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How Do Leadership, Business, and Entrepreneurship Evolve in the Digital Era through Global Research Insights? A Systematic Bibliometric Analysis

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ABSTRACT
— Over the past decade, scholarly attention to entrepreneurship and leadership in the context of digital transformation has grown remarkably. Yet, the field remains fragmented, lacking an integrated perspective that connects its conceptual and empirical foundations. This study addresses that gap by providing a comprehensive bibliometric analysis of research at the intersection of entrepreneurship, leadership, and digitalization. Drawing on 9,433 peer-reviewed publications indexed in the Web of Science from 1994 to 2025, it applies the R-based Bibliometrix package and VOSviewer software to examine publication performance, citation networks, and thematic structures. The analysis reveals two dominant clusters: one centred on management concepts such as models, frameworks, and big data, capturing the strategic and organizational dimension of entrepreneurship, and another emphasizing innovation, performance, and technology, representing its technological and performance-driven orientation. Together, these clusters illustrate how innovation and digital advancement reshape entrepreneurial behaviour and leadership approaches in the modern business environment. The study offers an integrated and visual overview of the field's intellectual structure, identifies key contributors and emerging trends, and provides actionable insights for scholars seeking to understand how digital transformation continues to redefine leadership and entrepreneurship worldwide..
Keywords: bibliometric analysis; Bibliometrix; business performance; digital transformation; entrepreneurship; innovation; leadership; research trends; VOSviewer

INTRODUCTION:

In the past few decades, entrepreneurship has been rightfully praised by scholars and researchers around the world. Therefore, it should come as no surprise that entrepreneurial activity serves as a key engine of economic growth. According to Avelar et al. (2024), it has the ability "to drive positive change and increase resilience in the economy". Chen et al. (2025) have gone one step further, stating that "sustainable entrepreneurship is a strategic focal point in business because it promotes inclusive and resilient economic progress while confronting environmental externalities". Interestingly, entrepreneurship has received the recognition and has been referred to as a "solution to, rather than a cause of, environmental degradation and social inequality" (Muñoz & Cohen, 2018). Galindo-Martín et al. (2024), on the other hand, highlight its role in pursuing certain economic goals, such as employment and economic growth. Moreover, they claim that digitalization, among other factors, drives entrepreneurship. Some scholars claim that "digital entrepreneurship is playing an increasingly prominent role in economic growth and development" (Berman et al., 2024). Calderon-Monge & Ribeiro-Soriano (2024) further emphasize the power and essential role of digitalization as "a powerful engine for economic growth in the world".

Digitalization compels organizations to rapidly adapt to technological trends to sustain and enhance their market position. To effectively respond to these trends, organizations are adopting a new leadership paradigm known in research and practice as Digital Leadership (DL). Leadership is considered "a crucial driver of efficient deployment of any Operations Management paradigm" (Diössy et al., 2025). Many studies on digital leadership have been published lately and have attracted the attention of scholars worldwide (Karakose et al., 2024). Although digital entrepreneurship and digital leadership have been analyzed individually through bibliometric or systematic reviews, no study integrates all three domains simultaneously to reveal their conceptual convergence, mutual dependencies, and structural evolution. This fragmentation limits theoretical synthesis and cross-domain understanding.

Given the topicality of the research subject at hand, the main objective of this study is to present a comprehensive systematic bibliometric analysis on the global research

trends in the intersection of entrepreneurship and leadership in the modern global business landscape, i.e. in the digital era. By surveying the Web of Science database, this study highlights the main research themes and clusters, and influential contributors (such as authors, documents, affiliations, and countries). For this reason, the R Studio's Bibliometrix (version 4.3.1) was applied together with the VOSviewer (version 1.6.20) software, as a means to illustrate the global trends in publication in this area.

To the best of the authors' knowledge, this is the first WoS-based bibliometric study systematically examining the nexus between entrepreneurship, leadership, and digitalization. This bibliometric investigation holds substantial relevance from both scientific and practical perspectives, addressing critical gaps in understanding how entrepreneurship, leadership, and digitalization converge and intersect in the modern business landscape. Scientifically, it provides the first Web of Science-based synthesis of these interdependent domains, mapping their intellectual structure through 9,433 publications and revealing dual thematic axes—strategic-organizational and technological-innovation—that prior fragmented reviews have overlooked, thereby enabling clearer theoretical integration and identification of underexplored areas like ethics and digital inequality. Practically, the findings equip leaders with actionable insights into competencies such as digital literacy, agility, and cross-sector collaboration (e.g., from clusters on fintech and sustainability), while guiding policymakers toward frameworks that foster skills development, public-private partnerships, and EU-aligned digital strategies to enhance organizational resilience and inclusive growth amid rapid technological disruption.

The remainder of this study is structured as follows. After the Introduction section, a theoretical and conceptual background and literature review on entrepreneurship and leadership and digitalization is conducted. The data and methodology used are laid out in Section 3 (Data and Method). The results and findings are revealed in Section 4. A discussion is thereafter opened in Section 5, and the paper concludes in Section 6.

Conceptual Background

2.1. Entrepreneurship and Digitalization

The impact of entrepreneurship on economic growth and development is undeniable. The subject has been researched by many scholars thus far, and they all tackled different aspects of the topic. Entrepreneurship is a dynamic process involving vision, transformation, and creativity, driven by energy and passion to develop and implement innovative ideas and solutions (Kuratko & Hodgetts, 2017). Digitalization, on the other hand, is increasingly emerging as a key driver of entrepreneurial activity, and the presence of a well-defined digitalization strategy is becoming a critical determinant of a company's success (Kraus et al., 2023). It is perceived as a rapid transformational force of the entrepreneurial landscape (Francu et al., 2025). Digitalisation and digital transformation of businesses have enabled entrepreneurs to form and maintain direct relationships with both their suppliers and buyers, and to engage closely with all stakeholders (Chatterjee et al., 2022).

Torres & Augusto (2020) dived into the impact of digitalisation and social entrepreneurship on national well-being and found that digitalisation benefits national well-being given "an adequate educational system, good governance, and a philanthropy-oriented financial system". Cavallo & Ghezzi (2021) found that digitalization mediates the relationship between entrepreneurship and economic growth. Ghazy et al. (2022) focused on the relationship between entrepreneurship and productivity for EU-27-member countries, where the findings revealed a strong positive link between entrepreneurship and productivity, along with a positive connection between digitalization and entrepreneurial activity. Franco et al. (2021) found that digital entrepreneurship brings advantages in 3 forms as follows: efficiency, customer relations and collaborator behaviour. Kraus et al. (2023) conducted a study on 242 Italian enterprises and found rather interesting insights. Namely, they found the major role of digitalization strategy for innovation in the enterprises that were less entrepreneurially oriented.

2.2. Leadership and Digitalization

In the context of leadership, digital transformation is profoundly reshaping managerial and leadership functions, customer and employee relations are becoming increasingly digital, new technologies are emerging, and models centred on sharing and collaboration are taking shape (Abdellah, 2024). Digital transformation has become essential for companies seeking to maintain competitiveness. Undoubtedly, the integration of digital technologies plays a fundamental role in improving overall business performance (Rialti & Filieri, 2024). In the face of digitalization, leaders of business organisations faced many new and specific challenges, that included "disruptive changes on the commercial landscape, with data-driven decision making, as well as with new ways of crowd-based working; and with a workforce with ubiquitous access to information and establishing new ways of communication" (Hesse, 2018). The process of digitalisation and digital transformation all around different industries was accelerated with the Covid-19 pandemic, which "has provided an additional unplanned impetus to maximize the digitalization of operations, although the process is not always running smoothly" (Staniulienė & Lavickaitė, 2022). Moreover, the pandemic and digital disruption have profoundly changed the world and business globally, thereby facing leaders with one-of-a-kind challenges and thus, creating new opportunities to delve into digital leadership (López-Figueroa et al., 2025).

However, modern times call for modern measures and transformations. In this context, nowadays employees expect their leaders to be more proactive and to develop and use certain skills related to a more effective digitalization in a leadership style (Staniulienė & Lavickaitė, 2022). This is also confirmed in the study of Erhan et al. (2022), on a sample of 320 Turkish companies operating in the textile industry, more specifically, the department managers. What they found is that the digital

leadership was positively perceived by the employees and it had a positively and significant effect on the innovative work behaviours demonstrated by employees in the workplace. Notwithstanding, the leaders with the best digital skills were worshipped by the employees, and they influenced employees to adapt more easily to innovative thinking and behaviours. More importantly, identifying the leadership behaviors most conducive to supporting digitalization enables companies to anticipate potential challenges and strategically focus their efforts on developing effective leaders (Tortorella et al., 2023).

Petrov et al. (2023) have conducted a study in which they explored the role in achieving sustainability and digitalization in a company. Their findings confirm that leadership played a major role in overcoming the challenges on the path towards digitalization. In the study of Rialti & Filieri (2024), agile leadership was found suitable approach for engaging organizational members in digital transformation initiatives.

Interestingly, Hooi & Chan (2022) found that an innovative culture mediates the link between transformational leadership and workplace digitalization, while rewards and recognition moderate the connection between transformational leadership and innovation. Their findings are in line with the results of Abbas et al. (2024), who found that digital leadership significantly impacts innovation and innovative operations, and that the interconnectedness between digital leadership and innovative work lies in the digital entrepreneurial orientation and digital organizational culture.

Taken together, the reviewed literature illustrates that entrepreneurship, leadership, and digitalization are increasingly interdependent, yet their theoretical integration remains incomplete. While scholars agree that digital transformation reshapes entrepreneurial strategy, organisational capabilities, and leadership behaviour, the direction and mechanisms of this influence are still debated—whether digitalization enables new entrepreneurial pathways or whether entrepreneurial agency drives digital adoption; whether digital leadership constitutes a novel paradigm or an evolution of adaptive and relational models; and whether digital capability building reduces organisational uncertainty or deepens structural tensions. Despite substantial empirical progress, existing reviews tend to examine these domains in isolation, providing limited insight into how they collectively shape the emerging socio-technical landscape of modern organisations. This fragmentation underscores the need for a comprehensive synthesis that maps how these research streams interact, converge, and diverge. By conducting an integrated bibliometric and systematic analysis, the present study addresses this gap and offers a consolidated view of the intellectual structure connecting entrepreneurship, leadership, and digitalization.

III. Data and Method

3.1. Research Method

Bibliometric methods have been increasingly employed to analyze publication patterns and knowledge structures in a variety of scientific disciplines, such as entrepreneurship learning models (Anggraini et al., 2026), sustainable energy (Ranjan et al., 2026), machine learning (Çakır et al., 2025), electric vehicle supply chain management (Soares et al., 2023), vaccines and immunisation (Fernandes et al., 2018), evolution of investor sentiment (Huynh et al., 2025) and so on.

This study adopts a systematic literature review (SLR) combined with bibliometric analysis to examine how entrepreneurship, leadership, and digitalization evolve and intersect within global research. This design was selected because the field is conceptually fragmented, dispersed across multiple domains, and characterized by heterogeneous terminology. An SLR enables a transparent, structured, and replicable synthesis of existing knowledge, while bibliometric techniques provide quantitative insights into intellectual structures, thematic clusters, and research evolution—dimensions that cannot be captured through narrative reviews alone. The SLR follows the PRISMA 2020 framework, which offers a rigorous protocol for identifying, screening, selecting, and documenting relevant studies. PRISMA is particularly appropriate for interdisciplinary fields because it ensures systematic filtering of large datasets where conceptual boundaries are fluid. In this study, PRISMA supports the methodological goal of moving from broad domain capture to fine-grained thematic relevance, thereby ensuring that the final dataset reflects the intersection of entrepreneurship, leadership, and digital transformation.

Bibliometric analysis complements the SLR by enabling performance indicators (e.g., document growth, authorship patterns), science mapping (e.g., keyword co-occurrence, conceptual clusters), and structural interpretation of research trajectories. This mixed-method approach—qualitative screening reinforced by quantitative mapping—provides stronger explanatory power than either method alone.

The open-source Bibliometrix tool (version 4.3.1) from the R-package, and the VOSviewer (version 1.6.20) were used to carry out the bibliometric analysis. VOSviewer features a user-friendly interface and allows direct import of various bibliometric data formats, making it suitable for generating general visualizations (Oyewola & Dada, 2022), whereas Bibliometrix provides a greater analytical flexibility and customization options but often requires prior data pre-processing and a basic command of programming to ensure accurate data management and analysis (Kemeç & Altınay, 2023). VOSviewer is a freely available software tool designed for constructing and visualizing bibliometric maps. It enables users to generate maps of authors, journals, or documents based on co-citation data, as well as keyword maps derived from co-occurrence analysis. The software includes an interactive visualizer that allows detailed exploration of bibliometric networks through multiple display modes, each emphasizing different map features. Its zoom, pan, and search functions enhance navigation and interpretation, making it a practical tool for analyzing and presenting complex bibliometric relationships (Kemeç & Altınay, 2023). Bibliometrix was used for performance indicators and thematic evolution, while VOSviewer enabled network-based cluster detection. Their combined application provides analytical triangulation, ensuring both statistical flexibility and structural visualization.

3.2. Database and Search Strategy

The bibliographic dataset for this study was retrieved from the Web of Science (WoS) Core Collection, which is widely recognized for its rigorous journal selection criteria and comprehensive coverage of high-quality, peer-reviewed research in management, business, and the social sciences. WoS was selected due to its reliability for citation-based analyses, standardized metadata formats, and extensive use in recent bibliometric studies examining interdisciplinary research fields.

Given that entrepreneurship, leadership, and digitalization constitute three partially overlapping and unevenly indexed domains, a single, narrowly defined search query using all three concepts simultaneously (e.g., entrepreneurship AND leadership AND digitalization) would have produced an overly restrictive and incomplete dataset. Preliminary test searches confirmed that many highly relevant studies address two of the domains explicitly, while the third domain emerges implicitly in the abstract, keywords, or theoretical framing. This is a well-known characteristic of rapidly evolving interdisciplinary fields, in which authors do not consistently include all conceptual dimensions in titles or keywords.

To avoid premature exclusion of relevant publications and ensure a comprehensive identification phase—consistent with PRISMA guidelines—the search strategy deliberately applied three two-domain search strings:

leadership style AND digitalization

entrepreneurship AND digitalization

business AND digitalization

This approach follows established bibliometric practice for emerging interdisciplinary topics, where retrieving domain pairs allows for the broad capture of the conceptual landscape before applying refined screening criteria. Using this strategy minimized the risk of undercoverage and enabled the identification of literature where the intersection between entrepreneurship, leadership, and digitalization appears conceptually—even if not explicitly indexed in database fields.

The search covered all available years (1994–30 June 2025) with language limited to English. Document types included peer-reviewed articles, reviews, and proceedings papers, as these are the main vehicles for scholarly contributions in the field. Books, editorials, notes, and non-scholarly materials were excluded.

After the initial retrieval, duplicate records, off-topic publications, and papers lacking relevance to at least two of the three focal domains were removed through a two-stage screening process (title/abstract screening and full-text relevance assessment). This ensured that the final dataset accurately reflected the thematic intersection of entrepreneurship, leadership, and digital transformation.

The complete PRISMA flowchart summarizing identification, screening, eligibility, and inclusion stages is presented in Figure 1.

3.3. Screening, eligibility and PRISMA protocol

The four PRISMA stages—identification, screening, eligibility, and inclusion—were applied as follows:

Identification:
All records returned by the three search strings were imported from WoS. Non-English documents, non-scholarly items (editorials, notes), and records lacking bibliometric metadata were excluded at this stage.

Screening:
Titles and abstracts were reviewed to determine relevance to at least two of the three core domains. Records clearly outside management, organizational studies, innovation, or digital transformation were removed. Duplicate entries were eliminated.

Eligibility:
Full-text assessments were conducted when the thematic fit was unclear. Studies focusing exclusively on technical engineering aspects without managerial or entrepreneurial relevance were excluded.

Inclusion:
The final dataset consisted of 9,433 publications, representing conceptually relevant research situated within the intersection of digitalization, entrepreneurship, and leadership.

The primary aim of this method is to plan, identify, and evaluate studies to extract and synthesize data from the literature (Tranfield et al., 2003), ensuring that the bibliographic research remains objective, transparent, and replicable (Calderon-Monge & Ribeiro-Soriano, 2024).

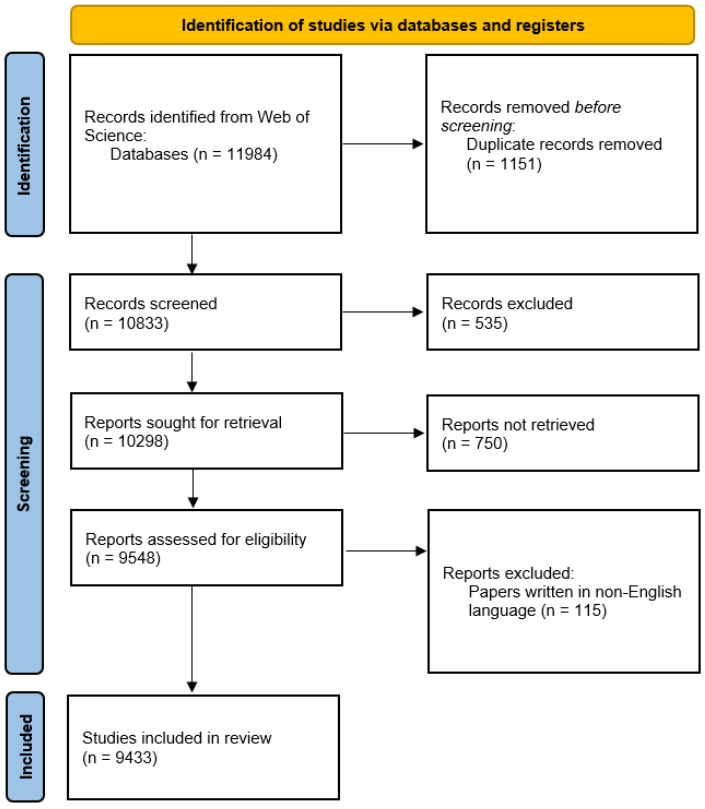

Figure 1. PRISMA flow diagram.

Source: Page et al. (2021)

3.4. Bibliometric Indicators and Analytical Techniques

To ensure analytical coherence, only indicators directly aligned with the study's objectives were selected. Using Bibliometrix (R package), performance indicators such as document growth, authorship patterns, and country productivity were calculated. VOSviewer was used to generate co-occurrence networks and conceptual clusters, as it is optimized for visualizing large-scale relational data.

The combination of these tools enables triangulation: Bibliometrix provides statistical depth and parameter flexibility, while VOSviewer offers intuitive visual mapping essential for interpreting thematic structures. Only analytical outputs relevant to understanding the intellectual structure, research evolution, and thematic interconnections were retained.

IV. Results

The insights from this bibliometric study point out interesting findings as follows. Table 1 and Figure 2 reveal the main information regarding the papers included in the bibliometric study. As shown, all of the surveyed 9,433 papers have been published in the time frame from 1994 to 2025, by 25,375 authors and in 2,964 sources (i.e. journals). The annual growth rate of papers is quite impressive at 25.25%, and the average number of authors per document is 3.58. Only 1,038 out of 9,433 papers are single-authored papers. Most of them are articles (5,890 papers), and 2,331 papers are proceeding papers.

This total author count is reasonable given the dataset's scale and temporal span, as similar bibliometric studies in interdisciplinary fields like sustainability, digital transformation, and business performance routinely report thousands to tens of thousands of distinct authors for comparable or smaller publication volumes, reflecting broad international participation and rising co-authorship norms. Namely, the observed total of 25,375 authors indicates a broad, internationally dispersed research community that has gradually coalesced around these research themes over the study period. When contrasted with the number of documents and years covered, this figure suggests that the field is characterized by extensive co-authorship and continuous entry of new researchers, which is consistent with wider trends of collaboration in this research area. In this sense, the average number of authors per document can be interpreted not merely as a descriptive indicator, but as evidence of the field's maturation toward more collaborative and cross-cutting research efforts.

Table 1. Main information about the data.

Description	**Results**
MAIN INFORMATION ABOUT DATA	
Timespan	1994:2025
Sources (Journals, Books, etc)	2964
Documents	9433
Annual Growth Rate %	25.25
Document Average Age	3.11
Average citations per doc	13.99
References	2938
DOCUMENT CONTENTS	
Keywords Plus (ID)	5830
Author's Keywords (DE)	21046
AUTHORS	
Authors	25375
Authors of single-authored docs	1038
AUTHORS COLLABORATION	
Single-authored docs	1133
Co-Authors per Doc	3.58
International co-authorships %	30.05

DOCUMENT TYPES	
article	5890
book	4
proceedings paper	2331
review	396

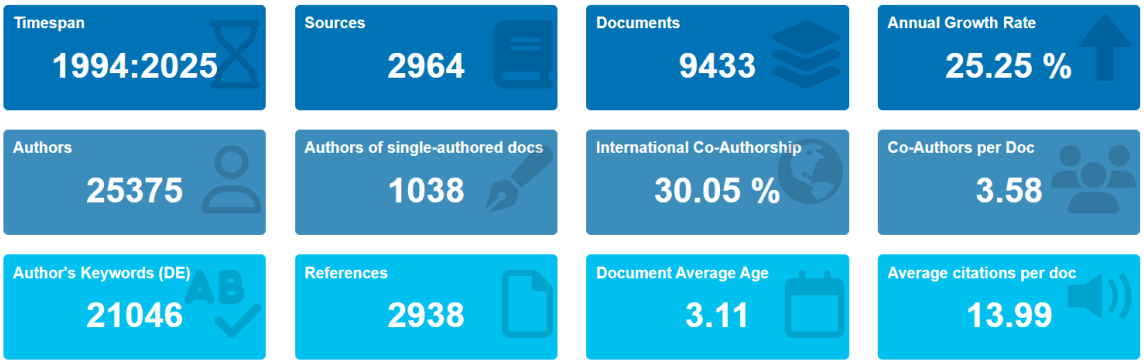

Figure 2. Main information regarding the bibliometric study.

As Figure 3 shows, there is an increasing trend in the publication of articles on the topic after 2016. Beforehand, ever since 1994, there has been a very modest publication productivity in this research area. However, considering that the research area of digitalisation became quite popular ever since 2010, the observed publication pattern suggests that the field is still in its formative stage, providing the foundational basis upon which subsequent research can advance and mature. The drop observed in the final period of Figure 3 reflects the incomplete indexing of publications for the most recent year, as records for the current year are still being processed in Web of Science. This is a common pattern in bibliometric analyses and does not indicate an actual decline in research activity.

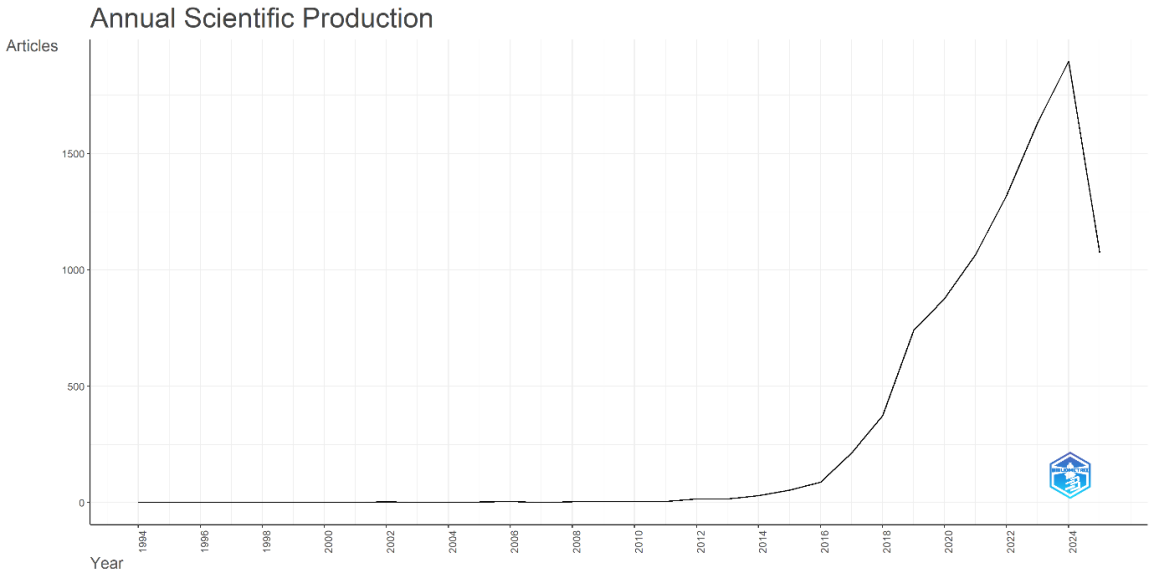

Figure 3. Annual scientific production: evolution of the research on the topic.

Figure 4 reveals the most relevant sources, i.e. the journals (venues) for the thus far published papers. MDPI Sustainability has emerged as the most relevant journal (with 422 published papers in this area), followed by Technological Forecasting and Social Change (with 143 papers) and Journal of Business Research (with 93 published papers). These results indicate that the core outlets are predominantly journals rooted in business, management, operations research, and environmental sustainability, rather than purely generalist or methodological venues. Within this set, multidisciplinary journals that bridge

sustainability with management and operations (for example, outlets similar in scope to Sustainability or Journal of Cleaner Production) appear especially prominent.

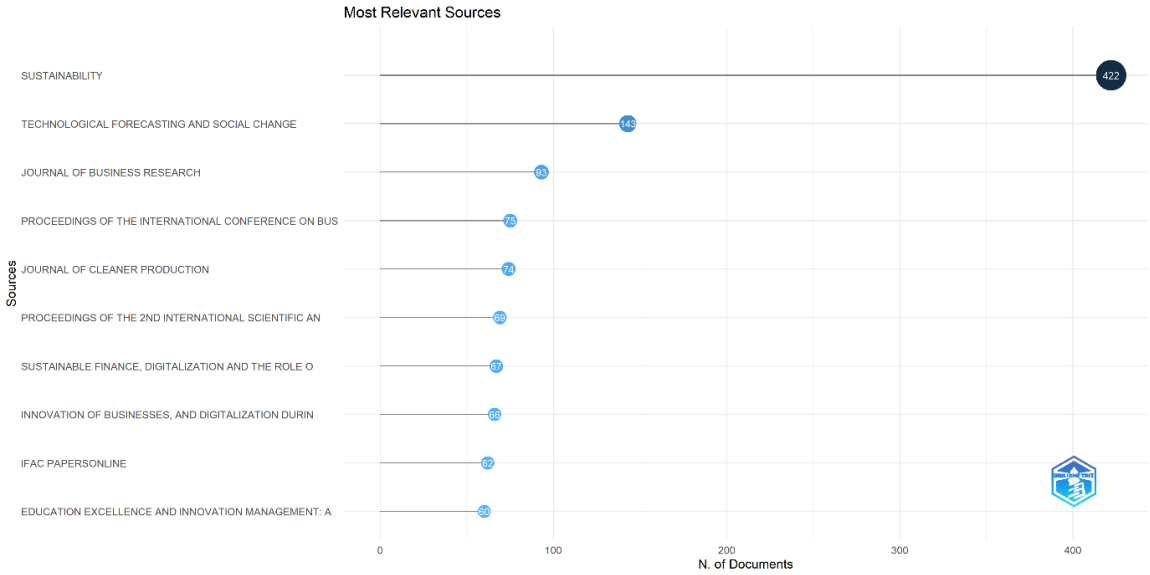

Figure 4. Most relevant sources.

The co-occurrence network is illustrated in Figure 5 and shows how research themes are interconnected. Each dot represents a keyword, and the size of the dot indicates its frequency of occurrence, while the links reflect the strength of the co-occurrence between keywords. There are two dominant clusters, highlighted in red and blue, which demonstrate the field's division into interrelated but distinct thematic domains.

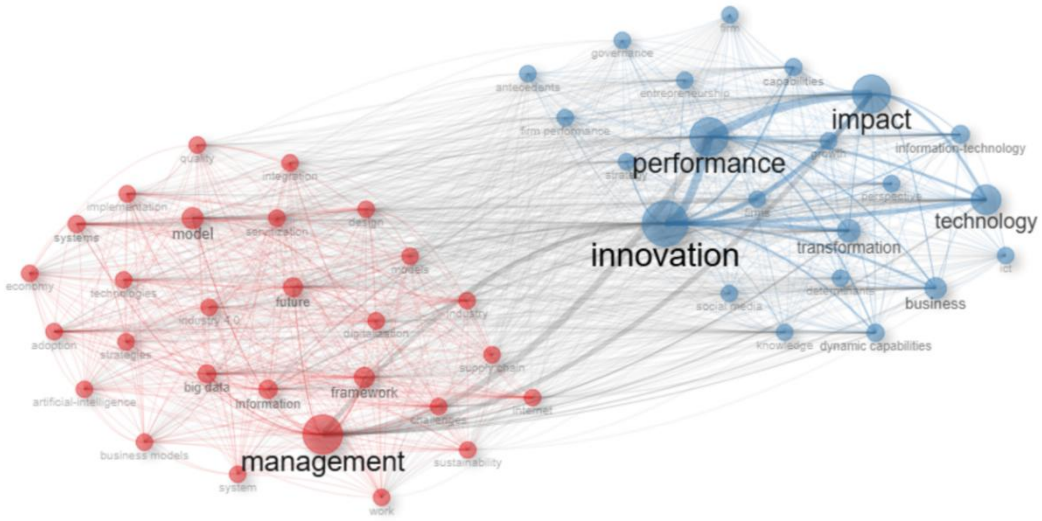

Figure 5. Co-occurence network.

The red cluster, focused on management, encompasses concepts such as model, framework, big data, information, and future. This cluster represents the organizational and strategic dimension of entrepreneurship research. It emphasizes the managerial processes, data-driven strategies, and structural frameworks that enable firms to adapt to technological disruption and maintain operational resilience. The focus on big data and artificial intelligence suggests a growing academic interest in how leadership integrates emerging technologies into decision-making and business model innovation. The blue cluster, on the other hand, anchored around innovation, performance, impact, and technology, represents the technological and performance-oriented dimension of the field. It highlights how innovation serves as a driver of performance and impact, linking

technological advancement with entrepreneurial outcomes. The dense interconnections between technology, transformation, and business indicate a systemic view of innovation as both a process and an outcome that enhances organizational capabilities and competitiveness. The connection between these two clusters is primarily through innovation, and it suggests that innovation acts as a conceptual connector between managerial processes and technological advancement. In other words, effective management practices enable technological innovation, which in turn drives firm performance and broader societal impact. Lastly, the co-occurrence network highlights the importance of two pillars converging around modern entrepreneurship and leadership research, which are a) strategic and managerial adaptation and b) technological innovation and its performance implications. All the interconnected themes underscore how leadership in the contemporary global business landscape requires both managerial agility and technological foresight to navigate through uncertainty and to guarantee long-term sustainable growth.

To identify the conceptual structure and thematic evolution of the research field, a term co-occurrence analysis was conducted using VOSviewer (version 1.6.20). The analysis was based on terms extracted from the abstracts of all documents included in the bibliometric dataset. During preprocessing, structured abstract labels (e.g., "Purpose," "Findings," "Originality") and copyright statements were removed to ensure clean text data. The binary counting method was used, so that each term was counted only once per document, regardless of the number of times it appeared, thereby preventing overrepresentation.

A total of 144,310 terms were initially identified. To reduce noise and focus on the most meaningful content, the minimum number of occurrences was set to 10. This filtering step reduced the dataset to 5,109 unique terms. For each term, VOSviewer computed a relevance score, and the 60% most relevant terms (3,065) were initially retained for potential inclusion in the co-occurrence map. However, after excluding geographical names, generic expressions, and words that did not contribute to the analytical objectives, the final map was built on 2,201 terms, resulting in a clear and interpretable visualization.

The excluded 864 terms consisted mainly of country names and other contextually irrelevant words that do not enhance understanding of the relationships among leadership, entrepreneurship, and digital transformation (ex. Eastern region; Egypt; First phase; Future research direction; Nexus; Novel concept; Special feature; Strong relationship). The resulting network map (Figure 6) displays 2,201 terms organized into seven thematic clusters, where each node represents a term, its size reflects its frequency of occurrence, and the link thickness represents the strength of co-occurrence relationships (Figure 6).

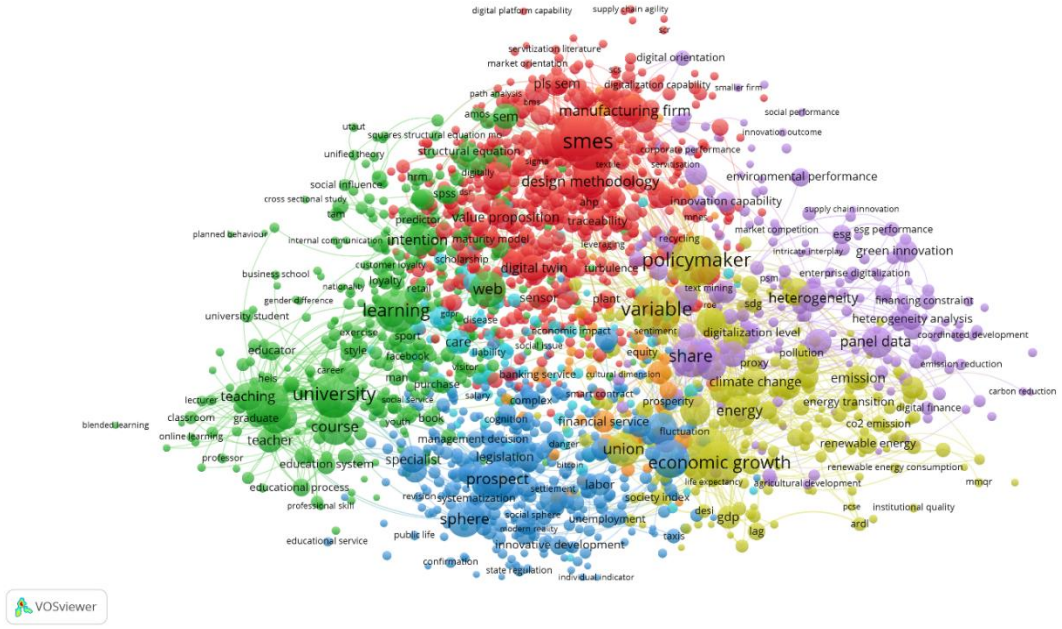

Figure 6. Network visualization map.

Cluster Structure and Interpretation

The visualization revealed seven major clusters, each representing a distinct but interrelated domain within the study of entrepreneurship and leadership in the digital era:

Cluster 1: Entrepreneurial Strategy and Digital Business Models (Red)

This cluster integrates terms such as SMEs, manufacturing firm, design methodology, digital twin, value proposition, PLS-SEM, etc. It reflects research focused on digital business model innovation, strategic agility, and data-driven entrepreneurship.

Cluster 2: Education, Learning, and Digital Competence (Green)

This cluster includes university, learning, course, student, educator, teaching, etc., representing the growing body of work on digital learning ecosystems and their role in cultivating entrepreneurial and leadership skills.

Cluster 3: Economic Growth, Innovation, and Sustainability (Yellow)

Containing economic growth, policymakers, renewable energy, climate change, etc., this cluster captures how digital transformation supports sustainable entrepreneurship and the green economy, linking technological advancement with sustainability goals.

Cluster 4: Sustainability, Environmental Performance and Heterogeneity (Purple)

This cluster groups terms that centre on environmental performance and the heterogeneous effects of digitalization on sustainability outcomes. Dominant terms include green innovation, ESG performance, emission, emission reduction, CO2 emission, renewable energy, energy transition, panel data, heterogeneity analysis, etc. Research in this cluster examines how digital and technological innovations interact with environmental outcomes, the measurement of those outcomes (often using panel-data techniques), and how effects differ across firms, sectors, or regions. Topics include green and sustainable innovation, the link between digitalization and emissions or energy use, policy-relevant measures of ESG performance, and analytical approaches that account for heterogeneity and institutional or financing constraints.

Cluster 5: Economic Systems, Human Capital, and Institutional Transformation (Blue) This cluster is anchored around terms such as sphere, prospect, economic activity, economic system, innovative development, human capital, unemployment, legislation, etc. It represents research concerned with the transformation of economic structures, labor relations, and institutional arrangements in the context of digitalization. The focus is on how digital transformation reshapes employment models, industrial organization, and the functioning of economic systems. Studies within this cluster often examine macro-institutional dynamics, including regulation, social policy, and innovation systems, that influence national and regional economic development. The cluster links discussions of human capital, social institutions, and governance with broader questions of modernization and sustainable growth, revealing how digital economies evolve through both technological progress and institutional adaptation.

Cluster 6: Digital Finance, Financial Innovation, and Market Transformation (Orange) This cluster encompasses terms such as fintech, financial service, financial market, financial inclusion, financial innovation, central bank, equity, digital financial service, crowdfunding, banking industry, etc. It captures the growing body of research examining how digital technologies are reshaping financial systems, services, and market structures. Studies in this cluster investigate the diffusion of fintech solutions, the rise of digital financial ecosystems, and the transformation of traditional banking through technological innovation and regulatory adaptation. Core themes include the role of central banks in supporting digital finance, the emergence of crowdfunding and peer-to-peer financing models, and the link between financial inclusion and technological progress. The cluster illustrates how the convergence of innovation, equity markets, and financial regulation is redefining value creation and access within the global digital economy. In this sense, it represents a bridge between entrepreneurship, technological advancement, and macroeconomic modernization.

Cluster 7: Healthcare Innovation Systems and Digital Transformation (Light Blue) This cluster centers on terms such as healthcare system, patient, hospital, care, medicine, incubator, innovation system, etc. It reflects a rapidly expanding research stream focused on the digital transformation of healthcare and the emergence of innovation-driven health ecosystems. Studies in this cluster examine how technological and organizational innovation reshape healthcare delivery, patient experience, and medical management. Key themes include the integration of digital tools into hospitals and clinical settings, the role of incubators and innovation systems in advancing health technology startups, and the development of collaborative networks linking research institutions, healthcare providers, and industry. The cluster highlights how digitalization fosters efficiency, connectivity, and innovation capacity across the healthcare sector, positioning health systems as critical arenas for technological and social progress in the digital economy.

Together, these seven clusters illustrate that the research landscape on entrepreneurship and leadership in the digital era is structured around two complementary and deeply interconnected dimensions.

The first dimension, the strategic-organizational axis, encompasses Clusters 1, 2, and 5, focusing on leadership, management, education, human capital, and institutional transformation. This stream of research highlights how digitalization redefines organizational strategy, learning processes, and labor systems, emphasizing adaptability, skills development, and governance reform as foundations of competitive advantage.

The second dimension, the technological-innovation axis, includes Clusters 3, 4, 6, and 7, capturing research on sustainability, environmental performance, digital finance, and healthcare innovation. These studies explore how technological progress and data-driven solutions accelerate sustainability transitions, financial modernization, and sectoral innovation, reflecting the pervasive influence of digital transformation across economic and social systems.

The strong interconnectivity among clusters demonstrates that entrepreneurship and leadership in the digital era are inherently multidimensional phenomena, shaped simultaneously by managerial agility, institutional evolution, and technological foresight. This integrative structure underscores a shift toward holistic approaches that link human, organizational, and technological capabilities as key drivers of sustainable and inclusive digital growth.

Across the seven clusters, a diverse set of methodological approaches reflects the field's growing analytical sophistication. Quantitative and hybrid methods

dominate, with frequent use of Data Envelopment Analysis (DEA) and Analytic Hierarchy Process (AHP) for performance measurement and decision-making in digital and entrepreneurial contexts. Structural Equation Modelling (SEM) and Partial Least Squares (PLS-SEM) are widely employed to test conceptual frameworks linking leadership, innovation capability, and digital transformation outcomes. Regression-based techniques and panel-data analyses are central in exploring relationships among economic growth, sustainability indicators, and environmental performance. In parallel, machine learning and text-mining approaches are increasingly applied to predict organizational performance, map innovation trends, and analyze large-scale datasets. This methodological diversity demonstrates a shift toward evidence-based, data-intensive, and computationally enhanced research paradigms that integrate managerial theory with advanced analytics and decision-support models.

Critical Interpretation of Country Patterns and Thematic Clusters

While our bibliometric mapping identifies Romania as one of the most productive and institutionally active contributors to the entrepreneurship–leadership–digitalization literature, this pattern warrants contextual explanation. Romania's prominence can be partially attributed to its participation in EU-funded digital transformation initiatives, national strategies promoting smart specialization, and a strong concentration of academic centers engaged in digital governance, administrative sciences, and innovation systems research. These structural factors create favourable conditions for publication growth, collaboration networks, and the development of digitalization-focused research agendas. The cluster positions of Romanian institutions also reflect their strategic emphasis on technology-enabled public administration and SME digital upgrading, themes that align closely with the core areas of this study.

Beyond country-level patterns, the thematic clusters show uneven but meaningful interconnections. Strong linkages exist between clusters focused on innovation performance, knowledge management, and digital capability, suggesting a conceptual core centered on technology-enabled organisational renewal. Clusters related to sustainability and digital business models exhibit moderate connections, indicating that although sustainability-oriented digital entrepreneurship is emerging, it is not yet fully integrated into the central knowledge structure. Conversely, some expected themes—such as ethics, digital inequality, data justice, and algorithmic accountability—are notably underrepresented despite their growing importance in digital transformation debates. Their absence suggests that the field remains predominantly focused on performance, innovation, and capability building, with less attention given to the societal and distributive implications of digital technologies.

The structural gaps between clusters indicate areas where theoretical integration is still emerging. For instance, connections between digital leadership and ecosystem governance appear weaker than anticipated, implying that leadership research may not yet fully incorporate multi-level perspectives involving platforms, stakeholders, and policy actors. Similarly, the limited visibility of human–technology interaction themes signals a need for more research on how digital tools reshape managerial cognition, employee experience, and organisational ethics.

Altogether, these interpretive patterns suggest that while the field has developed a strong foundation in digital capability, innovation, and leadership performance, it has yet to integrate socio-technical concerns or address equity-oriented dimensions of digital transformation. These gaps have direct implications for constructing a more holistic and responsible research agenda.

Moreover, the thematic clusters identified in the analysis offer valuable insights for developing targeted leadership competencies and informing policy tools that can accelerate digital transformation in organizations. For example, the strategic-organizational clusters emphasize the need for leaders to cultivate agility, digital literacy, and change management skills to drive organizational adaptation and foster innovation ecosystems. This aligns with cluster findings on education, human capital, and institutional transformation, highlighting the importance of continuous learning and governance reforms to support digital adoption. Meanwhile, clusters centered on technological innovation, such as those focused on sustainability, digital finance, and healthcare innovation, point to competencies in data analytics, technology integration, and cross-sector collaboration as critical for navigating complex, technology-driven environments. Policymakers can leverage these insights by designing frameworks that support skills development, incentivize interdisciplinary research, and promote public-private partnerships, thereby enabling leaders to address emerging digital challenges effectively and sustain inclusive growth. Linking these clusters to actionable leadership and policy strategies strengthens the practical relevance of the bibliometric findings and guides future research and practice in digital leadership development.

The most cited (therefore, the most influential) documents are presented in Figure 7. These are Warner & Wäger (2019) with 1,401 citations, followed by Ivanov et al. (2017) (with 1,010 citations) and Luo et al. (2023) with 711 citations.

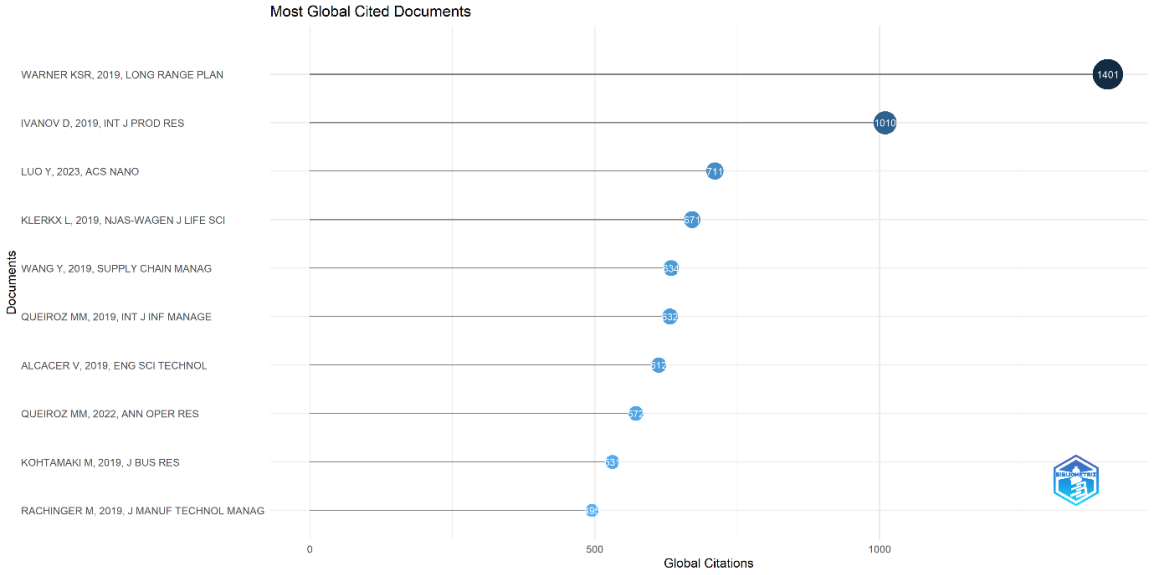

Figure 7. Most globally cited documents.

The most relevant affiliations are revealed in Figure 8. Namely, the Bucharest University of Economic Studies, Romania is leading by far with 338 published papers, and is followed by West University of Timişoara, Romania (with 135 published papers), Copenhagen Business School, Denmark (with 119 published papers), Lulea University of Technology, Sweden (with 117 published papers) and Peter the Great St. Petersburg Polytechnic University, Russia (with 114 published papers).

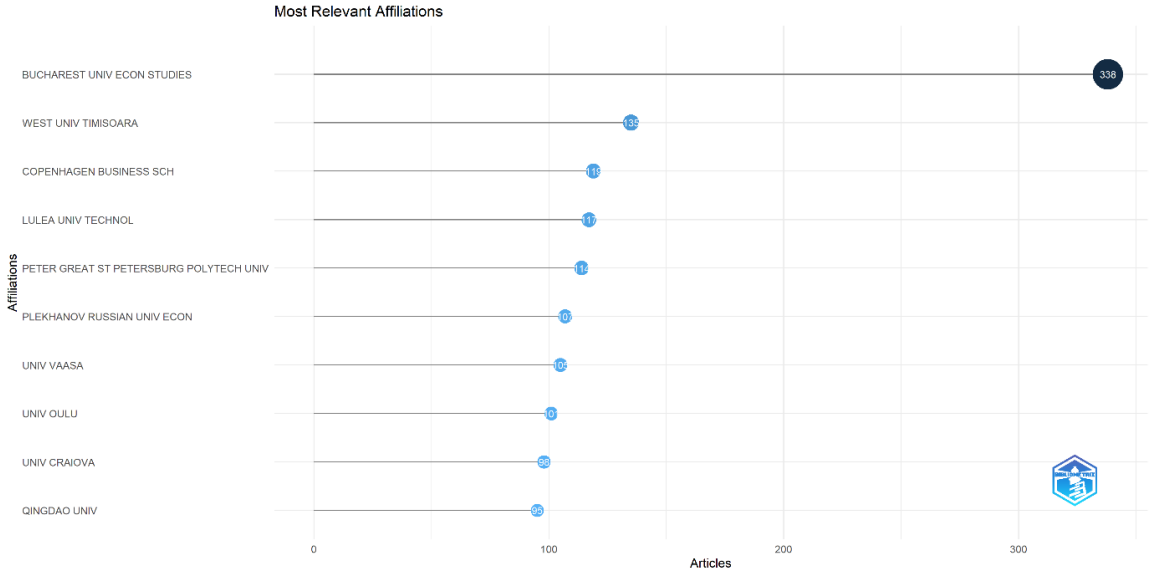

Figure 8. Most relevant affiliations.

As for the most relevant and influential authors, they are presented in Figure 9. These are Wang Y. (with 51 papers published), Liu Y. (with 49 papers published) and Parida V. (with 42 papers published).

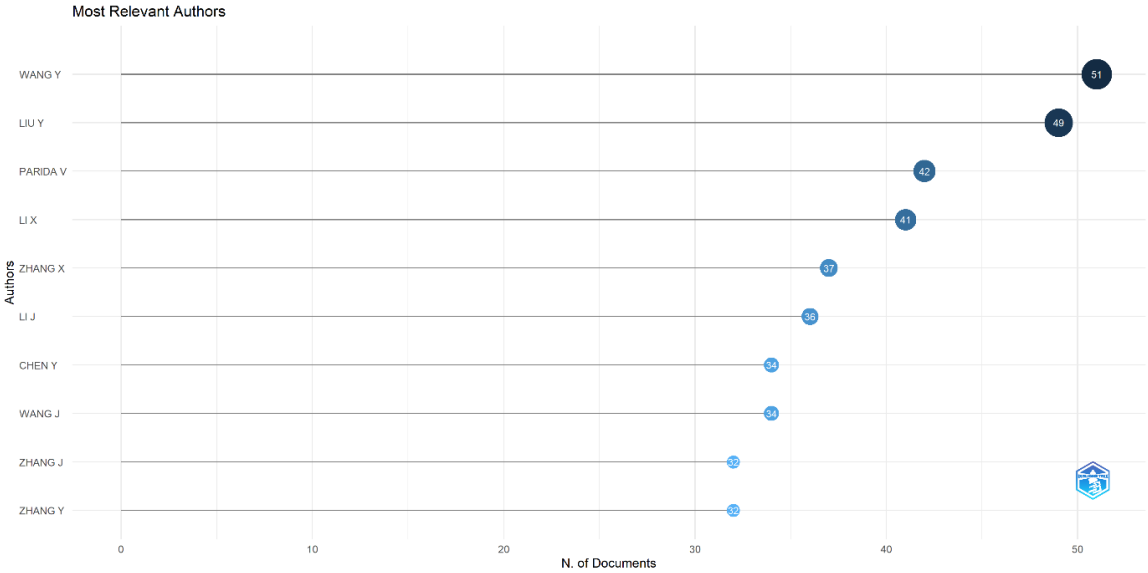

Figure 9. Most relevant authors.

The country-specific production in Figure 10 visually presents the corners of the world with the most productive publications in this research area. This visualisation adds a geographical dimension to the presented results, showing the global distribution of scientific production in entrepreneurship and leadership research. The intensity of color represents the volume and productivity of scientific production, with darker shades indicating higher publication activity.

The map reveals that research in this domain is globally dispersed but regionally concentrated. The highest levels of scientific production are observed in China, the United States, and several European countries, indicating their central role in shaping the theoretical and empirical foundations of entrepreneurship and leadership scholarship. These regions benefit from strong institutional research networks, policy support for innovation, and access to advanced technological infrastructures. Emerging contributions, on the other hand, are evident from countries in South and Southeast Asia, Latin America, and Oceania, highlighting the growing diversification of research perspectives beyond traditional Western contexts. The increasing participation of nations such as India, Brazil, and Australia signals a more inclusive global research landscape that reflects diverse socio-economic and cultural contexts. Conversely, limited scientific output is visible across parts of Africa and the Middle East, pointing to potential disparities in research funding, institutional capacity, and access to international collaborations. Addressing these gaps represents an opportunity for greater cross-regional cooperation and knowledge exchange, which could enrich the global understanding of entrepreneurial and leadership dynamics. Overall, this spatial distribution highlights the perspective that entrepreneurship and leadership research are expanding in scope and inclusivity, reflecting the worldwide significance of innovation-driven and leadership-centred strategies in addressing contemporary global challenges.

Relating Figure 10 (scientific production by country) to Figure 8 (most relevant affiliations) offers a more nuanced picture of how research capacity is structured geographically and institutionally within the entrepreneurship–leadership–digitalization field. Figure 10 shows that countries such as China, the United States, and several European economies are among the leading contributors in terms of publication volume, indicating strong national engagement with digital transformation topics. However, Figure 8 reveals that the most productive affiliations are not evenly distributed across all these countries but are instead concentrated in a limited set of universities and research institutes, with institutions such as the Bucharest University of Economic Studies prominently represented.

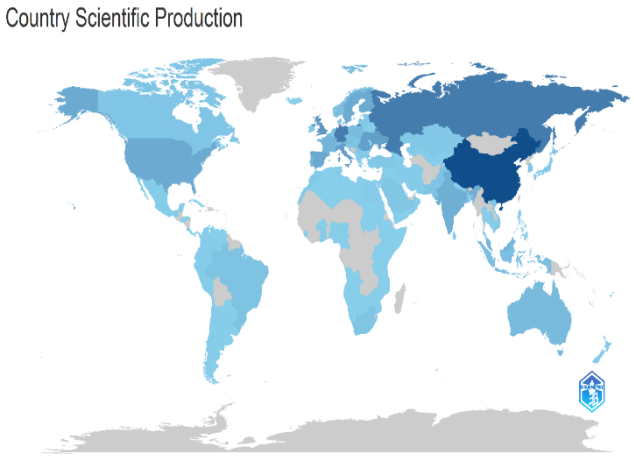

Figure 10. Country Scientific Production.

This is also in line with the findings in Figure 11. As presented in Figure 10, the countries that surfaced with the biggest number of citations are China (with 15,670 citations), the United Kingdom (with 12,135 citations)

and Germany (with 11,234 citations), followed by Sweden, Italy and Finland.

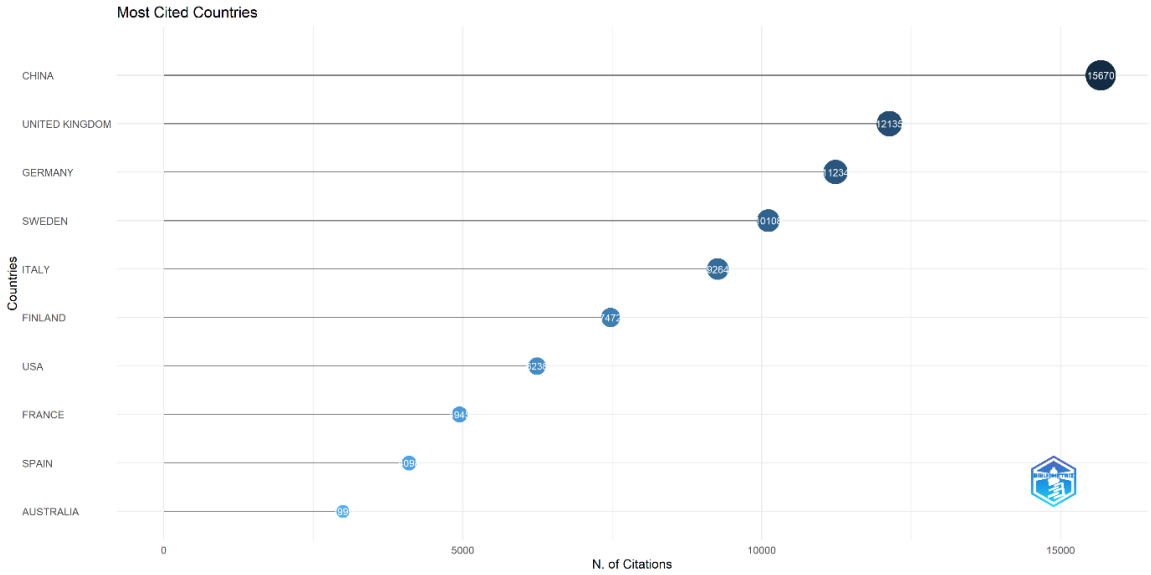

Figure 11. Most cited countries

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Figure 12 (Thematic map) presents a thematic map that categorizes the major themes in the field of entrepreneurship and leadership according to their development (i.e. density) and relevance (i.e. centrality). The four quadrants represent different types of themes, such as Motor Themes (upper right), which are well-developed and central to the field; Niche Themes (upper left), which are highly specialized but less influential; Emerging or Declining Themes (lower left), which are underdeveloped or losing relevance and lastly, the Basic Themes (lower right), which are fundamental concepts that are widely used but not yet highly developed. In the Motor Themes quadrant, the terms innovation, management, and performance emerge as dominant and mature research areas. These concepts form the core of discussions around entrepreneurial leadership, particularly in how innovation and performance management drive sustainable competitive advantage in dynamic business environments. The Basic Themes quadrant contains impact, technology, and model, suggesting that technological advancement and impact-driven strategies remain foundational to current research but still require further theoretical and empirical integration. These elements are crucial for understanding how leadership models adapt to digital transformation and global interconnectedness. Moving to the Niche Themes quadrant, terms such as behavior, trust, and user acceptance indicate more specialized research foci, often linked to the human and behavioral aspects of leadership and entrepreneurship. These studies deepen our understanding of trust-building, technology adoption, and stakeholder engagement in entrepreneurial ecosystems. Finally, the Emerging or Declining Themes quadrant includes economic growth, pointing to either a waning emphasis on traditional macroeconomic perspectives or an emerging reinterpretation of economic growth in light of sustainability and social entrepreneurship paradigms. Overall, this thematic map reveals the multi-dimensional nature of modern entrepreneurship and leadership research, and the development and evolution of modern entrepreneurship from macro-level economic models toward innovation-driven, technology-oriented, and behaviorally informed frameworks, thus reflecting the ongoing transformation of business practices worldwide.

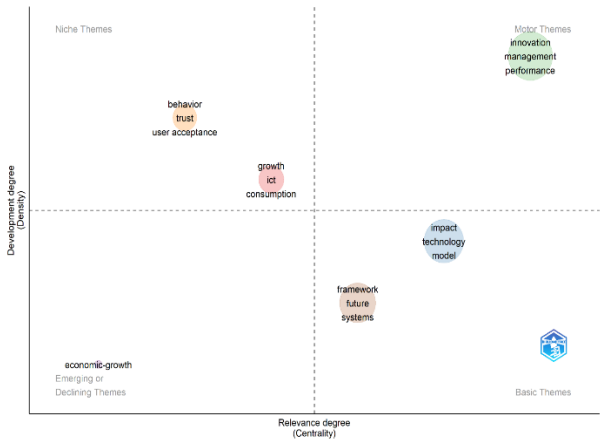

Figure 12. Thematic map.

Figure 13 (Tree Map of Research Themes) quantifies the prominence of key terms, with innovation (7%), management (6%), impact (6%), performance (6%), and technology (5%) emerging as the most frequently discussed concepts. These high-frequency topics confirm their centrality to the field and align with the previous figures' qualitative insights. Topics like framework, transformation, model, future, systems, and big data are secondary, but still rather significant and reflect the methodological and structural aspects of entrepreneurship and leadership studies. Terms such as digitalization,

capabilities, and governance have lower frequency and could be considered as emerging subtopics for further scholarly attention and focus.

Figure 13. Tree map of Research Themes.

Figure 14. Word cloud.

Figure 14 represents the word cloud of key terms and is a visual representation of the most frequently occurring keywords within the research papers. The size of each word corresponds to its relative frequency and importance in the analyzed body of literature. Prominent terms, such as innovation, management, performance, impact, and technology, dominate the visualization, reaffirming their centrality in entrepreneurship and leadership scholarship. This figure reinforces the quantitative findings from the tree map and thematic analyses. The prominence of innovation and management underscores their dual role as the conceptual backbone of entrepreneurial studies, linking organizational strategy with creative transformation. Performance and impact emphasize outcome-oriented perspectives, reflecting the field's concern with measurable success and societal contribution. Meanwhile, technology, transformation, and information systems highlight the pervasive influence of digitalization and technological capability on modern leadership practices.

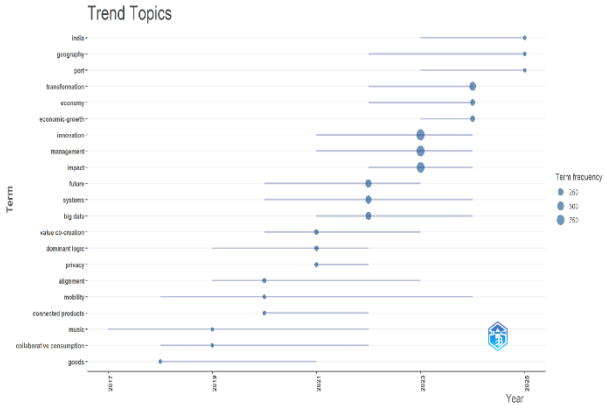

Figure 15. Trend topics.

Figure 15 presents the evolution of trend topics and key research within the field of entrepreneurship and leadership from 2017 to 2025. The horizontal timeline represents the years in which specific terms gained prominence, while the size of each bubble indicates the frequency of the term's occurrence in the analyzed corpus. Larger bubbles show higher term frequency, signalling greater research or discussion emphasis in that period. Notably, earlier years (2017–2019) show a focus on foundational themes such as goods, collaborative consumption, and connected products, reflecting the early influence of digital transformation and sharing economy models. As the timeline progresses, between 2020 and 2023, topics such as innovation, management, impact, future, systems, and big data become increasingly central. This shift corresponds to the heightened importance of technological integration, data-driven decision-making, and adaptive management practices in a rapidly evolving global business environment. In the most recent years (2023–2025), emerging topics such as transformation, economic growth, geography, and India indicate a growing interest in global expansion among scholars, regional economic dynamics, and the strategic transformation of business ecosystems. These trends align with the broader narrative of globalization and the diversification of entrepreneurial opportunities beyond traditional Western contexts. Overall, the trend analysis suggests that modern entrepreneurship and leadership research is transitioning from operational and product-centric discussions toward themes emphasizing innovation, sustainability, and global impact. This reflects the increasing complexity of leadership challenges in navigating interconnected economic, technological, and cultural landscapes.

Discussion

The findings of this study show that entrepreneurship, leadership, and digitalization have evolved into a multi-layered and interdependent research domain. However, rather than reiterating the performance indicators or cluster maps, the discussion interprets these patterns in light of broader theoretical debates, highlighting how digital transformation is reshaping foundational concepts in management research.

5.1. Digital transformation and the reframing of leadership theory

The shift toward digital transformation significantly challenges traditional leadership theories built around hierarchical control, individual decision authority, and stable task environments. Across the clusters identified, leadership increasingly appears as distributed, technology-augmented, and knowledge-centric. This aligns with emerging arguments that digital contexts require leaders to orchestrate ecosystems of data, platforms, and collaborative intelligence rather than exercise unilateral influence.

Our results point to an intellectual movement away from classical transformational or transactional models toward concepts such as e-leadership, digital leadership, and adaptive leadership, all of which emphasize the leader's capacity to integrate technological affordances into organizational processes. This reconfiguration suggests that digital leadership is not a separate subtype of leadership but a contextual extension of contemporary leadership theory, where influence is shaped through digital infrastructures, algorithmic decision support, and remote coordination.

5.2. Entrepreneurial orientation under technological and market pressures

The thematic clusters also highlight how entrepreneurial behavior is being reinterpreted under conditions of heightened technological unpredictability. Traditional entrepreneurial orientation dimensions—innovativeness, proactiveness, and risk-taking—manifest differently when organizations operate in digitalized markets.

For example, innovativeness is increasingly tied to data-driven experimentation, iterative learning, and platform-based innovation. Proactiveness shifts toward anticipation of technological discontinuities, and risk-taking becomes embedded in digital investment decisions characterized by shorter cycles and higher volatility. These findings align with contemporary views that entrepreneurial orientation in digital environments is less about singular opportunity recognition and more about continuous opportunity enactment, enabled by analytics, digital infrastructures, and decentralized organizational learning.

5.3. Integrating leadership and entrepreneurship through the lens of digital capability

A key conceptual insight emerging from the intellectual structure of the field is the growing convergence around digital capability—the organization's ability to mobilize technologies, data, and human competencies to enable innovation and transformation. This construct bridges the leadership and entrepreneurship literatures by positioning leaders not merely as coordinators but as architects of digital capability, shaping cultural, strategic, and structural conditions for entrepreneurial action.

This perspective helps explain the co-occurrence of leadership and entrepreneurship concepts within clusters centered on innovation performance, sustainability, and digital strategy. It also suggests that digital capability may function as a mediating or shaping mechanism linking leadership behavior to entrepreneurial outcomes—a relationship that warrants deeper theoretical elaboration in future studies.

5.4. Conceptual tensions and emerging directions

The clusters reveal several conceptual tensions that offer avenues for theory-building:

Human vs. technological agency: As organizations integrate AI and automation, leadership increasingly shifts from direct supervision to the governance of socio-technical systems.

Centralization vs. decentralization: Digital platforms facilitate both greater employee autonomy and greater algorithmic control, creating a paradoxical leadership environment.

Innovation vs. sustainability: Research increasingly grapples with reconciling rapid digital innovation cycles with environmental and social sustainability goals.

Organizational learning vs. digital overload: While digital tools enhance knowledge flows, they also risk overwhelming employees and complicating leadership's sensemaking functions.

These tensions indicate that the field is moving toward more complex theorization that accounts for multi-level, multi-actor dynamics inherent in digital environments.

5.5. Toward an integrated research agenda

The synthesis of the intellectual structure suggests that future research should pursue integrative frameworks that connect leadership behavior, entrepreneurial orientation, and digital capability within broader socio-technical systems. Such an agenda would move beyond isolated constructs and instead focus on how leaders enable continuous innovation through digital infrastructures, how organizations develop ambidextrous capabilities in volatile digital markets, and how entrepreneurial strategies incorporate ethical, governance, and sustainability dimensions.

By reframing digital leadership and digital entrepreneurship through these theoretical lenses, the field can progress from descriptive mapping toward explanatory and predictive models that more adequately reflect the complexities of digital transformation.

5.6. Connecting Digital Leadership, Ecosystem Enablers, and Capability Building

A clearer interpretation of the bibliometric clusters emerges when integrating contemporary field-specific literature on how organisations build digital capability and reshape leadership practices. Recent work on innovation labs and open innovation infrastructures (Schiuma & Santarsiero, 2024) highlights the importance of organisational spaces that facilitate experimentation, learning-by-doing, and cross-functional collaboration. These environments serve as "capability incubators," enabling firms to prototype digital solutions, develop new value propositions, and absorb emerging technologies. When viewed through this lens, the cluster patterns related to innovation, knowledge management, and digital transformation can be interpreted not merely as research

themes but as evidence of a broader organisational shift toward structured experimentation and capability evolution.

Similarly, recent advancements in transformative and digital leadership theory (Schiuma et al., 2024) provide a conceptual basis for understanding leadership behaviours that enable digital transformation. The emphasis on competencies such as sensemaking, data-informed decision-making, fostering digital learning cultures, and enabling distributed collaboration helps explain why our clusters converge around concepts such as innovation capability, organisational performance, and strategic adaptability. These leadership frameworks shift focus from hierarchical control to the orchestration of socio-technical systems, aligning closely with the cluster findings showing the rise of digital leadership, adaptive leadership, and ecosystem leadership.

Integrating these perspectives enriches our interpretation of the intellectual structure of the field. The bibliometric patterns suggest that digital transformation operates through a combination of leadership-driven cultural shifts, organisational capability-building mechanisms, and the development of innovation infrastructures that support ongoing renewal. Managers are depicted not only as coordinators of technological integration but as architects of organisational environments that enable continuous experimentation and learning. Likewise, institutions play a growing role in shaping digital ecosystems by providing governance, platforms, and knowledge infrastructures that accelerate capability development.

Taken together, these contemporary perspectives highlight that the field is moving toward a synthesis where leadership, entrepreneurship, and digital capability are mutually reinforcing elements. The convergence of these constructs across multiple clusters reflects an evolving understanding that successful digital transformation requires capability building at multiple levels—individual, organisational, and ecosystem—supported by leadership competencies that facilitate learning, experimentation, and innovation alignment.

Conclusions

This study examined the evolving intersection of entrepreneurship, leadership, and digitalization using a systematic literature review and bibliometric analysis of 9,433 publications retrieved from the Web of Science. Rather than merely documenting publication trends, our analysis reveals how digital transformation is reshaping foundational assumptions across these fields and generating new conceptual linkages that warrant deeper theoretical development. Three overarching insights emerge. First, digital transformation is recasting traditional leadership theories by shifting the locus of influence from hierarchical structures to digitally mediated networks, collaborative intelligence, and technology-enabled coordination. Leadership in digital contexts increasingly requires the orchestration of data, platforms, and distributed expertise, signalling a move toward more adaptive, integrative, and ecosystem-oriented models. Second, entrepreneurial orientation is

undergoing significant transformation. Innovativeness, proactiveness, and risk-taking now unfold within environments characterized by technological turbulence, data-driven experimentation, and rapid iterative learning. Entrepreneurship becomes less about discrete opportunity recognition and more about continuous opportunity enactment, supported by digital infrastructures that accelerate experimentation and reduce information asymmetries. Third, the intellectual structure identified in this study highlights digital capability as a bridging construct between leadership and entrepreneurship. Digital capability encompasses not only technological resources but also the human competencies, organizational routines, and cultural conditions that enable continuous innovation. The convergence around this construct indicates a growing recognition that digital

transformation operates across multiple levels—individual, organizational, and ecosystem—and requires integrated theoretical perspectives.

Practical implications

Our findings offer several important implications for practitioners:

For leaders: Digital transformation requires shifting from controlling processes to enabling them. Leaders must cultivate digital literacy, foster experimentation, and create organizational conditions that sustain learning and resilience.

For entrepreneurs: Leveraging digital technologies is no longer optional; it is central to opportunity development. Data analytics, platform integration, and agile experimentation shape entrepreneurial competitiveness in digitally intensive markets.

For policymakers: Supporting digital entrepreneurship ecosystems demands investments in digital infrastructure, regulatory flexibility, and cross-sector partnerships. Policy instruments should emphasize capability building, not only technology adoption.

Limitations and future research

As with all bibliometric studies, the dataset reflects the structure and indexing practices of the Web of Science. Future research could extend this work by triangulating with Scopus, incorporating full-text analytics, or conducting qualitative synthesis of specific clusters. More importantly, conceptual research is needed to integrate digital leadership, digital entrepreneurship, and digital capability into coherent multi-level frameworks that address tensions between human and technological agency, innovation and sustainability, and autonomy and algorithmic governance.

The rapid pace of digital transformation continues to reshape entrepreneurial behavior, leadership practices, and organizational strategy. By mapping the intellectual structure of this evolving field and connecting empirical patterns to broader theoretical debates, this study offers an integrated perspective that moves beyond descriptive trends. The findings underscore the need for a new generation of theories capable of explaining how organizations create, lead, and sustain value in increasingly digital and interconnected environments..

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