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Operational Optimization in SMEs through ICT: A Scientometric Study

Optimización operativa en las PYMEs a través de las TIC: Un estudio cienciométrico

Florencia Flen Rossi*
Universidad de Barcelona

Abstract
The role of Information and Communication Technologies (ICT) in enhancing operational efficiency among Small and Medium Enterprises (SMEs) has garnered significant attention in recent years. This study employs a scientometric approach to analyze global research trends on ICT and SMEs, covering publications from 1975 to 2023, although meaningful academic output on this topic has notably emerged since the early 2000s. Unlike prior studies that often focus on case-based analysis or regional perspectives, this research offers a comprehensive and global overview, identifying the most influential articles, authors, and countries contributing to this field.
Key findings reveal a significant shift in ICT's role -from operational tools to strategic enablers of innovation and sustainability- highlighting the intersection of digital transformation and circular economy practices. By mapping emerging trends and research gaps, this study provides a knowledge-based overview that can inform future academic inquiry and policymaking regarding ICT adoption in resource-constrained SMEs.
Keywords. Digital transformation, Operational efficiency, SME innovation, Technology adoption, Scientometrics.

Resumen
El impacto de las Tecnologías de la Información y la Comunicación (TIC) en la mejora de la eficiencia operativa de las Pequeñas y Medianas Empresas (PYMEs) ha despertado un creciente interés en los últimos años. Este estudio emplea un enfoque cienciométrico para analizar las tendencias globales de investigación sobre TIC y PYMEs, abarcando publicaciones desde 1975 hasta 2023, aunque ha surgido una producción académica significativa sobre este tema desde principios de la década de 2000. A diferencia de estudios previos, que suelen centrarse en análisis de casos o enfoques regionales, esta investigación ofrece una visión integral y global, identificando los artículos, autores y países más influyentes en el campo.
Los hallazgos revelan un cambio significativo en el papel de las TIC, que han evolucionado de ser meras herramientas operativas para convertirse en habilitadoras

* fflenr@gmail.com

estratégicas de la innovación y la sostenibilidad, evidenciando la convergencia entre la transformación digital y las prácticas de economía circular. Al cartografiar tendencias emergentes y vacíos en la investigación, este estudio proporciona una visión general basada en el conocimiento que puede informar futuras investigaciones académicas y la formulación de políticas con respecto a la adopción de las TIC en PYME con recursos limitados

Palabras clave. Transformación digital, Eficiencia operativa, Innovación en PYMEs, Adopción tecnológica, Cienciometría.

1. Introduction

This study employs scientometrics to analyze the relationship between Information and Communication Technologies (ICT), operational optimization, and Small and Medium Enterprises (SMEs). In rapidly evolving markets, ICT has been widely discussed in the academic literature as essential for enhancing efficiency and business performance (Ramos et al., 2020). However, SMEs face adoption challenges due to their size and resource constraints, making them a key focus of academic and practical interest. ICT encompasses a range of tools, from digital technologies to advanced innovations, that enable companies to improve operations and adapt to market changes (García et al., 2021). Operational optimization, defined as the continuous improvement of business processes and efficiency (Gunasekaran et al., 2000; Espín et al., 2022; Tapia and Cevallos, 2023), remains a prominent theme in the literature on ICT in SMEs (Brynjolfsson and McAfee, 2024).

Spanning the academic development of this field from its early stages in the late 2000s to 2023, this scientometric analysis investigates how ICT influences operational optimization in SMEs, it highlights the evolution of academic contributions, identifies foundational studies, and evaluates the global distribution of knowledge through the geographic and institutional affiliations of key researchers.

The study further uncovers collaboration networks among prominent authors, analyzes the most influential scientific journals, and delves into predominant research themes. These elements provide a thorough understanding of how ICT's strategic role in SME operations has been conceptualized in the academic literature, particularly regarding competitiveness and long-term value.

The findings contribute to understanding how academic literature has conceptualized the role of ICT in the operational optimization of SME and suggest potential future research directions. By identifying underexplored areas and collaboration opportunities, this study provides valuable insights for both academics and professionals interested in enhancing SME performance through innovative

technologies. This contribution aligns with the perspectives of Kim and Jee (2007), Hoyos and Valencia-Arias (2012), Tatoglu et al. (2016), and Quispe et al. (2017), who have worked on this topic.

This article follows a detailed structure. Section II presents the theoretical framework supporting the study, while Section III describes the methodology used for the scientometric analysis. The results are presented in Section IV, followed by the discussion in Section V. Finally, Section VI offers the conclusions, highlighting the main findings and their implications for the future of SMEs.

2. Literature review

This research builds on theories that explore the transformative impact of ICT and the factors influencing its adoption in SMEs, providing a robust foundation to analyze how ICT drives operational optimization through both empirical and theoretical lenses.

2.1 Catalyst for change in SMEs: Theoretical and practical approaches

ICT serves as a catalyst for significant changes in the organizational and operational structures of SMEs. Investments in ICT improve efficiency, productivity, and innovation capacity (Brynjolfsson and Hitt, 1996) while reshaping industries by enhancing competitiveness and transforming value chains (Porter, 1985). Tools like enterprise management systems, e-commerce platforms, social networks, big data, and cloud solutions streamline information processing and management. Beyond automation, ICT fosters innovation and digital transformation, enabling SMEs to adapt swiftly to dynamic markets (Laudon and Traver, 2020)

Due to their size and resource limitations, SMEs find in ICT an opportunity to overcome these barriers. Raymond and Melle (2001) argue that ICT not only enables SMEs to improve operational efficiency but also opens up new market possibilities. This argument is supported by Matt et al. (2015), who suggest that digitalization can fundamentally transform business processes, providing SMEs with greater flexibility and responsiveness.

2.2 The concept of operational optimization and its relationship with ICT

Operational optimization refers to the continuous improvement of internal processes to achieve greater efficiency and effectiveness. The integration of ICT allows companies to automate their processes and achieve greater consistency in operational management (Olusola et al., 2013; Yuwono et al., 2024). In this context, ICT facilitates process reengineering, which can lead to significant reductions in operational costs and improvements in organizational productivity, as proposed by Hitchner (1993) in his approach to business reengineering.

In the context of SMEs, operational optimization is critical for survival in a competitive environment. Love and Roper (2015) argue that SMEs that adopt ICT not only achieve improvements in operational efficiency but also gain greater adaptability to changes in the business environment, making them more resilient. This adaptability has been highlighted in the literature as crucial in dynamic markets, where flexibility may become a differentiating factor for SMEs compared to larger firms.

2.3 ICT Adoption in SMEs: A theoretical and practical analysis

The adoption of ICT in SMEs is explained by theories of technological innovation, particularly Rogers' Diffusion of Innovations Theory (1962), which analyzes how and at what pace new ideas spread within social groups. This theory emphasizes five elements: innovation, communication channels, time, social systems, and the decision-making process for adoption (Wani and Ali, 2015). Rogers outlines a progression through stages—knowledge, persuasion, decision, implementation, and confirmation—that individuals follow during the adoption process (Kaminski, 2011)

The relevance of this theory in the realm of Information and Communication Technologies (ICT) is significant, particularly for small and medium-sized enterprises. ICT serves as a crucial tool that can transform how SMEs operate, enabling the automation

of processes, improved information management, and enhanced decision-making (Azam, 2015). Rogers' theory suggests that the adoption of ICT in SMEs depends not only on the availability of technology but also on factors such as the perceived relative advantage of the innovation, its compatibility with existing practices, and ease of use. By understanding how SMEs progress through the stages of innovation diffusion, business leaders can design more effective strategies for ICT implementation (Plana et al., 2006).

On the other hand, Contingency Theory, developed by authors such as Donaldson (2006) and Fiedler (2006), posits that there is no one-size-fits-all approach to organizing a business or implementing technologies. In the context of ICT and operational optimization, this theory suggests that the benefits derived from ICT depend on the specific environment of the firm, such as its size, organizational structure, and the dynamism of the market in which it operates (Thong, 1999). This highlights the importance of strategic alignment between ICT and the company's internal characteristics to optimize performance.

Barney's Resource-Based View (1991) outlines four criteria for resources to provide sustainable competitive advantages (VRIO): they must be Valuable, Rare, Inimitable, and Organized (Fong Reynoso et al., 2017). ICT that meets these criteria can become a strategic resource, enabling SMEs to develop unique capabilities, such as improved service quality, innovation, and flexibility to adapt to market changes (Salgado et al., 2013).

The theories analyzed provide a solid foundation for understanding their strategic impact. Through scientometrics, it is possible to accurately evaluate trends and advancements in research on ICT and how this research discusses their potential contribution to the operational optimization of SMEs.

3. Methodology

Scientometrics is a discipline that employs quantitative methods to analyze scientific production and its impact across various fields of knowledge (Meneghini and Packer, 2010). Introduced by Nalimov

in the 1960s and further developed by authors like Garfield (1972), scientometrics enables the quantification and mapping of production, collaboration, and citation dynamics in academic research (Granovsky, 2001). This approach has proven essential for identifying trends, leading researchers, and emerging areas of focus within different scientific fields.

In this study, scientometrics is applied to the analysis of research on Information and Communication Technologies (ICT) and their impact on the operational optimization of Small and Medium Enterprises (SMEs). This approach allows for an evaluation of how knowledge in this area has evolved, identification of the most influential authors, and the revelation of dominant themes. As highlighted by Leydesdorff (2001) and Van Raan (1996), scientometrics provides a unique perspective on understanding the development and diffusion of scientific innovations in key areas such as ICT and business management.

3.1 Data source and software

To ensure a comprehensive and precise search, a search vector was developed using relevant keywords, logical conjunction connectors, and proximity restrictions applied to articles indexed between 1975 and 2023. This approach enabled the capture of a broad range of studies on Information and Communication Technologies, operational optimization, and their impact on Small and Medium Enterprises. The selection of this time frame ensures coverage of both historical and contemporary advancements in the field.

The process led to the identification of 763 articles, analyzed in detail. The query formulation used was as follows: ((((ALL=("information technology" OR "communication technology" OR "ICT" OR "digital technology" OR "IT" OR "internet technology" OR "technology" OR "tech innovation")) AND ALL=("operational optimization" OR "operational efficiency" OR "process improvement" OR "operational performance" OR "business optimization" OR "business performance" OR "performance improvement")) AND ALL=("SMEs" OR "small

and medium enterprises" OR "small businesses" OR "medium businesses" OR "small companies" OR "medium companies" OR "micro enterprises")) AND DT=(Article)) AND PY=(1975-2023).

This search focused exclusively on articles indexed in the Web of Science database, primarily within the Social Science Citation Index (SSCI), ensuring that the selected studies adhered to the highest standards of peer review. Inclusion and exclusion criteria were applied, selecting only studies that directly addressed the impact of ICT on the operational optimization of SMEs, while excluding duplicate articles or those with insufficient methodological rigor.

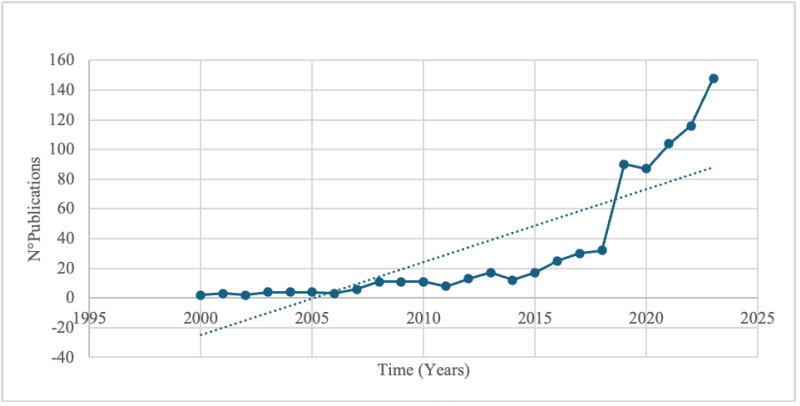
Using VOSviewer (version 1.6.19), co-citation and keyword co-occurrence analyses visualized knowledge structures and collaboration networks, highlighting key contributors and research areas (Van Eck and Waltman, 2010). A temporal analysis traced the evolution of research over time, identifying shifts in the academic narrative on ICT and SME operational optimization (De Solla Price, 1986).

4. Results

4.1. Articles and citations.

Between 2000 and 2023, the analysis of scientific production on Information and Communication Technologies (ICT) applied to operational optimization in Small and Medium Enterprises (SMEs) demonstrates sustained growth. During the early years of the studied period (1996-2010), the number of published articles was relatively low, ranging between 1 and 11 per year. However, from 2011 onwards, interest in digitalization and the adoption of ICT in business processes intensified, driving a steady increase in publications. This growth peaked in 2023, with 148 articles published (see Figure 1).

Graphic 1: Number of articles published per year.



Source: Own elaboration.

The linear regression analysis applied to the growth of academic production yielded the following equation: ART(YEAR) = 4.23201(YEAR) - 8478.785. This formula models the evolution of publications over time, indicating that the number of articles has grown by an average of 4.23 articles per year.

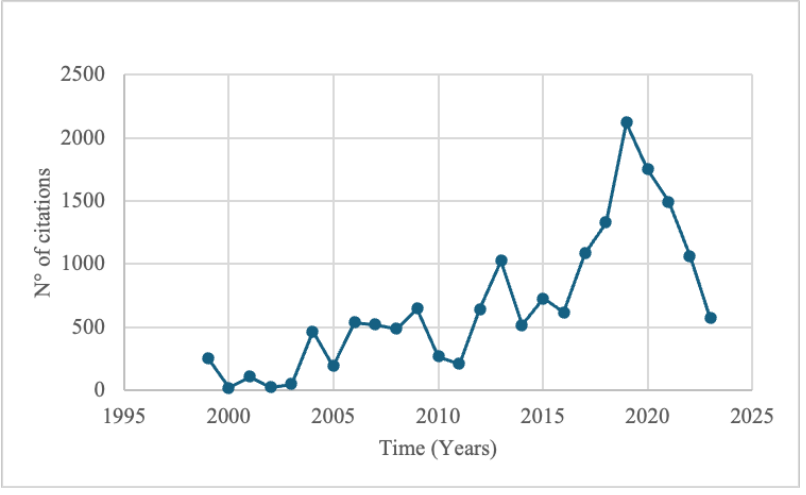
The intercept value, -8478.785, lacks practical significance within the range of years studied, but it is crucial for adjusting the regression line to fit the data. Regarding the model's quality, the R^2 value of 0.6252 suggests that approximately 62.5% of the variability in the number of publications can be explained by the passage of time. This value indicates a significant relationship between time and publication growth, although it also suggests that other factors may influence academic production, such as the development of new technologies or changes in research policies.

The fact that 37.5% of the variability remains unexplained by time opens the door to further studies investigating which additional factors are driving or limiting growth in this field. Such studies might include analyses of the actual adoption of ICT in SMEs or the impact of emerging technologies.

In line, the number of citations reveals that the studies accumulated a total of 16,976 citations. This citation volume

reflects growing academic interest, particularly in recent years. Citations are distributed unevenly over the analyzed period, with a considerably lower number in the early decades (1996-2000), suggesting nascent interest in the topic during that time. However, from 2000 onwards, a sustained increase in citations is observed, peaking between 2019 and 2020, when 2,123 and 1,750 citations were recorded, respectively (see Figure 2).

Graphic 2. Number of citations per year.



Source: Own elaboration.

According to Table 1, when classifying articles by the number of citations, 33.33% of the articles received 50 or more citations, while only 5.26% surpassed the threshold of 200 citations. This suggests that, although the field of ICT and operational optimization in SMEs has accumulated a significant number of citations, most articles have not yet achieved substantial high-impact citation levels.

Table 1. General structure of citations on Information and Communication Technology, Operational Optimization, and Small and Medium Enterprises in WOS.

Number of citations	Number of articles	% of articles
≥ 200 citations	9	1,18%
≥ 150 citations	9	1,18%
≥ 100 citations	15	1,97%
≥ 50 citations	57	7,47%
< 50 citations	673	88,21%
Total	763	100%

Source: Own elaboration.

Of the 763 articles analyzed, 88.23% received fewer than 50 citations, indicating that a significant portion of the publications in this field have yet to achieve widespread recognition or influence within the academic community. However, the fact that 33.33% of the articles received more than 50 citations, and 8.77% were cited over 100 times, demonstrates that there are smaller but key contributions that have had a considerable impact on advancing the field, while a broader majority continues to seek recognition and citations in the literature.

The academic production and citations in the field of ICT applied to operational optimization in SMEs reflect sustained growth in academic interest, potentially influencedby technological advances and structural shifts in the global business environment. Since the early 21st century, the increased digitalization of businesses has generated growing interest in the use of emerging technologies such as big data, cloud solutions, and process automation (Brynjolfsson and McAfee, 2014). This growth accelerated in recent years, partly in response to the COVID-19 pandemic, which forced SMEs to adopt new technologies to optimize their operations and survive in an uncertain economic environment (OECD, 2023). The significant increase in citations between 2019 and 2020 can be

linked to this global context, underscoring the relevance of these studies during times of technological and economic disruption. However, as Lotka (1926) noted, the concentration of citations in a small group of studies is a common phenomenon in emerging fields, where pioneering studies tend to attract more attention. As the field continues to develop, it is expected that a greater number of studies will achieve significant impact, allowing for a deeper understanding of how ICT can continue transforming SMEs' operations.

4.2 Authors

Table 2 reveals considerable variability in terms of productivity and academic impact. Mario Piattini, with 5 specific articles and 82 citations in the area, stands out as the most productive author, with 17% of his total output related to ICT and SMEs, along with an H-index of 36. This indicator is crucial for measuring a researcher's influence and relevance, as it reflects both the quantity and quality of their publications. In Piattini's case, his H-index and total of 5,823 citations confirm his sustained impact on research in ICT applied to SMEs. His work, focused on the integration of ICT to enhance operational efficiency in SMEs, has contributed conceptually to the development of technology management models aimed at resource-constrained organizations, promoting adaptability in dynamic markets.

Conversely, Sascha Kraus, with 202 citations from just 4 articles, stands out for the volume of citations in this area, suggesting a strong impact of his specific works. With an H-index of 68 and over 17,997 total citations, his presence in the field is notable not only for the number of articles but also for his ability to influence other researchers. Kraus's work has spurred new research on the link between technological innovation and sustainability in the SME sector, highlighting technology adoption as a sustainable competitive advantage. This underscores a central principle of scientometrics: authors with a high H-index not only publish frequently but are consistently cited, indicating lasting impact.

However, the fact that an author like Bojan Moric Milovanovic has an H-index of 3 and only 14 citations across 4 articles suggests that, while he has published in the field, his work has yet to gain significant recognition, which could be due to the emerging nature of his research or lack of visibility.

Table 2. Most Influential and Productive Authors on Information and Communication Technology, Operational Optimization, and Small and Medium Enterprises.

R	Author name	TP-TIC-OO-PY	TC-TIC-OO-PY	%TP-TIC-OO-PY	H	TP	TS
1	Piattini, Mario	5	82	17%	36	542	5823
2	Kraus, Sascha	4	202	14%	68	339	17997
3	Yousaf, Zahid	4	140	14%	15	50	872
4	Garcia, Felix	4	80	14%	24	122	1931
5	Pino, Francisco j.	4	80	14%	6	14	148
6	Ramayah, T.	4	36	14%	58	470	12878
7	Milovanovic, Bojan Moric	4	14	14%	3	25	40

Abbreviations: R: author's ranking; TP-TIC-OO-PY: author's total papers on ICT, Operational Optimization and SMEs; TC-TIC-OO-PY: total citations of the author in papers ICT, Operational Optimization and SMEs;%TP-TIC-OO-PY: percentage of author's total papers on ICT, Operational Optimization and SMEs only; H: author's H-index; TP: author's total number of papers; TC: total number of citations per author. Source: Own elaboration from Web of Science

The percentage of articles each author dedicates to ICT and SMEs in relation to their total output also provides valuable context. While most authors devote an average of 14% of their work to this field, higher productivity in individuals like Piattini suggests a more specialized focus, potentially explaining their greater influence in the area. In contrast, authors such as Ramayah T., with an H-index of 58 and 12,878 citations overall, but whose citations in ICT and SMEs are more modest (36 citations), reveal that while they are influential researchers, their primary impact extends to other research domains.

On the other hand, collaboration among authors reveals a limited structure in terms of academic cooperation. With only one cluster identified and a total link strength of 12, the level of collaboration between authors is notably low compared to more established fields. This result suggests that, although the field is growing, researchers tend to work more individually or in small groups, which could indicate an initial or fragmented phase in the development of research.

This phenomenon is characteristic of emerging fields, where collaboration networks have not yet fully consolidated. A low link strength may be associated with a lack of platforms or incentives that promote academic cooperation across institutions or geographical regions (Wagner and Leydesdorff, 2005). Therefore, for this field to evolve more rapidly, fostering greater collaboration between institutions and expanding cooperation networks among researchers will be essential.

4.3 Journals

The top 10 most influential journals in the area of Information and Communication Technologies (ICT), operational optimization, and SMEs are highlighted in Table 3. *Sustainability* leads the list with 53 articles, representing 6.9% of the total, and has accumulated 708 citations. With an H-index of 169 and an Impact Factor (IF) of 3.3, this journal stands out as one of the main platforms for disseminating research related to sustainability, ICT, and operational optimization in SMEs. Its relevance is reflected both in the volume of publications and the number of citations it receives, underscoring its ability to attract high-impact research.

Table 3. Most influential journals on Information and Communication technology, Operational Optimization and Small and Medium Enterprises

R	Journal	TP-TIC-OO-PY	TC-TIC-OO-PY	TLS	763%	H (*)	TP (*)	TC (*)	FI
1	Sustainability	53	708	5582	6,90%	169	30,833	229,213	3.3
2	Journal Of Manufacturing Technology Management	16	642	1795	2%	93	125	4,581	7.3
3	Journal Of Cleaner Production	13	726	1793	2%	248	10,567	317,153	9.7
4	Management Decision	13	488	2868	2%	109	274	10,185	4.1
5	Journal Of Asian Finance Economics And Business	13	67	1251	2%	24	3,941	4,327	*
6	Quality-Access To Success	10	9	640	1%	17	405	767	0.5
7	Industrial Management & Data Systems	9	848	676	1%	120	234	7,848	4.2
8	Small Business Economics	8	1027	821	1%	143	347	13,841	6.5
9	Technological Forecasting And Social Change	8	152	1639	1%	146	1,623	50,363	12.9
10	Benchmarking-An International Journal	8	95	1023	1%	65	363	5,425	4.5

Abbreviations: R: Ranking; TP-TIC-OO-PY: total number of papers with only ICT, Operational Optimization and SMEs; TC-TIC-OO-PY: total number of citations with only ICT, Operational Optimization and SMEs; TLS: Total link strength; TP(*): total number of papers in the journal (1975-2023); TC(*): Total number of citations in the journal (1975-2023); .H(*): H-index of the journal; FI: Impact factor of journal on 2023. Source: Own elaboration

Journal of Manufacturing Technology Management ranks second, with 16 articles and 642 citations. With an IF of 7.3 and an H-index of 93, this journal focuses on the implementation of ICT in the manufacturing sector, which is crucial for the operational optimization of SMEs. Despite having fewer articles, its strong presence in terms of citations and impact factor demonstrates its importance in the application of ICT to production processes.

In third place is Journal of Cleaner Production, which, although it has only 13 articles, has accumulated 726 citations, demonstrating the high impact of its publications. With an H-index of 248 and an IF of 9.7, this journal is notable for its focus on environmentally conscious and business efficiency, two key areas for SMEs seeking to integrate ICT to improve their operational performance.

Other journals such as Management Decision, Technological Forecasting and Social Change, and Small Business Economics also have a significant presence, although with fewer specific publications on ICT and SMEs. These journals show a trend towards interdisciplinarity, addressing topics related to technological foresight, business economics, and decision-making in environments of high uncertainty.

Of the 763 articles, 25 Web of Science (WoS) categories were identified, with Management (38%) and Business (32%) standing out the most (see Table 4). This emphasis reflects the importance of ICT in improving the management and operational optimization of SMEs, a central focus in influential journals such as Sustainability and Journal of Manufacturing Technology Management. These categories concentrate the majority of scientific production, underscoring the relevance of ICT in business administration and operational efficiency, which are critical areas for the growth and competitiveness of SMEs.

Table 4. Web of Science Categories Associated with Scientific Production

N	Web of Science Categories	Record Count	% of 763	% Accumulated
1	Management	291	38	38%
2	Business	244	32	70%
3	Economics	89	12	82%
4	Environmental Sciences	73	10	92%
5	Green Sustainable Science Technology	72	9	101%
6	Environmental Studies	70	9	110%
7	Engineering Industrial	62	8	118%
8	Engineering Manufacturing	33	4	122%
9	Computer Science Software Engineering	27	4	126%

Source: Own Elaboration.

In terms of organizations associated with scientific production in this field (see Table 5), there is a notable presence of academic institutions from Malaysia, with universities such as Universiti Utara Malaysia, Universiti Sains Malaysia, and Universiti Teknologi Malaysia leading the production with between 9 and 11 articles and a considerable number of citations. This highlights Malaysia's role as an important hub for research on ICT applied to operational optimization in SMEs, aligning with the Management and Business categories.

At an international level, institutions such as Cardiff University in England and Universidad de Castilla-La Mancha in Spain also have a significant impact. Although Cardiff has only contributed 6 articles, these have generated 419 citations, indicating a high level of influence in the field. This suggests that, while most articles come from Asia, certain European institutions have achieved substantial recognition in terms of scientific impact and visibility.

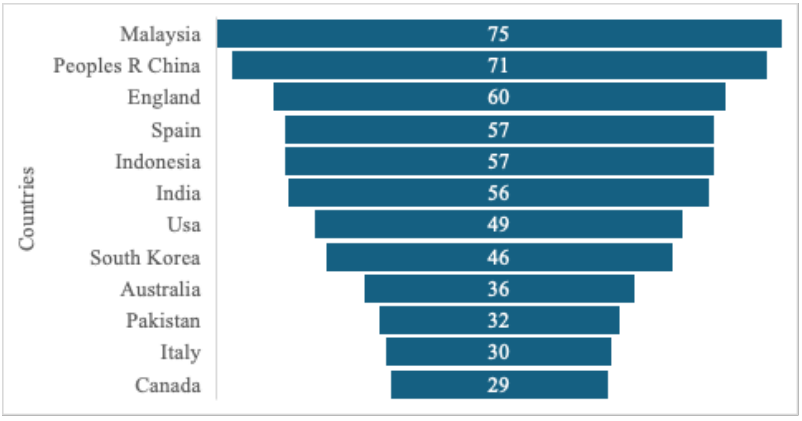
Table 5. Organizations Associated with Scientific Production, Based on Author Affiliation.

R	Oranizations	Country	Record	Citations
1	Univ Utara Malaysia	Malaysia	11	121
2	Univ Sains Malaysia	Malaysia	10	112
3	Univ Teknol Malaysia	Malaysia	9	109
4	Univ Kebangsaan Malaysia	Malaysia	9	67
5	Univ Castilla La Mancha	Spain	8	135
6	Univ Islam Indonesia	Indonesia	8	40
7	Cardiff Univ	England	6	419
8	Univ Malaysia Kelantan	Malaysia	6	112
9	Yeungnam Univ	South Korea	6	48
10	Shanghai Jiao Tong Univ	China	5	391

Source: Own Elaboration

Malaysia clearly leads in terms of the total number of scientific publications, with 75 documents and 1,008 citations, representing 9.8% of the total (see Figure 3 and Table 6). It is followed by China, with 71 documents and a higher citation impact (1,472), accounting for 9.3% of total production. England, with 60 documents, stands out with a high volume of citations (3,140), reflecting significant academic impact with 7.9% participation. Spain and Indonesia also play important roles, each contributing 57 documents, accounting for 7.5% of the total scientific production.

Graphic 3. Total Number of Publication by Country. Source: Own Elaboration.



Source: Own elaboration.

Table 6. Countries Associated with Scientific Production, According to Author Affiliation.

R	Country	Record Count	Citations	% of 763
1	Malaysia	75	1008	9,8%
2	Peoples R China	71	1472	9,3%
3	England	60	3140	7,9%
4	Spain	57	1436	7,5%
5	Indonesia	57	362	7,5%

Source: Own Elaboration.

The country-based analysis reveals that while most academic production originates from Asia, particularly Malaysia and China, the impact of England and Spain in terms of citations is substantial. This pattern suggests that international collaborations and the quality of research emerging from Europe have had greater visibility and academic influence, which could be linked to higher visibility and stronger participation in global academic networks.

Table 7. Top 10 Articles with Highest Citations.

N°	Authors	Article Title	Publication Year	Source Title	Cited Reference
1	Hossain, K; Abdullah, ASC; Balwi, MAFM; Lubis, A; Azizan, NA; Alam, MN; Taha, AZ	Linking entrepreneurial orientation with export performance: mediation effects of multiple differentiation strategies	2023	Journal Of Business & Industrial Marketing	269
2	Rafiki, A; Nasution, MDTP; Rossanty, Y; Sari, PB	Organizational learning, entrepreneurial orientation and personal values towards SMEs' growth in Indonesia	2023	Journal Of Science And Technology Policy Management	264
3	Asiaei, A; Ab Rahim, NZ	A multifaceted framework for adoption of cloud computing in Malaysian SMEs	2019	Journal Of Science And Technology Policy Management	256
4	Mohamed, MA; Abdul-Talib, AN; Ramlee, A	Determinants of the firm performance of returnee entrepreneurs in Somalia: the effects of external environmental conditions	2022	Journal Of Enterprising Communities-People And Places In The Global Economy	219
5	Rahman, MS; AbdelFattah, FA; Bag, S; Gani, MO	Survival strategies of SMEs amidst the COVID-19 pandemic: application of SEM and fsQCA	2022	Journal Of Business & Industrial Marketing	195
6	Gallardo-Vázquez, D; Valdez-Juárez, LE; Castuera-Díaz, AM	Corporate Social Responsibility as an Antecedent of Innovation, Reputation, Performance, and Competitive Success: A Multiple Mediation Analysis	2019	Sustainability	191

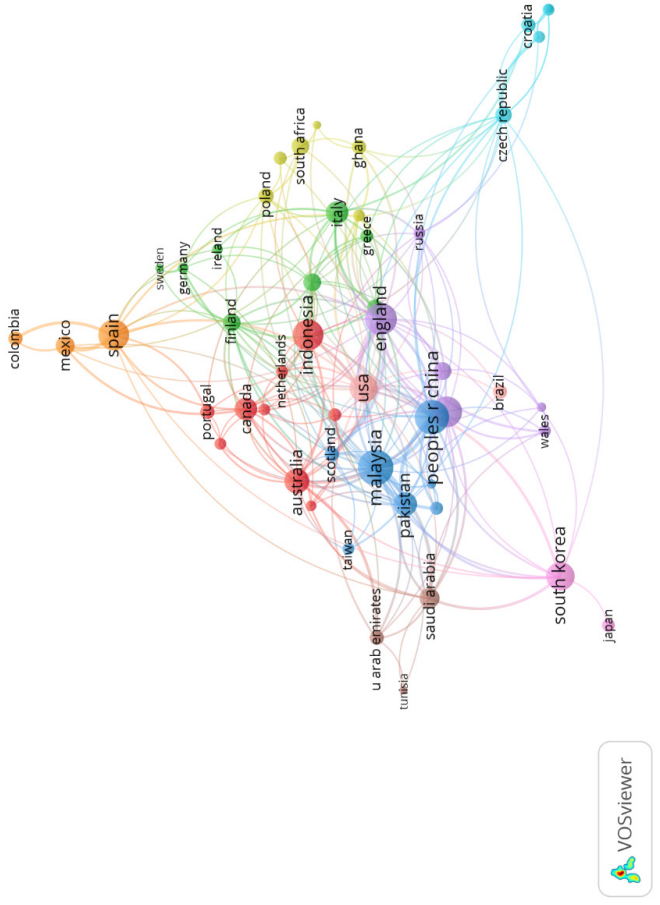
N°	Authors	Article Title	Publication Year	Source Title	Cited Reference
7	Mokhtarzadedeh, NG; Jafarpanah, I; Babgohari, AZ	Knowledge management capability, entrepreneurial creativity, entrepreneurial intensity and firm performance: the mediating role of ambidexterity	2022	British Food Journal	184
8	Rubio-Andrés, M; Ramos-González, MD; Sastre-Castillo, MA; Gutiérrez-Broncano, S	Stakeholder pressure and innovation capacity of SMEs in the COVID-19 pandemic: Mediating and multigroup analysis	2023	Technological Forecasting And Social Change	183
9	Ngo, QH	The Impact of Entrepreneurial Orientation on SMEs' Performance in a Transitional Economy: The Mediating Role of Differentiation Advantages and Innovation Capability	2023	Sage Open	180
10	Nguyen, PV; Huynh, HTN; Lam, LNH; Le, TB; Nguyen, NHX	The impact of entrepreneurial leadership on SMEs' performance: the mediating effects of organizational factors	2021	Heliyon	176

Source: Own Elaboration.

Among the top 10 most-cited articles (see Table 7), recent studies addressing key themes such as entrepreneurial orientation, export performance, and the survival strategies of SMEs during the COVID-19 pandemic stand out. The most-cited paper, with 269 citations, is by Hossain et al. (2023), which explores the relationship

between entrepreneurial orientation and export performance in SMEs, followed by Rafiki et al. (2023) with 264 citations. These studies not only lead in citation count but are also closely tied to the increasing h-index of their authors and the journals in which they were published, underscoring their academic impact and relevance to the evolution of this field.

Figure 1. Co-authorship Map among Countries.



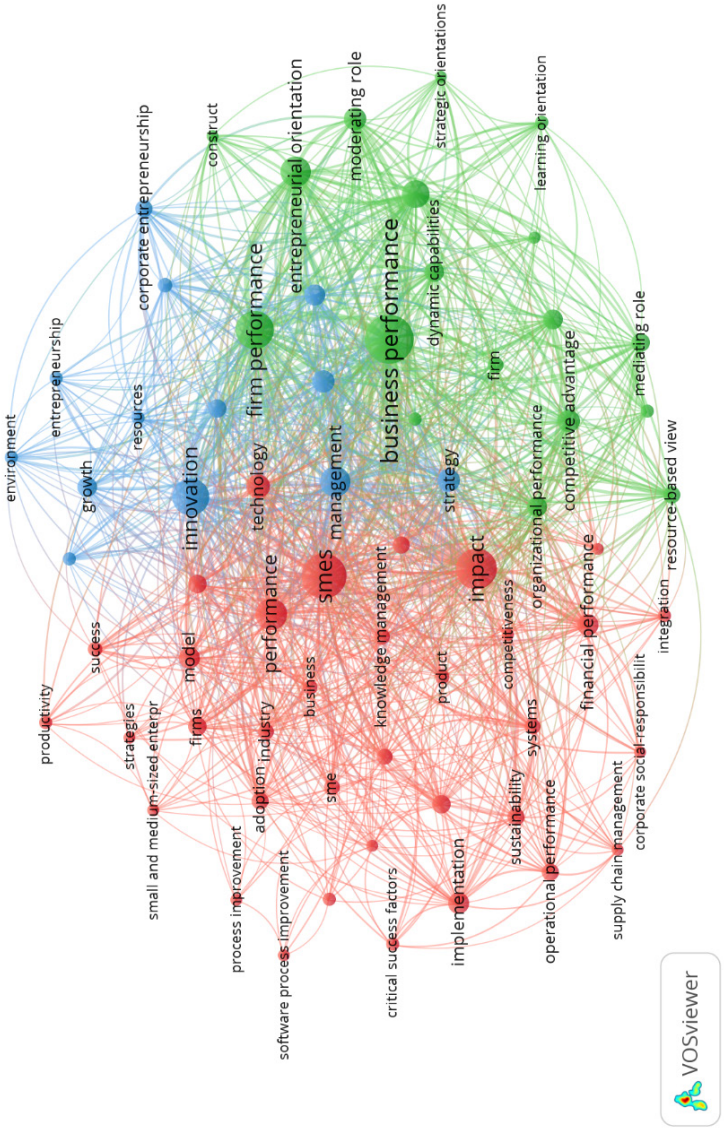
Source: Own elaboration.

Additionally, the co-authorship map (see Figure 4) highlights the importance of international collaboration, with Malaysia, China, England, Spain, and Indonesia emerging as key hubs of scientific production in this field. With 244 links and a total link strength of 436, the map reveals a robust structure of cooperation among these countries. Such international collaboration is crucial for enhancing the h-index of authors and countries involved, as it facilitates the global dissemination of research, subsequently increasing citations and visibility. This well-established co-authorship network is essential for driving competitiveness in research on ICT and operational optimization in SMEs.

4.4 Keywords

The co-occurrence analysis of keywords reveals a well-defined structure that highlights the main themes in the scientific production on Information and Communication Technologies (ICT), operational optimization, and Small and Medium Enterprises (SMEs) (see Figure 5). Of the 3,020 keywords present in the analyzed articles, only 66 meet the minimum threshold of 20 occurrences, indicating their relevance in the field. The co-occurrence map shows a network of 1,731 links with a total link strength of 10,719, reflecting a robust thematic interconnection within the literature.

Figure 2. Co-occurrence Map of Keywords Usage.



Source: Own elaboration.

Cluster 1 (Red) is composed of terms such as "adaption," "business," "competitiveness," "corporate social responsibility," "information technology," and "sustainability," highlighting the integration of ICT within the business sector and its impact on SME performance and sustainability. This cluster is clearly related to operational optimization, emphasizing terms like "operational performance," "process improvement," and "strategies," which indicate that the literature in this cluster focuses on how SMEs can enhance their competitiveness through the adoption of digital technologies and best management practices. The high occurrence of keywords such as "SMEs," "success," and "supply chain management" underlines the practical and business-oriented focus of this cluster, aligning with studies that explore operational efficiency and sustainability.

Cluster 2 (Green) focuses more on strategic aspects and organizational orientation. Key terms such as "competitive advantage," "dynamic capabilities," "entrepreneurial orientation," and "firm performance" indicate a particular interest in the internal capabilities that enable SMEs to be more competitive. This cluster is linked to concepts of competitive advantage, indicating that research here centers on how SMEs can leverage their resources and capabilities to innovate and grow in increasingly dynamic markets. Moreover, the presence of terms such as "learning orientation" and "market orientation" suggests that this thematic group explores how SMEs can adapt and learn to improve their performance.

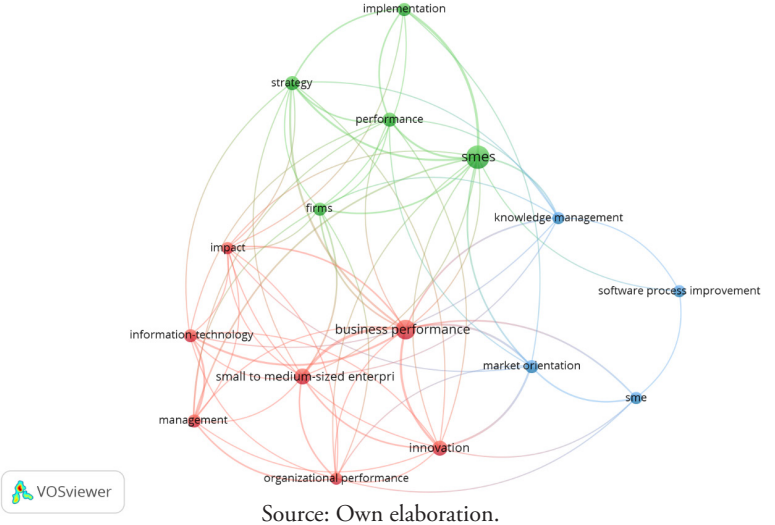
Cluster 3 (Blue) comprises terms like "absorptive capacity," "corporate entrepreneurship," "innovation," "knowledge," and "research-and-development," emphasizing the role of innovation and knowledge as drivers of business growth. This cluster highlights the importance of absorptive capacity and innovation strategies in SMEs, exploring how these companies can utilize knowledge and R&D to maintain competitiveness in a rapidly changing technological environment.

The evolution of key terms across periods reflects a shift in research focus. By dividing the analysis into two time frames, 1975-

2011 and 2012-2023, we observe how the research focus has shifted from operational approaches to broader strategies centered on innovation and environment-minded.

During the 1975-2011 period (see Figure 6), the number of keywords was limited (16 items, 73 links), reflecting a focus on the implementation of ICT and organizational performance. This early stage of technological adoption in SMEs concentrated on how ICT could improve operational and organizational efficiency.

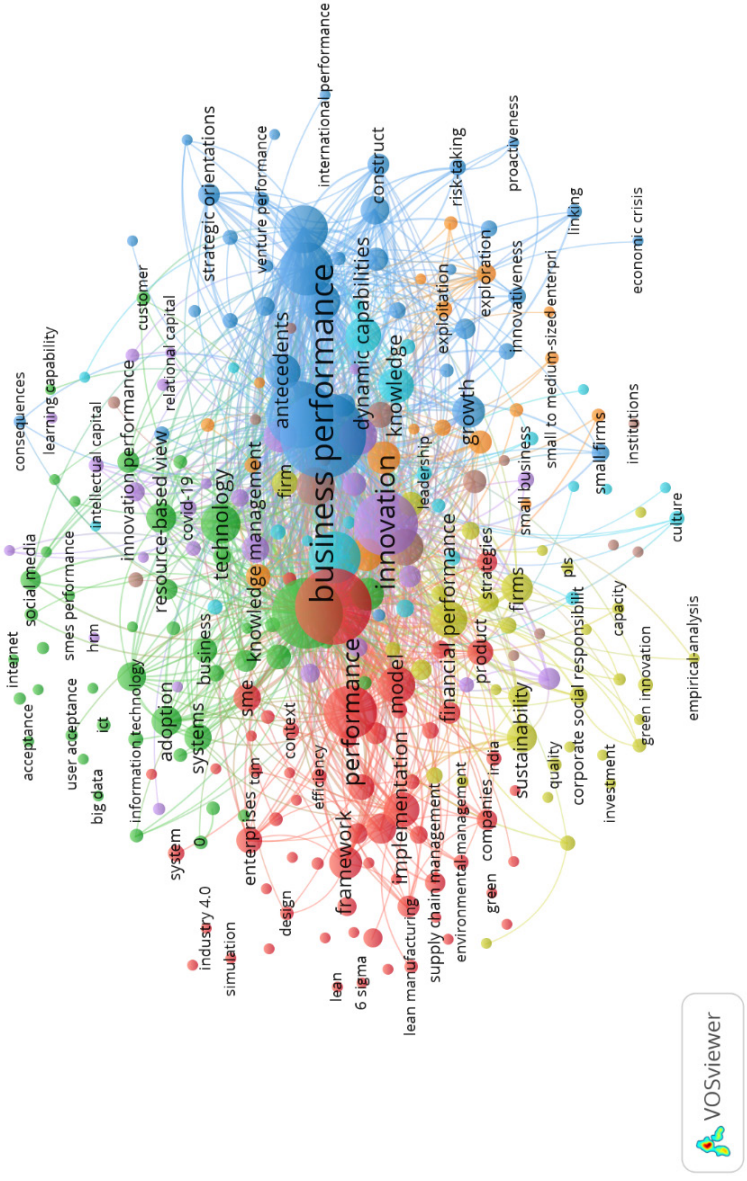
Figure 3. Keywords co-occurrence network map for 1975 to 2011.



Source: Own elaboration.

In contrast, the 2012-2023 period (see Figure 7) shows exponential growth in the number of keywords (262 items, 8,470 links), with terms such as sustainability, dynamic capabilities, innovation strategies, and entrepreneurial orientation taking center stage. This thematic shift suggests that ICT is no longer merely seen as a tool for improving operations but as a key driver for strategic transformation and sustainable growth in SMEs within a globalized and competitive business environment.

Figure 4. Keywords co-occurrence network map for 2012-2023.



Source: Own elaboration.

5. Discussion

This scientometric analysis sheds light on how the academic discourse surrounding ICT and SMEs evolved over time, offering a comprehensive view of how academic contributions have addressed this intersection over the past two decades. The findings reveal how academic literature has increasingly portrayed ICT as evolving from an operational tool to a strategic enabler of competitiveness, sustainability, and resilience, demonstrating its profound impact on SMEs' performance and adaptability.

A detailed review of publication and citation trends highlights notable peaks in academic output, driven by global technological and economic shifts. The steady rise in publications after 2011 correlates with the proliferation of big data, cloud computing, and mobile technologies, which have expanded SMEs' ability to optimize operations. The surge in publications during the COVID-19 pandemic (2020–2021) reflects a growing academic focus on the potential role of ICT in supporting business continuity during crises, particularly through tools for remote work and e-commerce (OECD, 2023). This analysis reaffirms the essential role of ICT in addressing both immediate challenges and long-term strategic needs in SMEs.

The co-citation and keyword co-occurrence analyses reveal distinct thematic clusters, reflecting the shift in research focus over time. Initially, studies centered on ICT's operational benefits, such as process efficiency and cost reduction (Love and Roper, 2015). More recent works emphasize innovation, dynamic capabilities, and sustainability, aligning with theoretical frameworks like Rogers' Diffusion of Innovations Theory (2003) and Barney's Resource-Based View (1991). These theories suggest ways in which SMEs could leverage ICT to enhance competitive advantages through adaptability and innovation, as discussed in the academic literatura.

The analysis of authors, journals, and institutional affiliations offers critical insights into the academic ecosystem surrounding ICT and SMEs. Prominent contributors such as Piattini and Kraus have shaped the discourse, while journals like *Sustainability* and *Journal*

of Cleaner Production serve as influential dissemination platforms. Despite these advancements, collaboration networks remain relatively weak, with limited co-authorship clusters, particularly across regions. Strengthening these networks could potentially enhance the global impact and integration of research findings, particularly in the academic domain.

From a geographic perspective, the dominance of countries like Malaysia, China, and England reflects strong governmental support for ICT adoption, as seen in initiatives like the Malaysia Digital Economy Blueprint (2021) and China's "Made in China 2025" (Xing and Shengjun, 2020). In contrast, regions such as Latin America and Africa face systemic barriers, including unequal access to technology and limited research funding, which constrain both the production of scientific research and the documented academic discussion about ICT adoption. Addressing these disparities is essential for fostering equitable progress in ICT-enabled SME growth.

While this study provides a comprehensive overview, it is not without limitations. The exclusive reliance on the Web of Science (WoS) database and English-language publications excludes valuable contributions from other sources and linguistic contexts, potentially skewing the analysis. Furthermore, a significant portion of knowledge related to ICT adoption in SMEs is produced outside peer-reviewed academic journals. Technical reports from national statistical agencies and international organizations—such as the International Labour Organization (ILO), the Economic Commission for Latin America and the Caribbean (ECLAC), the Economic and Social Commission for Western Asia (ESCWA), the Economic and Social Commission for Asia and the Pacific (ESCAP), among others—often contain detailed empirical data, implementation case studies, and context-specific analyses of barriers and enablers. These sources are particularly crucial in low- and middle-income regions, where publishing in high-impact English-language journals remains structurally constrained. By relying exclusively on WoS, this study inherently prioritizes countries and

institutions with greater access to indexed publishing, reinforcing global academic asymmetries and potentially overrepresenting theoretical discourses while underrepresenting practical realities. As a result, the scientometric map constructed here may reflect not only what has been studied, but also who has had the power, visibility, and infrastructure to publish—introducing a structural bias into the findings. This highlights the need to interpret these results as a reflection of academic discourse rather than a mirror of real-world ICT adoption among SMEs globally.

Future research should broaden the scope to include alternative databases and non-English studies, ensuring a more inclusive perspective. Investigating ICT's role in fostering circular and sustainable business models is also crucial, particularly in regions where digital transformation is constrained by structural inequalities. Moreover, the potential of emerging technologies like artificial intelligence, blockchain, and advanced analytics warrants deeper exploration to uncover their transformative impact on SMEs.

This study maps the academic landscape of ICT in SMEs and highlights potential directions for future research and policy discussions, while acknowledging the gap between scholarly focus and real-world application. By identifying key trends, gaps, and collaboration patterns, it provides a foundation for enhancing the strategic integration of ICT in SMEs globally. Policymakers and practitioners can leverage these findings to design targeted interventions that address specific regional and sectoral challenges.

In conclusion, this scientometric analysis elevates the understanding of ICT's critical role in SMEs, paving the way for more inclusive and impactful research. Fostering global collaboration and addressing research gaps may help better understand ICT's potential as a driver of innovation, resilience, and sustainability, particularly within the academic sphere.

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