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Financial and Technological Literacies: An Integrated Systematic Review Using PRISMA Workflow, Bibliometric Analysis and TCCM Framework for Future Research Agenda

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Abstract

This bibliometric analysis utilizes the Theory–Characteristics–Context–Methodology (TCCM) framework to elucidate the dynamic interplay between finance and technology within scholarly research. The investigation is anchored on the PRISMA guidelines for article selection and employs VOSviewer for rigorous data scrutiny. A total of 160 scholarly articles, spanning from 2001 to 2023, form the corpus of this study, offering a robust temporal perspective on the development of Financial and Technological Literacies (FTL). The analytical approach adopted here integrates bibliometric and network analyses to delineate critical themes, identify influential authors, and recognize nascent FTL literature trends. This research uncovers significant gaps within the FTL discourse, especially concerning cross-cultural applicabilities and sector-specific comparisons, which underscore the complexity and diversity of financial and technological integration across different economic and cultural landscapes. Furthermore, the study presents 16 targeted recommendations to enrich future research trajectories. These suggestions highlight the need for expansive empirical studies and the value of longitudinal research designs to track evolutionary trends and deepen understanding. This study furnishes comprehensive insights that are instrumental for educators, policymakers, and researchers engaged in the continuously evolving field of FTL through the meticulous integration of theoretical frameworks, data analysis tools, and systematic literature review protocols.

Keywords: Bibliometric Analysis, TTCM Framework, Financial Literacy, Technological Literacy, Systematic Literature Review.

Introduction

In contemporary society, the integration of FTL emerges as an essential driver of individual and business advancement (Ye & Kulathunga, 2019). Financial literacy empowers people as individuals and business practitioners with the skills necessary to navigate financial intricacies, including responsible budgeting, informed investment decisions, and effective debt management. This proficiency fosters individual financial stability and contributes to

broader economic resilience (Lusardi & Mitchell, 2013). Simultaneously, technological literacy has become increasingly pivotal in a world characterized by rapid digital innovation, enabling individuals to adapt to and leverage technological advancements effectively (Li & Yang, 2022). The interconnection between FTL becomes particularly significant as financial services progressively integrate with technology. Individuals and business practitioners require a solid understanding of financial principles and technological tools to engage effectively with digital platforms, online transactions, and emerging fintech solutions (Molina-García et al., 2022; Siddiqui & Liaquat, 2022). This convergence facilitates seamless engagement with digital financial solutions, enhancing access and efficiency in financial transactions.

A symbiotic relationship between FTL that extends beyond individual proficiency is the determining factor of success and sustainability in the business world (Kurniasari et al., 2023). Financial literacy is the fundamental basis for effective business management, encompassing critical skills such as budgeting, financial analysis, investment decision-making, and risk management (Kulathunga et al., 2020). Concurrently, technological literacy drives innovation and efficiency within companies, enabling the integration of advanced technologies, automation, and data analytics to streamline operations and enhance productivity (Kulathunga et al., 2020).

The convergence of FTL is exemplified in the rise of fintech – a rapidly growing sector that leverages technology to deliver financial services innovatively. Fintech transforms the conventional processes of financial operations and enables improvements in business transaction management, financial supervision, and customer interaction (Koskelainen et al., 2023). Businesses that use fintech solutions are better able to take advantage of new possibilities, adjust to changing market conditions, and stay competitive in the digital age (Hahm et al., 2021).

Over time, the evolution of FTL has become intertwined with the broader trajectory of business practices, reflecting a shift from traditional financial management towards a technology-driven landscape (Kirmani et al., 2015). Initially, financial literacy focused on basic accounting principles and fiscal responsibility, equipping businesses with foundational knowledge for financial stability. As technology advanced, the importance of technological literacy emerged, with businesses needing to understand and embrace innovations such as computerization and early forms of automation (Mabula & Ping, 2018).

In recent decades, the financial literacy and the technological literacy intersection has accelerated, marking a transformative era in business practices. Financial operations have been transformed by the internet, big data analytics, and cloud computing, which have made data accessible in real time and enabled data-driven decision-making (Chatterjee et al., 2021; Gupta & Krishnamurti, 2020).

Comprehensive understandings of the junction of FTL and its combined influence on decision-making processes are still developing, despite the growing recognition of their significance. Addressing this gap is crucial for promoting economic empowerment, fostering digital inclusion, and mitigating risks associated with technological advancements (Olaleye et al., 2023).

In addition to exploring the convergence of FTL, this study examines existing reviews and research within each domain. Table 1 reviews financial literacy from 2000 to 2023, showcasing the breadth of literature in this area. Conversely, Table 2 summarizes reviews in the technological literacy domain for the same period, highlighting the comparatively limited research attention received by technological literacy. Despite the growing recognition of the importance of both literacies, a persistent need remains for further exploration and

refinement of their intersection. Tables 1 and 2 serve as valuable references for understanding the existing literature landscape on FTL research.

Table 1
Summary of reviews in the financial literacy domain (2000-2023)

No	Author(s)	Scope of The Review	Type of Study
1	Koskelainen et al. (2023)	Financial literacy in digital age	Meta Analysis
2	Molina-García et al. (2022)	Financial Literacy in SME	Review
3	Ståhl et al. (2021)	Social insurance literacy	Review
4	Compen et al. (2019)	Impact of Teacher professional development on financial literacy	Review
5	Santini et al. (2019)	Factors and outcomes of financial literacy	Meta Analysis
6	Peeters et al. (2018)	Evaluation of group based financial education and counselling programmes	Review, Conceptual
7	Burrus et al. (2018)	Effectiveness of interventions in developing adolescents' skills for adulthood	Review
8	Steinert et al. (2018)	Impact of saving promotion interventions in consumption and investments	Review, Meta analysis
9	Aspinall et al. (2018)	Sustainability and financial system	Review
10	Kaiser & Menkhoff (2016)	Influence of education in finance on financial literacy and consequently behaviour	Meta analysis
11	Drever et al. (2015)	Role of parental socialisation, executive education and experience based financial education in youth and children	Review
12	Fernandes et al. (2013)	Impact of financial literacy and financial education on financial behaviour	Meta analysis
13	Miller et al. (2015)	Impact of financial education on financial literacy and behaviour	Meta analysis
14	Hastings et al. (2013)	Measuring financial literacy, financial education impact and financial outcomes	Review
15	Remund (2010)	Definitions and measures of financial literacy	Review, Conceptual
16	Huston (2010)	Measures of financial literacy	Review, Conceptual
17	Collins & O'rourke (2010)	Effectiveness of financial education and counselling programmes	Review

Note: Develop by Authors

At a glance, the gap is the lack of investigation into CEOs' financial literacy and its influence on technological innovation initiatives within Small Medium Enterprises (SMEs). More research is required to understand how CEOs' financial literacy affects SMEs' adoption and efficient use of technology for innovation and growth, even if there is already a body of knowledge on technological literacy in education and financial literacy in SMEs.

Table 2
Summary of reviews in the technological literacy domain (2000-2023)

No	Author(s)	Scope of The Review	Type of Study
1	Duréndez et al. (2023)	CEO's financial literacy on SMEs technological innovation	Quantitative
2	Suyanto et al. (2023)	Technological Literacy Studies in Education	Review, Meta analysis
3	Campanozzi et al. (2023)	Digital literacy in achieving health equity in the third millennium society	Review
4	Tegegne et al. (2022)	Adoption of Information Communication Technology in Ethiopian Healthcare Systems	Review
5	Nes et al. (2021)	Technological literacy in nursing education	Review
6	López et al.(2020)	Transmedia literacy and social networks	Case study
7	Yeow & Chua (2020)	Technology-vendor selection	Case Study
8	Uwamariya et al. (2020)	Mobile banking impact	Case Study
9	Reddy et al. (2020)	Digital literacy	Review
10	Gibson et al. (2018)	Information journey in the twenty-first century	Review
11	Du (2017)	Indigenous people and development ICT	Review
12	Chen et al. (2015)	Information and Communication Technology (ICT)	Review
13	Ghavifekr et al. (2013)	ICT Application for Administration and Management	Review
14	Alinaghian et al. (2011)	ICT Policy	Review
15	Tearle et al., (1998)	Information and technology in Higher education	Case Study

Note: Develop by Authors

To bridge this gap, this article presents a comprehensive bibliometric analysis aimed at identifying and analyzing existing knowledge on FTL and the prospects for future research. By leveraging the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) and TCCM (Theory, Context, Characteristics, and Methodology) frameworks, this study aims to provide structured insights into the concept and knowledge of FTL, particularly in the context of entrepreneurship (Donthu et al., 2021; Molina-García et al., 2022; Mukherjee et al., 2022).

This study will provide valuable insights into the development of financial and technological literacy tailored to entrepreneurs' needs and realities. Therefore, the following research questions guide this study:

RQ1. What is the research on FTL publication trends?

RQ2. Which authors, countries, and institutions are the most prolific in FTL publications?

RQ3. What is the knowledge structure of FTL?

RQ4. What are the prospective research avenues in FTL according to the TCCM framework?

The paper proceeds as follows: a comprehensive literature review providing an overview of the existing FTL research. The research method detailing the data collection, analysis, and interpretation process. Next, the research findings discuss the bibliometric analysis result, shedding light on the publication trends, key authors, countries, institutions, and knowledge structures in FTL. Based on these findings, a detailed discussion addresses the research questions and outlining potential avenues for further research. Finally, conclusions show the key findings and highlighting the significance and also limitations of the study.

Literature Review

This article extensively explores the intertwined financial literacy and technological literacy domains, delving into their theoretical foundations, practical implications, and avenues for future research. Drawing from a rich tapestry of scholarly literature, this review provides a comprehensive understanding of the complex dynamics shaping contemporary discourse surrounding FTL.

Financial Literacy

The foundation of economic empowerment is financial literacy, which equips people with the information and abilities to successfully negotiate the complex worlds of both personal and business finance. Defined by Adomako et al (2016) as the cognitive capabilities necessary for effective financial management, financial literacy encompasses various competencies encompassing budgeting, investment decision-making, risk mitigation, and strategic planning. Various theoretical frameworks shed light on the multifaceted nature and practical implications in the discussions surrounding financial literacy. As elucidated by Kulathunga et al (2020), Agency Theory delves into the complex relationships between principals and agents within organizational contexts, highlighting the way the financial literacy of decision-makers influences strategic decision-making processes and organizational outcomes. Eniola and Entebang (2017) assert the psychological underpinnings of financial decision-making, offering insights into how cognitive biases and heuristics shape individuals' financial behaviors.

The significance of financial literacy extends beyond personal finance to encompass the realm of SMEs, where it plays an important role in driving business success and sustainability. Numerous studies, including those by Babajide et al (2023); Owusu et al (2019), underscore the significant correlation between financial literacy and SME performance, highlighting its importance in enhancing financial management practices, decision-making processes, and overall business resilience.

Despite its critical importance, SMEs often need more access to formal financial education and resources to attain and apply financial literacy. Addressing these challenges requires targeted interventions, such as financial education programs and mentorship initiatives, as advocated by (Resmi et al., 2021; Ye & Kulathunga, 2019). Policymakers are urged to design policies promoting financial literacy among SME owners, recognizing its potential to foster economic growth and alleviate poverty.

Moreover, the impact of financial literacy extends beyond business enterprises to broader socio-economic development. As García-Pérez-de-Lema et al (2021) underscored, enhanced SME owners' financial literacy levels have the power to stimulate inclusive and sustainable development outcomes through accelerating economic growth, job creation, and poverty reduction.

Thus, investments in financial literacy initiatives yield manifold dividends at both individual and societal levels, underscoring the imperative of continued research and intervention in this domain.

Technological Literacy

Parallel to the rapid advancements in financial literacy, technological literacy has emerged as an indispensable skill set for individuals and organizations navigating the challenges of the modern digital world. Rooted in the understanding and application of technology, technological literacy encompasses diverse competencies, from basic digital skills to advanced data analysis and information management capabilities.

At the crux of technological literacy discussions are theoretical frameworks that elucidate its conceptual foundations and practical implications. Diffusion of Innovations Theory, proposed by Everett Rogers and discussed by Bowen and Johnson (2018), offers insights into the adoption and spread of new technologies within society, highlighting the role of perceived attributes and social influences in shaping individuals' attitudes toward technology adoption. As applied to technological literacy, information processing theory explores the cognitive processes involved in acquiring, interpreting, and applying technology-related information. This theory, discussed by Mabula & Ping (2018), sheds light on how individuals' cognitive abilities influence their understanding and utilization of technology, thereby influencing their technological literacy levels.

Moreover, Technological Determinism Theory suggests that technology plays a fundamental role in shaping societal norms and behaviors (Piabuo et al., 2017). In the context of technological literacy, this theory underscores the transformative power of technology in reshaping individuals' interactions with the world and driving societal change.

The importance of technological literacy extends beyond individual skill sets to organizational capabilities and societal development. As emphasized by Arvanitis et al (2016), the adoption of ICT not only enables organizations to enhance their operational efficiency and streamline communication channels but also provides them with the opportunity to access global markets, thereby fostering economic growth. However, challenges persist, particularly in developing nations, where enterprises often lack the necessary expertise and resources to leverage technology effectively.

Addressing these challenges requires concerted efforts from policymakers, industry stakeholders, and educational institutions to promote digital inclusion and foster technological literacy among businesses. Initiatives such as ICT training programs, digital literacy campaigns, and technology-focused entrepreneurship initiatives hold the potential to bridge the digital divide and empower individuals to harness the transformative power of technology for socio-economic development.

Research Methods

This study employs quantitative bibliometric analysis to examine the domains of FTL, aiming to uncover trends, timelines, and thematic synergies within the literature. Following the methodological approach outlined by Agbo et al (2021); Aria and Cuccurullo (2017), the analysis consists of three key steps: data extraction and article selection, data synthesis, and data analysis. Essential software tools include the PRISMA workflow for systematic article selection and VOSviewer version 1.6.16 for data visualization.

As highlighted by Agbo et al (2021), bibliometric research designs are instrumental in aligning data collection with chosen analysis techniques. This study adopts a descriptive and correlational subset of quantitative research design to elucidate trends, characteristics, and relationships within the literature on FTL. The research questions are carefully formulated to guide the analysis, focusing on delineating the knowledge landscape in these domains.

Bibliometric methods offer a robust means of tracing the evolution of research constructs, identifying patterns, and assessing impact through metrics such as publication and citation counts. Additionally, keyword co-occurrence and citation analyses provide insights into the significance of publications and research themes. The decision to employ bibliometric methods in this study is informed by the need to comprehensively review the literature on FTL and identify gaps for future research.

The integration of the TCCM framework enhances the study's analytical depth, enabling a systematic exploration of dominant theories, contextual factors, characteristic trends, and methodological approaches within the literature. Building on the insights of Paul et al. (2021), the study leverages TCCM to structure the analysis and propose avenues for future research that address identified gaps.

Secondary data sourced from the Scopus database provide a robust foundation for analysis, ensuring results' consistency, accuracy, and reproducibility. Scopus, renowned for its comprehensive coverage and rigorous content selection processes, offers access to a vast repository of peer-reviewed literature, conference proceedings, and books. The database's enriched metadata and advanced profiling algorithms facilitate precise data retrieval and analysis, bolstering the study's credibility and reliability.

The data extraction and article selection process adheres to rigorous standards, ensuring the inclusion of relevant literature while maintaining transparency and reproducibility. By retrieving data from Scopus, the study benefits from the database's extensive coverage and quality assurance mechanisms, mitigating biases and enhancing the robustness of findings. This meticulous approach, as outlined by Schöbel et al. (2021), underscores the study's commitment to methodological rigor and data integrity. The search terms" financial," "technological," and "literacy" were employed in the database search. The search strings were mostly used on the documents' titles, keywords, and abstract metadata. The database search engine's query structure is displayed in Table 3.

Table 3
Data collecting procedure demonstrating the search string and output database

	Search string	**Output**
Main search strings	TITLE-ABS-KEY(("Financial*" OR "Finance*") AND ("Technology*" OR "Technological*") AND ("Literacy*"))	886
Search string after sort by automation	TITLE-ABS-KEY (("Financial*" OR "Finance*") AND ("Technology*" OR "Technological*") AND ("Literacy*")) AND (LIMIT-TO (OA ,"all")) AND (LIMIT-TO (DOCTYPE,"ar")) AND (LIMIT-TO (PUBSTAGE,"final")) AND (LIMIT-TO (SRCTYPE,"j")) AND (LIMIT-TO (LANGUAGE,"English"))	231

Source: Scopus advanced search run by the authors

Moreover, the search was confined to documents categorized as articles and conference proceedings in both databases. This restriction was deliberate and aimed at facilitating an in-depth scientific analysis, as documents from these sources typically undergo peer review. After finalizing the review method, relevant keywords were extracted from existing FTL literature. This process yielded a dataset from 1978 to 2024, comprising 886 documents. Subsequent scrutiny revealed irrelevant entries, prompting the restriction of data to a more recent timeframe, specifically from 2001 to 2023, aligning with the emergence of finance and technology in the 21st century. The refine search filter function retrieved bibliographic data from the Scopus database, focusing on English-language, open-access journal articles published within the specified timeframe.

Documents were screened based on the keywords "financial" and "technology" in their titles, keywords, or abstracts, resulting in a refined dataset of 160 documents. However, only 110 documents were downloadable, serving as the basis for subsequent bibliometric analysis, including author, country, institution, publication performance, and thematic mapping. Figure 1 depicts the preferred reporting items for systematic reviews and meta-analyses (PRISMA)

protocol, which ensures transparency and methodological rigor throughout the data gathering and screening procedure.

Data analysis commenced with the utilization of the Web-based PRISMA interface to quantify data sources. VOSviewer software version 1.6.16 was then employed to analyze Scopus data. Initially, descriptive statistics of the literature were examined, followed by analytics and visualizations based on document and author metrics. Subsequently, the study delved into the knowledge structures of FTL. Using VOSviewer, theories and methodologies prevalent in finance and technology research were filtered and charted for clarity using Microsoft Excel. Additionally, Microsoft 365 Excel facilitated country mapping. The insights gleaned from data analysis are expounded upon in subsequent sections of this study.

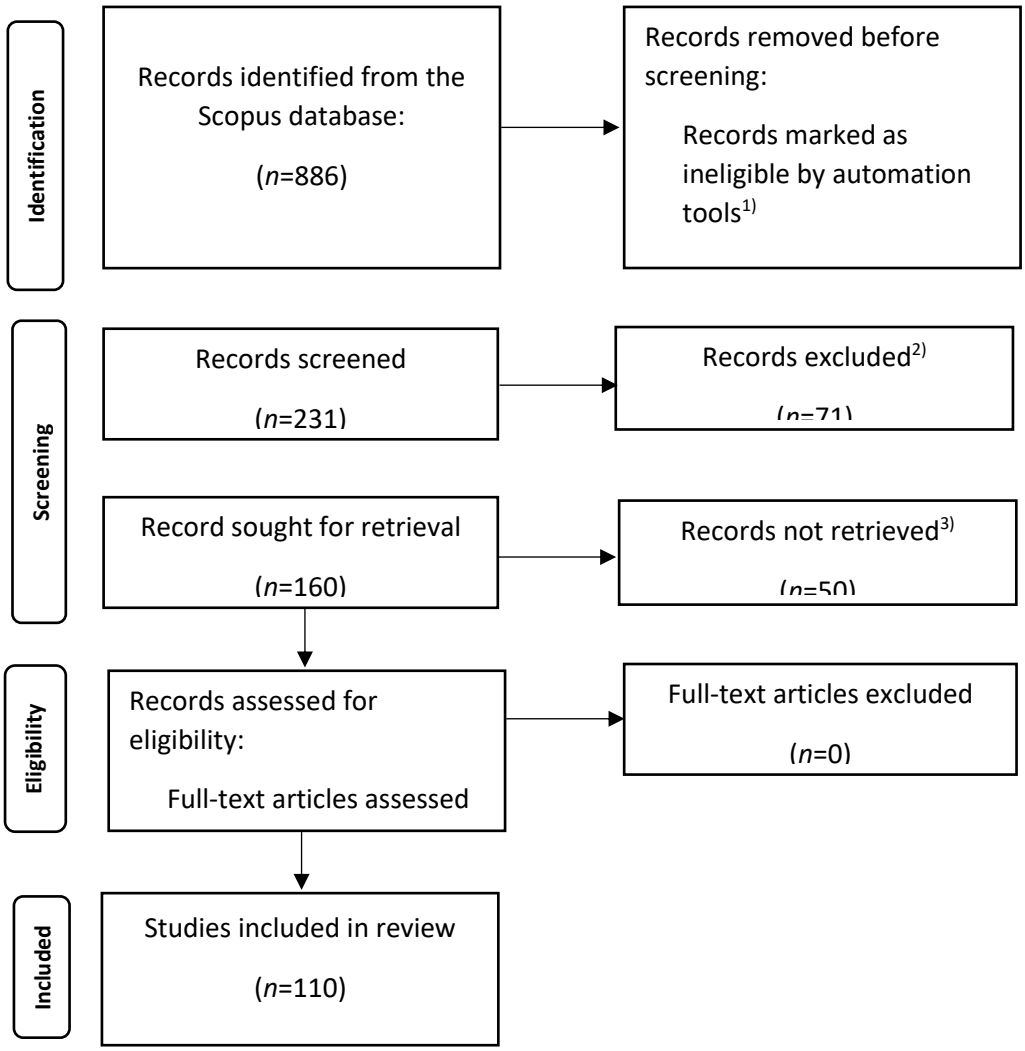

Figure 1: PRISMA workflow showing the data retrieval process

Research Findings

Research publication trends (RQ1)

Consistent with past bibliometric analyses conducted by Agarwal et al. (2023) and Hassan et al.2021), which provided a clear picture of the patterns of research growth in a given research field, RQ1 sought to understand the field's publication trend. To investigate the publication pattern, a total of 160 publications that were registered for the current study and published between 2001 and 2023 were retrieved (see Table 4). Only two categories of documents were found: conference papers (n=42) and research articles (n=118). Numerous academic fields,

such as psychology, business management, and the social sciences, have done research on FTL.

Table 4
Main information of selected FTL publications

Information	Statistics
Data Information	
Period	1978-2024
Documents	886
Timespan used for study	2001 - 2023
Documents	160
Article	118
Conference paper/proceedings	42
Average years from publication	7.2
Average citation per document	10.2
Average citation per year document	2.1
References	8118
Authorship information	
Authors	392
Authors of single-authored documents	15
Authors of multi-authored documents	377

The earliest piece on financial literacy, a book, was published in 1978. However, this analysis concentrates on the recent two decades during which finance and technology have emerged as significant topics of interest. Initially, in 2001, only a few articles were published. Research on FTL showed a sporadic early pattern, with intervals of one to two years between publications until 2013, when interest in this area began to intensify. Notably, over half of the studies were published between 2018 and 2023, indicating a growing focus among scholars on FTL. An observable trend in Figure 2 is the slow but steady increase in publications, from single digits up to 2019 to a peak of 45 publications in 2023. The R^2 value of 0.615, resulting from an exponential regression of publication numbers over time conducted in Microsoft Excel, confirms the exponential growth in this field.

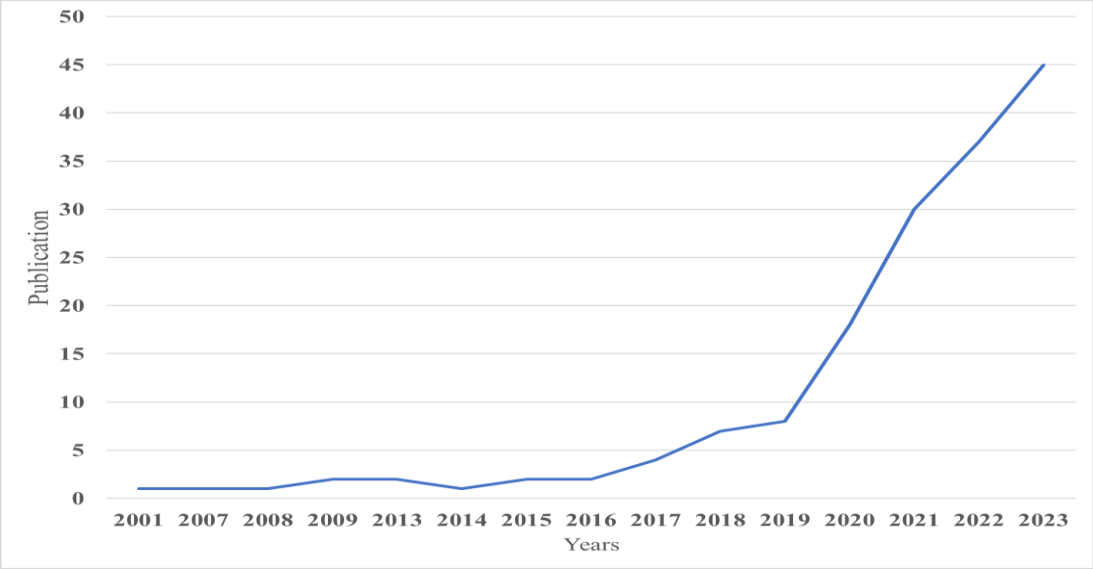

Figure 2: Publication trend of FTL (2001 – 2023)

Most Productive Authors, Countries, and Institution (RQ2)

Research Question 2 (RQ2) aimed to identify key contributors to research on Financial Technology Literacy (FTL), including the most productive authors, countries, territories, and institutions. This analysis is an essential component of bibliometric reviews, as it helps to pinpoint the significant contributors to the intellectual development of a research area and those advancing the research agenda. Such analyses are routinely performed in bibliometric studies (Donthu et al., 2021; Goyal & Kumar, 2021; Mukherjee et al., 2022).

The analysis revealed contributions from 392 authors, averaging 0.41 authors per document. Table 5 highlights the leading authors in this field. Among them, Nathan from Malaysia and Setiawan from Hungary were the most productive, with three publications and 78 citations. Following closely were Mogaji from Indonesia and Nguyen from Africa, each with 93 publications and an average of 46.5 citations, indicating high citation impacts despite their second-place ranking in productivity.

Table 5 also shows that several authors share the same rank based on their publication count, with nine authors appearing among the top 10, while others are noted for only a single publication. This pattern suggests moderate interest in the field, underscored by rapid business changes that highlight the need for continued research. For newcomers to this research area, this information could be invaluable for seeking potential collaborations and understanding the broader scope of FTL research.

Table 5
Top authors for FTL research

Rank	Author	Affiliation	TP	TC	C/P
1	Nathan	Universiti Teknologi MARA	3	78	26
1	Setiawan	Multimedia University Malaysia	3	78	26
2	Kurniasari	Hungarian University of Agriculture and Life Sciences	2	13	6.5
2	Lestari	Universitas Negeri Semarang	2	1	0.5
2	Mogaji	Universitas Indo Global Mandiri	2	93	46.5
2	Nguyen	University of Cape Town	2	93	46.5
2	Nugraha	The University of Rhode Island	2	58	29
2	Okoli	University of Zululand	2	3	1.5
2	Tewari	University of Dhaka	2	3	1.5

Note(s): TP = Total Publications, TC = Total Citations, C/P = Citations per Publication.

The network in Figure 3 highlights a trend that shows a significant need for more collaboration between authors from various institutions in the context of the study on FTL. The author collaboration graph shows that most scientific contributions come from authors more likely to work independently or limited to limited collaboration with colleagues at the same institution. No lines between points indicate the need for cross-institutional collaboration in exploring FTL. The lack of synergy between institutions can be a potential area for improvement, with an emphasis on establishing partnerships and collaboration that can enrich the quality of research and insight in this field.

Table 6 and Figures 4 identify the top 10 countries most actively publishing research on Financial Technology Literacy (FTL). Countries not listed among the top 10 typically have only one publication and are consequently not included in the ranking. According to Table 6, Indonesia leads in FTL publications with 25, followed by India and the United States with 18 publications. Previous research highlights the significance of FTL among SME owners and

managers in these regions, particularly in Indonesia, as evidenced by studies such as those by (Kurniasari et al., 2021; Setiawan, 2017). This body of work supports the high publication output from Indonesia. Additionally, the data reveal that most authors contributing to this area of study hail from Asia and Europe, indicating a regional focus on developing FTL research.

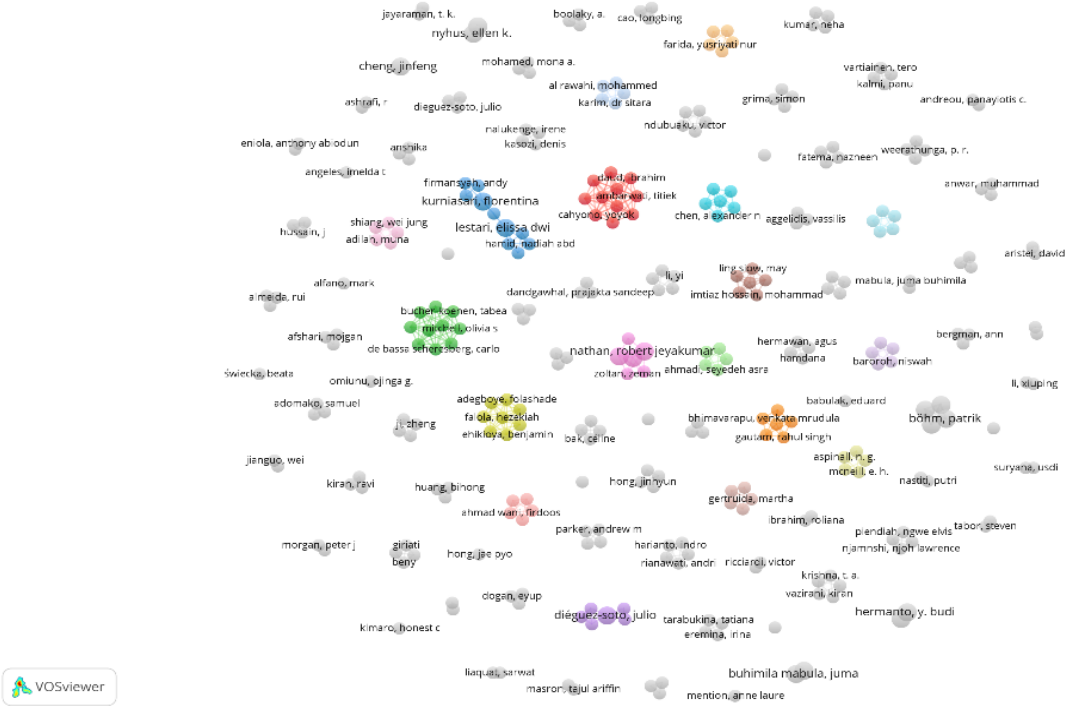

Figure 3: Co-authorship on FTL research

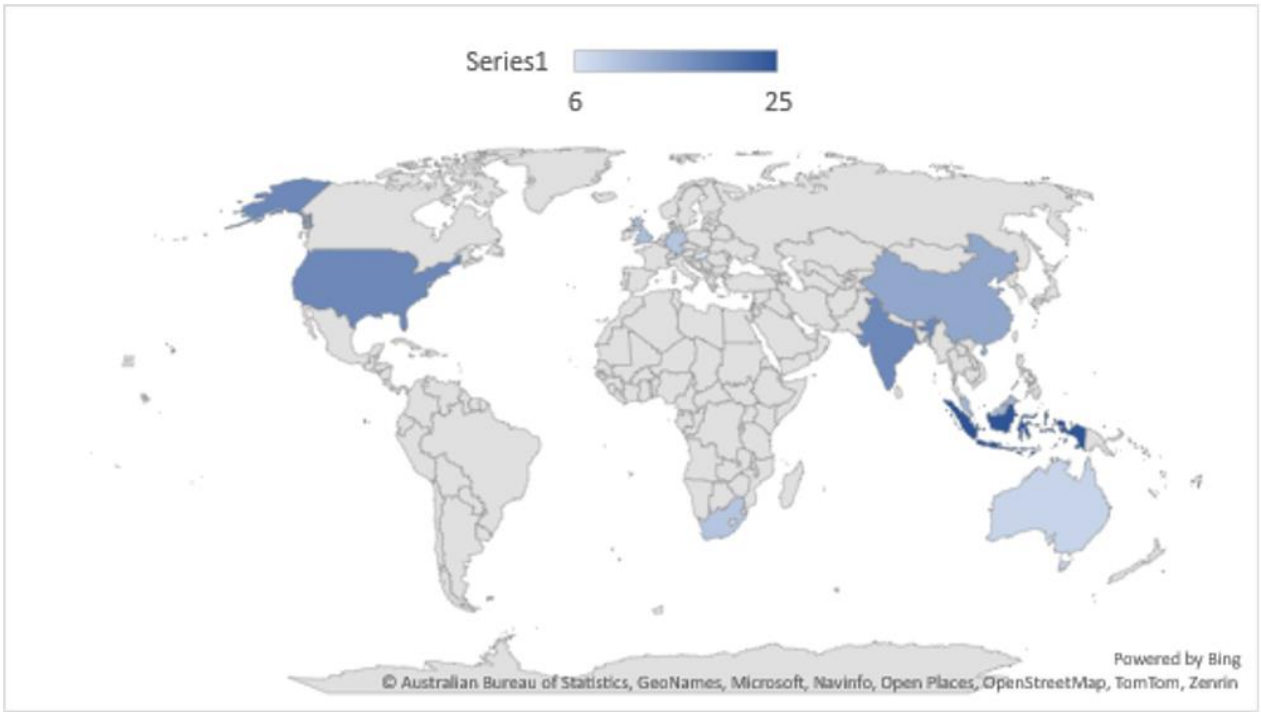

Figure 4: Geographical mapping of FTL research

Table 6
Top countries for FTL research

Continent	Country	TP	TC	C/P	SCP	MCP	MCP Ratio
ASIA	Indonesia	25	490	19,6	4	21	0.7
	India	18	211	11,7	6	12	0.5
	China	14	79	5,6	2	12	0.9
	Malaysia	12	791	65,9	0	12	1
	Philippines	6	4	0,7	0	6	1
	Taiwan	5	143	28,6	0	5	1
AFRICA	South Africa	10	104	10,4	2	8	0.8
	Nigeria	5	29	5,8	0	5	1
AMERICA	United States	18	564	31,3	5	13	0.7
EROPA	United Kingdom	11	356	32,4	0	11	1
	Germany	10	113	11,3	3	7	0.4
	Hungary	6	79	13,2	0	6	1
	Netherlands	4	51	12,8	0	4	1
	Sweden	4	17	4,3	1	3	0.9
	Ukraine	4	5	1,3	1	3	0.9
	Netherlands	4	54	13,5	1	3	0.9
	Czech Republic	4	12	3,0	0	4	1
	Italy	4	23	5,8	0	4	1
	Russian Federation	4	61	15,3	0	4	1
Total		172	3,186	19.1	25	143	

Note(s): TP = Total Publications, TC = Total Citations, C/P = Citations per Publication, SCP = Single-Country Publications, MCP = Multi-Country Publications.

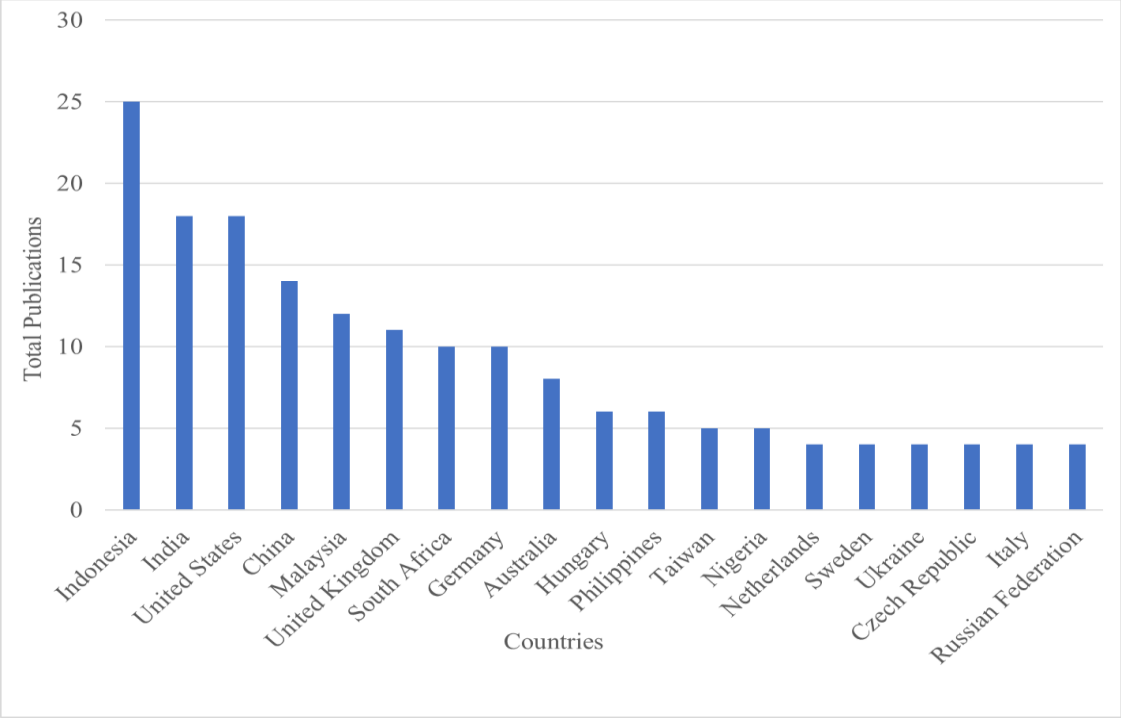

Figure 5: Number publication on FTL research around the world

The top 10 institutions involved in research on FTL are presented in Table 7. Table 7 shows that publications on FTL are limited; each institution with research on FTL only has at most three publications, and the rest have less than three publications. Only five institutions in the top five are working on FTL, with three publications; the other five have only two on FTL research. The top 10 FTL research publications are in Malaysia, Indonesia, South Africa, the United States, Taiwan, and Bangladesh. Interestingly, several institutions with only a few articles about FTL research have high citation rates, such as the University of Cape Town and Indo Global Mandiri University; each has two articles with 93 citations. The higher number of citations is related to open access to publishers that are easily accessible to everyone.

Table 7
Top 10 institution of FTL research

Institutions	Country	TP	TC	TC/TP
Universiti Teknologi MARA	Malaysia	3	78	26
Multimedia University Malaysia	Malaysia	3	78	26
Hungarian University of Agriculture and Life Sciences	Hungary	3	13	6.5
Universitas Negeri Semarang	Indonesia	3	1	0.5
Universitas Indo Global Mandiri	Indonesia	3	93	46.5
University of Cape Town	South Africa	2	93	46.5
The University of Rhode Island	The United States	2	58	29
University of Zululand	South Africa	2	3	1.5
University of Dhaka	Bangladesh	2	3	1.5
Cheng Shiu University	Taiwan	2	71	35.5

Note(s): TP = Total Publications, TC = Total Citations, C/P = Citations per Publication.

Thematic Knowledge Structure of FTL (RQ3)

Research Question 3 (RQ3) focused on a co-occurrence analysis of keywords and a network analysis to visualize keyword co-occurrences, consistent with established methodologies (Goyal & Kumar, 2021; Mukherjee et al., 2022; Singh & Sahu, 2020). Initially, author keywords from the documents to perform a co-occurrence analysis were utilized, following the approach by (Callon et al., 1983). This method and subsequent network visualizations help illustrate the convergence of themes within the Financial Technology Literacy (FTL) field, a technique frequently employed in bibliometric studies to uncover the foundational topics of a research area (Donthu et al., 2021).

The analysis revealed 43 keywords that appeared at least three times, forming five distinct clusters within the co-occurrence network. Each cluster represented a unique theme prevalent in FTL research. Subsequently, a keyword co-occurrence network was constructed, and five major themes were identified that defined the knowledge structure of FTL studies. Notably, as FTL has evolved into an independent research field since 2001, this structure incorporates various digital advancements that have significantly influenced the evolution of FTL.

Keyword Co-occurrence

The keyword co-occurrence network for Financial Technology Literacy (FTL) consists of five principal clusters, each representing a distinct theme within the literature, as detailed in Table 8. Figure 6 illustrates these clusters through network graphs, highlighting the main themes

derived from keyword co-occurrence analysis. Subsequent figures delineate the sub-themes of each cluster, identified through further analysis of keyword co-occurrences. Each node symbolizes a keyword in these network graphs, with the node's size indicating the frequency of co-occurrences.

Stronger thematic relationships are suggested by the linkages between nodes, which are represented by thicker links and show a higher frequency of co-occurrence (Donthu et al., 2021). Notably, as previously indicated, the discussion of each sub-cluster looks at (a) how its keywords relate to other keywords both inside and outside the sub-cluster and (b) the particular documents linked to the keywords.

Table 8
Themes and Author keywords in FTL research

Cluster 1: Entrepreneurship and Digital impact	**Cluster 2: Digital Finance for Sustainable Development**	**Cluster 3: Navigating the Financial Landscapes**	**Cluster 4: Digital Connectivity and Economic Dynamics**	**Cluster 5: Empowering in the Digital Era**
Digital Literacy	Availability	Banking	Bidirectional Causality	Digital Age
Entrepreneur	Digital Finance	Context	Communication Technology	Digital Financial Literacy
Financial Access	Digital Finance Service	Demographic Factor	Design Methodology	Education
Firm Performance	Financing	Financial Product	Digital Platform	Effectiveness
Information Technology	Green Finance	Fintech Service	Economic Growth	Financial Capability
Medium Enterprise	Inclusion	Fintech Usage	Empirical Result	Financial Decision Making
Panel Data Anlysis	Interview	Future Research	ICT	Financial Risk
PLS SEM	Moderating Effect	Investment Decision	ICT Infrastructure	Measure
Positive Effect	MSMEs	Policy Maker	Originality Value	Mediating Effect
Purposive Sampling	Significant Role	Review	Recommendation	Prediction
Quantitative Method	Stakeholder	Survey Data	Significance	Private Sector
SME Performance	Sustainable Development	Systematic Literature Review		

Source: Developed by authors using the inputs from VOSviewer

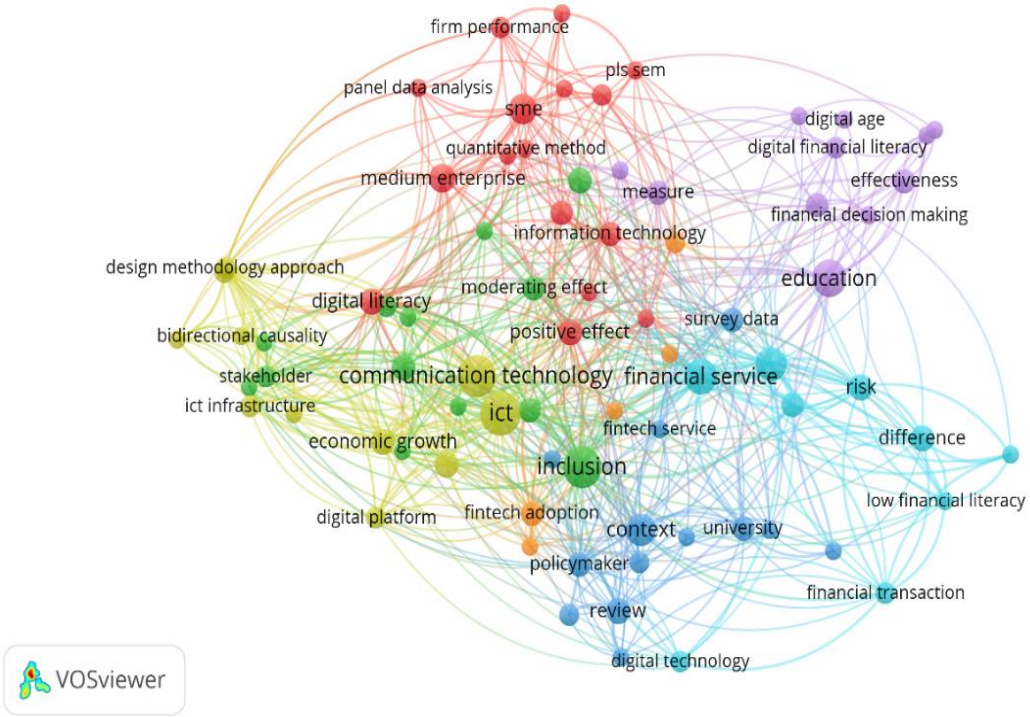

Figure 6: Network of FTL research. Cluster1: entrepreneurship and digital impact, Cluster 2: digital finance for sustainable development, Cluster 3: navigating the financial landscapes, Cluster 4: digital connectivity and economic dynamics, Cluster 5: empowering in the digital era.

Cluster 1, highlighted in red on Figure 6, emphasizes the intertwining dynamics of entrepreneurship and digital impact within the realm of FTL. This cluster underscores the significance of digital literacy in shaping business decisions and strategies, particularly within SMEs (Denicolai et al., 2021). The findings underscore the essential role of digital understanding and skills in navigating the challenges posed by increasingly interconnected businesses.

Moreover, the presence of elements related to entrepreneurship and SMEs underscores the pivotal role of digital literacy in influencing company performance amidst the rapid changes characteristic of SME environments. This connection highlights the potential impact of digital literacy on facilitating access to financial services for SMEs, thereby contributing to enhanced company performance (Pandey et al., 2022; Ratnawati, 2020). These insights underscore the importance of understanding how digital literacy can bolster the competitiveness and sustainability of SMEs in today's digital landscape.

Additionally, the inclusion of information technology and quantitative methods within this cluster emphasizes the importance of employing advanced analytical approaches in studying the impact of digital literacy on entrepreneurship and company performance (Gargallo-Castel & Galve-Górriz, 2007; Kirongo & Odoyo, 2020; Sridevi et al., 2019). Utilizing techniques such as panel data analysis and Partial Least Squares Structural Equation Modelling (PLS-SEM) is crucial for gaining deeper insights into the complex relationships within this thematic domain.

Cluster 2, depicted in green in Figure 6, provides insights into the multifaceted role of digital finance in advancing sustainable development within FTL. This cluster illuminates the transformative potential of digital finance services in reshaping the landscape of financial

transactions and services (Hahm et al., 2021; Stofkova & Sukalova, 2020), marking a significant paradigm shift in financial practices.

The core themes of digital finance and digital finance services underscore the ongoing evolution towards digitization within the financial sector, signaling a fundamental change in how financial services are delivered and accessed (Cossu, 2022). Moreover, incorporating elements related to green finance underscores the growing recognition of the importance of environmental sustainability within financial practices, aligning financial services with broader sustainable development objectives (Mohd & Kaushal, 2018).

Insights into inclusion and SMEs within this cluster highlight the potential of digital financial services to broaden financial inclusion, particularly among microenterprises (Danladi et al., 2023), thereby contributing to sustainable economic growth and development (Singh et al., 2021). Additionally, the presence of elements related to financing underscores the pivotal role of digital finance in facilitating access to financial resources for individuals and businesses alike (Kou et al., 2020), underscoring its significance in fostering economic empowerment and growth.

Furthermore, the thematic exploration of stakeholders underscores the collaborative nature of digital finance initiatives, involving various stakeholders in their implementation and impact (Thathsarani & Jianguo, 2022). The inclusion of elements representing moderating or mediating roles further emphasizes the importance of seamless access to digital financial services in achieving the objectives of financial inclusion and sustainable development.

Cluster 3 focuses on navigating the financial landscapes, describing a framework that involves various aspects, ranging from technology-based financial services (fintech) and banking to policy perspectives. This cluster is indicated in blue in Figure 6.

Banking and financial products are the central elements of this theme, highlighting the central role of the banking sector and the diversity of financial products in the financial ecosystem. Fintech services and fintech usage show the transformation of the financial industry through technological innovation, creating significant alternatives to meet people's financial needs (Akomea-Frimpong et al., 2021).

Demographic factors and investment decisions emphasize the complexity of financial decision-making, which is influenced by demographic factors (Widityani et al., 2020). This theme reflects an effort to understand how demographic characteristics affect investment decisions and financial service preferences.

The context element underlines the importance of understanding the specific context in which financial decisions and fintech applications were made. Survey data and systematic literature reviews demonstrate the methodological approaches used to comprehensively understand trends and findings in the literature.

Future research for the needs of policymakers focuses on the direction of future research and the role of policymakers in managing modern financial dynamics. This theme includes the importance of future research in anticipating further developments in the financial industry and the role of policymakers in forming regulations that support innovation and stability.

Cluster 4 focuses on digital connectivity and economic dynamics, emphasizing the interplay between digital connectivity and economic growth (Chernykh et al., 2020). This cluster is indicated in green-yellow in Figure 6. Bidirectional causality is at the heart of this theme, reflecting the reciprocal dynamics between advances in digital technology and economic development.

Communication technology and ICT infrastructure show the critical role of communication and information technology infrastructure in shaping digital connectivity (Verma et al., 2023).

This theme underlines the importance of developing communication technology and ICT infrastructure as a driver of economic growth.
Digital platforms have emerged as a critical element, demonstrating the evolution of digital platforms and their role in supporting innovation, connectivity, and economic growth (Tiwari et al., 2020). Thus, this theme reflects a paradigm shift in business interactions and economic activities through digital platforms.
The design methodology approach and empirical results highlight the methodological approach and empirical findings used in research related to digital connectivity and economic growth. This shows an effort to provide a robust and relevant knowledge base.
Recommendations and significance indicate research results that can provide suggestions and a new understanding of the bidirectional causality between digital connectivity and economic growth. This theme outlines the practical and theoretical implications of the research findings, highlighting their significance in the context of the digital economy.
With the element of originality value, this theme reflects an effort to make a new contribution to the understanding of the relationship between digital connectivity and economic growth, highlighting the value of originality in the context of this research.
Cluster 5 focuses on empowering in the digital era with financial literacy, education, and decision-making processes. This cluster is indicated in purple in Figure 6. The "digital age" element reflects the context of an increasingly digitally connected era, demanding adjustments in financial literacy and decision-making. Digital financial literacy and financial capability are the main focus, showing that financial understanding in the digital era significantly impacts individual financial capabilities (Morgan et al., 2019).
Education emerged as an essential element, indicating the need for formal and informal education to increase financial literacy and provide the knowledge needed to face financial challenges in the digital era (Compen et al., 2019). This theme pays special attention to efforts to increase the effectiveness of education in the context of financial literacy.
Financial decision-making is the core theme, emphasizing how financial literacy and education can influence an individual's financial decision-making ability. The mediating effect indicates that financial literacy can mediate the influence of education on financial decision-making, highlighting the complex relationship between these variables (Lontchi et al., 2023).
Exploration of financial risk and measurement shows attention to understanding financial risk and efforts to measure the impact of financial literacy in managing these risks (Havierniková & Kordoš, 2019). With the element of prediction, this theme includes efforts to predict the impact of financial literacy and education on future financial behavior.
The private sector is present as an element that indicates the role of the private sector in supporting financial literacy and education in the digital era. The implication is that private companies can contribute to developing initiatives and programs that promote financial literacy among the public.

Keyword Frequency and Total Link Strength

Initially, the keyword analysis set the minimum number at five occurrences. As that criterion provided limited results, then reduced the threshold to three. The cumulative strength of connections (links) between keywords in a network visualization is shown in Table 9. In the VOSviewer analysis of the presented keywords, the total link strength values unveil distinctive patterns in the interrelationships among financial and technological concepts within the examined literature. "Financial Literacy" emerges as a central and extensively discussed theme, boasting a total link strength of 38. This indicates its pivotal position in research

dialogues, implying its intrinsic importance or frequent co-occurrence with other pivotal terms.

Although "Financial Knowledge" and "Financial Technology" exhibit slightly lower total link strengths at 11 each, they reveal a moderate association level with other keywords, signifying their relevance and presence in the scholarly discourse. With a total link strength of 10, "Financial Behavior" underscores an active and interconnected discussion on behavioral facets within the financial domain.

Similarly, "Financial Attitude," with a total link strength of 9, denotes a noteworthy albeit potentially more focused conversation. The keyword "SMEs" stands out with a total link strength of 9, underscoring its substantial relevance and interconnection with various financial dimensions. These nuanced insights into the total link strength values provide researchers with a comprehensive understanding of the dynamic relationships and key focal points within the literature surrounding financial literacy, knowledge, technology, behavior, and attitudes in SMEs.

Figure 7 presents the results of the keyword analysis. There are five clusters. In addition to refining the clusters, keyword analysis sheds light on research streams. Figure 7 indicates that FTL studies fall into four classes: general studies on financial literacy (yellow cluster), the role of financial technology (blue cluster), the influence of financial inclusion (red cluster), and technology advancement (green cluster).

Table 9
Keywords frequency and total link strength

Keywords	**Occurrences**	**Total Link Strength**
Financial Literacy	36	38
Financial Knowledge	6	11
Financial Technology	9	11
Financial Behavior	4	10
Financial Attitude	3	9
SMEs	10	9
Financial Inclusion	8	8
Fintech	7	7
COVID-19	3	5
Financial Behaviour	3	5
Mobile Payment	3	5
Developing Countries	4	4
SEM	3	4
Economic Growth	4	3
ICT	6	3
Green Finance	3	2
Sustainability	3	2

Source: VOS viewer output

Financial literacy is the main focus of co-occurrence analysis. The high frequency of occurrence indicates that financial literacy is a central concept often related to other topics, indicating its great importance in the research domain. The strong link between financial literacy and financial technology (FinTech) reflects a significant trend in financial

development. The joint emergence of both shows that FinTech has a role in supporting or increasing financial literacy levels. The linkage with SMEs shows that financial literacy and technology are essential for businesses. This could refer to efforts to increase financial literacy among SME business owners or integrate financial technology into brand financial management.

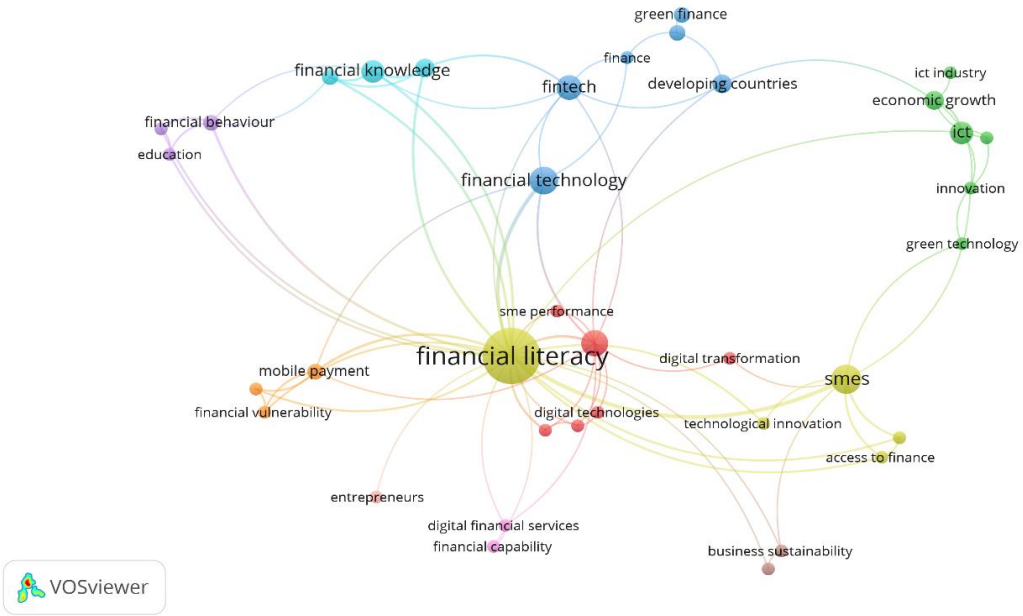

Figure 7: Network of keywords in FTL research

These findings reflect a paradigm shift where financial literacy and financial technology applications are becoming critical for business growth and survival, especially in SMEs. Despite the strong relationship, challenges may need to be overcome regarding the integration of financial technology among SMEs. Further analysis can detail the barriers or obstacles in implementing FinTech in SMEs. This conclusion highlights the importance of policy support and training for SME business owners to understand and adopt financial technology. These initiatives may include financial literacy programs integrated with technology and policies supporting FinTech access and adoption.

Discussions

This bibliometric review provides an objective retrospective analysis of the existing literature on FTL spanning from 2001 to 2023. Through an examination of the most productive authors, countries/territories, and institutions, along with keyword co-occurrence analysis, the study addresses the first four research questions (RQs) and yields several key findings: FTL research has experienced exponential growth, with a noticeable increase in publications from 2018 onwards (RQ1); Nathan, from Malaysia, emerged as the most prolific author, while Indonesia led in terms of country contributions, with Universiti Teknologi MARA Malaysia being the leading institution in FTL research (RQ2); Pioneering articles by Olaleye et al (2023) and Nguyen (2022) have remained highly influential in FTL research, followed by works by Nathan et al (2022); Setiawan et al (2021) (RQ3); and the knowledge structure of FTL research reveals five broad clusters/themes: Entrepreneurship and digital impact, Sustainable development through digital finance, Navigating financial landscapes through technological development,

Digital connectivity and its impact on economic dynamics, and Empowering resources in the digital era (RQ4).

Proposals for further research are also guided by a thorough analysis of the most cited articles and best publications from each cluster of the term co-occurrence network. The literature underscores the necessity for integrated educational interventions that address both financial literacy and technological literacy, recognizing their interconnectedness in today's complex landscape. Scholars advocate for innovative teaching methods, tailored curricula, and collaborative efforts between educational institutions and industry stakeholders to bridge the gap between theory and practice. Moreover, there is a growing interest in empirically exploring FTL from individual, institutional, and societal perspectives, indicating a shift towards a more comprehensive understanding of its implications for economic development, innovation, and societal well-being. While European authors have been prominent in FTL research, countries like Indonesia, Malaysia, and India have shown notable growth in recent years, highlighting the global significance of FTL research.

The Way Forward: TCCM Framework Analysis (RQ4)

The forthcoming section delves into the forward-looking analysis of FTL through the lens of the TCCM framework, addressing the fourth research question (RQ4). This examination offers insights into the theoretical underpinnings, contextual considerations, characteristic features, and methodological approaches that pave the way for future research endeavors in this dynamic field. Additionally, a recap of the TCCM framework results, visually represented in Figure 8, provides a concise overview of the key findings.

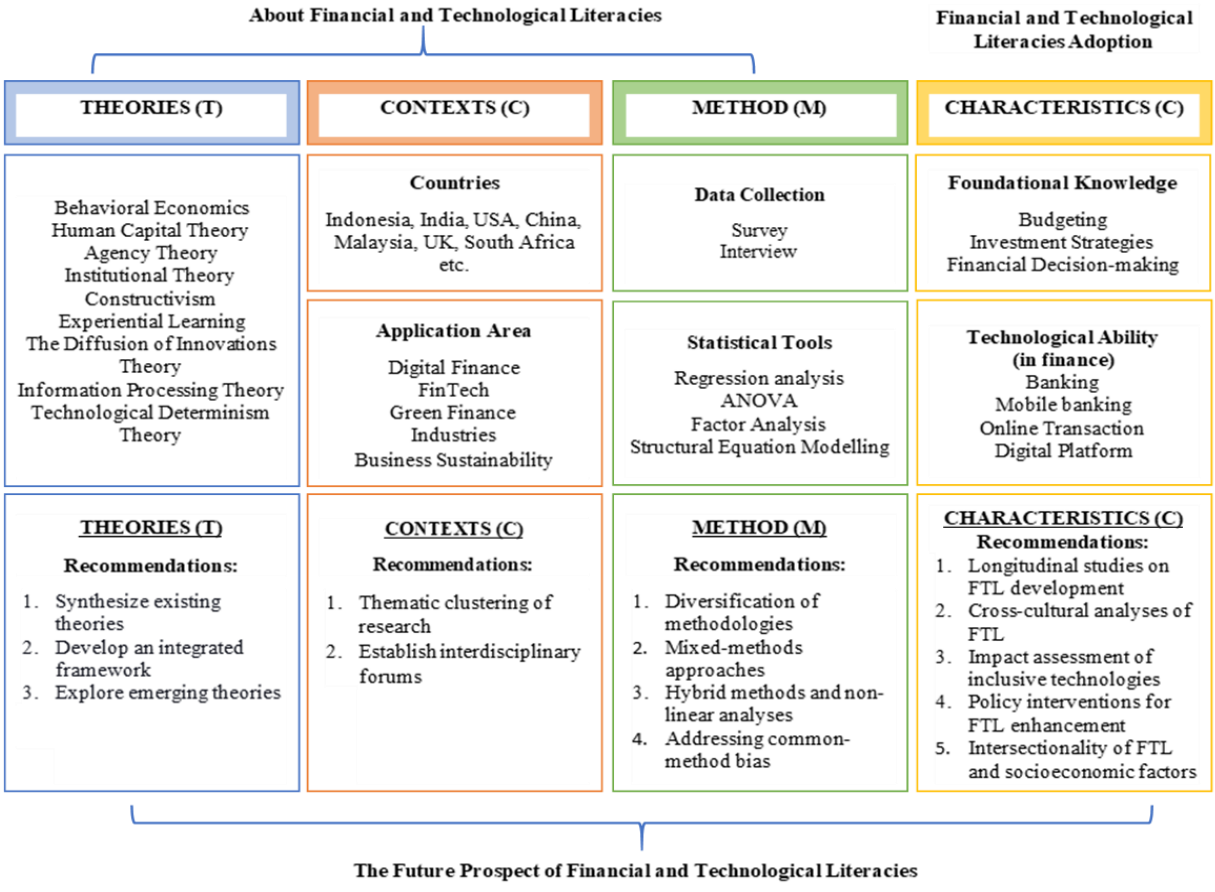

Figure 8: The overview of TCCM framework on FTL

Theory Development (T)

Theoretical developments in FTL draw from various disciplines, including Behavioral Economics, Human Capital Theory, Agency Theory, Institutional Theory, Constructivism, Experiential Learning, and the Diffusion of Innovations Theory. These theories offer insights into individual behaviors, economic structures, pedagogical strategies, and technological adoption in the context of FTL (Fauzi & Sheng, 2020; García-Pérez-de-Lema et al., 2021; Koskelainen et al., 2023; Nguyen, 2022). However, the absence of a cohesive theoretical framework presents a significant gap in FTL literature, hindering a comprehensive understanding of its dynamics. To address this gap, this study proposes synthesizing existing theories from diverse disciplines into a unified framework, developing an integrated theoretical model that incorporates elements from cognitive, economic, educational, and emerging theories. Additionally, scholars are encouraged to explore innovative theoretical perspectives to enrich the understanding of FTL in evolving financial and technological landscapes. Establishing standard metrics, including defining key variables, measurement tools, and evaluation criteria, is essential for facilitating systematic and comparable assessment of research progress in FTL. Furthermore, advocating for longitudinal research initiatives can track the evolution of FTL theories over time, identifying trends and addressing gaps in the literature.

Context (C)

The application of FTL spans various contexts, including digital finance in industrial/business applications, fintech, green finance, and business sustainability. However, the interdisciplinary nature of FTL research often leads to a dispersion of studies across diverse fields, making it challenging to pinpoint a singular domain with the highest research output (Huang, 2020; Mohd & Kaushal, 2018; Widagdo & Sa'diyah, 2023). The dynamic nature of financial and technological landscapes continually gives rise to new application areas, further contributing to the dispersion of research efforts. FTL underscores pervasive influence across multiple domains and emphasizes the need for a comprehensive and adaptable approach in research and practical applications. Consequently, this study recommends two approaches to address this complexity: Firstly, thematic clustering of research should propose systematically categorizing studies based on overarching themes or application domains, facilitating a clearer understanding of research trends and outputs within specific contexts. Thematic clustering could provide insights into emerging domains and guide stakeholders toward areas where FTL applications are actively evolving. Secondly, establishing collaborative research platforms should be advocated, aiming to bring together experts from diverse fields. By creating interdisciplinary forums, researchers can share knowledge, collaborate on projects, and collectively address challenges in specific application domains, fostering synergies and enhancing the overall impact of FTL research.

Characteristics (C)

Our literature study reveals the characteristics and composition of FTL structure, with five themes emerging broadly categorized into financial literacy, financial technology's role, financial inclusion's influence, and technological advancement. Financial literacy encompasses foundational knowledge and skills of financial concepts, budgeting, investment strategies, and overall financial decision-making. Financial Technology explores fintech's evolving role in shaping and enhancing financial literacy, including the impact of digital platforms, online transactions, mobile banking, and other fintech innovations (Mabula & Ping,

2018). The influence of financial inclusion is a critical dimension, focusing on the accessibility and availability of financial services to all segments of society, examining how inclusivity or exclusivity affects opportunities for entrepreneurs to develop financial literacy and engage with emerging technologies. Technological advancement, central due to the rapid evolution of technology, explores how advancements such as artificial intelligence, blockchain, and data analytics influence the financial landscape and subsequent technological literacy required for effective financial decision-making. These discussions lead to recommendations for future research: Firstly, longitudinal studies on FTL development to track its evolution over time and investigate its response to changes in financial technologies, inclusion efforts, and advancements. Secondly, cross-cultural analyses of FTL will help to understand how varying cultural contexts influence individuals' FTL. Thirdly, the impact assessment of inclusive technologies is used to evaluate their effect on literacy levels and financial behaviors, especially in populations facing barriers to traditional financial services. Fourthly, policy interventions for FTL enhancement should be explored to assess their effectiveness in fostering comprehensive literacy. Lastly, the intersectionality of FTL with socioeconomic factors should be examined to understand how income levels, education, and technology access interact and influence individuals' abilities to acquire and apply financial and technological knowledge.

Methodologies (M)

Most studies on FTL adopt quantitative methodologies, utilizing statistical tools like regression analysis, bootstrap analysis, ANOVA, factor analysis, and SEM. While some incorporate qualitative data from interviews with research participants, such efforts are limited. Concerns arise regarding the common-method bias associated with single-source, self-reported survey questionnaires. Therefore, the following recommendations are proposed: Firstly, diversifying methodologies beyond quantitative approaches should be encouraged, including qualitative methods like in-depth interviews and case studies. Secondly, promote the adoption of mixed-methods approaches combining quantitative and qualitative techniques to provide a holistic view of FTL. Thirdly, explore hybrid methods such as Structural Equation Modeling-Artificial Neural Network (SEM-ANN) analysis to capture non-linear relationships and complex interactions in FTL. Lastly, strategies to mitigate common-method bias in survey-based research should be implemented, such as using control variables to address potential biases.

Conclusions

Over the past two decades, research on FTL has significantly expanded, underscoring their crucial impact on individuals, organizations, and broader society. Increasingly, FTL is recognized as vital for economic inclusion and technological empowerment (Duréndez et al., 2023; García-Pérez-de-Lema et al., 2021; Kulathunga et al., 2020).

This bibliometric review, enhanced by the TCCM framework, aims to delineate the knowledge structure and bibliometric contours of FTL, advocating for a detailed research agenda to further comprehend the dynamics of FTL. The review highlights the necessity for industry stakeholders to address challenges related to insufficient FTL and points out a significant gap in understanding behaviors that foster FTL, proposing areas for future research. The current literature’s lack of a unified theoretical framework calls for scholarly attention to bridge this gap. The review recommends adopting new data collection methods, advanced analytical techniques, and qualitative research approaches to advance FTL research.

Additionally, investigating the cognitive processes associated with FTL and examining variations across cultures and sectors are identified as vital future research directions. By integrating quantitative and qualitative analyses, the review seeks to deepen the epistemological discourse on FTL, aiding in the development of policies and practices that enhance FTL in various contexts.

Contributions

This research makes significant theoretical and contextual contributions by applying the TCCM framework to the nuanced interplay between financial and technological literacies, complemented by the rigorous systematic review guidelines of PRISMA. Theoretically, it enhances understanding of these literacies by synthesizing concepts from agency theory, diffusion of innovations, and experiential learning theories, which are crucial for grasping the complex dynamics of financial and technological integration (Kulathunga et al., 2020; Bowen and Johnson, 2018; Mabula & Ping, 2018). The use of the TCCM framework allows for a structured exploration of the theory, context, characteristics, and methodologies prevalent within this field, ensuring a comprehensive academic approach to dissecting the literacies. Meanwhile, PRISMA guidelines provide a transparent and meticulous method for article selection and data analysis, enhancing the reliability and reproducibility of the research findings. Contextually, the study underscores the crucial role of digital literacy in the financial sector, particularly within SMEs, and its impact on economic resilience and growth. By identifying gaps in current research, especially in cross-cultural and sector-specific applications, this analysis informs future scholarly work and policy formulation, emphasizing the need for comprehensive strategies that enhance financial and technological literacy across various economic and cultural landscapes. This study not only broadens the academic perspective on financial and technological literacies but also provides actionable insights for policymakers and educators to foster environments conducive to digital inclusion and financial empowerment. Through the application of PRISMA and TCCM, the research offers a rigorous, structured approach that sets a precedent for future studies in the field, aiming to bridge the gap between theoretical research and practical implementation.

Limitations

The study does have limitations. It relies exclusively on data from the Scopus database, which may change as new research is added, potentially affecting citation metrics and the perceived prominence of scholars and institutions. Moreover, the field often overlaps with other financial technologies like digital finance, creating conceptual overlaps that challenge the clarity of distinctions within this dynamic field. This overlap can complicate research focus, measurement, and analytical methods, possibly leading to misinterpretations. Researchers are encouraged to clearly define and justify their categorizations to ensure clarity and precision in studying fintech within the broader financial technology landscape. Furthermore, the search terms used might have missed relevant studies if those terms were not included in their titles or abstracts, which could limit the comprehensiveness of the data collected.

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