

A Comprehensive Informetric and Bibliometric Exploration of Scholarly Communication and Knowledge Structures in Digital and Scientific Research

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Abstract

The quantitative study of recorded knowledge has evolved through several conceptual and methodological traditions that now collectively form the domain of informetrics, bibliometrics, scientometrics, and webometrics. These traditions emerged from a common intellectual concern with understanding how scientific and scholarly communication develops, spreads, and accumulates influence over time. The present study provides an original, theoretically grounded, and methodologically integrated analysis of how these traditions interact and how contemporary bibliometric tools and databases shape the evaluation of research performance, thematic evolution, and scholarly networks. Drawing strictly from the established literature on informetrics, bibliometrics, citation analysis, coauthorship networks, and open access, this article develops a comprehensive framework for interpreting the structure and dynamics of modern scientific communication.

Building upon the foundational conceptualizations of bibliometrics as articulated by Pritchard and the early scientometric formulations by Nalimov and Mulcenko, the article situates bibliometric analysis within a broader epistemological and sociological context of science. It further integrates the informetric perspective articulated by Nacke and Wilson, emphasizing that quantitative indicators are not mere technical artifacts but social constructs embedded in institutional, disciplinary, and technological systems. By linking classical citation studies such as those of Salton and Bergmark with contemporary visualized network approaches exemplified by Mou, Cui, and Kurcz, the study demonstrates how bibliometric methodologies have transformed from simple counting procedures into complex analytical systems capable of mapping intellectual structures and research communities.

The article also addresses the expansion of bibliometric analysis into web based and open access environments, drawing on the contributions of Thelwall, Vaughan, and Bjorneborn, as well as the policy oriented perspective of OpenAccess.nl. These developments are interpreted not only as technical innovations but as structural shifts in the way knowledge is produced, disseminated, and evaluated. In addition, the integration of bibliometric databases such as the Lens is examined through the work of Penfold, highlighting how data infrastructures influence institutional research assessment and individual scholarly visibility.

Keywords: Bibliometrics, Informetrics, Scientometrics, Citation Analysis, Research Evaluation, Scholarly Communication.

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1. Introduction

The systematic study of recorded knowledge has long been a central concern of librarianship, information science, and the sociology of science. As scientific and scholarly production expanded dramatically during the twentieth century, researchers increasingly sought quantitative methods to describe, measure, and interpret this growth. Bibliometrics emerged as one of the earliest and most influential approaches to this challenge, defined initially as the application of mathematical and statistical methods to books and other media of communication by Pritchard in his seminal formulation of the field (Pritchard, 1969). This definition was not merely a technical description but a conceptual repositioning of bibliographic analysis as a scientific enterprise capable of producing generalizable insights about knowledge systems.

At nearly the same time, in a different intellectual and geographical context, Nalimov and Mulcenko introduced the term scientometrics to describe the quantitative study of science itself, including its growth, structure, and dynamics (Nalimov and Mulcenko, 1969). Scientometrics was grounded in the idea that science could be studied empirically as a social and cognitive system whose outputs were observable through publications, citations, and institutional affiliations. The convergence of bibliometrics and scientometrics reflected a broader epistemological shift in which knowledge production became an object of systematic inquiry rather than merely an implicit background of scientific practice.

The term informetrics later emerged to describe a still broader domain encompassing all quantitative aspects of information production, dissemination, and use. Nacke proposed informetrics as a new name for a new discipline that would integrate bibliometrics, scientometrics, and other quantitative approaches under a unified conceptual umbrella (Nacke, 1979). Wilson further elaborated this vision by defining informetrics as the study of the quantitative aspects of information in any form, not limited to scientific publications alone (Wilson, 1999). This expansion signaled an important recognition that the patterns observed in scholarly literature are part of a wider informational ecology that includes digital documents, web resources, and emerging forms of communication.

Despite these conceptual advances, early bibliometric research was often constrained by limited data sources and relatively simple analytical techniques. Citation analysis, for example, initially relied on manual or semi automated examination of reference lists to determine patterns of

influence and connectivity. Salton and Bergmark demonstrated the potential of citation analysis for understanding the structure of computer science research, showing that citation networks could reveal intellectual linkages among authors and topics (Salton and Bergmark, 1979). Their work laid the foundation for later developments in co citation and bibliographic coupling, which would become central tools of modern bibliometric analysis.

Over time, the scope and sophistication of bibliometric research expanded dramatically. The development of large citation databases, the digitization of scholarly journals, and the rise of computational tools for network analysis transformed bibliometrics into a powerful instrument for mapping scientific fields and evaluating research performance. Mou, Cui, and Kurcz illustrated this transformation through their bibliometric and visualized analysis of major e commerce journals using CiteSpace, demonstrating how complex visual representations of citation and keyword networks can reveal the evolution of research themes and the emergence of influential authors and institutions (Mou et al., 2019).

The contemporary relevance of bibliometrics extends far beyond academic curiosity. Universities, funding agencies, and governments increasingly rely on bibliometric indicators to assess research productivity, allocate resources, and formulate science policy. This growing dependence raises important theoretical and ethical questions about what bibliometric measures actually capture and how they should be interpreted. As Wilson emphasized, informetric indicators are not neutral reflections of reality but socially constructed representations shaped by database coverage, disciplinary norms, and institutional incentives (Wilson, 1999). A critical and theoretically informed understanding of bibliometrics is therefore essential for responsible research evaluation.

Within this broad context, the present article seeks to provide a comprehensive and original analysis of the conceptual foundations, methodological practices, and applied implications of bibliometric and informetric research. Drawing strictly on the provided references, it integrates classical theoretical contributions with contemporary empirical studies to illuminate how quantitative analysis of scholarly communication has evolved and how it continues to shape our understanding of knowledge production. The central problem addressed in this study is the tension between the growing sophistication of bibliometric tools and the persistent risk of

misinterpreting or misusing their outputs. While bibliometric techniques offer unprecedented insight into the structure and dynamics of research fields, they also risk oversimplifying complex intellectual and social processes into numerical indicators.

The literature reviewed here reveals several important gaps that motivate the present study. First, while many bibliometric analyses focus on specific disciplines or topics, there is a lack of integrative theoretical work that connects these empirical findings to the broader informetric framework proposed by Nacke and Wilson. Second, methodological debates about counting methods, network construction, and database selection often remain isolated from discussions of their epistemological and social implications. The comparison between full and fractional counting by Perianes Rodriguez, Waltman, and Van Eck, for example, has profound implications for how collaboration and contribution are conceptualized, yet these implications are rarely explored in depth (Perianes Rodriguez et al., 2016). Third, the rapid expansion of web based and open access publishing environments has introduced new dynamics into scholarly communication that are not fully captured by traditional bibliometric models.

By addressing these gaps through an extensive theoretical elaboration and critical synthesis of the provided literature, this article aims to advance a more nuanced and reflexive understanding of bibliometrics and informetrics. Rather than treating bibliometric indicators as self evident measures of quality or impact, it situates them within the historical, social, and technological contexts that give them meaning. In doing so, the study contributes to a more sophisticated and responsible use of quantitative methods in the analysis and evaluation of scholarly communication.

2. Methodology

The methodological approach of this study is rooted in the principles of informetrics and bibliometrics as articulated in the foundational and contemporary literature provided. Rather than generating new empirical data through database extraction or computational modeling, the present research adopts a theoretically grounded and text based analytical methodology that synthesizes, interprets, and critically integrates existing bibliometric studies. This approach is fully consistent with the tradition of informetric research, which has always combined quantitative analysis with conceptual reflection in order to understand the structure and dynamics of scholarly communication (Wilson, 1999).

At the core of this methodology lies the recognition that

bibliometric indicators and networks are constructed representations of underlying scholarly activity rather than direct measurements of intrinsic quality or significance. Perianes Rodriguez, Waltman, and Van Eck emphasized that even seemingly straightforward operations such as counting publications or citations involve methodological choices that shape the resulting representation of the research landscape (Perianes Rodriguez et al., 2016). Full counting assigns equal weight to each coauthor or citation, while fractional counting distributes credit proportionally, leading to different interpretations of productivity and influence. By explicitly acknowledging these methodological contingencies, the present study treats the findings of the cited bibliometric analyses not as absolute truths but as context dependent perspectives on scholarly communication.

The primary analytical procedure employed here involves a systematic and comparative reading of the provided references, focusing on their theoretical premises, methodological designs, and substantive findings. This procedure follows the informetric tradition of identifying patterns, regularities, and divergences across studies in order to construct a coherent interpretive framework. For example, the bibliometric study of digital libraries by Singh, Mittal, and Ahmad provides insights into thematic concentration and authorship patterns within a specific domain, while the analysis of social science journals by Thanuskodi offers a contrasting perspective on publication and citation behavior in a different disciplinary context (Singh et al., 2007; Thanuskodi, 2010). By comparing these studies, the present methodology reveals how disciplinary cultures and communication practices shape bibliometric outcomes.

Another key methodological dimension of this study is the integration of network based approaches to bibliometric analysis. Perianes Rodriguez, Omelda Gomez, and Moya Anegon demonstrated that coauthorship networks can be used to detect and visualize research groups, revealing the social structure of scientific collaboration (Perianes Rodriguez et al., 2010). Similarly, Mou, Cui, and Kurcz used visualized networks of keywords and citations to map the intellectual structure of e commerce research (Mou et al., 2019). Rather than reproducing these networks, the present study analytically reconstructs their implications, explaining in descriptive and theoretical terms how network structures reflect underlying processes of knowledge production, collaboration, and competition.

The methodology also incorporates a critical examination of data sources and infrastructures. Penfold highlighted the

role of the Lens database in supporting institutional publication tracking and research evaluation, illustrating how bibliometric analysis is shaped by the coverage, metadata, and interoperability of digital repositories (Penfold, 2020). OpenAccess.nl provided a policy oriented definition of open access that emphasizes the free availability and reuse of scholarly outputs (OpenAccess.nl, n.d.). By integrating these perspectives, the present methodology recognizes that bibliometric data are produced within specific technological and policy environments that influence what can be measured and how.

Importantly, this study adheres strictly to the provided reference list as its evidentiary base. All claims, interpretations, and theoretical developments are grounded in the cited literature, ensuring that the analysis remains faithful to the intellectual traditions and empirical findings that define the field. This constraint does not limit the scope of the study but rather deepens its analytical rigor by requiring a thorough and creative engagement with the foundational texts of informetrics and bibliometrics.

In sum, the methodological approach of this research is a form of advanced bibliometric hermeneutics, combining systematic literature analysis with theoretical synthesis and critical reflection. By treating bibliometric studies as both data and discourse, the methodology reveals not only what these studies show about scholarly communication but also how they construct and shape our understanding of it.

3. Results

The synthesis of the provided bibliometric and informetric literature yields a rich and multifaceted set of results that illuminate the structure, dynamics, and evolution of scholarly communication across disciplines, time periods, and technological contexts. These results do not take the form of numerical tables or statistical outputs but rather emerge as coherent patterns and interpretive insights derived from the convergence and divergence of the cited studies.

One of the most striking results is the persistent growth and diversification of scientific literature, a phenomenon documented across multiple domains and historical periods. Pratt, in his analysis of a decade of AIDS literature, observed a rapid expansion of publications reflecting the urgency and global significance of the epidemic (Pratt, 1992). Similarly, Onyancha documented the substantial growth of HIV and AIDS research in Eastern and Southern Africa between 1980 and 2005, highlighting how regional and social needs drive the production of scientific

knowledge (Onyancha, 2007). These studies demonstrate that bibliometric indicators such as publication counts are not merely measures of academic activity but also proxies for the alignment of science with societal challenges.

Another important result concerns the thematic and disciplinary structuring of research fields. Singh, Mittal, and Ahmad found that digital library research exhibits a concentration of output in a relatively small number of core journals and authors, suggesting the presence of a tightly knit intellectual community (Singh et al., 2007). Thanuskodi reported a similar pattern in the Journal of Social Sciences, where a limited group of prolific contributors accounted for a disproportionate share of publications (Thanuskodi, 2010). These findings align with classical bibliometric laws, such as Lotka law and Bradford law, which describe the uneven distribution of productivity and journal relevance, even though these laws are not explicitly invoked in the present references. The result is a picture of scholarly communication as a stratified system in which a small core of highly active actors plays a central role in shaping the field.

Citation analysis further reveals the hierarchical and networked nature of knowledge production. Salton and Bergmark demonstrated that citation patterns in computer science form identifiable clusters corresponding to research specialties and methodological approaches (Salton and Bergmark, 1979). Zhao and Logan extended this insight to web based publications, showing that even in the relatively decentralized environment of online XML research, citation networks still exhibit structured patterns of influence and connectivity (Zhao and Logan, 2002). These results indicate that citations function not only as acknowledgments of intellectual debt but also as signals of membership in epistemic communities.

The construction and visualization of bibliometric networks provide additional insight into the social organization of research. Perianes Rodriguez, Omelda Gomez, and Moya Anegon showed that coauthorship networks can be used to identify research groups, revealing how collaboration patterns reflect institutional affiliations, disciplinary norms, and funding structures (Perianes Rodriguez et al., 2010). Mou, Cui, and Kurcz similarly demonstrated that keyword and citation networks in e commerce research reveal the emergence of dominant themes, the convergence of subfields, and the rise of influential authors (Mou et al., 2019). The result is a dynamic map of scientific activity that captures both cognitive and social dimensions of knowledge production.

A further result concerns the methodological sensitivity of bibliometric indicators. The comparison between full and fractional counting by Perianes Rodriguez, Waltman, and Van Eck revealed that different counting methods can lead to significantly different assessments of productivity and impact, particularly in fields characterized by high levels of collaboration (Perianes Rodriguez et al., 2016). This finding underscores the constructed nature of bibliometric measures and the importance of methodological transparency in research evaluation.

The expansion of bibliometric analysis into web based and open access environments represents another major result. Thelwall, Vaughan, and Bjorneborn showed that webometrics extends traditional bibliometric principles to the analysis of hyperlinks, web pages, and online visibility, capturing new dimensions of scholarly communication in the digital age (Thelwall et al., 2005). OpenAccess.nl emphasized that open access publishing increases the accessibility and potential impact of research outputs, thereby altering the patterns of dissemination and citation that bibliometric studies measure (OpenAccess.nl, n.d.). Penfold further demonstrated that modern bibliometric databases such as the Lens integrate diverse data sources, enabling more comprehensive and institutionally relevant analyses of research output (Penfold, 2020). Together, these results indicate that the infrastructure of scholarly communication is undergoing a profound transformation, with significant implications for bibliometric analysis.

Finally, the results of the thematic bibliometric studies in the provided literature reveal the increasing interdisciplinarity and global reach of research. Mustafa and colleagues showed that pro environmental behavior research in computer science has grown steadily over more than four decades, reflecting the integration of environmental concerns into technological innovation (Mustafa et al., 2020). Onyancha demonstrated the regional diversification of health research, while Yeoh and Kaur highlighted the use of bibliometric tools in collection development to support diverse subject areas (Yeoh and Kaur, 2008). These findings collectively point to a scholarly communication system that is both increasingly interconnected and deeply shaped by social and environmental priorities.

4. Discussion

The results synthesized from the provided bibliometric and informetric literature invite a deep and multifaceted interpretation that extends beyond the descriptive patterns of publication and citation. At their core, these findings reveal that scholarly communication is a complex adaptive

system in which cognitive, social, technological, and institutional forces interact to shape the production and circulation of knowledge. Informetrics, as conceived by Nacke and elaborated by Wilson, provides the conceptual lens through which these interactions can be understood, emphasizing that quantitative indicators are embedded within broader information processes (Nacke, 1979; Wilson, 1999).

One of the most important implications of the results is that bibliometric indicators are not neutral measures of quality or importance but reflections of underlying social and disciplinary structures. The concentration of publications and citations among a small core of authors and journals, as observed in studies of digital libraries and social sciences, suggests that scholarly fields are organized around centers of influence that shape what topics are pursued and which voices are amplified (Singh et al., 2007; Thanuskodi, 2010). This concentration can facilitate cumulative knowledge building by providing stable reference points, but it can also marginalize innovative or interdisciplinary work that falls outside established networks.

The network based analyses of coauthorship and citation further highlight the social nature of scientific knowledge. Research groups identified through coauthorship networks are not merely collections of individuals but institutionalized communities with shared norms, resources, and strategic interests (Perianes Rodriguez et al., 2010). These communities play a crucial role in training new researchers, securing funding, and setting research agendas. Mou, Cui, and Kurcz showed that in e commerce research, as in many other fields, the emergence of dominant themes and influential authors is closely tied to these collaborative networks (Mou et al., 2019). From an informetric perspective, networks are not just analytical tools but representations of the social fabric of science.

The methodological sensitivity of bibliometric measures raises further interpretive challenges. The choice between full and fractional counting, for example, reflects different normative assumptions about what constitutes contribution and credit (Perianes Rodriguez et al., 2016). Full counting implicitly treats each coauthor as having made an equal and independent contribution, while fractional counting assumes that credit should be divided proportionally. Neither assumption fully captures the complex realities of collaborative research, where contributions may be uneven, complementary, or difficult to quantify. This methodological ambiguity underscores Wilson's argument that informetric indicators must be interpreted critically and contextually rather than taken at face value (Wilson, 1999).

The expansion of bibliometrics into web based and open access environments further complicates the interpretive landscape. Webometrics captures forms of visibility and influence that are not reflected in traditional citation counts, such as hyperlink structures and online engagement (Thelwall et al., 2005). Open access publishing, by making research freely available, can increase readership and citation potential, but it can also introduce new inequalities if publication fees create barriers for researchers from less well funded institutions (OpenAccess.nl, n.d.). Penfold's discussion of the Lens database illustrates how the integration of diverse data sources can enhance institutional research assessment while also raising questions about data quality, coverage, and interoperability (Penfold, 2020). These developments suggest that bibliometric analysis is increasingly shaped by technological infrastructures that must themselves be subject to critical scrutiny.

The thematic studies in the provided literature also highlight the responsiveness of scientific research to societal needs and values. The growth of HIV and AIDS research in Africa reflects the urgent health challenges faced by the region, while the rise of pro environmental behavior studies in computer science reflects a growing recognition of the environmental implications of technological development (Onyancha, 2007; Mustafa et al., 2020). Bibliometric indicators thus serve not only as measures of academic activity but also as barometers of social concern and policy relevance. However, this responsiveness is mediated by funding priorities, institutional incentives, and publication practices, all of which can amplify certain topics while neglecting others.

Despite the richness of bibliometric analysis, the literature also points to important limitations that must be acknowledged. Citation counts, for example, cannot distinguish between positive and negative citations, nor can they capture the substantive content or quality of the cited work. Coauthorship networks reveal patterns of collaboration but not the intellectual or ethical dimensions of those relationships. Web based indicators can be influenced by factors such as search engine algorithms and social media dynamics that are only loosely connected to scholarly merit. As Tiew's study of self citation demonstrates, even the most basic indicators can be shaped by strategic behavior, as authors seek to increase their visibility and perceived impact (Tiew, 2000).

These limitations do not invalidate bibliometric and informetric research but rather underscore the need for a theoretically informed and reflexive approach. By integrating quantitative indicators with qualitative

understanding of disciplinary cultures, institutional contexts, and technological infrastructures, researchers can use bibliometrics as a powerful tool for exploring the dynamics of knowledge production without reducing those dynamics to simplistic metrics. This integrative perspective is precisely what Nacke envisioned when he proposed informetrics as a unifying framework for the quantitative study of information (Nacke, 1979).

Looking to the future, the continued evolution of scholarly communication presents both opportunities and challenges for bibliometric research. The proliferation of digital platforms, preprint servers, and open data repositories will generate new forms of information that can be analyzed to understand scientific activity in real time. At the same time, the increasing use of bibliometric indicators in evaluation and funding decisions raises ethical and practical concerns about gaming, inequality, and the narrowing of research agendas. Addressing these challenges will require not only technical innovation but also sustained theoretical reflection on the meaning and purpose of measuring knowledge.

5. Conclusion

The comprehensive analysis presented in this study demonstrates that bibliometrics, informetrics, scientometrics, and webometrics together constitute a powerful and multifaceted framework for understanding the production, dissemination, and evaluation of scholarly knowledge. Drawing strictly from the provided literature, the article has shown how these quantitative traditions emerged from early efforts to apply statistical methods to bibliographic data and have evolved into sophisticated analytical systems capable of mapping intellectual structures, social networks, and thematic trends across disciplines and time.

From the foundational definitions of bibliometrics by Pritchard and scientometrics by Nalimov and Mulcenko to the integrative vision of informetrics proposed by Nacke and elaborated by Wilson, the field has been guided by a commitment to understanding science as a measurable and analyzable phenomenon. The empirical studies reviewed here, ranging from citation analyses of computer science and AIDS research to network visualizations of e commerce and coauthorship, illustrate the remarkable diversity of applications and insights that bibliometric methods can provide.

At the same time, the study has emphasized that bibliometric indicators are constructed representations shaped by methodological choices, technological

infrastructures, and social contexts. The comparison of counting methods, the role of open access and web based data, and the influence of databases such as the Lens all highlight the need for critical and reflexive interpretation. Bibliometrics is most valuable not when it is treated as a set of definitive metrics but when it is understood as a lens through which the complex realities of scholarly communication can be explored.

In an era of rapid digital transformation and increasing reliance on quantitative evaluation, the insights of informetrics are more important than ever. By situating bibliometric analysis within a broader theoretical and social framework, researchers, institutions, and policymakers can use these tools to support more informed, equitable, and responsible approaches to knowledge production and assessment. The present study contributes to this goal by providing an extensive and integrated interpretation of the bibliometric literature, reaffirming the central role of quantitative analysis in understanding the evolving landscape of science while also acknowledging its inherent limitations and responsibilities.

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