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Review Article

Mapping Digital Transformation in Small and Medium-Sized Enterprises Through OpenAlex: A Bibliometric and Lexical Clustering Analysis

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Abstract

Digital transformation in small and medium-sized enterprises (SMEs) has expanded from a technology-adoption issue into a broader question of organizational capability, knowledge integration, market adaptation, and resilience. This study maps the development and conceptual structure of the OpenAlex-indexed literature on SME digital transformation from 2017 to 2025. The current cleaned corpus contains 755 articles and reviews. Descriptive bibliometrics were combined with keyword co-occurrence analysis, document-level term frequency-inverse document frequency and k-means lexical clustering, and co-authorship network analysis. The corpus shows a sharp increase in publication activity in 2024-2025, substantial dispersion across journals and authors, and a strong geographic concentration of Indonesian affiliations among records with usable country metadata. Keyword communities position knowledge management close to digital transformation and SME capability development, while five lexical research fronts emphasize micro, small, and medium enterprise financial literacy; digital adoption and knowledge management; performance, innovation, and sustainability; digital marketing and social media; and COVID-19 resilience. Co-authorship analysis further indicates a highly fragmented collaboration structure, with 2,260 authors distributed across 689 connected components and only 89 of 755 studies recording international co-authorship. The study contributes by distinguishing among concept-level keyword communities, document-level lexical research fronts, and collaboration structures within an openly reproducible OpenAlex corpus. The findings suggest that SME digital transformation is best interpreted as a knowledge-intensive capability reconfiguration process rather than as simple technology acquisition. Because OpenAlex coverage is broader and geographically different from that of curated databases, the results are database-sensitive and require cross-database and citation-based validation.

Categories: SME Entrepreneurship, Computational Intelligence and Information Management, Digital business

Keywords: digital transformation, smes, bibliometric analysis, knowledge management, lexical thematic clustering, bibliometric mapping

Introduction And Background

Digital transformation has become a central concern in business and management because digital technologies increasingly alter how firms create value, coordinate activities, develop capabilities, interact with customers, and respond to environmental change. For small and medium-sized enterprises (SMEs), these pressures are particularly consequential. Compared with large firms, SMEs frequently operate with limited financial slack, fewer specialist employees, less formalized information infrastructure, and greater dependence on owner-managers and external networks. Digital

transformation in this context therefore involves more than acquiring software or adopting isolated digital tools; it requires the reconfiguration of organizational routines, knowledge processes, decision systems, market interfaces, and business models (Anatan and Nur, 2023) (Jeza and Mpele Lekhanya, 2022) (Rupeika-Apoga et al., 2022).

The literature reflects this multidimensional character. Research addresses digital readiness and maturity, leadership and culture, technology adoption, knowledge management, dynamic capabilities, business performance, innovation, marketing, financial inclusion, sustainability, and organizational resilience (Achieng and Malatji, 2022) (Costa Melo et al., 2023) (Hokmabadi et al., 2024) (Sagala and Őri, 2024). Recent empirical work also emphasizes that successful SME digital transformation depends on combinations of technological, organizational, and environmental conditions rather than on technology alone. This has encouraged the use of theoretical perspectives such as the Technology-Organization-Environment framework and dynamic capabilities to explain why firms exposed to similar technologies experience different transformation outcomes.

At the same time, the rapid growth and disciplinary dispersion of the literature make the field difficult to interpret using narrative synthesis alone. Previous systematic and scientometric reviews have examined success factors, sustainability, resilience, and the general evolution of SME digital transformation (Parra-Sánchez and Talero-Sarmiento, 2024) (Sagala and Őri, 2024). The present study therefore does not claim novelty from being the first review of the topic. Instead, its contribution lies in integrating several complementary views of the research domain within an openly reproducible OpenAlex corpus: descriptive bibliometrics show how the publication base has developed; keyword co-occurrence reveals concept-level communities; lexical clustering identifies document-level research fronts; and co-authorship mapping shows the structure of scholarly collaboration. These analytical layers are conceptually distinct and are used together to avoid treating publication counts alone as evidence of the field's intellectual organization.

A second contribution is methodological transparency regarding database effects. OpenAlex offers open access to structured scholarly metadata and broad source coverage, making it attractive for reproducible bibliometric research. However, database coverage is itself a methodological condition. Comparative research shows that OpenAlex indexes substantially more open-access journals than Scopus or Web of Science and that the geographic composition of indexed sources differs across databases. Consequently, a bibliometric pattern observed in OpenAlex should be interpreted as a pattern of the OpenAlex-indexed corpus rather than automatically generalized to the global literature. This consideration is especially important in the present study because Indonesian affiliations account for 60.2% of records with usable country information.

The study therefore asks the following questions: (1) How has OpenAlex-indexed research on SME digital transformation developed from 2017 to 2025? (2) Which sources, authors, countries, and documents are most visible in the corpus? (3) What communities appear in the keyword co-occurrence network? (4) What document-level research fronts emerge from lexical thematic clustering? (5) What does the co-authorship structure indicate about collaboration and consolidation in the field? Together, these questions move the analysis from simple productivity description toward an integrated interpretation of the field's conceptual, thematic, and collaborative organization.

Review

Literature review and theoretical foundations

Conceptualizing Digital Transformation in SMEs

Digital transformation should be distinguished from the narrower concepts of digitization and digitalization. Digitization commonly refers to converting analog information into digital form, whereas digitalization refers to the use of digital technologies to improve or redesign processes. Digital transformation is broader because it involves organization-level changes in strategy, capabilities, routines, structures, customer relationships, and value creation. In SMEs, the distinction is important because the adoption of an e-commerce platform, cloud service, accounting application, or social-media channel does not necessarily constitute transformation unless the technology is integrated into organizational processes and decision making.

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Empirical studies demonstrate that SME transformation is shaped by internal and external constraints. Resource limitations, insufficient employee skills, weak digital readiness, risk aversion, legacy processes, and limited managerial expertise may slow adoption, while leadership commitment, learning capacity, ecosystem support, platform use, and market pressure can accelerate it (Anatan and Nur, 2023) (Kallmuenzer et al., 2025) (Leso et al., 2023). The literature consequently treats SME digital transformation as a socio-technical process in which technologies interact with knowledge, managerial choices, organizational routines, and institutional environments.

Dynamic Capabilities and the Reconfiguration of SME Resources

Dynamic capabilities provide one theoretical lens for interpreting this process. Teece describes dynamic capabilities through the capacities to sense opportunities and threats, seize opportunities, and reconfigure organizational resources (Teece, 2007). This perspective is particularly relevant to SMEs because digital transformation frequently requires firms to recognize technological and market changes, select feasible digital responses despite resource constraints, and reorganize routines and capabilities around new tools. Recent SME research has applied this perspective directly, showing that digital transformation depends on learning, strategic foresight, resource mobilization, and organizational reconfiguration rather than on technology ownership alone (Saeedikiya et al., 2024).

Within the present research domain, terms such as competitive advantage, business models, entrepreneurship, dynamic capabilities, innovation, and organizational performance therefore should not be interpreted as isolated topics. They describe different stages or manifestations of a capability-reconfiguration process. Technologies create possibilities, but organizational capabilities determine whether these possibilities are translated into new routines, offerings, and performance outcomes.

Knowledge-Based View, Knowledge Management, and Absorptive Capacity

The knowledge-based view conceptualizes the firm as an institution for integrating specialized knowledge (Grant, 1996). This perspective offers a direct explanation for the prominence of knowledge management in SME digital transformation research. Digital tools generate access to information, but SMEs must acquire, interpret, share, combine, and apply that information if transformation is to affect decisions and operations. Knowledge management therefore operates as a mechanism connecting digital resources to organizational capability.

Absorptive capacity complements this interpretation by emphasizing the ability to acquire and assimilate external knowledge and then transform and exploit it for organizational purposes. For SMEs, whose digital expertise may be distributed across employees, consultants, platforms, suppliers, customers, and public-support programs, absorptive processes are particularly important. Knowledge management can therefore be viewed as a micro-level bridge between technology adoption and dynamic capability development: it supports sensing through environmental and market learning, seizing through knowledge-informed decisions, and transformation through the codification and diffusion of new routines.

This theoretical interpretation is also consistent with recent review evidence specifically linking knowledge management to SME digital transformation. The growing intersection of the two literatures suggests that transformation outcomes depend not only on the technological resources available to SMEs but also on the processes through which knowledge is generated, transferred, retained, and converted into action.

Technology-Organization-Environment Perspective

The Technology-Organization-Environment framework provides a complementary contextual perspective. It proposes that organizational adoption and implementation of technological innovation depend on technological conditions, organizational characteristics, and the external environment (Tornatzky and Fleischer, 1990). This framework is useful for SMEs because digital transformation decisions are constrained simultaneously by technology affordability and compatibility, internal readiness and managerial capabilities, and external pressures such as customers, competitors, regulation, infrastructure, and public support.

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Recent empirical research on SMEs demonstrates that these dimensions often operate configurationally. Different combinations of technological readiness, organizational resources, and environmental pressure can produce successful transformation, meaning there is unlikely to be one universal path for all SMEs. Technology-Organization-Environment therefore helps explain variation in adoption conditions, while dynamic capabilities and the knowledge-based view explain how firms translate those conditions and resources into organizational change.

Empirical Research Streams

The empirical literature can be organized into several interacting streams. The first concerns organizational capability, leadership, culture, and knowledge. Studies show that transformation is facilitated by managerial commitment, flexible structures, learning, and the capacity to explore and exploit knowledge (Hafeez et al., 2025) (Leso et al., 2023). A second stream focuses on performance and competitiveness, examining whether digitalization improves productivity, customer responsiveness, e-commerce performance, innovation, and market outcomes (Ballerini et al., 2023) (Harini et al., 2023) (Kallmuenzer et al., 2025) (Teng et al., 2022).

A third stream concerns customer-facing digital capabilities. Digital marketing, social media, e-commerce, and platform adoption allow SMEs to expand market access and interact with customers at lower cost, but outcomes depend on complementary organizational capabilities and market conditions (Amin et al., 2025) (Sharabati et al., 2024). A fourth stream connects digital transformation with sustainability and innovation. Research increasingly examines whether digitalization contributes to economic, environmental, and social performance and how it interacts with circular-economy practices (Arroyabe et al., 2024) (Costa Melo et al., 2023) (Yesuf and Fields, 2026).

A fifth stream emphasizes resilience. During the COVID-19 pandemic, technology adoption became a mechanism for operational continuity, remote interaction, new channels, and business-model adjustment (Mishrif and Khan, 2023) (Priyono et al., 2020). Later work has extended this discussion toward organizational resilience and marketing capability (Hokmabadi et al., 2024) (Malik and Terzidis, 2026). A sixth stream, especially visible in emerging-economy MSME (micro, small, and medium enterprises) research, concerns financial literacy, accounting, digital payments, and financial inclusion, illustrating that digital transformation may involve not only production and marketing technologies but also improved access to financial infrastructure and managerial information.

Research Gap and Analytical Contribution

Although these streams are individually well developed, they are often examined separately. Theoretical work emphasizes capabilities and organizational change, empirical work frequently tests specific adoption or performance relationships, and bibliometric studies summarize publication trends or thematic structures. What remains useful is an integrated mapping that distinguishes different analytical levels. Keyword co-occurrence identifies how concepts are associated across the corpus; lexical clustering identifies document-level thematic similarity; and co-authorship mapping identifies the social structure through which knowledge is produced. These structures should not be conflated.

The present study uses these complementary lenses to examine whether the field's descriptive growth corresponds with conceptual integration and collaborative consolidation. Particular attention is given to knowledge management because its central network position provides a theoretically meaningful link between digital inputs, organizational capability formation, and outcomes such as innovation, competitiveness, sustainability, and resilience.

Methods

Research Design

A bibliometric design was used to map publication patterns and the conceptual organization of research on SME digital transformation. Bibliometric analysis is suited to rapidly growing multidisciplinary fields because it enables systematic description of productivity, citation influence, and conceptual associations (Donthu et al., 2021) (Lim et al., 2024). The design is descriptive and interpretive: it maps patterns in the literature but does not test the causal effects of digital transformation on firm performance, competitiveness, resilience, or sustainability.

Data Source and Rationale for Using OpenAlex

Bibliographic records were retrieved from OpenAlex, an open scholarly index of works, authors, sources, institutions, concepts, and citation relationships (Priem et al., 2022). OpenAlex was selected for three reasons. First, it provides openly accessible structured metadata, which enables researchers to reproduce the retrieval and analysis workflow without a proprietary database subscription. Second, its broad source coverage is useful for a topic such as SME digital transformation, which spans business, management, economics, information systems, engineering, and regional or applied journals. Third, the openness of its identifiers and metadata facilitates programmatic cleaning and network construction.

The use of OpenAlex also requires explicit caution. Comparative database research indicates that OpenAlex, Scopus, and Web of Science differ substantially in journal coverage and geographic representation. OpenAlex includes a much larger number of open-access journals, while curated commercial indexes are more selective. Accordingly, this study treats publication, country, source, author, and thematic results as characteristics of the OpenAlex-indexed corpus rather than as direct estimates of the total global literature. This limitation is especially relevant to the country analysis and is revisited in the discussion.

Search Strategy

The literature search covered publications dated January 1, 2017 through December 31, 2025. The initial broad OpenAlex search used the following Boolean string:

("digital transformation" OR digitalization OR digitisation OR digitization OR "digital readiness" OR "digital capability" OR "digital maturity") AND ("small and medium enterprise" OR "small and medium enterprises" OR SME OR SMEs OR "micro, small and medium enterprise" OR "micro, small and medium enterprises" OR MSME OR MSMEs OR "small business" OR "small businesses")

This broad identification search yielded 2,188 records. A focused refinement was subsequently applied using the exact phrase "digital transformation" together with SME/MSME terms:

"digital transformation" AND ("small and medium enterprise" OR "small and medium enterprises" OR SME OR SMEs OR "micro, small and medium enterprise" OR "micro, small and medium enterprises" OR MSME OR MSMEs)

English-language articles and reviews published between 2017 and 2025 were retained and subsequently screened for substantive business and management relevance. The focused refinement removed 1,271 records, leaving 917 records for title-and-abstract screening. Because the refinement stage required the phrase "digital transformation," studies addressing related constructs such as digital readiness, digital capability, digital maturity, or digitalization without explicitly using that phrase may have been excluded. This potential construct-selection limitation is acknowledged in the "Limitations and Evidence-Based Future Research Agenda" section.

Inclusion and Exclusion Criteria

Studies were eligible when they addressed digital transformation or a closely related construct - such as digitalization, digitization, digital readiness, digital capability, or digital maturity - in SMEs or MSMEs and had a substantive business or management focus. Relevant outcomes or contexts included business performance, competitiveness, innovation, resilience, strategy, leadership, organizational capability, financial inclusion, and sustainability. Studies primarily concerned with technical system design, software development, engineering optimization, or non-business institutional transformation were excluded. Records mentioning a digital tool without a clear SME transformation focus were also excluded.

Screening Process

Figure *1* reproduces every numerical transition. The broad OpenAlex query identified 2,188 records. Focused query refinement excluded 1,271, leaving 917 records for title-and-abstract screening. Title screening excluded 114 records and abstract screening excluded 16, leaving 787 reports for eligibility and metadata checks. A further 16 records were

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removed during those checks, leaving 771 records. Final quality review excluded another 16 records: 11 Zenodo repository records, one duplicate, three records lacking essential author or journal information, and one non-English record. The final bibliometric dataset contained 755 studies.

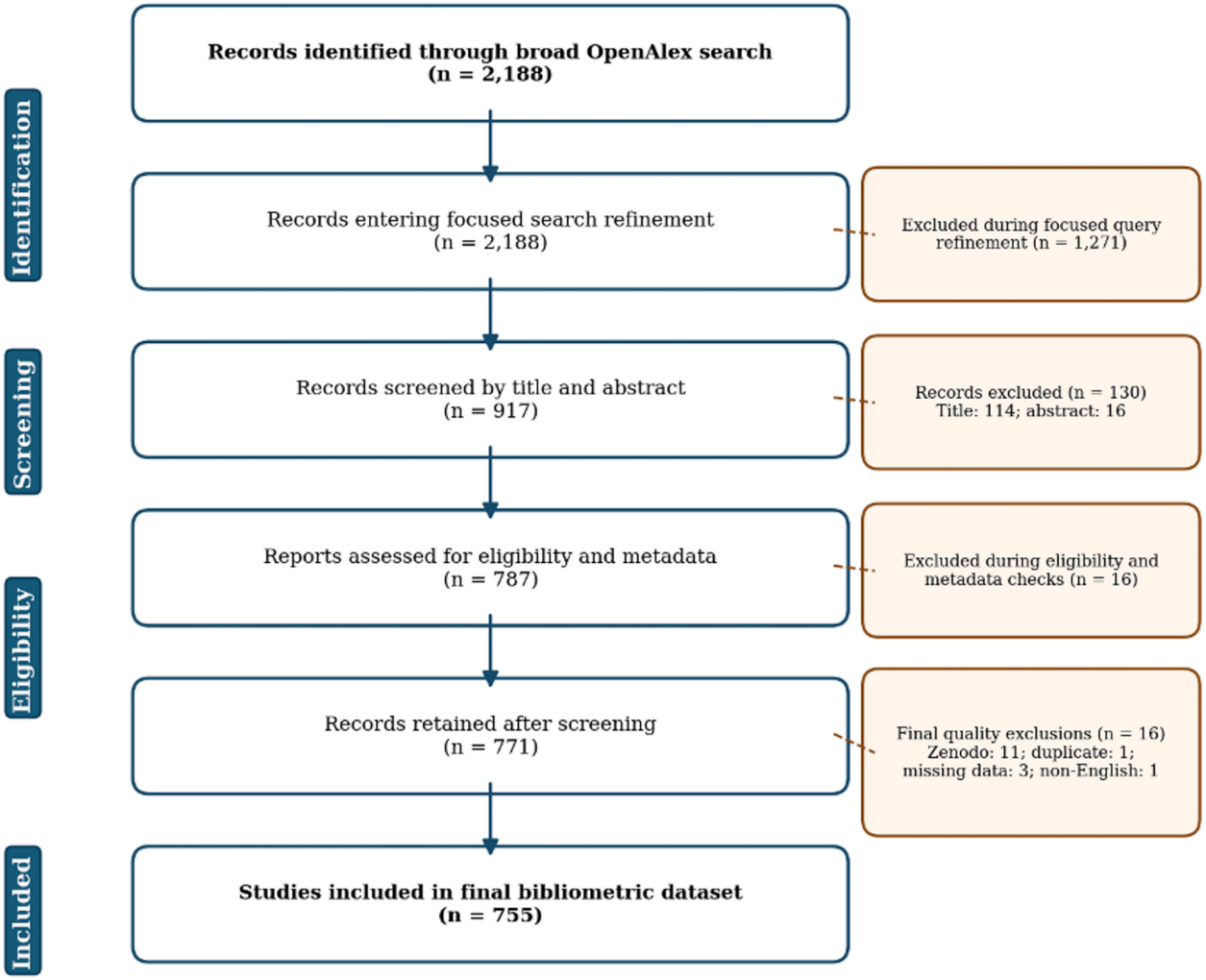


FIGURE 1: Flow of records from OpenAlex identification to the final bibliometric dataset

Source: Author's creation based on the record search and screening counts.

Data Analysis and Software

OpenAlex served as the retrieval platform. Data cleaning, descriptive statistics, citation aggregation, and table preparation were conducted in Python 3 using pandas. Keyword co-occurrence and co-authorship networks were constructed and analyzed with NetworkX and visualized with Matplotlib. Document text was processed with scikit-learn: term frequency-inverse document frequency (TF-IDF) vectorization represented titles, abstracts, and keywords; k-means partitioned documents into five lexical clusters; and high-dimensional vectors were projected to two dimensions for visualization. Microsoft Excel was used for final manual verification of counts and labels.

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The analyses represent three distinct structures. Keyword co-occurrence maps conceptual association among terms. Lexical clustering groups documents according to similarity in their textual content. Co-authorship mapping represents collaboration among authors. These methods should therefore be interpreted as complementary rather than interchangeable.

Keyword Co-occurrence and Cluster Labeling

After standardizing capitalization, merging obvious variants, and removing broad low-information OpenAlex labels (e.g., Business, Geography, and Economics), 763 unique keywords remained. Keywords formed network nodes; node size represented frequency; weighted edges represented the number of documents in which two keywords occurred together. A weighted modularity-based community analysis partitioned the network into six communities. The colors in Figure *7* show these memberships. The labels reported in Table *4* were assigned inductively by examining the highest-frequency and most connected terms within each community. Thus, Table *4* does not introduce a separate classification: it translates the community structure visible in Figure *7* into interpretable thematic labels for the 35 most frequent keywords.

Lexical Thematic Clustering

Document-level themes were identified through lexical thematic clustering. Titles, abstracts, and author keywords were combined, cleaned, and represented as TF-IDF vectors. K-means grouped the 755 documents into five clusters. Cluster labels were assigned after examining each cluster's highest-weighted terms and representative documents. This text-based procedure maps thematic proximity; it is distinct from citation-based methods such as bibliographic coupling and co-citation analysis, which use shared references or citations to recover intellectual relationships.

Co-authorship Mapping

A co-authorship network was generated from the author lists in the final 755-record dataset. Each unique author was represented as a node, and an undirected edge was created when two authors appeared on the same publication. Repeated collaboration increased edge weight. Network fragmentation was assessed using the number and size of connected components and isolated authors, while author connectedness was summarized through degree and weighted degree. International co-authorship was also reported from the country-affiliation indicator contained in the cleaned dataset.

Network density was calculated for the undirected co-authorship network using the standard formula $D = 2E/[N(N-1)]$, where N represents the number of authors (nodes) and E represents the number of unique co-authorship ties (edges). With 2,260 authors and 3,623 unique co-authorship ties, the calculated density was 0.001419, rounded to 0.0014. Repeated collaborations were represented through edge weights but did not increase the number of unique edges used in the density calculation.

Results

Descriptive Profile of the Bibliometric Dataset

The final dataset comprised 755 articles and reviews published across 565 sources. Table *1* summarizes the dataset, including the total citation base of 4,364 OpenAlex citations used in subsequent calculations. The table's category headers are merged across both columns to distinguish primary data, document types, and authors.

Description	Result
Primary Data Information	
Source database	OpenAlex

Timespan	2017–2025
Documents	755
Total citations	4,364
Average citations per document	5.78
Total journal/source titles	565
Document Types	
Articles	737
Review articles	18
Authors	
Unique authors	2,260
Average authors per document	3.15
Single-authored documents	130

TABLE 1: Descriptive profile of the bibliometric dataset

Source: Author's own calculations based on the dataset.

Annual Publication Trend

Figure *2* shows limited publication activity in the early years: 1 study in 2017, 4 in 2018, 6 in 2019, 12 in 2020, 22 in 2021, 47 in 2022, and 74 in 2023. Output then increased to 202 publications in 2024 and 387 in 2025. The final two years account for 589 of 755 records (78.0%), indicating that the OpenAlex-indexed literature expanded sharply near the end of the study period.

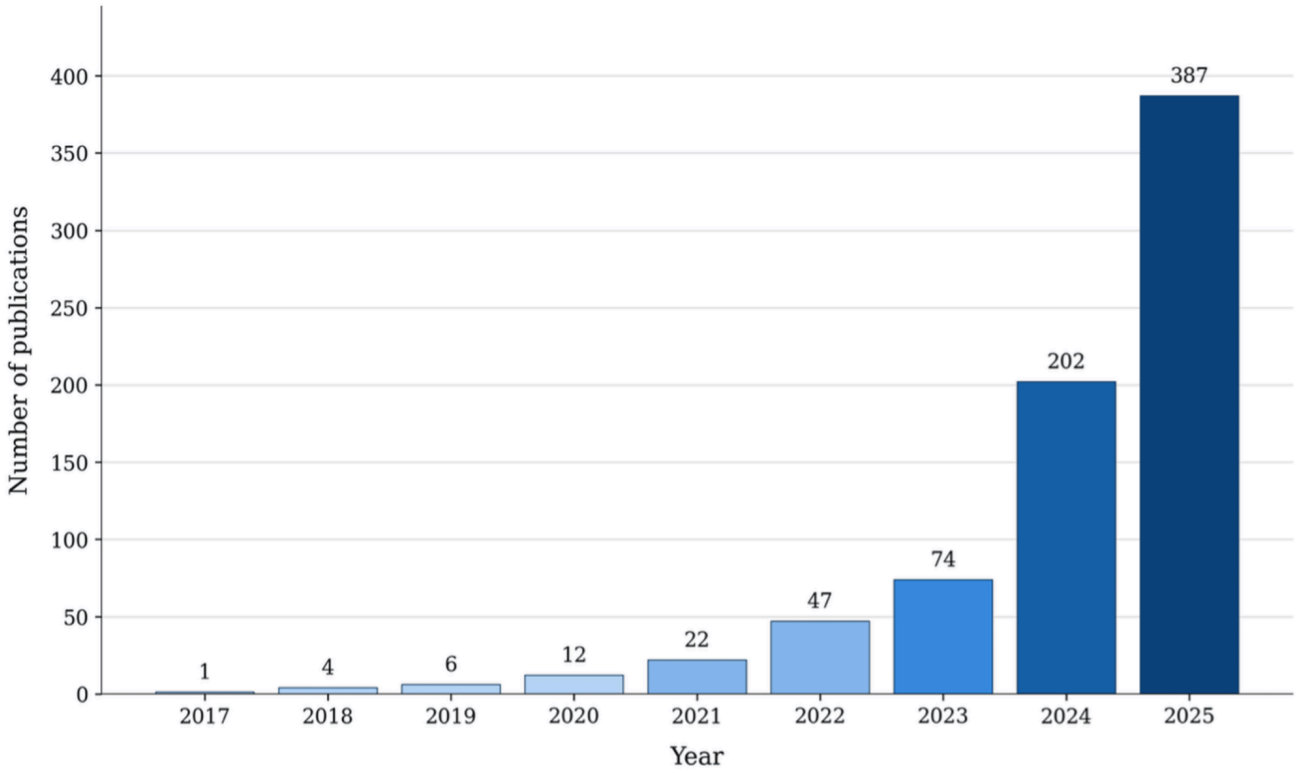


FIGURE 2: Annual publication trend on digital transformation in SMEs, 2017–2025

Source: Author's visualization based on the dataset.
SME, Small and Medium-Sized Enterprise

Average citation counts vary by publication year (Figure *3*). Papers published in 2020 had the highest observed mean (65.42), followed by those published in 2018 (56.25). Means were lower for recent years, including 4.95 in 2024 and 0.64 in 2025, largely because recent publications have had less time to accumulate citations. These descriptive averages should therefore be interpreted with the citation window in mind.

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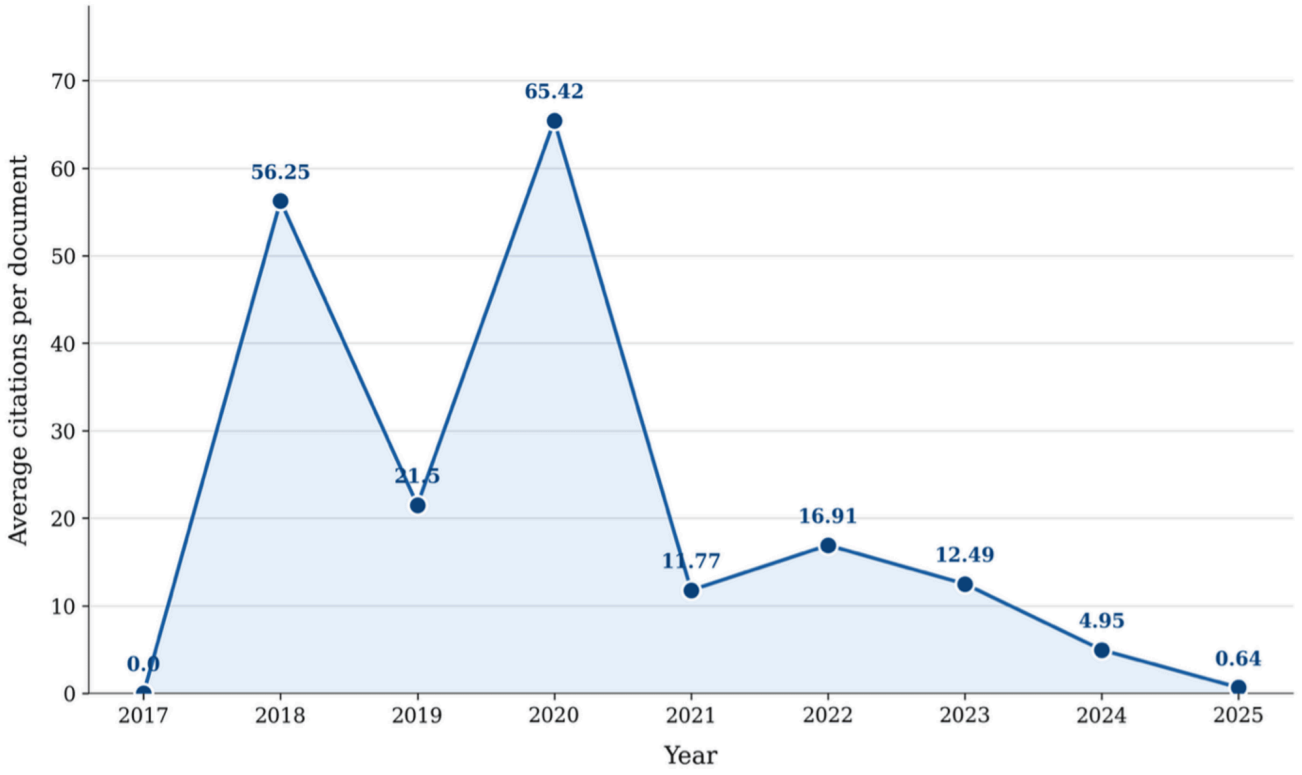


FIGURE 3: Average OpenAlex citations per publication year

Source: Author's visualization based on the dataset.

Interpretation of the Most Productive Sources

The 755 records were distributed across 565 non-empty journal or source titles, demonstrating substantial source fragmentation. Sustainability ranked first with 14 publications, followed by the International Journal for Multidisciplinary Research with eight and two journals with seven publications each. Importantly, Sustainability's first-place position should not be interpreted as dominance of the field or as evidence of superior journal quality or intellectual influence. Its 14 papers represent only approximately 1.9% of the corpus, while 469 of the 565 identified sources appeared only once. The ranking therefore reflects relative productivity within a highly dispersed OpenAlex source landscape. The journal's broad scope across sustainability, innovation, technology, management, and SME development also overlaps with several prominent themes in the corpus, which helps explain its visibility. Figure *4* presents the 10 most productive sources in the OpenAlex corpus.

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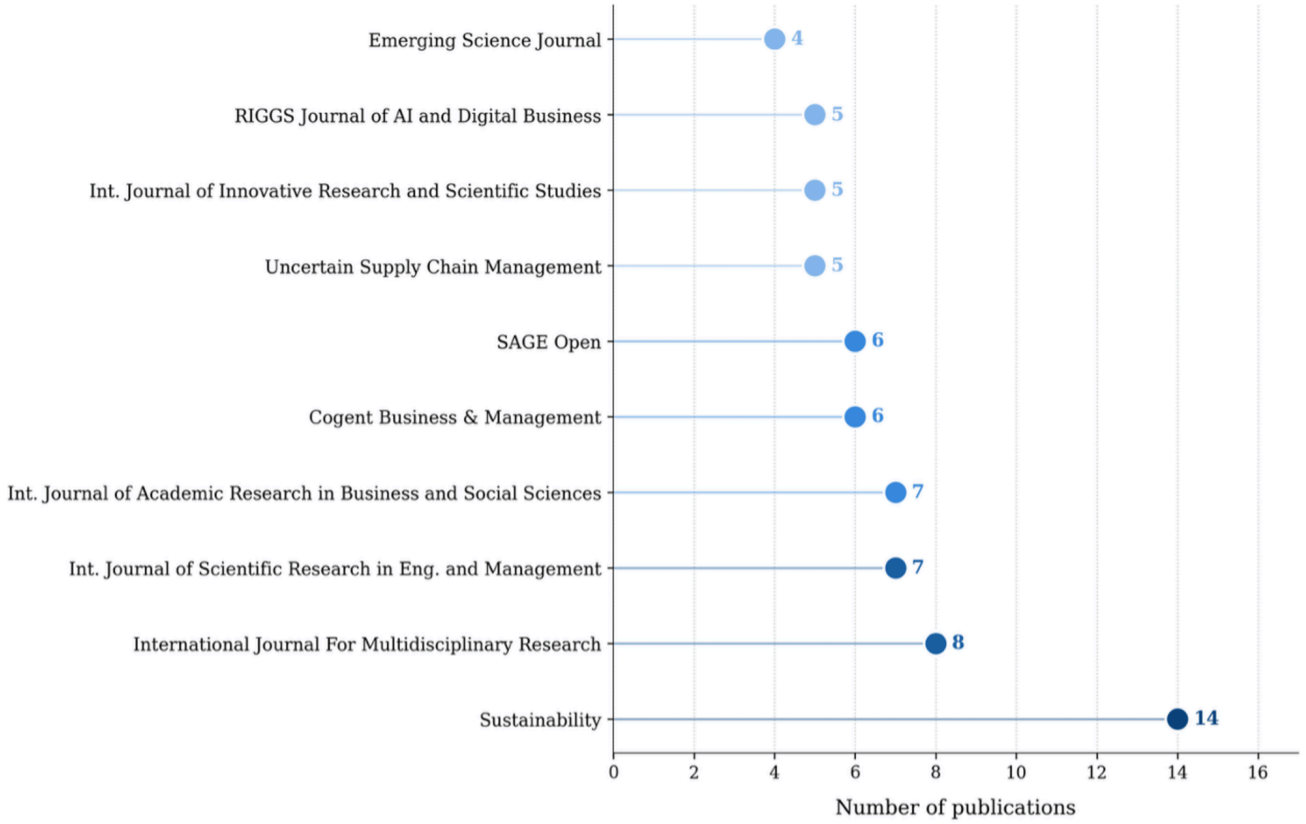


FIGURE 4: Top 10 most productive sources in the recorded dataset

Source: Author's visualization based on the dataset.

Most Productive Authors

Author productivity was similarly dispersed (Figure *5*). Puji Handayati, Henrique São Mamede, Loso Judijanto, Sudarmiatin, and Agus Hermawan each had four publications. Five additional authors had three publications. Overall, 2,185 of 2,260 authors (96.7%) appeared in only one record, showing that the corpus has not consolidated around a small, stable group of contributors.

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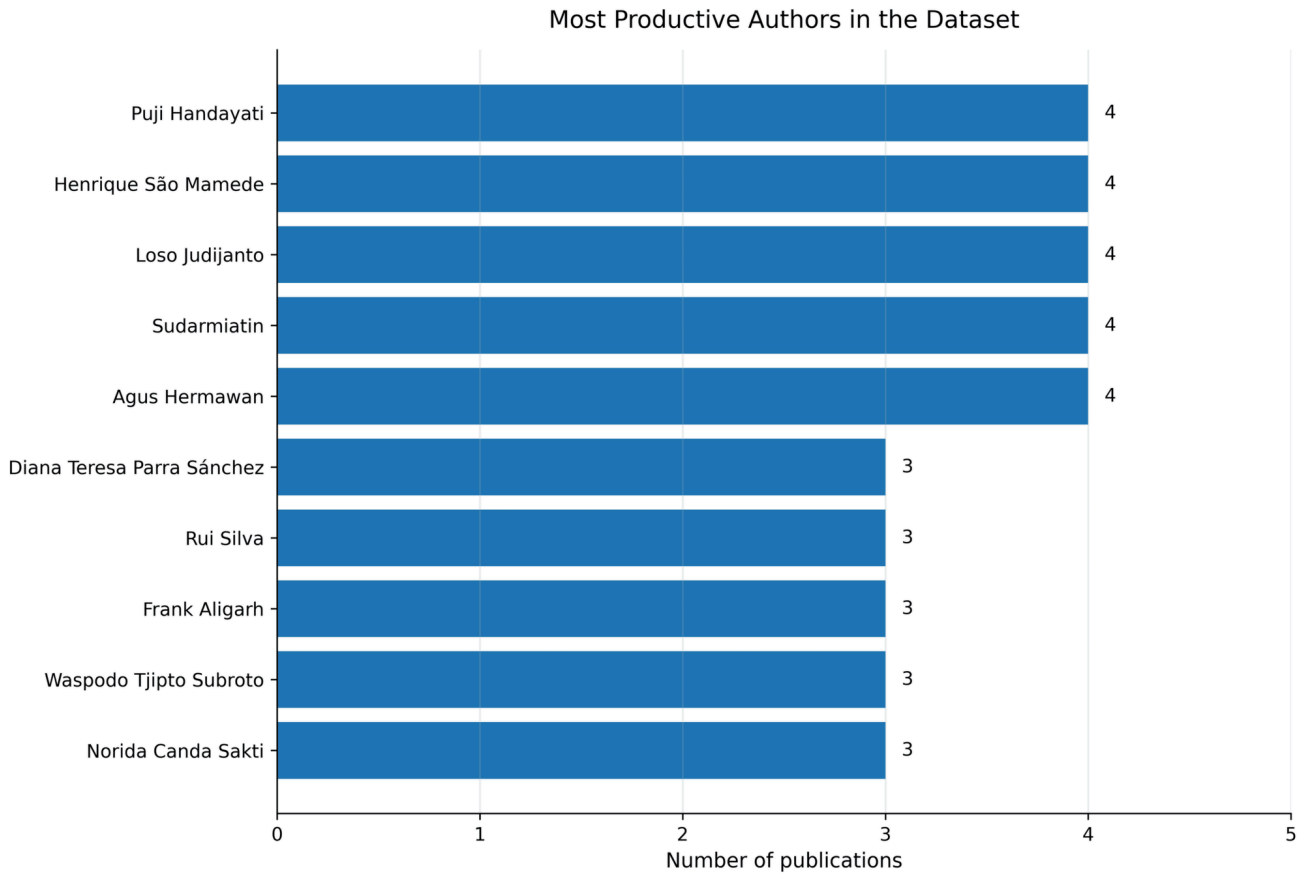


FIGURE 5: Most productive authors based on the dataset

Source: Author's visualization based on the recorded data.

Most Influential Documents

Table *2* lists the 10 documents with the highest OpenAlex citation counts. Together they received 1,733 of the dataset's 4,364 citations, or 39.7%. This concentration makes the calculation independently verifiable while also showing that a small set of studies accounts for a substantial share of observed citation influence.

Rank	Title	Authors	Citations
1	Identifying Digital Transformation Paths in the Business Model of SMEs during the COVID-19 Pandemic	(Priyono et al., 2020)	665
2	Sustainable Digital Transformation in Small and Medium Enterprises (SMEs): A Review on Performance	(Costa Melo et al., 2023)	180

3	Industry 4.0 and the Digital Society: Concepts, Dimensions and Envisioned Benefits	(Fonseca, 2018)	174
4	The Contribution of Organizational Culture, Structure, and Leadership Factors in the Digital Transformation of SMEs: A Mixed-Methods Approach	(Leso et al., 2023)	170
5	The Impact of Digital Marketing on the Performance of SMEs: An Analytical Study in Light of Modern Digital Transformations	(Sharabati et al., 2024)	112
6	Digital Transformation of Small and Medium Enterprises: Aspects of Public Support	(Rupeika-Apoga et al., 2022)	92
7	Business Resilience for Small and Medium Enterprises and Startups by Digital Transformation and the Role of Marketing Capabilities—A Systematic Review	(Hokmabadi et al., 2024)	87
8	Technology Adoption as Survival Strategy for Small and Medium Enterprises During COVID-19	(Mishrif and Khan, 2023)	86
9	Investigating the Strategic Role of Digital Transformation Path of SMEs in the Era of COVID-19: A Bibliometric Analysis Using R	(Ragazou et al., 2022)	85
10	Micro, Small, and Medium Enterprises' Readiness for Digital Transformation in Indonesia	(Anatan and Nur, 2023)	82

TABLE 2: Top 10 most influential documents on digital transformation in SMEs

Source: Author's own calculations based on the dataset.
SMEs, Small and Medium-Sized Enterprises

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Priyono et al. leads the ranking with 665 citations, reflecting the centrality of pandemic-era business-model adaptation (Priyono et al., 2020). The remaining documents span performance, Industry 4.0, leadership and culture, public support, marketing, and resilience. The mix of empirical, review, and bibliometric studies indicates that the citation base combines foundational conceptual work with synthesis papers.

Interpretation of Country Representation

Country-affiliation information was usable for 590 of the 755 publications. Indonesia accounted for 355 of these records (60.2%), followed by Malaysia, India, Vietnam, the United States, and the United Kingdom. The magnitude of the Indonesian share is analytically important but should not be interpreted as evidence that Indonesia produces 60.2% of the global scholarship on SME digital transformation. It indicates that Indonesian-affiliated research is exceptionally visible in this particular OpenAlex corpus. This may reflect substantive research activity on MSME digitalization in Indonesia as well as OpenAlex's broader coverage of local and regional journals. Because database-comparison studies demonstrate that OpenAlex, Scopus, and Web of Science differ in geographic and journal coverage, the country pattern is best treated as database-sensitive. A cross-database sensitivity analysis is recommended before making claims about global geographic leadership. Figure *6* illustrates the geographic distribution of publications with usable country-affiliation data, while Table *3* summarizes the 10 most productive countries among the 590 records with country information.

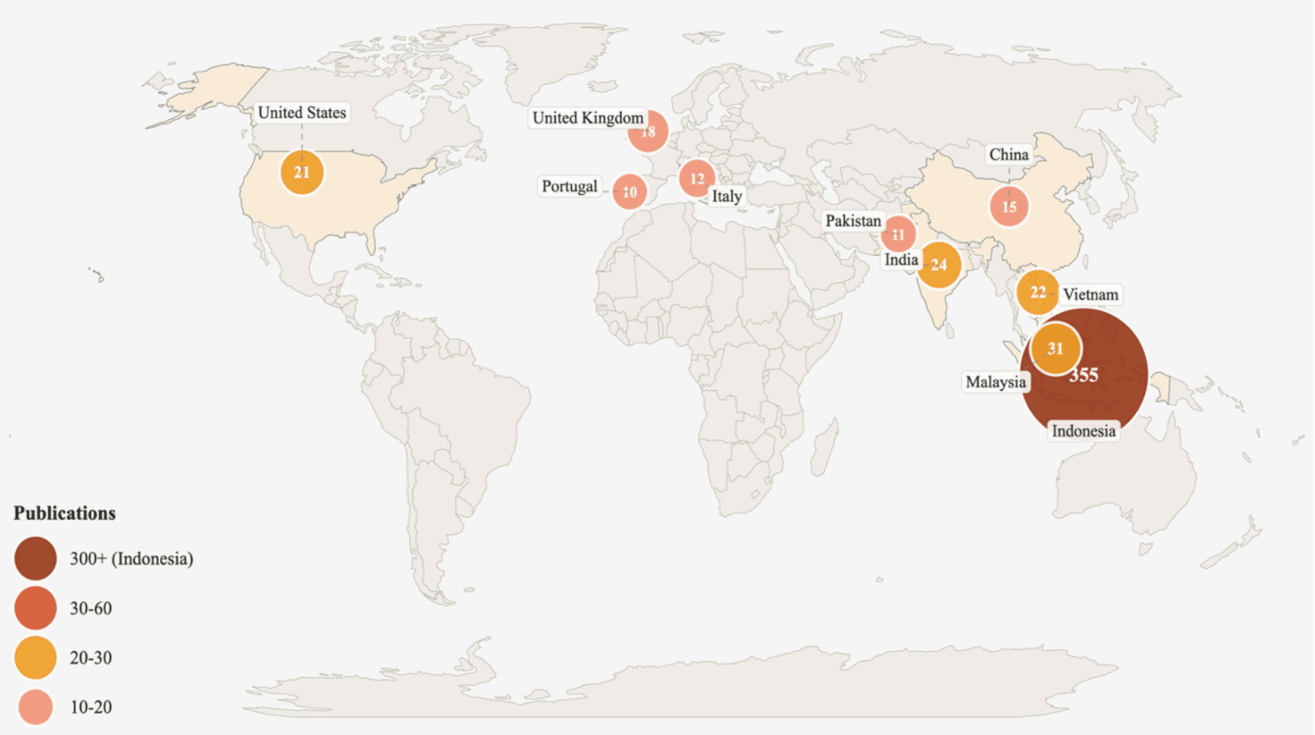


FIGURE 6: Geographic distribution of publications among records with usable country-affiliation data (n = 590)

Source: Author's visualization and calculations based on 590 OpenAlex records with usable country-affiliation data.

Rank	Country	Publications	Share of 590
1	Indonesia	355	60.2%
2	Malaysia	31	5.3%

3	India	24	4.1%
4	Vietnam	22	3.7%
5	United States	21	3.6%
6	United Kingdom	18	3.1%
7	China	15	2.5%
8	Italy	12	2.0%
9	Pakistan	11	1.9%
10	Portugal	10	1.7%

TABLE 3: Top 10 countries by author affiliation among records with country information (n = 590)

Source: Author's own calculations based on the dataset.

Indonesia accounts for 355 of the 590 records with country data (60.2%). This concentration is an observation about the OpenAlex corpus and may reflect both substantial Indonesian attention to MSME digitalization and the index's coverage of local and regional sources. It should not be interpreted as definitive evidence of global research leadership. Malaysia, India, Vietnam, the United States, the United Kingdom, China, Italy, Pakistan, and Portugal complete the top 10. Replication with Scopus, Web of Science, or merged databases is needed to determine whether this distribution persists across indexing systems.

Keyword Co-occurrence Analysis

The cleaned keyword set contained 763 terms across 755 studies. Figure *7* displays the weighted co-occurrence network. Node size represents keyword frequency, edge weight represents the number of shared documents, and node color represents the network community identified in the method described in section "Keyword Co-occurrence and Cluster Labeling". Table *4* reports the 35 most frequent keywords and uses those same community memberships; the thematic labels summarize the most frequent and connected terms within each colored community.

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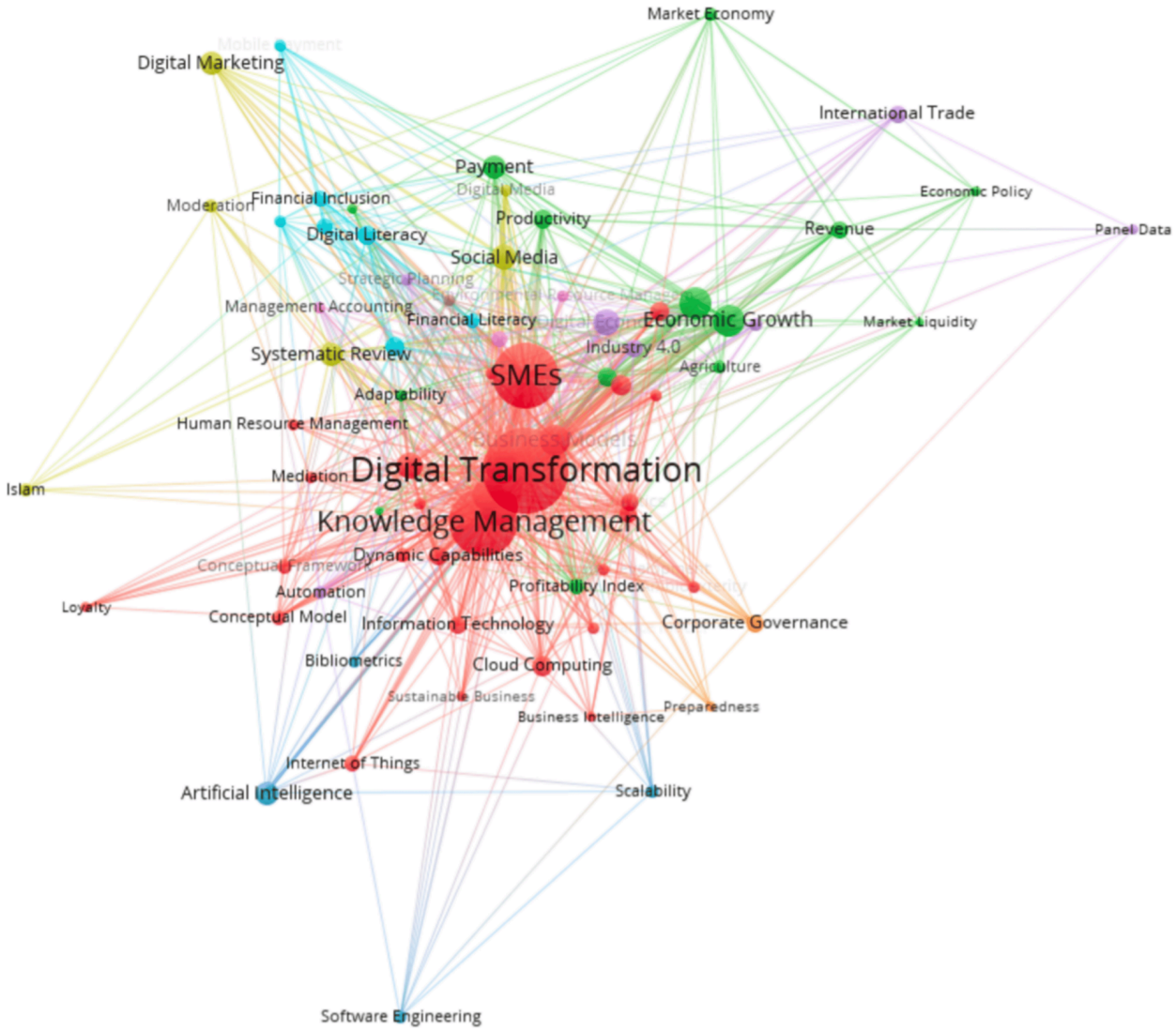


FIGURE 7: Keyword co-occurrence network for the most frequent cleaned keywords

Source: Author's visualization using NetworkX and OpenAlex keyword data.

Rank	Keyword	Frequency	Community Label
1	Digital Transformation	276	Core capabilities
2	Knowledge Management	172	Core capabilities
3	Small and Medium-Sized Enterprises	159	Core capabilities
4	Sustainability	55	Sustainability & resilience
5	Competitive Advantage	41	Core capabilities

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6	Entrepreneurship	41	Core capabilities
7	Economic Growth	40	Economic impact
8	COVID-19	38	Sustainability & resilience
9	Business Models	35	Core capabilities
10	Payment	29	Financial services
11	Structural Equation Modeling	26	Digital marketing & social media
12	Digital Economy	26	Economic impact
13	Social Media	24	Digital marketing & social media
14	Digital Marketing	20	Digital marketing & social media
15	Systematic Review	20	Core capabilities
16	Sustainable Development	17	Sustainability & resilience
17	Artificial Intelligence	17	Technology & infrastructure
18	Cloud Computing	16	Technology & infrastructure
19	Emerging Markets	15	Economic impact
20	Supply Chain	15	Sustainability & resilience
21	Productivity	14	Economic impact
22	Digitalization	14	Technology & infrastructure
23	Dynamic Capabilities	14	Core capabilities
24	Digital Literacy	14	Technology & infrastructure
25	Big Data	13	Technology & infrastructure
26	Industry 4.0	13	Technology & infrastructure
27	Revenue	13	Economic impact
28	Information Technology	12	Core capabilities
29	Psychological Resilience	11	Sustainability & resilience

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30	Tourism	10	Sustainability & resilience
31	Financial Services	10	Financial services
32	Financial Inclusion	10	Financial services
33	Telecommunications	10	Financial services
34	Profitability Index	10	Economic impact
35	Work	10	Sustainability & resilience

TABLE 4: Top 35 keywords with co-occurrence community assignments

Source: Author's own calculations based on the dataset.

Digital transformation (276), knowledge management (172), and SMEs (159) form the network's central triad. These terms co-occur rather than function interchangeably: digital transformation and knowledge management co-occurred in 100 studies, while digital transformation and SMEs co-occurred in 79. The network consequently places knowledge processes and organizational capability close to the field's defining technology and enterprise terms (Costa Melo et al., 2023) (Hafeez et al., 2025) (Sagala and Őri, 2024).

Six communities surround this core. The core-capabilities community connects competitive advantage, business models, entrepreneurship, dynamic capabilities, and review literature. Technology and infrastructure links artificial intelligence, cloud computing, big data, Industry 4.0, digital literacy, and digitalization. Economic impact groups growth, the digital economy, productivity, emerging markets, revenue, and profitability. The digital marketing and social media community combines social media and digital marketing with structural equation modeling, reflecting the prevalence of model-testing survey designs. Financial services links payment, financial inclusion, telecommunications, and related services. Sustainability and resilience connects sustainability, sustainable development, COVID-19, supply chains, tourism, work, and psychological resilience. These labels summarize community membership and do not imply that boundaries between communities are absolute.

Lexical Thematic Clusters and Research Fronts

The TF-IDF and k-means procedure produced five document-level clusters. Table *5* summarizes their sizes and representative terms, and Figure *8* shows the two-dimensional projection. The largest cluster is digital adoption and knowledge management (n = 255), followed by MSME financial literacy (n = 226). Together they account for 63.7% of the corpus.

Cluster	Theme	Papers	Share	Representative Terms
1	MSMEs & Financial Literacy	226	29.9%	MSMEs, financial, accounting, literacy, Indonesia, economic
2	Digital Adoption & Knowledge Management	255	33.8%	SMEs, management, knowledge, adoption, industry, technologies

3	Performance, Innovation & Sustainability	121	16.0%	Performance, innovation, leadership, sustainability, organizational, SEM
4	Digital Marketing & Social Media	94	12.5%	Marketing, digital marketing, media, village, community, social media
5	COVID-19 Response & Resilience	59	7.8%	COVID, pandemic, resilience, coronavirus, survival

TABLE 5: Lexical thematic research fronts in the OpenAlex corpus

Source: Author's own calculations based on the dataset.
MSMEs, Micro, Small, and Medium Enterprises; SEM, Structural Equation Modeling; SMEs, Small and Medium-Sized Enterprises

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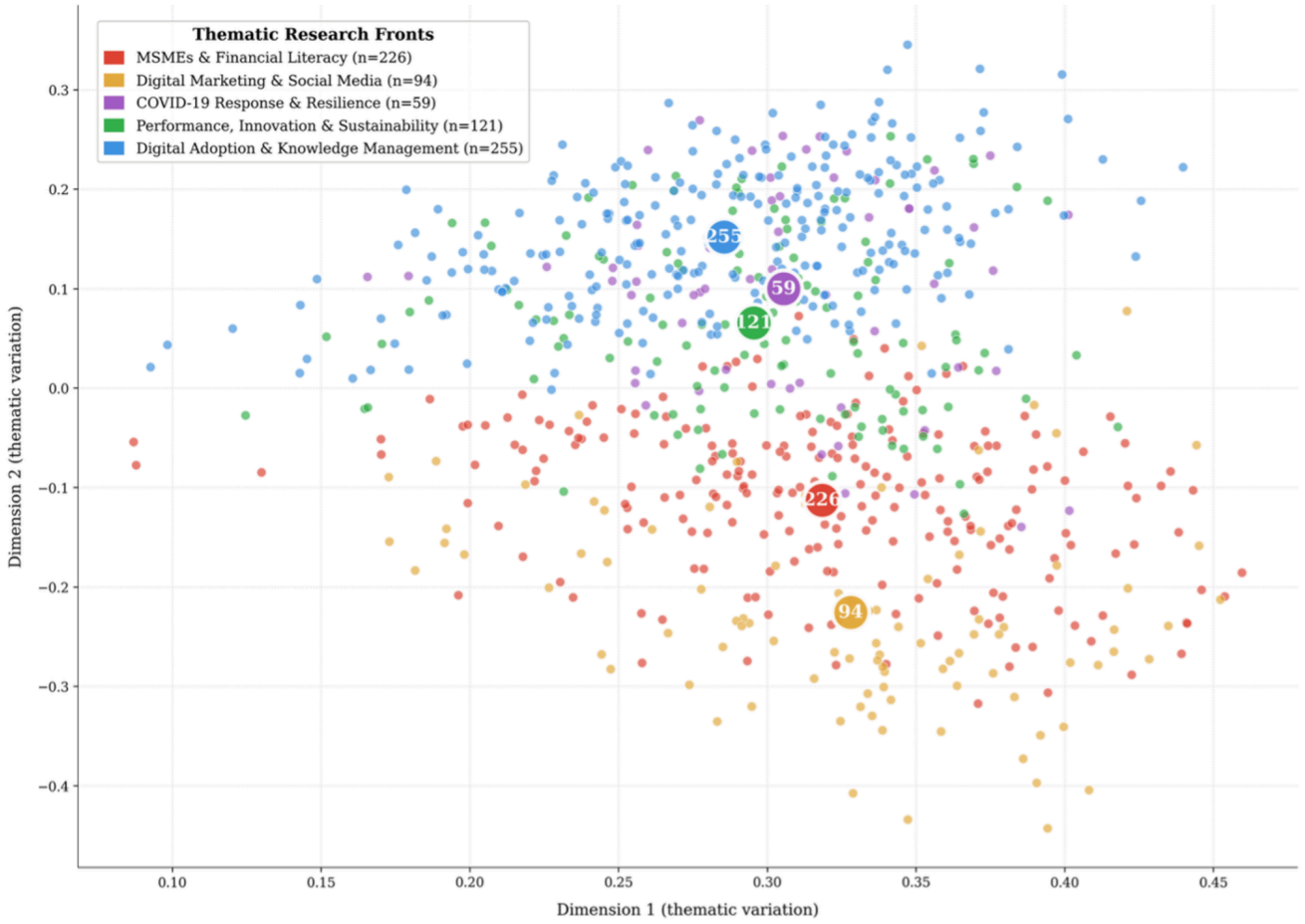


FIGURE 8: Two-dimensional projection of the five lexical thematic clusters

Source: Author's visualization using scikit-learn and OpenAlex text data.
MSMEs, Micro, Small, and Medium Enterprises

Cluster 1 combines MSMEs, financial literacy, accounting, technology use, and Indonesia, reflecting a policy- and inclusion-oriented research front. Cluster 2 centers on adoption, knowledge, management, and industry applications and therefore captures the organizational integration of digital tools. Cluster 3 links firm performance, innovation, leadership, sustainability, and structural equation modeling-based empirical modeling. Cluster 4 concentrates on digital marketing, social media, and community- or village-level MSME engagement. Cluster 5 isolates pandemic response, survival, and resilience. Because the clusters are based on vocabulary rather than shared references, they should be interpreted as thematic research fronts rather than citation-based intellectual lineages.

Co-authorship Structure

The 755-document dataset contained 2,260 unique authors and 3,623 co-authorship ties. The network was highly fragmented, comprising 689 connected components; the largest connected component contained only 30 authors, or approximately 1.3% of all authors. In addition, 125 authors were isolates in the network, corresponding to single-authored papers. Network density was approximately 0.0014, further indicating that collaboration is distributed across many small teams rather than consolidated into one integrated scholarly community.

The most connected authors in the current network included Melda Agnes Manuhutu and Natasya Virginia Leuwol, each connected to 16 distinct co-authors, followed by Frank Aligarh with 14. Weighted-degree patterns also identified repeated collaboration around several locally dense teams. However, these network positions should not be conflated

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with publication productivity or citation influence: an author can occupy a highly connected position because of participation in a large team even with relatively few publications.

International collaboration was limited. Only 89 of the 755 documents (11.8%) were marked as involving international co-authorship. Taken together, the large number of components, small largest component, and modest international collaboration rate suggest that the field is expanding faster than its collaboration structure is consolidating. This result complements the descriptive author findings, where 96.7% of authors appeared in only one record. Figure *9* presents the largest connected component of the co-authorship network, comprising 30 authors, and illustrates the locally clustered nature of collaboration within the corpus.

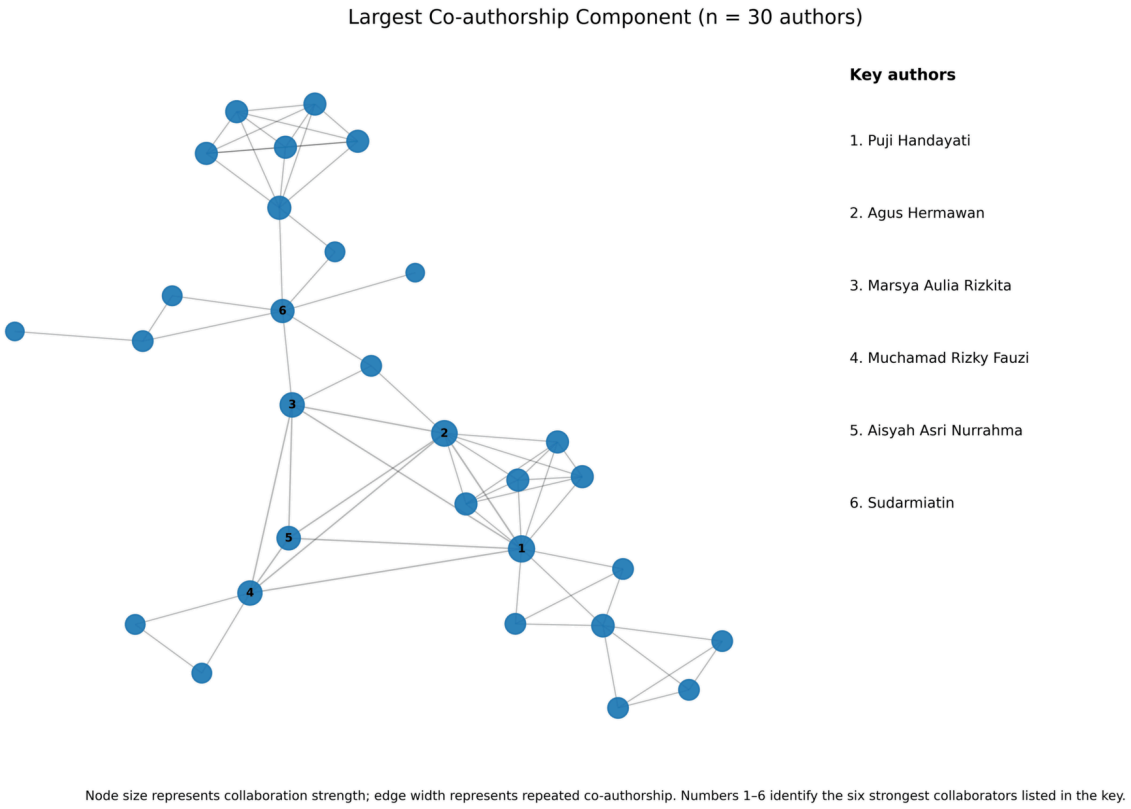


FIGURE 9: Largest co-authorship component in the OpenAlex SME digital transformation corpus

Node size represents weighted collaboration strength, while edge width represents the frequency of repeated co-authorship. Only the six authors with the highest collaboration strength are labeled to improve readability. The component contains 30 connected authors.
SME, Small and Medium-Sized Enterprise

Discussion

From Publication Growth to Capability Transformation

The most striking descriptive feature of the corpus is its recent acceleration: 78.0% of the current 755 records were published in 2024 and 2025. This expansion confirms that SME digital transformation has become a high-growth research domain, but publication volume alone does not explain how the field is developing intellectually. The keyword and lexical structures suggest that growth is occurring around a broader transition in how SME digitalization is conceptualized. The literature is moving from a narrow focus on adopting technologies toward a capability-based interpretation in which knowledge, organizational readiness, market channels, financial practices, innovation, sustainability, and resilience are interconnected.

This distinction matters theoretically. Under a dynamic-capabilities interpretation, digital technologies are resources or opportunities rather than outcomes in themselves. SMEs must sense relevant technological and market changes, seize feasible opportunities, and reconfigure processes and resources. The visibility of business models, competitive advantage, entrepreneurship, dynamic capabilities, innovation, and performance in the mapped structures is consistent with this view. Digital transformation is therefore better understood as the organizational process through which SMEs convert digital possibilities into new routines and value-creation mechanisms.

Knowledge Management as a Bridge at the Micro-Level

The central position of knowledge management in the network warrants deeper theoretical interpretation. Knowledge management is one of the most frequent and central concepts and appears close to digital transformation and SME capability terms.

Knowledge management can therefore be conceptualized as a bridge between digital inputs and capability transformation. At the sensing stage, knowledge processes help SMEs recognize changes in customer behavior, technology, competition, and regulation. At the seizing stage, knowledge integration supports decisions about which technologies, channels, and investments are feasible. At the reconfiguration stage, knowledge sharing and organizational learning allow new digital practices to be embedded in routines. This interpretation also explains why the digital adoption and knowledge-management lexical cluster is the largest cluster in the corpus. The literature is not merely discussing technologies; it is examining the organizational capacity to make technologies useful.

Relationships Among the Five Lexical Research Fronts

The five lexical clusters should not be treated as independent silos. They can be interpreted as interacting parts of an SME transformation system. The MSME financial-literacy cluster represents the informational and financial foundation needed to make investment and operating decisions, particularly in emerging-economy settings. The digital adoption and knowledge-management cluster represents the organizational integration mechanism through which technologies are understood and embedded. The performance, innovation, and sustainability cluster represents strategic and organizational outcomes associated with successful capability development. The digital-marketing and social-media cluster represents customer-facing deployment of digital capability. The COVID-19 resilience cluster represents transformation under environmental shock, where digital tools and organizational adaptability became mechanisms of continuity and survival.

Seen together, these fronts suggest a sequence rather than five unrelated topics: access to financial and digital resources enables adoption; knowledge processes convert adoption into organizational capability; capabilities are deployed internally and toward markets; and the resulting flexibility influences performance, innovation, sustainability, and resilience. This sequence is a conceptual interpretation of the mapped literature and should not be read as a causal model tested by the present bibliometric design.

What the Source and Geographic Patterns Mean

The source analysis reveals fragmentation rather than journal dominance. Even the leading source contributes fewer than 2% of records, while more than four-fifths of source titles appear only once. This dispersion is consistent with the multidisciplinary nature of SME digital transformation, which crosses management, economics, information systems, engineering, sustainability, marketing, and regional development research.

The geographic pattern requires greater caution. The 60.2% Indonesian share among records with country information is too large to be presented simply as a country ranking. It is instead a finding about the interaction between the substantive topic and database coverage. Indonesia has a large MSME sector and substantial policy and academic interest in digitalization, which plausibly contributes to the pattern. At the same time, comparative database research shows that OpenAlex indexes many more open-access and regionally distributed journals than Scopus or Web of Science. The correct inference is therefore that Indonesian research is highly visible in the OpenAlex corpus, not that Indonesia necessarily dominates the global intellectual structure of the field.

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Collaboration and Fragmentation of the Research Community

The co-authorship analysis reinforces the interpretation that the field is rapidly expanding but not yet socially consolidated. A network of 2,260 authors is separated into 689 components, and the largest component contains only 30 authors. Only 11.8% of records involve international co-authorship. These findings imply that small, locally bounded teams produce much of the literature, rather than a dense international research network.

This fragmentation may have substantive consequences. Weak cross-country collaboration can limit comparative research designs and encourage repeated single-country studies using locally specific measures. It may also contribute to the coexistence of partially disconnected streams such as financial inclusion, marketing, resilience, sustainability, and capability research. More cross-national collaboration would help test whether the relationships identified in the thematic map are robust across institutional and market contexts.

Methodological Contribution and Remaining Structural Limitation

Methodologically, the study demonstrates the value of separating conceptual, textual, and social structures. Keyword co-occurrence reveals which concepts are discussed together; TF-IDF clustering groups documents that use similar vocabularies; and co-authorship mapping reveals who works with whom. Agreement across these analytical layers strengthens interpretation, while disagreement can reveal hidden fragmentation.

A remaining limitation is the absence of citation-based structural mapping. Lexical similarity cannot establish intellectual lineage. Two papers may use similar vocabulary while drawing on different theoretical traditions, and two papers may share foundational references while using different terminology. Bibliographic coupling and co-citation analysis would therefore provide an important fourth layer by tracing shared references and cited intellectual foundations. This step should be added once cited-reference identifiers are retrieved.

Limitations and Evidence-Based Future Research Agenda

This study has four principal limitations. First, its findings are conditional on OpenAlex coverage and metadata. The strong Indonesian representation illustrates why database coverage is part of the result rather than a neutral technical choice. Future work should conduct a structured sensitivity analysis using Scopus and Web of Science, comparing source, country, keyword, and thematic distributions before considering a merged dataset.

Second, the original refinement stage narrowed the focal construct to the phrase "digital transformation," even though the broad search included digitalization, digital readiness, digital capability, and digital maturity. The search should therefore be rerun with the full synonym block retained throughout screening. This is necessary to assess whether the thematic and geographic patterns are robust to broader construct operationalization.

Third, the present structural analysis is primarily lexical and relational rather than citation-based. Future analysis should add bibliographic coupling to identify contemporary research fronts that share references and co-citation analysis to identify foundational intellectual traditions. These analyses would enable researchers to test the lexical clusters against the field's citation structure.

Fourth, the corpus itself points to specific substantive research needs. The prominence of financial literacy and Indonesian MSME research supports more cross-country comparisons of digital finance, financial capability, and transformation outcomes. The knowledge-management cluster supports longitudinal and process-oriented studies examining how knowledge acquisition, sharing, and absorptive capacity convert digital investments into dynamic capabilities. The performance-innovation-sustainability cluster supports studies separating economic, environmental, and social outcomes rather than treating performance as a single construct. The digital-marketing cluster supports research on platform dependence, algorithmic visibility, data capability, and customer analytics. Finally, the resilience cluster supports post-pandemic research distinguishing temporary digital adaptation from durable organizational transformation.

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The collaboration findings add a further recommendation: future studies should prioritize international and multi-institutional designs. Cross-national teams can help determine whether the relationships visible in the OpenAlex corpus are specific to local institutional environments or generalizable across SME ecosystems.

Conclusions

This study maps the growth, conceptual organization, thematic structure, and collaboration patterns of OpenAlex-indexed research on SME digital transformation between 2017 and 2025. The current 755-document corpus demonstrates rapid recent expansion, substantial dispersion across journals and authors, a concentrated citation base, and strong Indonesian visibility among records with usable country information. These patterns describe the OpenAlex corpus and should not be interpreted as database-independent measures of global research leadership. The analysis moves beyond publication counts by showing that SME digital transformation organizes itself around interacting capability, knowledge, financial, technological, market, sustainability, and resilience themes. Keyword co-occurrence positions knowledge management near the conceptual core of the field, while lexical clustering shows that digital adoption and knowledge management form the largest document-level research front. Interpreted through the knowledge-based view and dynamic capabilities perspective, this pattern suggests that knowledge processes are a central mechanism through which SMEs convert digital resources into sensing, decision-making, organizational reconfiguration, and market-facing capabilities.

The five lexical research fronts are therefore best understood as interdependent rather than independent. Financial and digital readiness shape access to transformation resources; knowledge and organizational processes integrate those resources; marketing and platform capabilities deploy them toward customers; and performance, innovation, sustainability, and resilience represent strategic outcomes examined in the literature. The co-authorship network adds a social dimension to this interpretation: despite rapid publication growth, the field remains fragmented across many small research teams and has relatively limited international collaboration. The study's principal contribution is thus both substantive and methodological. Substantively, it synthesizes SME digital transformation as a knowledge-intensive capability-reconfiguration process rather than simple technology procurement. Methodologically, it demonstrates the value of distinguishing concept networks, lexical research fronts, and collaboration networks while explicitly recognizing database coverage as an interpretive boundary. The next stage of research should test the robustness of these conclusions through a synonym-consistent search, cross-database sensitivity analysis, and citation-based bibliographic coupling and co-citation mapping. Such work would determine which patterns are specific to the OpenAlex corpus and which represent more durable features of the global intellectual structure of SME digital transformation research.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Cesario Jr M. Labajo

Acquisition, analysis, or interpretation of data: Cesario Jr M. Labajo

Drafting of the manuscript: Cesario Jr M. Labajo

Critical review of the manuscript for important intellectual content: Cesario Jr M. Labajo

Supervision: Cesario Jr M. Labajo

Disclosures

Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following:

- **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work.
- **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.
- **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

Data Availability Statements

The datasets (and/or code) supporting this study are available from the corresponding author upon reasonable request.

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