Accounting for Oslo Manual: Reflecting on the Past and Setting the Stage for Future Research

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Abstract

The Oslo Manual is the internationally recognized reference for guiding the collection and interpretation of evidence on innovation. This research explores its three-decade-long implementation and influence, emphasizing its role within the research community. We assess the content's quantity and quality through an advanced bibliometric and textmetric analysis of over 1300 research papers published in internationally indexed journals. Our study offers an evidence-based understanding of the Oslo Manual's adoption and impact, elucidating disciplinary integration, geographical interest, and reception phases. Notably, the findings unveil the increasing significance of innovation-related topics since its inaugural edition in 1992, with a pronounced surge gaining momentum after 2008. Furthermore, the consistently cited references underscore the researchers' focus, highlighting the rising importance of innovation and interconnected domains like entrepreneurship, performance, knowledge, and management. This study enhances our understanding of the Oslo Manual's use and influence, revealing its enduring relevance and its broader impact on shaping innovation research.

Keywords: Oslo Manual; innovation; bibliometrics; policy

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Introduction

Innovation is a practical topic that holds significant importance for individuals, institutions, productive sectors, and countries, as it enhances living standards and economic growth (OECD, Eurostat, 2018). Nevertheless, it is also an object of research in itself. Indeed, the study of innovation has recently developed into a vibrant field in its own right (Castellaci et al., 2005; Santos, Mendonça, 2022a). A valuable resource bridges these two worlds: the tool known as the Oslo Manual. The Oslo Manual is an internationally recognized reference that provides guidelines for collecting and interpreting evidence on innovation (Smith, 1992).

In innovation studies, researchers delve into key topics from existing literature or uncover their dynamics (Rossetto et al., 2018; Sun, Zhai, 2018). Some works, like those by Nelson and Winter (1977) and Abernathy and Clark (1985), provide comprehensive literature reviews on innovation. Additionally, Merigó et al. (2016) and Cancino et al. (2017a) conducted literature reviews on innovation. Other research utilises bibliometric and textmetric analyses to examine innovation literature (Rakas, Hain, 2019; Santos, Mendonça, 2022a), scientific journals (Kajikawa et al., 2022), and authors (Mendonça, 2017) in the field of science, technology, and innovation.[1] This paper employs advanced analytical techniques, including text mining, to evaluate the review process of a technical report called the Oslo Manual.

This paper aims to compare changes in different editions of the Oslo Manual over the years and present a comprehensive and evidence-based analysis of its development. Using text mining techniques, we examine a collection of internationally peer-reviewed publications, conducting a content analysis of research articles that assess the evolution of the Oslo Manual's structure and content (primary areas of analysis).

In this study, we apply a comprehensive approach, combining bibliometric and textmetric analytical dimensions, to evaluate 1,388 scientific papers that cite the Oslo Manual. These papers are authored by individuals affiliated with various entities from every country, spanning 30 years from 1992 to 2021. The methodological shifts (do economic and social changes impact innovation definitions?) and the increasing interest in the Oslo Manual (are emergent economies more engaged to use metrics for measuring innovation?) are discussed. This study can provide helpful evidence for those interested in innovation studies. Policymakers can gain insights into key stakeholders and potential partners for collaboration in innovation-related initiatives. On the other hand, researchers can understand the trends, gaps, and emerging areas related to innovation. They can identify potential research collaborations and knowledge-sharing opportunities, as well as gauge the visibility and influence of their work in the context of innovation.

The Oslo Manual

Genealogy of the Oslo Manual

Before the 1970s, innovation was primarily measured using proxies such as patents and industrial expenditures on R&D (Freeman, 1987). Jacob Schmookler pioneered the extensive use of patents as an indicator of innovation in the 1950s (Schmookler, 1950, 1954). Industrial R&D data was relatively easier to collect and measure than other aspects of innovation (Godin, 2005). However, these early measures were limited in providing a comprehensive view of innovation (OECD, 1976).

OECD members' interest in direct measures of innovation dates back to the late 1970s when their work on direct or proxy output indicators led to seminars at the end of the decade (OECD, 1992). However, systematic innovation surveys were only widely conducted in the 1980s. Before then, there had been some sporadic data collection by government departments (e.g., US Department of Commerce), statistical institutes (e.g., Statistics Canada), and research units (e.g., SPRU, University of Sussex, UK), but rarely in a standardized way (Freeman, 1971; Rothwell et al., 1974; Pavitt, 1983).

In 1980, the OECD arranged a conference to explore output indicators and discuss national innovation surveys and indicators. Subsequently, workshops dedicated to innovation took place in 1982 and 1986, recognizing that patents were a poor indicator of a country's technological position (OECD, 1980, 1982, 1986).

The OECD's involvement in innovation surveys began with the Nordic Fund for Industrial Development's initiative to collect data on innovation activities in Scandinavian countries (Nordic Industrial Fund, 1991). In 1988, a workshop organized by the Nordic Fund invited the OECD and its member countries to participate (OECD, 1988). The workshop introduced a conceptual framework for developing innovation indicators (Smith, 1989). This framework underwent revisions in a subsequent workshop and was presented to the OECD Group of National Experts on Science and Technology Indicators (NESTI) in 1989, which recommended that the Nordic Fund prepare a draft Manual (OECD, 1990).

The draft Manual, prepared by Keith Smith and Mikael Akerblom, was discussed and amended by OECD member countries between 1990 and 1991 (OECD, 1991a). The first edition, named after the city of Oslo, was officially adopted in 1992 (OECD, 1991b).

[1] Fagerberg et al. (2012) analysed the development of innovation research and used an empirical approach based on the analysis of chapters in authoritative innovation research handbooks to determine which original publications had the most significant influence (see also: Fagerberg, Verspagen, 2009).

In 1993, a significant milestone was achieved when delegates from twelve European countries collaborated to carry out the first-ever coordinated survey of innovation activities based on the Oslo Manual (Godin, 2005). After completing the initial round of surveys in member countries, the Manual was reviewed and further developed based on the valuable experience gained during the process (OECD, 1992). As a result, the Oslo Manual underwent its first review in 1996 and was subsequently published in collaboration with the European Commission (Eurostat) in 1997 as the second edition.

While the Oslo Manual's initial focus was primarily on technological innovations within manufacturing industries (OECD, 1992), the concept of innovation and the need for comprehensive measurements started to evolve. Recognizing these shifts, the Manual expanded its scope to include additional dimensions of innovation beyond technology. This expansion encompassed non-technological innovations and services, acknowledging their growing significance in innovation (OECD, Eurostat, 1997). The second edition's publication in the same year marked a crucial shift in perspective, reflecting a broader conceptual framework that embraced the evolving nature of innovation measurement and its applications.

The subsequent editions of the Oslo Manual continued to adapt and respond to changing perspectives and demands in the field of innovation. There was a noticeable increase in emphasis on services, reflecting the growing recognition of their role in fostering innovation. With each new edition, the Manual's genealogy mirrored the dynamic evolution of innovation measurement. It illustrates the ongoing efforts to refine and update the framework, ensuring its relevance in capturing the multifaceted nature of innovation in an ever-changing global landscape. The Oslo Manual's journey exemplifies the commitment to staying abreast of emerging trends and methodologies, ultimately contributing to a more comprehensive understanding of innovation and its impact.

Oslo Manual comes of age

Between the first and fourth editions, the Oslo Manual experienced an increase of 50% or more in the number of pages, starting with 62 pages and reaching 258 in the fourth edition. Figure 1 displays the evolution of the Oslo Manual concerning its contents. Notably, the first three editions shared four common topics: "Objectives and scope of the Manual", "Basic definitions", "Innovation process", and "Survey procedures". Furthermore, upon comparing only the first two editions, we observed another shared chapter: measuring the cost/expenditure on innovation.

The first edition of the Oslo Manual, published in 1992, laid the foundation for measuring and analysing innovation. This first edition had two primary objectives: to establish a framework that enables existing surveys to evolve towards comparability and to assist researchers in innovation. According to the OECD (1992, p. 35), "From the policy viewpoint, indicators of the outcomes of the innovation process are perhaps the most important results of innovation surveys".

Regarding the methodological change from the first to second editions, the second edition of the Oslo Manual expanded the scope of innovation measurement beyond R&D to include non-technological areas such as marketing, organizational changes, and design (OECD, Eurostat, 1997). The second edition emphasized capturing the innovation process's inputs, activities, and outputs. It highlighted the need to measure innovation inputs (e.g., R&D expenditures, human resources dedicated to innovation) and outputs (e.g., new products, improved processes, market success). The guidelines covered various aspects, including measuring expenditures on innovation, identifying innovation sources, assessing innovation's impact on firm performance, and introducing a new chapter related to "Institutional classifications" (Chapter 4), as shown in Figure 1.

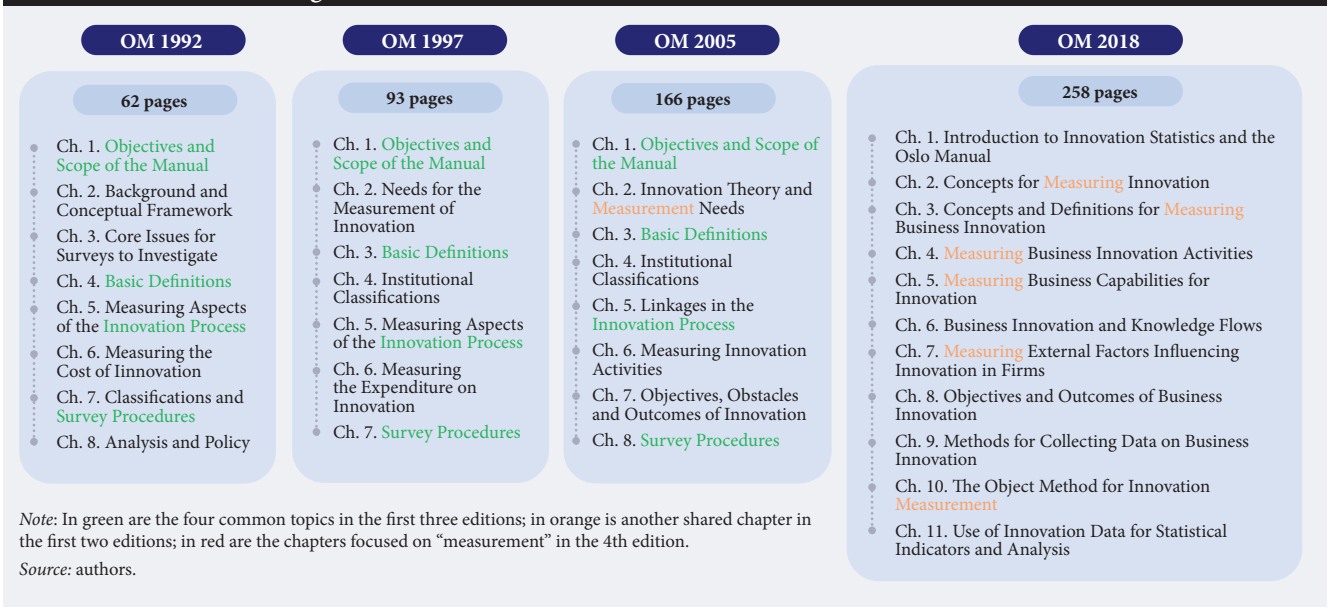
The Manual has progressively expanded its coverage and definitions to accommodate a broader range of industries and capture the complexity and heterogeneity of innovation, reflecting the maturation and growing significance of innovation research as a multidisciplinary field (Castellaci et al., 2005).

Regarding the methodological change from the second to third editions, the third edition of the Oslo Manual provided more explicit guidelines on capturing and measuring non-technological innovations, such as organizational and marketing innovations (OECD, Eurostat, 2005). It recognized that innovation is not limited to technological advances and that firms can innovate in various dimensions.

The Manual expanded the discussion on measuring intangible assets, such as intellectual property and human capital. Moreover, the third edition introduced the concept of "innovation cooperation". It recognized that innovation often involves partnerships, alliances, and networks among different actors and provided guidance on measuring and assessing these collaborative efforts. It emphasized the role of innovation systems in fostering organizational innovation. In addition to the four chapters common with the first edition, the third edition retained the new chapter introduced in the second edition, the "Institutional Classifications", and included a new chapter dedicated to "objectives, obstacles and outcomes of innovation" (OECD, Eurostat 2005, Chapter 7).

The fourth edition of the Oslo Manual incorporates methodological changes from the third edition, including advances in data collection methods, such as new data sources and techniques for measuring innovation (OECD, Eurostat, 2018). It guides the use of new data collection tools, such as web-based surveys

Figure 1. **Table of Contents of the Four Oslo Manual Editions**



Note: In green are the four common topics in the first three editions; in orange is another shared chapter in the first two editions; in red are the chapters focused on "measurement" in the 4th edition.

Source: authors.

and big data analytics. The fourth edition introduces the concept of «open innovation», emphasising the importance of collaboration and knowledge sharing between organizations.

Comparing the fourth edition with the previous editions, in addition to the increase in the number of pages and chapters, we can also observe a new chapter (Chapter 11) dedicated to the "Use of innovation data for statistical indicators and analysis". Moreover, more than half of the chapters (six out of eleven) focus on "measurement" (see Figure 2): "measuring innovation", "measuring business innovation", "measuring business innovation activities", "measuring business capabilities for innovation", "measuring external factors influencing innovation in firms", and "the object method for innovation measurement".

The Oslo Manual evolved over the four editions to capture a more comprehensive understanding of innovation. It expanded from a focus on R&D-related activities to encompass various dimensions of innovation, including non-technological, organizational, marketing, and business innovation. The different editions also incorporated advances in data collection methods and highlighted the importance of measuring innovation impacts and outcomes. Open innovation, innovation cooperation, and systemic innovation were introduced to reflect innovation processes' collaborative and interconnected nature.

Materials and Methods

Article subject matching system

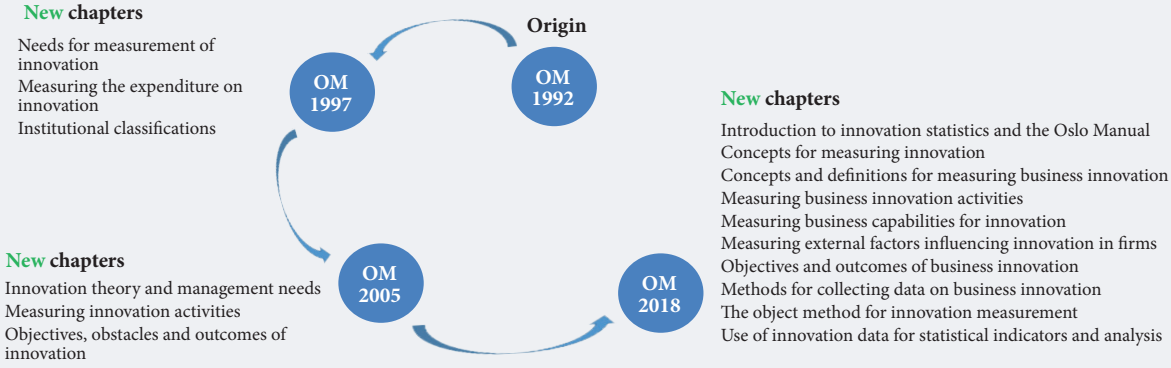
The field of innovation embraces diverse methodologies and approaches, drawing upon disciplines such as economics, management, and sociology. Researchers have utilized a range of quantitative and qualitative research methods to explore innovation processes, employing surveys, case studies, interviews, and various data analysis techniques. For instance, Nelson (1959) pioneered the application of economic theories to the study of innovation, while Burns and Stalker (1961) introduced organizational and management perspectives. Furthermore, Rogers (1962) made significant contributions by examining how innovation diffuses through social networks. As time passed, the field of innovation developed into a global research community, promoting collaboration and knowledge exchange among researchers worldwide (Martin, 2012).

The exponential growth in the number of scientific platforms and their online journals, coupled with the massive increase in research outputs, has made it challenging for researchers to select the appropriate journal to publish their work, as these platforms represent the privileged channel for disseminating their research (Bornmann, Mutz, 2015; Confraria, Godinho, 2015; Gu, Blackmore, 2016; Ioannidis et al., 2018; Santos, Mendonça, 2022a; Shifrin et al., 2018; Ware, Mabe, 2015).

The first attempt to describe authors' motivations for submitting an article to a particular journal dates back to the 1950s and 1960s, when de Solla Price (1965) treated science as a measurable entity, developed some quantitative techniques and introduced the concept of scientometrics (see also Rousseau, 2021). Later, Kochen and Tagliacozzo (1974) identified five fundamental factors influencing journal selection: relevance, acceptance rate, circulation, prestige and publication lag.

Until now, we can observe bibliometric and textmetric materials on innovation literature (Klarin, 2019; Santos, Mendonça, 2022b), scientific journals (Singh

Figure 2. **Oslo Manual timeline**



Note: For each new edition, the new chapters are identified. Regarding the 4th edition, the chapters related to the "measurement" are highlighted in red.

Source: authors.

et al., 2020) and authors (Meyer et al., 2004) with contributions to the study of science, technology and innovation. This paper assesses the review process of a technical report – The Oslo Manual. For this purpose, we assemble a set of observations to compose a meaningful understanding of the Oslo Manual review.

The raw observations for the analysis are scientometric data, that is, the publication (bibliometric) and content (textmetric) materials on scientific-level types of knowledge (Saheb et al., 2021; Eom, 2009). The scientometric toolbox is usually deployed to understand the scientific enterprise (Mendonça et al., 2022). We extracted and tabulated all the relevant academic publications that focus on or refer to the Oslo Manual. A supervised machine learning algorithm was developed to enable textmetric analysis.

However, despite its complex nature, this methodology offers a high level of granularity, comparability, and adaptability to effectively address the changing demands of analytical and policy requirements (Glänzel et al., 2019)[2]. What sets our integrated approach, combining bibliometric and textmetric analyses, apart is its ability to reveal the underlying processes that drive the review of the Oslo Manual.

This paper extends our analysis to incorporate social network analysis techniques, specifically focusing on centrality measures such as degree, betweenness, and closeness. We investigate the network's most influential journals and authors, exploring their pivotal role.

Analysing the Oslo Manual review: a comprehensive scientometric approach

Scientific publication data have been used in many econometric analyses (Griliches, 1990; Hall et al., 2001; Jaffe, Trajtenberg, 2002). Three fields – bibliometrics, technometrics and econometrics – converged as publication statistics started to be used in economic and policy analysis (Meyer et al., 2004). By conducting bibliometric analysis, the evolution of a topic can be analysed. The bibliometric analysis employs a quantitative approach to describe, evaluate, and monitor published research (Dzikowski, 2018; Small, 1973). This study employs quantitative bibliometric analysis in reviewing a technical report – The Oslo Manual.

Bibliometric methods are effective approaches to support a comprehensive understanding of the journal because they use tools and statistical methods for publications, including research articles (Thelwall, 2008). They facilitate the comprehension of large amounts of data and enable the discovery of hidden patterns. Bibliometrics is applied to studying academic disciplines, topics, or journals (Mejia et al., 2021).

Bibliographic items are appealing because they span time, space, and institutional and thematic categories. They can be examined individually, aggregated or put into a relational perspective. As indicators of creative enterprise, formal publications in scientific peer-reviewed journals provide a robust data pool (Mendonça et al., 2022).

To process the substantial amount of data, specialized software like R, VOSviewer, and Gephi (Manoj Kumar et al., 2022) was employed. A comprehensive computer-assisted literature exploration was conducted on the Web of Science (WoS) database to capitalize on this potential.[3] The following citation indexes were queried: SSCI, ESCI, SCI-EXPANDED, CPCI-SSH, CPCI-S, and A&HCI. The Scopus database supplies authors' identification since retrieval could be automated through an Application Programming Interface (API). Bibliometrix (an R package) was used since it automatically adds affiliation dates to authors' identifications. Descriptors regarding the standing and prestige of periodicals were gleaned from Scimago Journal Rank (SJR), the public repository of journal metrics. Finally, a search for academic journal articles only was performed for the complete database with no date restrictions to ensure completeness.

Research findings can be represented in different formats, such as tables, charts, citation maps and net-

work displays. Many indicators can be identified from bibliometric analysis, offering valuable insights into the research landscape. These include the top journals and articles, the most active authors, institutions and countries, the most popular research subjects or keywords, and patterns of collaboration and citation among researchers, institutions and countries. It can also facilitate the identification of research gaps and contribute to formulating research objectives or policies in a specific subject (Cancino et al., 2017b; Ellegaard, Wallin, 2015). The bibliometric indicators also measure the quantity and quality of publications, where quantity is measured in terms of the number of publications, whereas the impact of received total number of citations by a publication measures quality.

In this study, the final sample includes 1388 articles that cited the Oslo Manual in the above citation indexes. Each article can be classified in more than one index. Items were published in 403 journals (unique ISSNs) and classified into 94 different categories, where five (Management, Business, Economics, Environmental Studies/Sciences, and Regional & Urban Planning/Geography) out of 94 different categories aggregate two-thirds of the articles and containing 56,600 references to other documents.

The publication records and their characteristics were processed from a descriptive perspective. In addition, summary statistics were computed (namely, the conventional concentration index), and network analysis was carried out (graph representations and the usual network metrics). Finally, we incorporated WoS's subject and disciplinary framework without any limitations. However, it is widely acknowledged that it may not always offer an optimized bibliometric classification for every research endeavor. The identification of individuals is challenging, and their identities are retrieved via Scopus ("rscopus" package)[4].

A Bibliometric Account of Oslo Manual-related Research

An overview of the studies published about the Oslo Manual until 2021

Trends in Oslo Manual citations. The total entries related to the Oslo Manual are shown in Figure 3. The 1388 articles that cited the Oslo Manual were authored by 1735 individuals (estimated) from 87 countries between 1997 and 2021. The first publication was in 1997, the same year as the second edition. From 2006 onwards, after the publication of the third edition, we can observe a persistent and rising production ensues until 2018. The peak in the number of published articles coincides with the year of the publication of the fourth edition, 2018. We can also observe an identical number of publications in the three years before and three years after the publication of the fourth edition. Between 2015 and 2021, this period concentrates on two-thirds of all publications.

The geography of authorship. It is possible to picture the international distribution of knowledge production by processing authorship information. Figure 4 presents the number of articles by region published in the time series per year. We can observe that most of the authors are established in Europe, East Asia & Pacific, and Latin America & Caribbean. The distribution of the publications in Europe can explain the distribution observed in Figure 3. As can be observed in Europe, the peak of the number of publications coincides with the year of the publication of the fourth edition, and the distribution of the number of publications in the three years before and three years after the publication of the fourth edition is very similar, representing almost half of the total of publications.

In analyzing the geography of authorship, we focused on the peak of the distribution, which aligns with the year of publication of the fourth edition of the Oslo Manual, along with the three years preceding and following it. This period accounts for approximately two-thirds of the total publications we examined. To gain a comprehensive understanding, we further explored the trends before and after the publication of the last edition, 2018. The figures below (Figure 5 for the period before 2018 and Figure 6 for the period after 2018) depict the distribution of knowledge production during these distinct timeframes.

Despite the evidence that the number of published articles is spread among different countries across all regions (mainly Europe, East Asia & Pacific, and Latin America & Caribbean) after the publication of the fourth edition of the Oslo Manual, the share of the publications among the non-OECD countries, in the total of the publications increased from 11% to 18% of total publications. This fact is even more significant since 24 out of the top 25 scientific journals (see Figure 10) from the different indexes of the Web of Science are from the OECD countries.

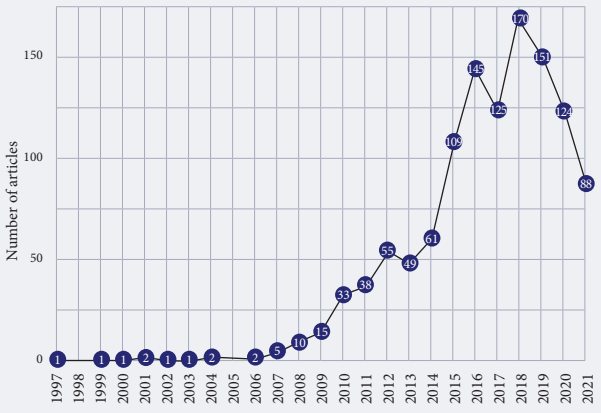
International diffusion of Oslo Manual-related research. Figure 7 accounts for the spread of research around the Oslo Manual over time. The period in which the Oslo Manual comes alive as the research topic is after the publication of the third edition of the Oslo Manual. Before the third edition, only a few countries were engaged in the topics related to the Oslo Manual. However, during the last decade, before

[2] Other indicators could have been used, from the most conventional like patents (e.g. Mendonça et al., 2019) to less conventional ones, like trademarks (Castaldi, 2020; Mendonça et al., 2004; Mendonça 2012, 2014) and standards (Foucart, Li, 2021; Laer et al., 2021; Teubner et al., 2021).

[3] This source is well-known and has extended coverage, and its findings are highly correlated with other databases (Archambault et al., 2009).

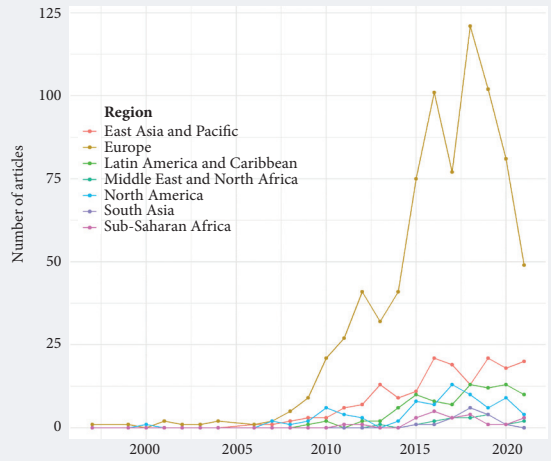
[4] Authors may have changed affiliations throughout their careers. This implies making decisions: papers were counted for the affiliation at the year of the publication, and where the change happened, all those papers were assigned to the institution and country of the authors' last paper in the database.

Figure 3. **Number of Published Articles, by year**



Source: authors.

Figure 4. **Number of Articles per Region, by year**



Source: authors.

(as a result of the increasing interest that the review of the Manual implied) and after (as a result of the new structure of the Manual) the publication of the fourth edition in 2018, there was a significant increase in the number of countries active in the Oslo Manual agenda, particularly the BRICs. Compared with the third edition's dissemination period, by the fourth, approximately ten times more countries participated in research activities related to the Oslo Manual.

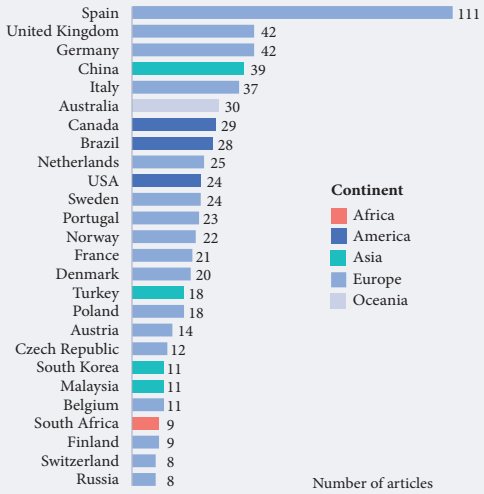
A consequence was the steady decline in the country's concentration of research in publication shares, as can be gleaned from the Hirschman-Herfindahl index in Figure 7. That is to say, over the years, but mainly after the second edition's publication, the interest in the Oslo Manual has become increasingly distributed, opened up, and more participated.

Institutions, journal platforms and thematic profile

Major research actors. Regarding research volume (number of articles), in Figure 8, we can observe that the top places are occupied by European Institutions, namely the ZEW (Zentrum für Europäische Wirtschaftsforschung), the United Nations University Maastricht and the Universidad Complutense de Madrid. Of the top 10 institutions more active, only one is from outside Europe: Universidade de Sao Paulo.

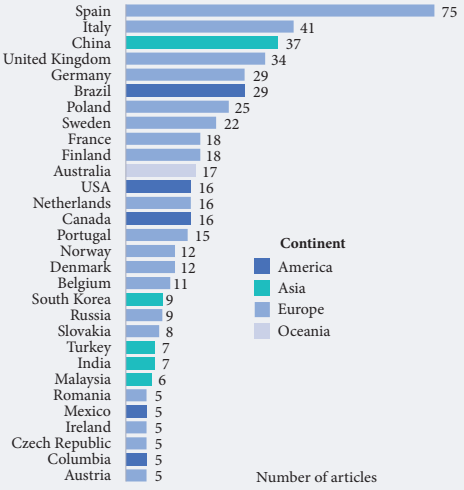
However, regarding the average number of citations, Figure 9 shows that the top higher scores were observed in the Universiteit Hasselt, the EIM Group, the Technische Universiteit Eindhoven, and the Ecole Polytechnique Federale de Lausanne. The European institutions are the most active and present a relevant average number of citations. Figure 9, presenting the top 25 institutions with the higher average number of citations, also allows us to see the discrepancies between institutions – the first institution has more than five times more citations than the 25th, on average.

Figure 5. **Number of Published Articles before 2018, by region and country**



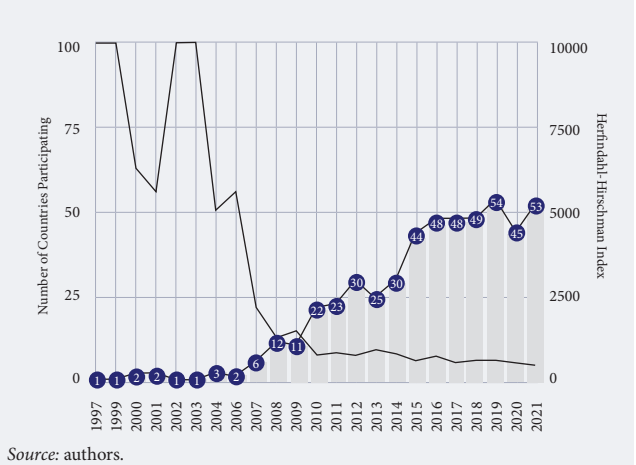
Source: authors.

Figure 6. **Number of Published Articles after the Publication of the 4th Edition of the Oslo Manual**



Source: authors.

Figure 7. **Increasing Participation in Oslo Manual – Related Publications per year**



Source: authors.

Main publishing outlets. Figure 10 shows the major journals in which the research appears. *Research Policy* is dominant among the top venues for Oslo Manual–related research. We can see that the first journal (*Research Policy*) has more than twice as many publications as the second journal (*Technological Forecasting and Social Change*). These results confirm previous research (Chesbrough, 2003; Dahlander, 2010; Rossetto et al., 2018). Regarding the major journals in which the research appears, 9out of 25 were among the 20 most influential journals in Innovation Studies[5] identified by Fagerberg et al. (2012).

During the second half of the last decade, there was a significant shift in the number of scientific journals publishing articles related to the Oslo Manual, with an increase from just a few journals prior to the publication of the third edition to dozens of diverse scientific journals coinciding with the release of the latest edition of the Manual. This statistic is not just about growth in the distribution capacity of research; it should also be understood as indicating the increase in the branching out of thematic strands. Different journals position themselves differently, tackling other topics and angles of analysis and addressing distinct audiences.

According to the Scimago Journal Rank, the journals are classified in a specific subject and within each subject in a specific category. Table 1 shows how each journal out of the top 25 from Figure 10 is classified in subject and category terms. Table 1 shows that 17 out of 25 journals are classified as "Business, Management and Accounting". On the top 25 journals, the other subjects more representative are "Social science" (#7), "Environmental science" (#6), and "Engineering" (#6). Regarding the categories, within the "Business, Management and Accounting", the most representative is the "Management of Technology and Innovation" (8 out of 17).

In Figure 11, some well-known domains related to innovation are singled out: the rising trends highlight their differential dynamics. In particular, we confirm how relevant and linked to innovation are or have become domains like Management, Business and Economics.

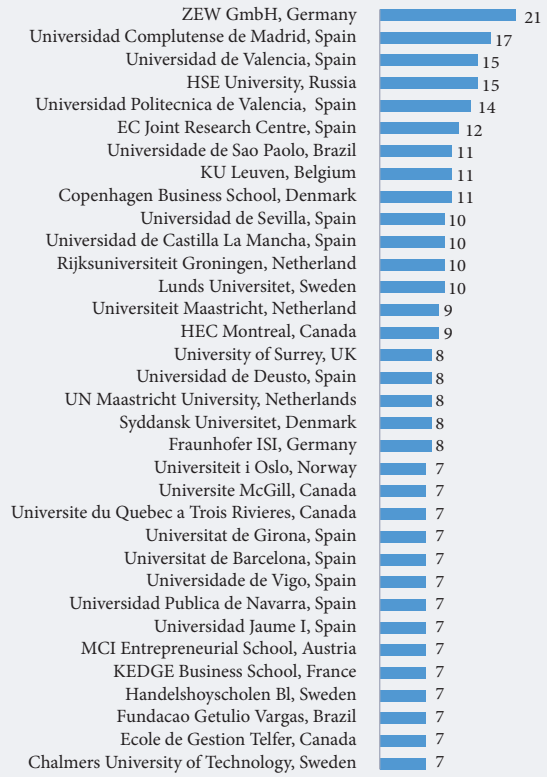
Figure 11 also shows that the persistent and rising production that ensues from 2006 and 2007 is mainly explained by three main domains: Management, Business and Economics. More recently, a significant increase was observed in Environment Studies/Sciences and Regional & Urban Planning/Geography domains in the last five years.

Evidence on performance and impact. Influence can be unpacked by investigating leadership in terms of authorship but also in terms of consequences. Here we look at outputs (publications) and outcomes (number of citations). In Figure 12, we can observe the top 15 influential authors based on the number of citations and that the author with more citations has more than twice the second author with more citations.

Research networks

Figure 13 expands the analysis by offering a representation of the authorship network – a graph with 74

Figure 8. **Most Active Institutions (number of articles)**



Source: authors.

[5] *Research Policy, Technological Forecasting and Social Change, Technovation, Industrial and Corporate Change, Regional Studies, Technology Analysis & Strategic Management, Small Business Economics, R&D Management, International Journal of Technology Management.*

Table 1. **Top 25 Journals by Subject and Category**

Rank	Journal	Subject	Category
1	Research Policy	Business, Management and Accounting; Decision Sciences; Engineering	Management of Technology and Innovation; Strategy and Management; Management Science and Operations Research; Engineering (miscellaneous)
2	Technological Forecasting & Social Change	Business, Management and Accounting; Psychology	Business and International Management; Management of Technology and Innovation; Applied Psychology
3	Sustainability	Computer Science; Energy; Environmental Science; Social Sciences	Computer Networks and Communications; Hardware and Architecture; Energy Eng. And Power Tech.; Renewable Energy, Sustainability and the Environment; Environ. Science; Management, Monitoring, Policy and Law; Geography, Planning and Development
4	Journal of Business Research	Business, Management and Accounting	Marketing
5	International Journal of Innovation Management	Business, Management and Accounting	Business and International Management; Management of Technology and Innovation; Strategy and Management
6	Journal of Cleaner Production	Business, Management and Accounting; Energy; Engineering; Environmental Science	Strategy and Management; Renewable Energy, Sustainability and the Environment; Industrial and Manufacturing Engineering; Environmental Science
7	Industrial and Corporate Change	Economics, Econometrics and Finance	Economics and Econometrics
8	Technovation	Business, Management and Accounting; Engineering	Management of Technology and Innovation; ; Engineering (miscellaneous)
9	Economics of Innovation and New Technology	Business, Management and Accounting; Economics, Econometrics and Finance	Management of Technology and Innovation; Economics, Econometrics and Finance
10	Industry and Innovation	Business, Management and Accounting;	Business, Management and Accounting; Management of Technology and Innovation
11	Regional Studies	Environmental Science; Social Sciences	Environmental Science; Social Sciences
12	Technology Analysis & Strategic Management	Business, Management and Accounting; Decision Sciences	Strategy and Management; Management Science and Operations Research
13	Science and Public Policy	Environmental Science; Social Sciences	Management, Monitoring, Policy and Law; Geography, Planning and Development; Public Administration
14	Small Business Economics	Business, Management and Accounting; Economics, Econometrics and Finance	Business, Management and Accounting; Economics and Econometrics
15	International Journal of Technology Management	Business, Management and Accounting; Computer Science; Engineering ; Social Sciences	Industrial Relations; Strategy and Management; Computer Science Applications; Engineering; Law
16	Journal of Technology Transfer	Business, Management and Accounting; Engineering	Accounting; Business and International Management; Engineering
17	Industrial Marketing Management	Business, Management and Accounting	Marketing
18	R&D Management	Business, Management and Accounting	Business and International Management; Business, Management and Accounting; Management of Technology and Innovation; Strategy and Management
19	Innovation-Organization & Management	N/A	N/A
20	Forest Policy and Economics	Agricultural and Biological Sciences; Economics, Econometrics and Finance; Environmental Science; Social Sciences	Forestry; Economics and Econometrics; Management, Monitoring, Policy and Law; Sociology and Political Science
21	Annals of Regional Science	Environmental Science; Social Sciences	Environmental Science; Social Sciences
22	Journal of Engineering and Technology Management	Business, Management and Accounting; Decision Sciences; Engineering	Industrial Relations; Strategy and Management; Information Systems and Management; Management Science and Operations Research; Engineering (miscellaneous)
23	European Planning Studies	Social Sciences	Geography, Planning and Development
24	European Journal of Innovation Management	Business, Management and Accounting	Management of Technology and Innovation
25	Applied Economics	Economics, Econometrics and Finance	Economics and Econometrics

Source: authors.

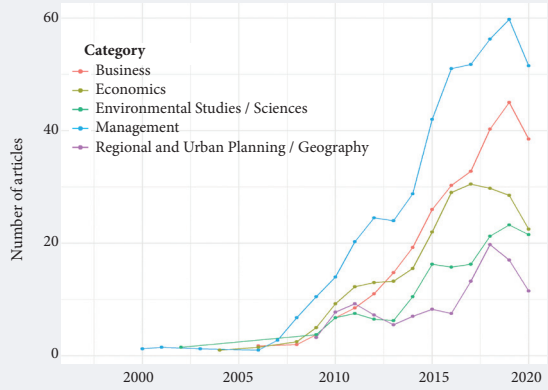
Figure 9. **Average Number of Citations, per institution**

Source: authors.

Figure 10. **Top 25 Journals, number of total articles published**

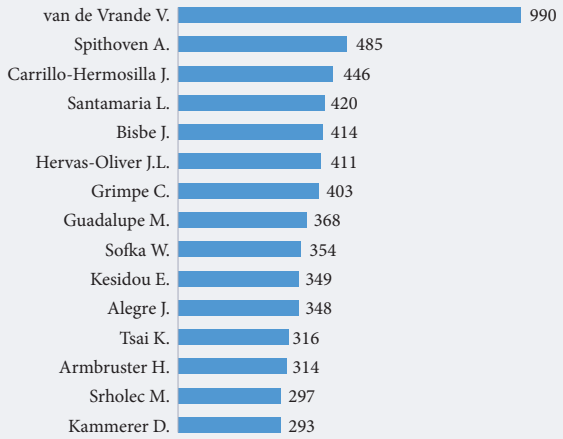
Source: authors.

Figure 11. **Number of Published Articles by scientific domain, 2000-2021**



Source: authors.

Figure 12. **Impactful Contributors, Top 15, in number of citations**

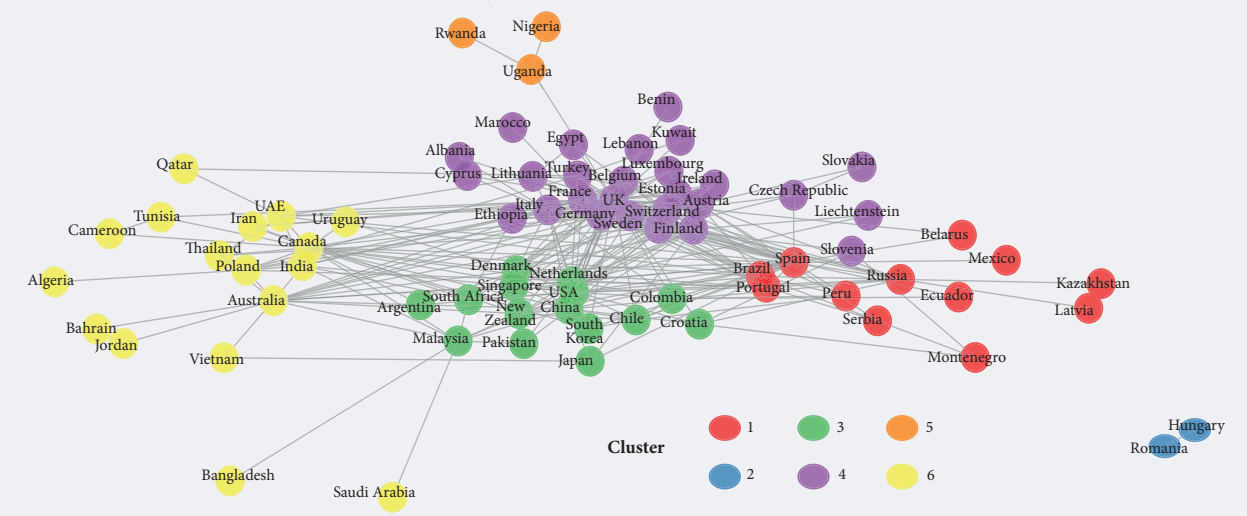


Source: authors.

nodes (countries). This visualization highlights the connections and clusters among countries. The distance between each pair of nodes on the map indicates their similarity and connection. The proximity of two nodes on the map reflects the similarity and correlation of their bibliometric attributes (McAllister et al., 2022). Different colours on the map represent distinct clusters, which are groups of countries more strongly connected than others on the map. The map shows unexpected connections due to the geographical distances of some countries in the same cluster. These unexpected connections, however, represent opportunities for further collaboration among these countries. The network has a density of 0.11, the proportion of existing links relative to the possible number.

Furthermore, the diameter is 5, the shortest distance between the two farthest nodes, and the average path length is 7.2. These metrics jointly underscore a significant level of interaction, indicating that there is diversity and a role for positive effects from the periphery to the centre that cannot be ignored (Gilsing *et al.,* 2008). Additionally, the network is not homogeneous, and six clusters of countries can be identified. Cluster 1 includes countries that share Spanish (e.g., Mexico, Spain, Peru, Ecuador), Portuguese (e.g., Brazil, Portugal), and Russian (e.g., Russia, Belarus) as their mother tongues. The common language facilitates communication and collaboration in re-

Figure 13. **Country Collaboration**



Source: authors.

search and authorship. Cluster 3 includes countries with English as their mother tongue (e.g., USA, New Zealand, South Africa). The common language and historical ties promote strong collaboration among these countries). Cluster 4 mainly consists of European countries (e.g., the UK, Germany, France, Italy). These countries' scientific solid and research infrastructure likely fosters robust collaborative networks. Clusters 2, 5 and 6 gathers countries close geographically, respectively, from Central Europe, Africa and the Middle East.

The clustering and the overall network structure may reflect the degree to which different countries have adopted and utilized the Oslo Manual's guidelines for innovation data collection and reporting. Countries within the same cluster may exhibit similar approaches to innovation practices and research methodologies, as defined by the Oslo Manual, thus fostering stronger collaborations among them.

Table 2 presents measures of the influence and position of countries in the network. The UK has the highest "pagerank" and "betweenness" centrality. In a statistical sense, it is the country with the most direct and indirect connections to other countries. It is also the most central by the shortest paths that flow through it, making it an information intermediary (Wasserman, Faust, 1994).

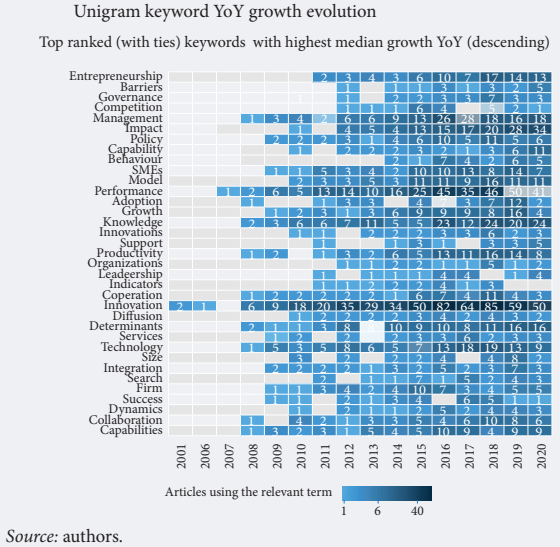
Research directions

In order to understand the dynamics of content over time, we employed keyword processing, mainly focusing on term extraction and textmetric analysis related to Oslo Manual publications. Our approach is based on analysing single words or unigrams.

Figure 14 visually represents the presence and growth of specific themes. Dark colours indicate a heavy relative presence, while the numbers in the tiles represent the frequencies of these themes in abstracts for each year. The Y-axis displays the terms with the highest growth rates (year-on-year) in descending order. Notably, we observe a rapid rise in mentions of «Entrepreneurship.» Furthermore, this analysis highlights the distinctive importance of key features of the Oslo Manual, including «Innovation,» «Performance,» «Knowledge,» and «Management.»

These straightforward observations demonstrate textmetric approaches' effectiveness in capturing the Oslo Manual's underlying characteristics and developments. Additionally, the content analysis provides insights into central thematic and sub-thematic categories directly associated with the manual and potential future developments.

Figure 14. **Thematic Keywords (unigrams)**



Source: authors.

Table 2. **Country Network Statistics, ranked**

Country rank	Cluster	Pagerank Centrality	Country rank	Betweenness Centrality	Country rank	Closeness Centrality
UK	4	0.0455	UK	790.92	Romania	0.10000000
USA	3	0.0333	Spain	664.57	Hungary	0.10000000
China	3	0.0328	The Netherlands	316.97	Spain	0.00336700
France	4	0.0305	Australia	267.56	UK	0.00335570
Spain	1	0.0305	Canada	263.98	The Netherlands	0.00321543
Canada	6	0.0305	France	242.19	USA	0.00320513
Germany	4	0.0293	USA	215.31	China	0.00313480
Sweden	4	0.0286	Russia	215.08	Denmark	0.00313480
Italy	4	0.0269	Malaysia	152.79	Germany	0.00311526
Austria	4	0.0265	Italy	146.27	France	0.00309598
Belgium	4	0.0260	Uganda	143.00	Australia	0.00309598
Australia	6	0.0240	Croatia	142.00	Canada	0.00309598
Norway	4	0.0237	Austria	129.40	Russia	0.00306748
The Netherlands	3	0.0223	Germany	112.26	Italy	0.00304878
Finland	4	0.0219	Belgium	95.46	Brazil	0.00303951
Russia	1	0.0201	Denmark	89.13	Portugal	0.00303951
Malaysia	3	0.0190	China	88.09	Colombia	0.00298507
Estonia	4	0.0187	Poland	86.60	New Zealand	0.00297619
Brazil	1	0.0185	South Africa	85.53	South Korea	0.00295858
Poland	6	0.0182	Brazil	82.29	Finland	0.00295858

Source: authors.

Framing factors and rising themes around Oslo Manual

In Figure 15, distinct domains associated with the Oslo Manual have been identified through the identification and assessment of specific keywords. These domains are recognized for their unique dynamics, reflected in emerging trends. Notably, trends observed in Figure 15 confirm the significance of dimensions such as innovation and performance in the context of the Oslo Manual. Furthermore, other aspects such as knowledge, management, and firms are also evident, although they appear less frequently.

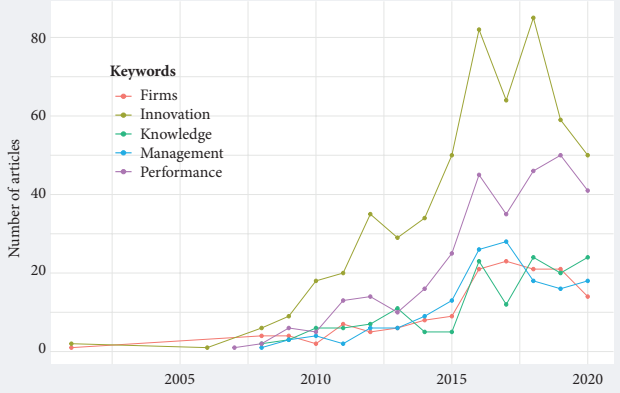
Conclusions

Innovation is vital in enhancing living standards and has far-reaching impacts on individuals, institutions, economic sectors, and countries. As a guide for collecting and interpreting evidence of innovation, the Oslo Manual has evolved through three revisions, reflecting the need to adapt to the changing landscape of innovation and accommodate new practices. This research article employs an enhanced bibliometric and text-mining approach, analysing a comprehensive dataset from 1992 to 2021 to gain insights into the quantitative and qualitative aspects of the Oslo Manual's review. The findings offer valuable contributions to innovation research and serve as an orientation for future theoretical developments.

The longitudinal analysis revealed significant streams of thought underpinning current innovation research. By studying a substantial database comprising 1,388 research articles, this study demonstrates an increased interest among researchers and policymakers in innovation-related topics, including entrepreneurship, performance, knowledge, and management. This growing interest aligns with previous studies (Chesbrough, 2003; Dahlander, 2010; Rossetto et al., 2018), affirming the integration of innovation with established management and economic theories (Van de Vrande et al., 2010).

This research stands out by focusing on the interpretation of innovation within the context of the Oslo Manual, utilizing network analysis methodology. It complements previous works (e.g. Rossetto et

Figure 15. **Main Categories (Keywords) Related to the Oslo Manual**



Source: authors.

al., 2018; Cancino et al., 2017a; Merigó et al., 2016; Shafique, 2013), offering a more comprehensive understanding of the theoretical basis of innovation research and providing valuable insights for future theoretical developments in the field.

By examining the references cited in the analyzed papers, the study provided insights into how this literature connects with broader management and innovation studies, further contributing to understanding innovation research's theoretical foundation.

However, challenges such as changes in definitions and methodologies across different editions of the Oslo Manual and comparability issues across countries need careful consideration when interpreting trends. Future research can explore specific themes, authors, and relationships and employ innovative methodologies to illuminate emerging areas within innovation research (Sharma, Lenka, 2022; Silva et al., 2023; Wulff et al., 2023; Rahman et al., 2024). This study offers valuable insights into the evolution and practical implications of the Oslo Manual, highlighting its critical adaptability to capture the dynamic innovation landscape and foster global cooperation.

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