950s, when Forrester (1958) leveraged a feedback view and a computer simulation model to investigate complex issues related to order oscillations and subsequent supply chain management. Forrester's efforts in applying SD in industrial contexts led to his seminal book *Industrial Dynamics* (Forrester, 1961). Since those prominent studies, research on this topic has been published for more than 70 years, and SD studies have been translated from the engineering and computer science domains to analyze different research areas at varying analysis levels. Additionally, after industrial applications of SD, Forrester focused his attention on managing urban planning issues and applying SD principles to guide the sustainable development of economies, which gave rise to two other seminal books, *Urban Dynamics* (Forrester, 1970) and *World Dynamics* (Forrester, 1971). In this sense, as Fig. 2 shows, starting in the late 1990s, scholars began devoting increasing interest to SD, which

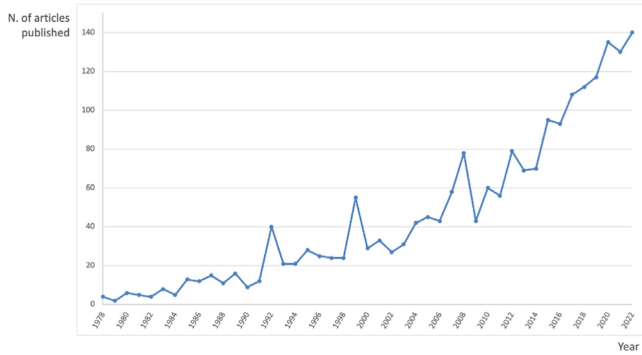

Fig. 2. Distribution of publications related to SD over time.

reached its first peak in terms of the number of papers published. This increase was further spurred by the formation of a SD research group around Jay W. Forrester's figure at the MIT Sloan School of Management. Indeed, some of the most influential scholars from this group have emerged in this research stream. For example, Peter Senge, who wrote *The Fifth Discipline* (Senge, 1990), a central book in divulgating systems thinking and SD principles to the broad public; John Sterman, who wrote another seminal handbook in explaining SD applied to businesses and organizational learning processes (Sterman, 2000); and John Morecroft, who mainly investigated bounded rationality decision-making problems (Morecroft, 2015). In particular, Morecroft played a fundamental role in spreading SD in Europe by reinvigorating the link between SD and strategic management studies. Although scholars' interest in SD has increased over the years, it has received significant attention only recently, and more than half of the total articles related to this topic have been published only in the last 10 years. This trend can also be explained by considering industry and practitioners' recognition of the relevance of thinking systemically and leveraging SD to address complex and dynamic problems. In conclusion, it can be assumed that SD is still an underdeveloped research stream that offers plenty of progress and studies that can take place.

To determine which articles most influenced the scientific debate around SD in the investigated research fields, the number of citations received by each article was considered. Indeed, citations can adequately synthesize the influence of a publication among scholars (Merigó et al., 2015). Table 1 shows the 10 most cited documents of the sample, showing the total citations (TCs) received by other papers in the dataset as accounted for by Scopus and the average citations received per year (TC/Y). Surprisingly, Sterman occurs four times in this ranking and can be considered one of the seminal authors in advancing SD knowledge in the business and management domains. Moreover, as a reference journal for SD studies, it is not surprising that "System Dynamics Review" appears six times in the list of the top ten most influential articles. The most cited paper is a methodological one from Barlas (1996) addressing model validation issues, such as structural and behavioral issues, and counting 950 citations. The second most cited article comes from Daim et al. (2006), in which the authors mixed bibliometric techniques and patent analysis with SD to model the ecosystem surrounding disruptive technologies and forecast their future diffusion. Third, it is possible to find a reflection from Forrester (1994) about the usefulness of SD models to advance theory in the operation research field, followed by two conceptual papers from Sterman (2001, 2002), both of which aimed at reinforcing the general awareness about the relevance of adopting a systemic lens to interpret complex systems, as well as using formal models to test decision-makers' mental models and simulating the implementation of different policies.

Authors and countries

A total of 3552 authors from 65 countries and 2050 different institutions contributed to publishing the 2622 articles in the analyzed dataset. Thus, by leveraging authors as a unit of analysis, their productivity and impact were considered to investigate which scholars mainly influenced business and management studies on SD. Fig. 3 visually portrays the 15 most influential authors, matching their productivity, represented by the number of papers published each year (i.e., bubble size), and impact, represented in terms of citations per year received (i.e., bubble darkness). The TCs per year were preferred to TCs, not to penalize scholars whose careers started in more recent years. Therefore, Saeed, Sterman, Richardson, Andersen, and Morecroft show the most extended timelines, with an unbroken series of publications starting in the early 1980s to date. However, considering the h-index, Sterman (24), Richardson (19), and Lane (18) are among the most influential authors. Indeed, the h-index indicates the minimum number of publications cited at least h times by other scholars in the dataset (Hirsch, 2005) and is considered a well-established and robust indicator that simultaneously combines productivity and relevance (Vanclay, 2007). It is also interesting to note that Rahmandad started publishing in recent years (his first publication in the dataset was released in 2008) but ranks second in terms of citations per year received by the 15 most influential authors. To offer a more precise

Table 1
The 10 most relevant documents in the dataset.

#	Author(s)	Title	Year	Journal	TC	TC/Y
1	Barlas	Formal Aspects of Model Validity and Validation in System Dynamics	1996	Syst. Dynam. Rev.	950	33.93
2	Daim, Rueda, Martin, & Gerdsri	Forecasting emerging technologies: Use of bibliometrics and patent analysis	2006	Technol. Forecast. Soc. Change	765	42.50
3	Forrester	System dynamics, systems thinking, and soft OR	1994	Syst. Dynam. Rev.	609	20.30
4	Sterman	System Dynamics Modeling: Tools for Learning in a Complex World	2001	Calif. Manage. Rev.	549	26.14
5	Sterman	All Models Are Wrong: Reflections on Becoming a Systems Scientist	2002	Syst. Dynam. Rev.	539	24.50
6	Rahmandad & Sterman	Heterogeneity and Network Structure in the Dynamics of Diffusion: Comparing Agent-Based and Differential Equation Models	2008	Manage. Sci.	456	28.50
7	Dejonckheer, Disney, Lambrecht, & Towill	Measuring and avoiding the bullwhip effect: A control theoretic approach	2003	Eur. J. Oper. Res.	437	20.81
8	Vennix	Group model building: tackling messy problems	1999	Syst. Dynam. Rev.	375	15
9	Wilson	The impact of transportation disruptions on supply chain performance	2007	Transp. Res. E: Logist. Transp. Rev.	345	20.29
10	Gino & Pisano	Toward a Theory of Behavioral Operations	2008	Manuf. Serv. Oper. Manag	341	21.31

Note: Papers are ordered by total citations received by other documents in the dataset (TC). The right column reports the total citations received per year (TC/Y).

Fig. 3. Top 15 authors in terms of productivity and impact.

Table 2
Top 15 scholars in the dataset based on productivity.

#	Author	NP	TC	h_index	PY_start	TC/Y
1	Sterman J	34	4238	24	1985	114.54
2	Richardson G	30	2138	19	1985	57.78
3	Lane D	30	1444	18	1991	46.58
4	Andersen D	29	1646	16	1988	48.41
5	Saeed K	26	273	10	1982	6.82
6	Morecroft J	24	727	15	1983	18.64
7	Wolstenholme E	22	1044	14	1982	26.1
8	Vennix J	20	1280	16	1992	42.67
9	Kunc M	18	520	13	2007	34.67
10	Ford D	17	1032	9	1998	43
11	Larsen E	17	368	12	1993	12.69
12	Größler A	17	306	9	2001	14.57
13	Rouwette E	16	971	13	1996	37.35
14	Rahmandad H	16	907	12	2008	64.79
15	Naim M	15	782	12	1991	25.23

Note: Records are ordered by the total number of publications in the dataset (TP). Other performance measures are related to citations received (TC), h-index, first document retrieved in the dataset (PY_start), and total citations per year recjeived (TC/Y).

view of the performance indicators associated with each scholar represented in Fig. 3, the productivity (i.e., total publications in the dataset) and impact measures (i.e., TCs received, h-index, and TCs per year received) are also reported in Table 2.

Furthermore, considering the authors' affiliations, both countries' productivity and impact were analyzed. Hence, the top 15 countries, here based on their productivity, are plotted in Fig. 4. In particular, productivity was differentiated to capture the rate of intracountry collaboration (i.e., single-country publication or SCP) and intercountry collaboration (i.e., multiple-country publication or MCP). Thus, the SCP includes publications with all authors affiliated with the same country, while the MCP includes publications with authors from different countries. Out of the 65 total countries involved, only 457 documents were single-authored (approximately 21.86 % of the dataset), meaning that collaboration is a significant aspect of authors adopting or investigating SD. This assumption is further corroborated by Fig. 4, which shows how both advanced economies (e.g., the USA, the UK, Germany) and developing ones (e.g., China, India, Iran) appear among the most productive countries and are all open to multinational collaboration. Interestingly, neither African nor Latin American (except for Colombia) countries appear on this list.

Table 3 reports the top 15 countries in terms of the total number of citations received. Therefore, as shown in Fig. 4, the USA proves to be a leader in both productivity and relevance, followed by the UK. Interestingly, almost all the most prolific countries are also the most influential, with only India and Spain giving way to Sweden and Greece.

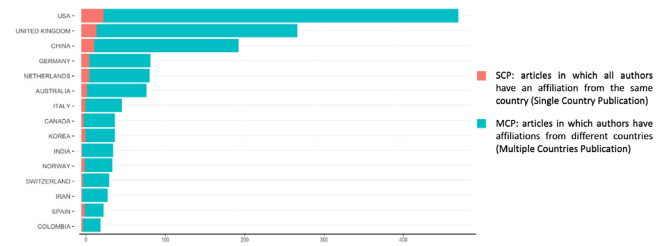

Fig. 4. The 15 most productive countries based on authors' affiliations.

Table 3
The top 15 countries were ordered by the total number of citations received.

#	Country	TC	TC/TP
1	USA	22,957	48.33
2	United Kingdom	10,762	39.57
3	China	5002	25.26
4	Netherlands	3487	40.55
5	Australia	2215	27.01
6	Germany	2158	24.80
7	Sweden	1829	87.10
8	Italy	1201	23.55
9	Greece	1043	61.35
10	Canada	984	23.43
11	Korea	930	22.14
12	Colombia	854	35.58
13	Switzerland	850	24.29
14	Norway	824	21.13
15	Iran	605	18.33

Table 4
The 15 most relevant journals are ordered by the total number of publications in the dataset.

#	Journal	TP	TC
1	Syst. Dynam. Rev.	495	17,911
2	J. Clean. Prod.	229	6598
3	Eur. J. Oper. Res.	103	4896
4	J. Oper. Res. Soc.	138	4313
5	Technol. Forecast. Soc. Change	97	3107
6	Int. J. Prod. Econ.	52	2027
7	Syst. Res. Behav. Sci.	150	2200
8	Int. J. Prod. Res.	66	2104
9	J. Constr. Eng. Manag.	26	1048
10	Int. J. Proj. Manag.	18	1031
11	J. Manag. Eng.	21	648
12	Decis. Support Syst.	16	658
13	Reliab. Eng. Syst	20	507
14	Manage. Sci.	12	1518
15	Syst. Pract. Act. Res.	27	392

Journals

The 15 most prolific journals in which the dataset's documents were published are presented in Table 4. Not surprisingly, *System Dynamics Review* ranks first, with 495 publications (i.e., approximately one-quarter of the dataset). Indeed, this journal focuses exclusively on advancing systems thinking and SD and their applications in a broad range of areas (e.g., societal, technical, managerial, and environmental). However, it is interesting to note that the *Journal of Cleaner Production* also performs very well in terms of publications related to SD used as a theoretical lens and practical approach to investigating sustainability-related issues. The analysis of the other most productive journals present on the list shows that great attention was given by scholars to manufacturing, industrial engineering, and operations research, together with the sociotechnical implications of adopting a systemic view. In addition to journals'

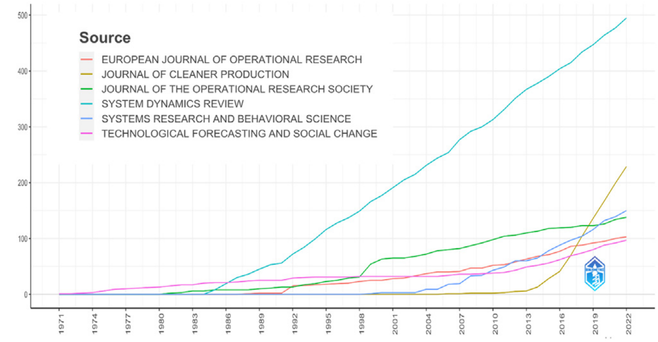

Fig. 5. The publication trends of the six most productive journals.

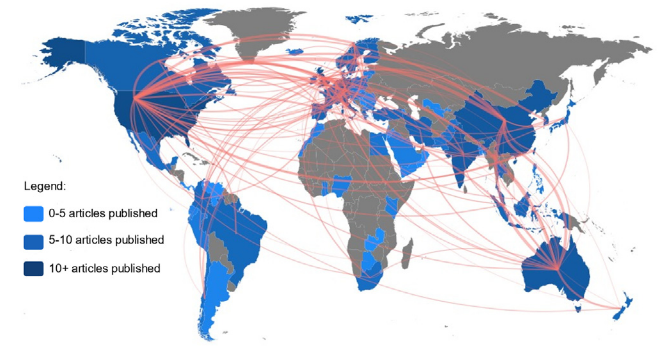

Fig. 7. The rate of collaboration between countries, here based on authors' affiliations.

productivity, Table 4 also considers their impact in terms of TCs. In this sense, however, there are no significant differences compared with sorting journals for their productivity, except in the case of *Management Science*. Indeed, some very influential articles coauthored by Sterman (e.g., Oliva & Sterman, 2001; Rahmandad & Sterman, 2008; Sterman et al., 1997) have been published in that outlet.

Moreover, in Fig. 5, the publication trends of the six most productive journals are shown. In this sense, it can be easily noted that, excluding *the System Dynamics Review*, the *Journal of Cleaner Production's* publication trend outstands all other journals. On the other hand, the *Journal of the Operational Research Society* and *Systems Research* and *Behavioral Science* shows an increasing trend, followed by the *European Journal of Operational Research* and the *Technological Forecasting and Social Change*.

Discussion of the social and conceptual structures

To complete the bibliometric analysis of studies about SD in the business and management domains, this section presents the results of the network analysis performed to provide an overview of the social and conceptual structures characterizing such studies and their authors. Therefore, it would be possible to answer RQ2 of this study.

Social structure

Concerning the social structure of studies related to SD, the co-occurrences of the top 50 authors (i.e., coauthorship) were analyzed (Forliano et al., 2021). Fig. 6 shows the network resulting from applying the normalization of association strength (Van Eck & Waltman, 2009). In particular, the greater the number of documents authored by a scholar, the greater its node; the greater the number of documents coauthored by two or more scholars, the closer their bubbles appear, and the more robust the links connecting them are. Interestingly, by applying Louvain's cluster algorithm (Blondel et al., 2008), Fig. 6 shows the existence of 15 clusters (each defined by a different color) among the 50 most influential authors. In this sense, most of them act as isolated nodes or as niche research groups, suggesting the existence of few influential communities of scholars. It must be noted that the largest SD community includes some of the fathers of this discipline (e.g., John Sterman, David Andersen, George Richardson) and the founders of the System Dynamic Review, the reference journal in this research field. Interestingly, most of them studied as Ph.D. students at MIT (such as Saeed or Morecroft, which appear in a different cluster), where Forrester started to teach SD in the early years of such a discipline.

Moreover, considering the authors' affiliations, in line with the performance analysis results, a high level of engagement exists around SDs worldwide. This collaboration rate is represented by more robust lines connecting countries in Fig. 7, while the countries' productivity is portrayed based on color intensity. Thus, a very high collaboration rate exists between China and English-speaking countries (i.e., the USA, Australia, Hong Kong, and the UK), which also collaborate with each other. With respect to Europe, except for the UK, the most active communities can be found in Norway, the Netherlands, and Italy, three countries where some consistent research groups on SD are located (i.e., especially Norway, which hosted the first international conference on SD in 1976). In contrast, there is still a paucity of engagement from Latin American (apart from Colombia) and African authors.

Conceptual structure

This analysis highlights the relational patterns among keywords that frequently co-occur within our dataset, which are known as co-

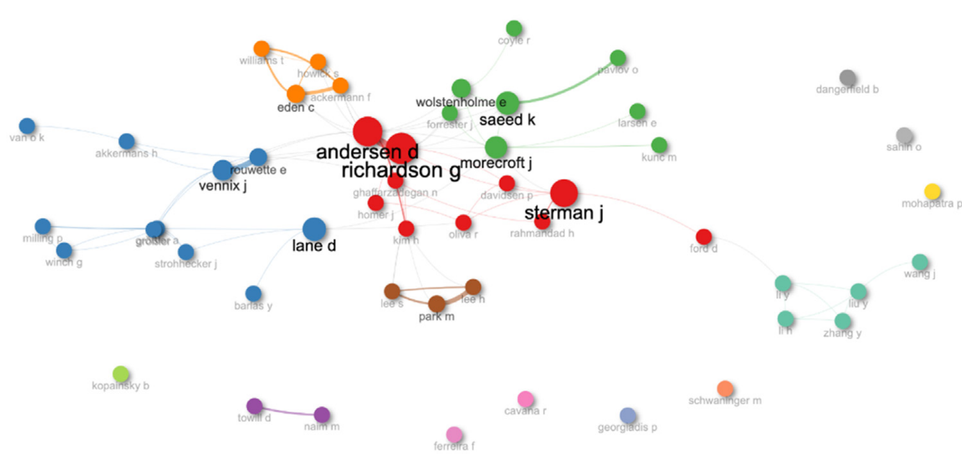

Fig. 6. Coauthorship analysis depicting the social structure of the discipline.

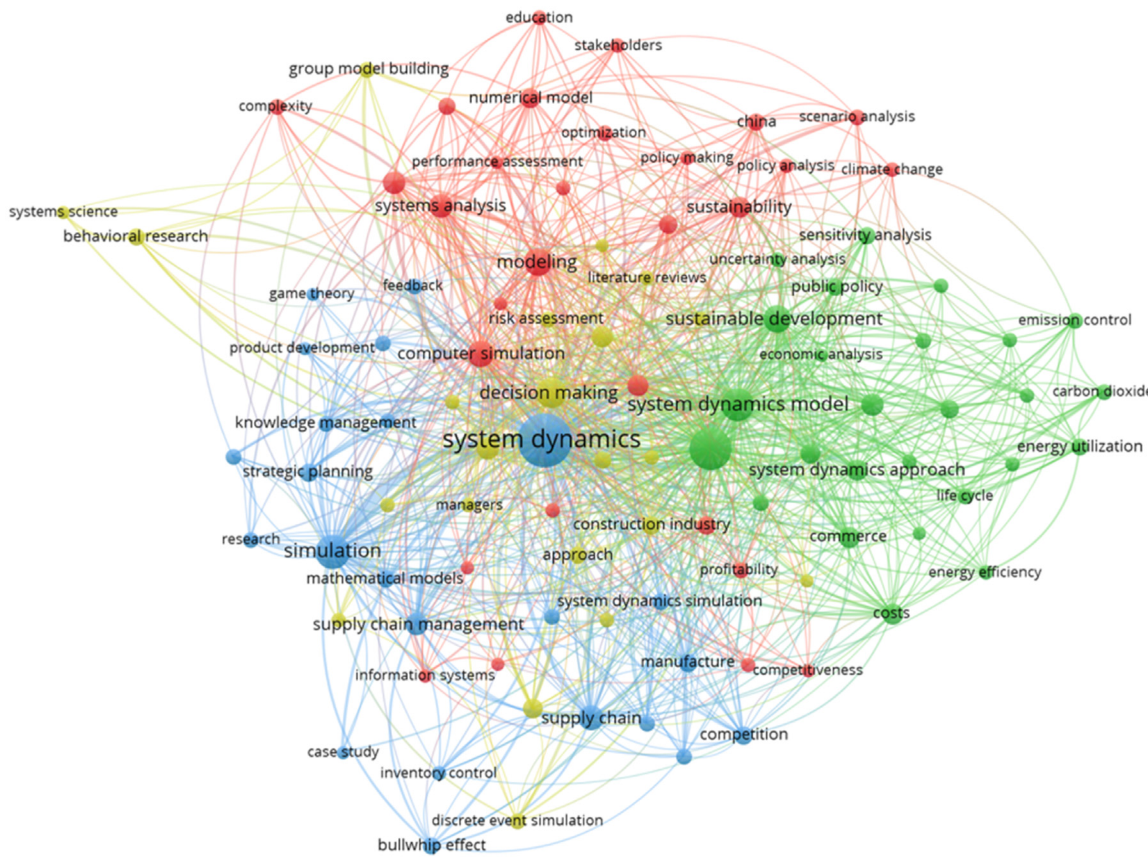

Fig. 8. The conceptual structure of the dataset, here based on co-occurrence keywords.

occurrences (Van Eck & Waltman, 2009). In our study, we examined both authors' keywords and index keywords, with the latter added by professional indexers and sometimes deemed more informative than the authors' keywords (Campedelli, 2020). With VOSviewer, we concentrated on the 100 most co-occurring keywords, each occurring at least 18 times. Using the Louvain algorithm with a resolution parameter of one across 10 iterations (Blondel et al., 2008), we identified four distinct thematic clusters, each represented by a different color in Fig. 8. The size of a keyword's node in the network signifies its frequency of use by scholars, and the proximity and line thickness between keywords indicate their co-occurrence rates. These clusters serve as preliminary automatic structuring facilitated by VOSviewer's use of the Louvain algorithm, a community detection method that optimizes modularity to partition the network into clusters of densely interconnected nodes with sparser connections between clusters. According to the analysis presented in Fig. 8, the following four thematic clusters emerged:

- Cluster 1: Operations research and strategy formulation (blue cluster);
- Cluster 2: Behavioral studies and collaborative approaches (yellow cluster);
- Cluster 3: Dynamic performance management (red cluster);
- Cluster 4: Systems thinking to support sustainable development (green cluster).

Following other bibliometric studies and systematic literature reviews (e.g., Bertello et al., 2023; Martínez-Climent et al., 2018; Sánchez-Robles et al., 2023), after this algorithmic clustering, we conducted a manual content analysis of the 30 most cited articles in each cluster to extract deeper thematic insights. This manual analysis allowed us to further unveil how the core topics defined the conceptual structure of the topics under investigation. The findings from this detailed manual examination form the basis of the discussions presented in the following subsections.

Operations research and strategy formulation

The roots of SD as a research field have been deeply connected with operations research since its origins, when Forrester (1958) recognized that a company's supply chain management could be described as a complex system characterized by feedback loops that imply time delays, nonlinearities, unintended consequences, and suboptimal behavioral decisions. Thus, keywords in the first cluster reflect how SD has been broadly adopted to investigate industrial issues, such as inventory control, capacity building adjustments, oscillations in order backlog, and instability in market shares (Richardson, 1999; Rahmandad & Repenning, 2016). For example, scholars have made great efforts to frame the financial and information flows that can lead to fluctuations in inventories (Barlas & Gunduz, 2011; Fiala, 2005), which were first conceptualized by Forrester (1961) as the famous bullwhip effect.

In this sense, several scholars consider SD simulation and mathematical models to be better than traditional linear approaches for framing operation management issues that otherwise would be difficult to identify and handle (Größler et al., 2008; Warren, 2005). Indeed, SD can be leveraged to explain every complex system, whose behavior is intimately determined by the interactions occurring among the variables constituting its underlying structure (Sterman, 2000). These variables are mainly related to those resources that can be considered strategic in the closed boundaries of the system under analysis and the capacity to effectively manage the flows between them. For this reason, several SD studies have adopted the resource-based view (RBV) of a firm and its knowledge-based (knowledge-based view, KBV) or intangible-based (intellectual capital-based view, ICBV) extensions as theoretical lenses for analyzing successful strategies characterizing a firm rather than another (Johnson, 1999;

Kunc & Morecroft, 2009; Wassmer & Dussauge, 2012). However, possessing the right resources is not enough to spur firm performance, and the causal relationship between resource acquisition and depletion should also be captured and framed (Bianchi et al., 2010; Kim & Park, 2006; Kunc & O'Brien, 2017). Currently spurred by the rise of the Industry 4.0 paradigm, novel technologies such as big data, cloud computing (Hofmann, 2017; Kochan et al., 2018), and open innovation strategies (Yun et al., 2016; Vignieri, 2020) seem to play a fundamental role in guiding such processes and helping to cope with those regulatory and market-based challenges in existing and emerging markets (Kobos et al., 2018).

Given the above, the way managers and decision-makers respond to a given situation largely depends on SD models' capacity to refer to correct assumptions. Indeed, these assumptions guide strategic and operational decisions, such as perceiving orders, evaluating material flows and inventory adjustments, scheduling production, and hiring a new workforce. Hence, SD has strict links with resource accumulation and implementation (Li et al., 2018) and strategy formulation (Gary et al., 2008; Cosenz & Noto, 2016) and can represent a proper approach to avoid capability erosion (Rahmandad & Repenning, 2016). SD modeling can support future research in understanding the nonlinear and delayed effects of supply chain policies and strategies, the causal relationships between the business environment and organizational capabilities, and the role of Industry 4.0 technologies in reshaping operations research in dynamic and complex contexts.

Behavioral studies and collaborative approaches

The second cluster reveals the interest of scholars in applying SD to understand how models can affect people's behavioral changes and vice versa; since early studies on SD leveraged some insights from psychology and cognitive sciences (Bendoly, 2014; Bendoly et al., 2010; Gino & Pisano, 2008). For example, Liu et al. (2015) showed how people who act in turn-based simulations are involved in learning processes that iteratively guide their decisions. Therefore, they responded to other actors' decision rules, altering their behavior and, at the same time, the steady state of the system, which, in turn, alters other people's experiences.

Thus, if a great variety of SD studies assume that managers and decision-makers are rational agents, they often do not adequately perceive the underlying structure of the complex and dynamic systems in which they behave. Subsequently, they often suffer from misperception issues, even if they have to deal with simple dynamic systems (Moxnes, 2004; Moxnes & Davidsen, 2016).

Although recent studies have focused on revealing the microfoundations of problem solvers' and decision-makers' behaviors (Mohaghegh & Größler, 2020) and knowledge management practices (Chen & Fong, 2015), these problems are not new to systems dynamicists. Indeed, they were already recognized in the late 1980s, when Forrester conceptualized a behavioral theory endogenously characterizing actors' decision rules by investigating the experimental scenario of its famous "Beer Distribution Game" (Sterman, 1989). Hence, he recognized how the short-termism and lack of a systemic perspective of people in recognizing the feedback loops characterizing a supply chain could lead to nonlinearities and time delays typical of the bullwhip effect. Based on this conclusion, several articles have investigated misperception problems in experimental settings. For example, Weinhardt et al. (2015) investigated how people's different cognitive styles and analytical orientations affect their understanding of the accumulation and depletion processes typical of systems characterized by the presence of stocks and flows. In this sense, they confirmed the same results as Cronin and Gonzalez (2007), who found that even highly educated people often do not understand the basic principles guiding stock and flow model behavior.

In addition, it must be highlighted that the first applications of SD adopted in organizational settings were mostly leveraging SD specialists as consultants who used to build models without involving the impacted stakeholders in the process (Cosenz & Noto, 2016). However, thanks to the book "The Fifth Discipline" by Senge (1990), which shed light on the importance of systems thinking and the rise of a new public governance paradigm, scholars, and practitioners started giving more attention to collaborative methods aimed at model building and value cocreation processes. Indeed, systems thinking serves as a theoretical framework for guiding human actions and mental models to understand the big picture around specific issues and avoid concentrating on direct, short-term, and linear causal relationships (Meadows, 1989; Ricciardi et al., 2020). Collaborative approaches and group model building came to the fore as methods to involve the relevant stakeholders of determined processes in framing the feedback loops characterizing the complex and interconnected systems under analysis in which they are embedded (Rouwette et al., 2002). Thus, involving such actors in a prior exploration of a model's result or building a causal loop or stock and flow diagram would help untangle the complexity of specific systems and raise SD models to full potential, hence taking care of their different interests and logics, which often compete with each other (Kopainsky et al., 2014; Forliano et al., 2020). In this vein, by leveraging institutional theories, adaptive comanagement, and the body of knowledge on the (new) commons, Ricciardi et al. (2020) recently proposed a conceptual causal loop diagram aimed at offering a participatory SD modeling method to overcome the fragilities raised when common resources are at stake. Therefore, involving managers, decision-makers, practitioners, or even citizens through participatory techniques and group model building could represent a critical step in achieving shared consensus behind SD models and different stakeholders' understanding of the system of interest, effectively guiding behavioral change processes.

The insights from this cluster suggest many ways to advance SD research in management and organization studies. SD must be used, for instance, to include/mitigate human biases in complex decision-making processes, to explore the dynamics of sense-making processes in terms of stakeholders impacted, and to shed light on the interplay between individuals, organizations, and communities in value cocreation processes.

Dynamic performance management

As with the other thematic clusters, performance management has also been a topic that has characterized SD studies since the origins of this research field. To overcome the difficulties related to applying SD principles by solving differential equations and using spreadsheets, the development of simulation software and computer-aided modeling is a critical step (Richmond, 1994). Indeed, the possibility of graphically representing system archetypes, causal loop diagrams, and stock and flow models is fundamental to disclosing SD to a broader public than specialists and mathematics (Wolstenholme, 2003). Following this idea, scholars started building "management flight simulators" for applying SD methods to business management in the 1980s (Forrester, 2007; Sterman, 2014). Through user-friendly dashboards and key performance indicators, these tools provide inexperienced users with an interactive learning environment that can be used to design and test different policies, evaluate diverse scenarios, and increase their acceptance of complex SD models (Bianchi & Bivona, 2000; Davidsen, 2000; Größler et al., 2000). Conversely, in other cases, it was found that participants' performances can be leveraged by involving them in a prior exploration of the model, even if it is not in its final form (Kopainsky et al., 2014). Whereas its underlying structure characterizes the behavior of a system, organizational performance results from that behavior. Thus, understanding and communicating how that behavior is related to a system's processes and activities represent critical steps for ensuring participants' performance (Schoenberg et al., 2020).

Currently, combining SD principles and traditional performance management systems seems to be an even more urgent need (Santos et al., 2018), especially in the public management sector (Cosenz, 2014; Forliano et al., 2020). Current organizations are characterized by an increased level of complexity at which fast markets and turbulent environments have further exacerbated. Although traditional performance management systems have evolved greatly in recent years to include both financial and nonfinancial measures (Paolone et al., 2020), they are usually unable to capture such complexities, nonlinearities, time delays, and causal relationships (Bianchi et al., 2010; Nielsen & Nielsen, 2013; Oladimeji et al., 2020). In particular, recognizing and managing nonlinearities and time delays is relevant because it enables a company to effectively monitor its progress and implement corrective measures in a timely manner to adjust deviations from its objectives. At the same time, considering the causal connections between the variables of a system is a critical and often counterintuitive step for ensuring that a company achieves its intended short- (i.e., outputs) and long-term (i.e., outcomes) objectives (Bianchi, 2016). For example, in Akkermans and Van Oorschot (2018), by applying SD, the authors found that a Dutch insurance company's performance had to decrease in the short term to increase significantly in the near future. Moreover, contradicting managers' ex ante assumptions, the authors showed how customer and employee satisfaction should not compete with each other or with companies' productivity goals. Such elements can, in fact, be leveraged to form a virtuous reinforcing loop to sustain organizational performance.

Combining traditional performance systems with SD, in what scholars call dynamic performance management principles and tools, can help overcome such fragilities in large and small-to-medium enterprises (Bianchi, 2016; Bianchi et al., 2018; Cosenz & Noto, 2015). In particular, through causal loop diagrams and stock and flow models, dynamic performance management provides mathematical and graphical evidence of existing loops among key variables that should be reinforced or balanced, usually unpredictable, using traditional systems thinking approaches (Bianchi, 2016; Sterman, 2000). Thus, several studies have explored how SDs can be used to bring to their full potential traditional reporting systems (Paolone et al., 2020; Ramanna, 2013), strategic tools such as balanced scorecards (Akkermans & Van Oorschot, 2018; Kunc, 2008; Nielsen & Nielsen, 2013) or value stream maps (Noto & Cosenz, 2020); SDs can also be used to guide the definition of the value proposition of a company and its business model innovation processes (Bianchi & Bivona, 2000; Cosenz & Bivona, 2020).

Research on dynamic performance management may inform management and organization studies in many ways in the future. We recommend, for instance, investigating the most effective interacting learning environments to increase practitioners' understanding of complex models and organizational performance. Particular importance needs to be given, especially to the nonfinancial end results of systems. In this regard, clashes between different systems of beliefs and values as well as outcomes at the systemic level must be taken into account in the development of performance management models.

Systems thinking to support sustainable development

After the first applications of SD principles and tools in industrial and organizational settings, as discussed by analyzing the evolution of this research topic in Paragraph 3, the systems dynamics group at MIT started analyzing urban planning issues and criticized different policies implemented in U.S. cities. One year after the publication of "Urban Dynamics" (Forrester, 1970), because of the collaboration between MIT researchers and the newly founded Club of Rome, two other seminal books were published: *World Dynamics* (Forrester, 1971) and *Limits to Growth* (Meadows et al., 1972). Notably, the Club of Rome is an international research group composed of scientists, economists, practitioners, former politicians, and generally thought leaders whose mission was (and still is) to help humanity cope with societal and economic global challenges. By framing three different subsystems of our planet (i.e., the industrial production subsystem, the human population subsystem, and the agri-food subsystem), the combined work of the System Dynamics Group and the Club of Rome stimulated the public debate about the impact of human activity on the planet's health (Randers, 2000). Thus, they alerted the world about the urgency of starting to deal with a sustainable transition of economies and societies. Since then, several articles have investigated environmental and social issues at the organizational and system levels. To name a few, these studies include waste management (Ding et al., 2018; Sudhir et al., 1997; Wang et al., 2015), water consumption and access (Hjorth & Bagheri, 2006; Sahin et al., 2015; Sun et al., 2017), emissions, energy, and transport (Bassi et al., 2012; Del Vecchio et al., 2019), healthcare and diseases (Dangerfield, 1999; Darabi & Hosseinichimeh, 2020), and public security and crime control (Eisenstein, 2008; Xavier & Bianchi, 2020). Nevertheless, because of the recent interest of the *Journal of Clean Production* in publishing papers adopting SD to investigate sustainable development issues, the fourth cluster contains more recent studies than previous ones.

In recent years, disruptive changes in technological and societal scenarios have increasingly created new challenges to be addressed and investigated, and the recent COVID-19 pandemic is expected to further exacerbate some of these issues. Moreover, scholars have started recognizing how actors other than companies or public regulators can also contribute to addressing them, such as the cities of the future (i.e., smart cities) or universities that embrace the paradigm shift brought about by the third mission and the growth of their entrepreneurial role (Forliano, 2023; Maruccia et al., 2020; Ruutu et al., 2017).

All the abovementioned trends can explain why keywords related to environmental problems and wicked problems (e.g., climate change, environmental sustainability, and population growth) appear to be the most recent. Wicked problems (often referred to as grand challenges), in particular, represent problems that require collective effort and a big-picture perspective to be addressed. Indeed, they involve a large number of actors and logics, require the need to analyze their shifting from micro- to macro-level burdens and are counterintuitive and interconnected in nature, making their evolutionary path challenging to forecast (Raven & Walrave, 2020; Waddock et al., 2015). Hence, traditional mechanistic approaches are not adequate for coping with such issues, which are often related to complex, ambiguous, and self-organizing sociotechnical systems (Hjorth & Bagheri, 2006). Systems thinking represents an essential paradigm for capturing the complexity of large-scale sustainability issues and addressing wicked problems (Nabavi et al., 2017; Ricciardi et al., 2020). In fact, systems thinking is particularly adaptable for overcoming the shortcomings of linear thinking approaches and acquiring a holistic perspective on the problem to be addressed (Forrester, 1994; Senge, 1990). Moreover, according to Meadows (1989), this paradigm shift should be reached at the community level, even without communicating complex mathematical models or leveraging technical and difficult terms. Once mental models are framed to observe the big picture and capture the intricate structure of causal relationships underlying a specific system, SD tools can be used to operationalize such mental models, identify strategic stock and flow resources, measure their levels, and test different policies (Doyle & Ford, 1998). SD modeling can support future organizational actors' attempts to address sustainable development by providing analytical instruments to explore stakeholders' interactions within sustainable entrepreneurial ecosystems, to identify potential undesired and unintended consequences of human behavior and decisions, and to develop new theories and/or methods that address and explain the collaborative dynamics of social innovation systems.

Setting a future research agenda

Based on the content analysis presented in Section 4 and following Saura et al. (2021), to answer RQ3, the current study outlines eight propositions and 16 possible research questions to assist scholars and practitioners who are keen to explore this field of study.

In this regard, Cluster 1 probes the intricate web of supply chain dynamics, calling for a nuanced understanding of policies and strategies that grapple with the nonlinearities and temporal delays endemic to today's volatile markets. It questions how SD can empower practitioners to navigate turbulence, mitigate capability erosion, and manage innovation with agility (Olivares-Aguila & ElMaraghy, 2021). Within this realm, scholars have delved into the modeling of intangibles and their strategic management, pondering the effects of accumulation or depletion on organizational performance. The transformative impact of the Industry 4.0 paradigm on operations research is scrutinized, with a focus on emerging technologies that could improve SD methods (Kochan et al., 2018). Furthermore, this cluster contemplates the variances in strategic management applications between large-scale enterprises and small-to-medium-sized businesses through the prism of SD (Kazantsev et al., 2023). Accordingly, we formulate the following research proposals:

Proposition 1.1: The more accurately supply chain policies and strategies are framed within SD models to capture nonlinearities and time delays, the more effectively organizations can navigate volatile and fast-changing markets.

Proposition 1.2: The greater the integration of SD principles and tools with the Industry 4.0 paradigm, the more significantly operations research will transform to meet the challenges of dynamic and complex contexts.

Cluster 2 shifts the lens toward educational methodologies and the role of technologies in enhancing collaborative governance and sense-making processes (Costanza, 2022). It explores how learners can more effectively engage with the modeling of complex systems and how actor misperceptions in the adoption of these models can be addressed. The cluster examines the behavioral implications for stakeholders and the potential of SD to foster value cocreation at the individual, organizational, and community levels. It also considers the policies necessary to drive community resilience and trust and counteract policy resistance (Vignieri, 2020). It examines the impact of SD on stakeholder behavior and the alignment of outcomes across different organizational levels (Schoenberg et al., 2020) and how public policies can foster community resilience (Forliano et al., 2020). Therefore, we advance the following propositions:

Proposition 2.1: The better the introduction and involvement of learners in the SD modeling process of complex systems, the lower the prevalence of misperception issues among the actors involved in modeling and adopting such models will be.

Proposition 2.2: The more novel technologies are utilized to enhance collaborative governance and sense-making processes, the greater the improvement in stakeholder engagement and the greater the alignment of behavioral implications with organizational objectives.

Cluster 3 casts light on the interactive learning environments that can enhance practitioners' grasp of complex models and their implications for organizational performance. It challenges us to reimagine performance management systems that transcend financial metrics and accommodate diverse logics and perspectives with an eye to managerial and organizational consequences (Paolone et al., 2020). This cluster also considers dynamic performance models that account for systemic outcomes, collaborative incentives, policy drivers, and the creation of public value (Gozali et al., 2023). Accordingly, this cluster calls for models that promote accountability extending beyond the confines of individual organizations (Bivona, 2023). Hence, we propose the following:

Proposition 3.1: The more interactive and immersive the learning environment is for understanding complex SD models, the greater the improvement in practitioners' comprehension of organizational performance dynamics.

Proposition 3.2: The more performance management systems innovate to capture nonfinancial end results and diverse logics, the better organizations can frame and address the managerial and organizational implications of those results.

Cluster 4 addresses the roles of innovation and entrepreneurial ecosystems in tackling wicked problems. It investigates the roles played by key stakeholders within these ecosystems, including smart cities and entrepreneurial universities (Maruccia et al., 2020). The cluster inquires how SD models can contribute to the resolution of GCs, the role that public regulators play, and how public policy can spur technological advances to meet broad societal needs (Ricciardi et al., 2020). Finally, it invites the exploration of new (or the adaptation of existing) theories and methods to elucidate the nexus between collaborative efforts and social innovation. Following this, we posit that future research should investigate the following propositions:

Proposition 4.1: The greater the role that innovation and entrepreneurial ecosystems play in addressing wicked problems, the more effectively societies can engage with and solve these grand challenges.

Proposition 4.2: The more SD models are employed to analyze and address GCs, the greater the contribution of public policy and regulators to fostering sustainable technological and societal development.

Following the main themes explored in the literature, Fig. 9 visually synthesizes the themes that characterize this research domain, showing the main findings of our review, along with questions that could guide future research. However, it must be noted that each cluster not only represents a distinct domain of inquiry but also interweaves with the others, reflecting the multifaceted nature of systems thinking and SD applications.

Conclusion

The present paper aimed to systematize the current knowledge about the scientific applications of systems thinking and SD applications in management and organization studies. Using bibliographic data from 2091 peer-reviewed articles retrieved from Scopus and WoS, this review first conducted a performance analysis to answer RQ1 by shedding light on the field's key contributors based on the criteria of articles, authors, and journals. Second, to answer RQ2, the social and conceptual structures characterizing the discipline were depicted through a science mapping analysis of coauthorships, which was completed by a manual content analysis of the most influential articles characterizing each thematic cluster. Third, according to RQ3, the papers have proposed several propositions and possible future research questions to guide scholars and practitioners interested in this research domain. By doing so, the present paper can provide several theoretical and practical implications, as detailed in the following subsections.

Theoretical implications

In terms of theoretical implications, this research offers a multifaceted contribution to the field of systems thinking and SD, which has evolved significantly since its inception in the late 1950s. Initially,

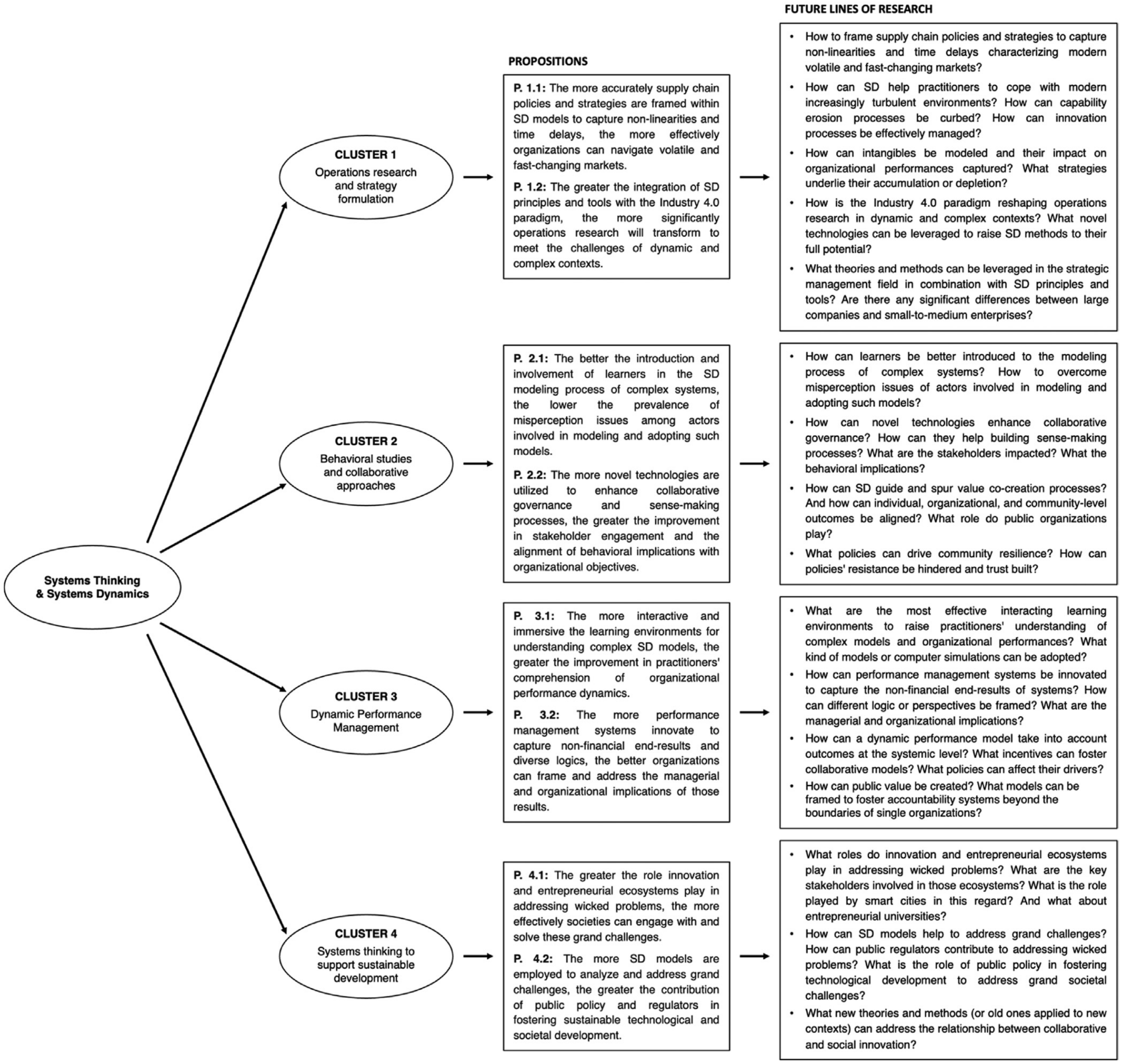

Fig. 9. Main findings and future lines of research.

underrecognized, SD gained broader appeal through advancements in technology and the pioneering work of the System Dynamics Group, underscoring the importance of transforming complex theories into practical tools for a wider audience.

First, the current paper contributes to the theoretical discourse on complexity science by emphasizing the critical role of systems thinking and SD in navigating dynamic and complex environments heightened by disruptive social and technological changes. The burgeoning relevance of SD over the past two decades indicates its integral role in addressing modern challenges and calls for interdisciplinary problem-solving approaches.

Second, the research underlines the expanding interdisciplinary appeal of SD, as evidenced by its coverage across various academic journals. Each journal's thematic focus on SD, from environmental and ecological issues to real-world applications and the exploration of mental models, demonstrates the adaptability of SD methodologies. This versatility extends the theoretical significance of SD beyond traditional domains and suggests a trend of integrating SD principles with other disciplinary insights, potentially bridging cognitive psychology and systems thinking.

Third, the present paper contributes to the strategic management literature by highlighting the enhanced role of SD in capturing the complexities of modern volatile markets, as suggested by the first thematic cluster. The corresponding propositions argue for a theoretical shift toward dynamic modeling techniques that reflect the rapid changes and uncertainties of contemporary economic systems, thus expanding the traditional frameworks of supply chain management and capability development. An additional contribution arises from the second cluster, which emphasizes the theoretical intersection of SD with cognitive sciences and collaborative governance. This suggests a foundational role for SD in enhancing learning environments and decision-making processes, potentially reshaping educational models and governance structures. The propositions developed here call for an extended theory of learning that integrates systems thinking into the cognitive processes of individuals and groups interacting with complex systems. The present paper has contributed to an expanded theory of organizational performance informed by the third cluster, which advocates for performance management frameworks that account for nonfinancial results and systemic health, challenging traditional quantifiable metrics. This work also contributes to the sustainability and public policy literature, suggesting the utility of SD as a theoretical framework for understanding innovation ecosystems and societal grand challenges, as delineated in the fourth cluster. It proposes a method to examine the complex interplay of stakeholders and processes within entrepreneurial ecosystems, offering a basis for inclusive policymaking.

Finally, the current paper calls for more diverse geographical contributions to SD research, particularly from underrepresented regions. This represents an opportunity to deepen the theoretical foundations of SD with a variety of cultural and contextual perspectives, potentially leading to new models and concepts that are globally inclusive and reflective of diverse challenges. Contributions from these regions could redefine existing assumptions and contribute to a more comprehensive understanding of system dynamics.

Practical implications

The practical implications of the present research extend directly to the operational and strategic initiatives of managers and the policymaking processes of government leaders, embedding the insights of SD into the fabric of organizational and societal change.

For managers, the practical application of SD models offers a tangible pathway to strategic adaptability in an era defined by volatile markets and complex supply chains. The current research provides managers with a robust framework for simulating various scenarios, allowing them to anticipate and navigate nonlinearities and time delays effectively. Such foresight is crucial for making informed decisions that can steer organizations through turbulent times. In addition, the integration of cognitive sciences with SD provides managers with a unique opportunity to enhance collaborative decision-making. By understanding the underlying behavioral patterns that SD models can unveil, managers are better positioned to engage teams in sensemaking processes, aligning individual and group actions with broader organizational goals. This approach empowers managers to design interventions that are both effective and harmonious with the organizational culture. Moreover, in the realm of performance management, the expanded framework proposed by this research encourages managers to go beyond traditional financial metrics. By adopting a more comprehensive view that includes nonfinancial indicators, managers can ensure a holistic assessment of their organization's health and drive more sustainable business practices. This dual focus on financial and nonfinancial outcomes fosters a more nuanced approach to measuring and managing performance.

Finally, within entrepreneurial ecosystems, managers can utilize SD models to predict and manage intricate interactions between stakeholders. This capability is particularly crucial for fostering resilience and spurring innovation, enabling managers to create environments where new ideas can flourish and organizational agility can be maintained.

Along with its implications for managers and decision-makers, the present research also aims to provide guidance to policymakers. For policymakers, the application of SD takes on a strategic dimension, providing a robust platform for policy design and evaluation. By using SD models, policymakers can develop and implement policies that accurately capture the complexity of societal systems, thus enhancing the impact and sustainability of their initiatives. These models serve as valuable tools for anticipating the broader implications of policy decisions, helping to avoid unintended consequences that could undermine policy goals. SD also aids policymakers in creating public value, particularly through the development of collaborative models that consider systemic impacts. This approach ensures that policy initiatives contribute positively to the public domain, fostering community resilience and aligning with broader societal objectives. Furthermore, the operationalization of sustainable development goals through SD offers policymakers a clear framework for identifying strategic points of intervention. This research underlines the significance of SD in assessing the long-term effects of policies on sustainable development, ensuring that policy choices are aligned with those goals. Finally, the call for culturally and contextually sensitive policy formulation is emphasized through the encouragement of SD research and its application in diverse geographical regions. This inclusivity ensures that a wide array of perspectives are reflected in policy decisions, leading to outcomes that are relevant and effective across different cultural and societal contexts.

In sum, the present research equips managers and policymakers with the insights and tools necessary to effectively address the complexity of modern challenges. By embracing the principles of SD, they can enhance their foresight, strategic planning, and policy formulation, leading to more resilient organizations and societies.

Limitations and further developments

Despite its implications, the current study is not free from limitations. First, the dataset was collected considering only articles retrievable in Scopus and WoS, excluding books, proceedings, and the so-called gray literature (e.g., reports or business cases). Second, as stated in the Methodology section, some indicators can lead to inconsistencies when used to compare different publications or authors. Therefore, each indicator should be read together with the other indicators, for example, as in the case of the h-index, if used to compare authors at different advancements in their careers or coming from different research fields. Finally, to provide better comparability and be in line with the research questions of the present study, only the business and management fields were chosen as units of analysis, excluding disciplines from the hard sciences (e.g., engineering, environmental science) and health-related research fields. Each of these limitations provides opportunities for future work by scholars and practitioners interested in the advancement of such a promising future research area.

CRediT authorship contribution statement

Canio Forliano: Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Paola De Bernardi:** Writing – review & editing, Writing – original draft, Supervision. **Zoltan Rozsa:** Writing – review & editing, Writing – original draft, Validation. **Alberto Bertello:** Writing – review & editing, Writing – original draft, Conceptualization.

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