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Technical Efficiency and Growth of Banks: A Bibliometric Analysis

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Abstract
This study delves into the complex relationship between technical efficiency and growth of the banks using a bibliometric approach. While it is commonly believed that efficient banks should grow, the literature on this relationship remains sparse and ambiguous. Our research aims to identify and analyze key publications, authors, academic affiliations, source titles, countries, languages, document types, subject areas, and citation matrices addressing above issue. By examining these factors, we seek to offer valuable insights for guiding future research in this field. This study employs a bibliometric analysis to investigate the current trends and patterns in the research on technical efficiency and growth of the banks. By analyzing 217 documents sourced from the Scopus database, the study identifies key research areas, influential authors, and significant publications. The most cited papers were written in 2002 (468 total citations), 'Economics, Econometrics, and Finance' being the dominant subject area (32.68% publications). Articles being the most published (87.55%), English is the key language (96.8%), the United States is the top country (31 publications), and 'Journal of Banking and Finance' is an important journal (11 publications). Isik, I. is the most influential author (705 total citations). This study elucidates publications pertaining to the technical efficiency and growth of banks, encompassing key contributors, authors, countries, journals, publishers, and significant keywords. Researchers can leverage this paper for their further investigations, particularly in establishing the relationship between technical efficiency and the growth of banks. The study is constrained by its limitation that only Scopus database has been employed to the analysis. Our paper is first of its kind in exploration into the relationship between technical efficiency and the growth of banks using bibliometrics method.

Keywords – Bibliometrics analysis, technical efficiency, growth, banks, VOSviewer

Introduction

The financial sector facilitates the transfer of funds from agents who have surpluses of them to agents who are in the deficit for investment purposes. This process stimulates economic dynamics and provides the necessary liquidity, ultimately enhancing the overall welfare of society (Khan and Zahler, 1986). Banks play a crucial role in the financial ecosystem for individuals, businesses, and the broader economy. They efficiently channel funds from savers to borrowers, acting as key intermediaries in the financial system. This efficient allocation of capital supports economic growth and stability by ensuring that resources are available where they are most needed (Diamond, 2023). Measuring an industry's productive efficiency is vital for both economic theorists and policymakers. Empirical efficiency measurements are essential to test theoretical arguments about the efficiency of different economic systems. The effective economic planning requires understanding how much an industry can increase its output by enhancing efficiency alone, without additional resource input.

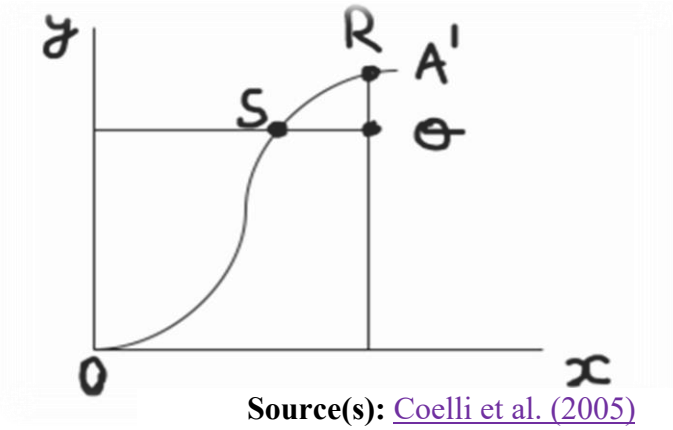
The efficiency of the financial system is measured by how well it collects savings from those with extra money and distributes it to those who need it. Recently, countries that are changing their economies have focused on improving bank efficiency by allowing foreign investments and privatizing banks. Inefficiency, waste, and slothfulness at branches lead to low productivity and high spreads in banks. The key challenge is transforming the sector from high operating costs and low productivity to becoming more efficient, productive, and competitive (Barman, 2007).

Technical efficiency (dubbed as TEF) measures how effectively a firm utilizes inputs to produce outputs. In India, like in other emerging countries, there is limited empirical evidence on how technical efficiency affects bank performance (Maji and Hussain, 2021). Technical efficiency means a bank's ability to maximize output with a given number of inputs or to produce a given output with minimal inputs (Horvatova, 2018). Azad *et al*. (2016) argue that traditional methods of assessing bank efficiency—such as the intermediation, production, or profitability approaches—tend to produce biased results. For instance, focusing solely on profitability overlooks critical factors like long-term sustainability, particularly a bank's capital ratio, which could lead to a profitable institution becoming insolvent. To overcome this issue, they suggest adopting the CAMELS (Capital Adequacy (C), Asset Quality (A), Management Competence (M), Earnings Performance

(E), and Liquidity (L)) framework as a more comprehensive tool for evaluating bank efficiency. Most studies on bank efficiency use a frontier efficiency analysis to benchmark performance. Ramcharan (2016) conducted an empirical study on the efficiency of bank lending to small and medium enterprises (SMEs) in India, revealing a positive relationship between efficiency and the growth of the industrial sector of SMEs. Similarly, Wijesiri *et al.* (2015) assessed the efficiency of microfinance institutions in Sri Lanka, indicating a direct causality between efficiency and the growth of these institutions. In the banking industry, growth is influenced by various factors, with efficiency levels being a key determinant. The efficiency can lead to reduced intermediation spreads (Proaño-Rivera and Feria-Dominguez 2024).

The efficiency of the banking system is measured using the Data Envelopment Analysis (DEA) model, as assessed by Farrell (1957), this is the most classic literature on this topic. He has decomposed the global efficiency of a companies into two elements: "technical efficiency" and "allocative efficiency". He defines technical efficiency as the firm's capacity to achieve the maximum output from a given set of inputs, with its values ranging from 0 to 1. A value close to zero indicates significant inefficiency, while a value close to one indicates high efficiency. A TEF value of one means that the firm is operating on the efficient isoquant. Similarly, allocative efficiency (Kalirajan, and Shand 1992) is the ability of a firm to mix inputs in the most cost-effective proportions, taking into account their relative costs and the production function, also ranges from zero to one, with a value less than one indicating inefficiency. The product of TEF and allocative efficiency will be equals to overall efficiency, and it also ranges between zero and one. It's important to know the relationships between TEF and productivity; a firm can be technically efficient yet still improve its productivity by exploiting economies of scale (Keat and Young, 2004). To understand this first we need to know the meaning of efficiency. 'Efficiency is the property of society getting the most it can from its scarce resources' (Mankiw *et al*., 2007). The primary function of any firm is to transform inputs into outputs, which is crucial for measuring its performance. The natural metric for performance is the productivity ratio, defined as the ratio of outputs to inputs. A higher productivity ratio signifies better performance. Performance is a relative concept that must be compared against other factors such as time, other firms, or industry benchmarks. Productivity = Outputs / Inputs. Inputs can be either single or aggregated (a composite index of inputs). Total factor productivity (TFP) measures productivity by considering all factors of production and outputs. In contrast, partial productivity measures focus on specific inputs, such as labour productivity or land productivity. However, using partial measures in isolation can lead to misleading results. Although 'productivity' and 'efficiency' are often used interchangeably, they have distinct meanings (Jubilee *et al*., 2022; Kamarudin *et al*., 2022; Llorens *et al*., 2020).

Figure 1. Technical efficiency and production frontier.



Source(s): Coelli et al. (2005)

To illustrate this, imagine a production process where a single input (x) generates a single output (y).

If we plot various combinations of these inputs and outputs as shown in figure 1, the resulting line OA' represents a production frontier, showing the maximum achievable output for each input level and the current state of technology in the industry. Firms operating on this frontier are technically efficient, while those operating below it are not. For example, in the Figure 1, point Q represents an inefficient point, whereas points R and S are efficient. Point Q is inefficient because the firm could increase its output to the level at point R without additional inputs.

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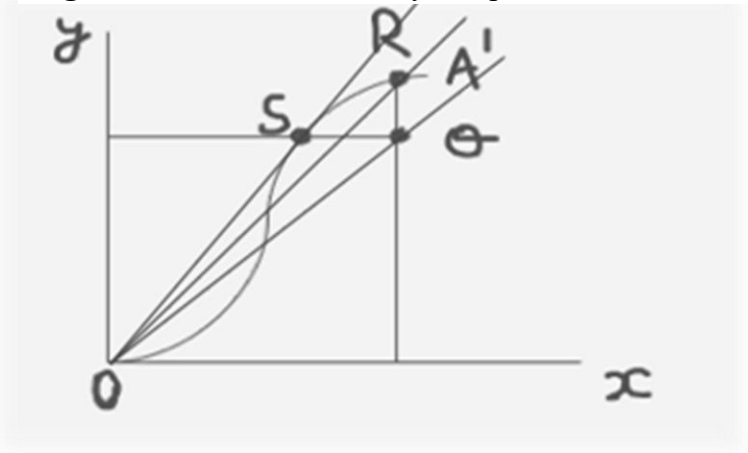
Figure 2. Technical efficiency and production frontier.



Source(s): Coelli et al. (2005)

The feasible production set includes all input-output combinations between the production frontier OA' and the x-axis. Points along the production frontier define the efficient subset of this feasible production set.

To distinguish between technical efficiency and productivity, imagine a ray passing through the origin to points Q, R, and S. The slope of this ray (y/x) measures productivity. The slope at point R is higher, indicating greater productivity. At point S, the ray is tangent to the production frontier, representing the maximum possible productivity. This lateral movement exemplifies exploiting scale economies. Point S is the point of optimal scale (technically). Therefore, a firm may be technically efficient but can still improve its productivity by exploiting scale economies (Coelli *et al*., 2005).

Researchers are using two methods to measured efficiency: a parametric method called the 'stochastic frontier production function', and a non-parametric method called 'linear programming' (Favero and Papi, 1995; Sangeetha, 2020; Asmare and Begashaw, 2018; Forsund *et al*., 1980). Kaparakis *et al*. (1994) review the literature on bank efficiency and used the non-parametric method, specifically data envelopment analysis (DEA). Many studies have also used DEA (Pampurini *et al*., 2022; Wanke *et al*., 2019 used Dynamic Network DEA; Du and Sim, 2016; Kamarudin *et al*., 2016a, b) to study bank efficiency.

Cyre *et al*. (2000) in their paper, they reviewed the factors influencing growth of the banks. They also examined the decisions to grow externally or not and evaluated types of growth. Banks can now more easily buy other banks and turn them into branches without needing expensive multi-bank holding companies or can start new branches from scratch, which could be the growth of banks. Additionally, banks can grow by offering new products, like real estate or consumer loans. As per other researcher banks have three pivotal growth strategies to consider. Firstly, a branching strategy involves opening new branches, either by acquiring banks and converting them into its branches, avoiding the requirements for costly multi-bank holding companies (Biswas and Sinha, 2022) or by building new branches from scratch (Silva *et al*., 2023). Secondly, acquisitions play a crucial role, where banks buy other banks across state and convert them into branches, facilitating expansion and market penetration (King, 2019). Lastly, product expansion is essential, allowing banks to diversify into related areas, thereby broadening their service offerings and revenue streams (Lian, 2024). These strategies collectively enable banks to enhance their market presence and drive sustainable growth (Ang, 2021).

Literatures increase ambiguity regarding the real impact of TEF on the growth of banks. There is an emergent need to clarify and establish the relationship between a bank's technical efficiency and its growth. The authors state that highly technically efficient banks will perform better in various outputs and grow. However, inefficiencies are not just apparent; there is also a lack of knowledge and management control systems. Additionally, the banking industry is highly regulated and focused on social securities, making it difficult to achieve technical efficiency, which in turn hampers growth.

Based on this discussion, we set forth the objectives of the study and use bibliometric analysis. Thus, the objective of our study is to identify and examine most prominent publications, authors, academic affiliations (publishing institutions), source title, countries, language, document type, subject area and citation matrix. Also, to offer insights for future research directions in technical efficiency and growth of banks. To address these complexities, we have conducted a

comprehensive analysis using scientific mapping and a combination of qualitative and quantitative methodologies. By exploring historical trends and recent advancements our study enlightens the multifaceted nexus between technical efficiency and growth specifically in banks. We have analysed the extensive literature spanning 48 years on the technical efficiency-growth nexus in banks. This period, also, covers significant events such as the Asian Financial Crisis, the savings and loan crisis, the global financial crisis, oil price volatility, the economic impacts of the recent pandemic 2019, and technological advancements like financial digitalization. Hence, our study is most comprehensive examined paper hitherto.

This study addresses the critical research questions such as:

1. What is the annual and global patterns of publications and its popularity in terms of citations (Ellegaard and Wallin, 2015) of the TEF and growth nexus of banks? How the changes have been occurred in it over time (trend)?
2. Which papers and publications are most influential and impactful (Wallin, 2005; Waltman *et al*., 2012)?
3. Which language is the most predominant (Shahab et al., 2024)?
4. Who are the most prolific authors (Lin, 2012; Zhuang *et al*., 2013)? Also, what are their h index, g index and parent institution?
5. Which institute and countries have made important contributions (Tang, 2013; van Eck *et al.*, 2010)?
6. What are the keywords used frequently (Song and Zhao, 2013)? What networks have been emerged based on the authors' keywords?
7. What are the patterns of author keywords co-occurrence and co-citation (Shahab and Nayan, 2024)?

The findings provide a crucial foundation for scholars, academicians, practitioners, policymakers, and banking decision-making units. This guides future research and helps identify key themes related to the technical efficiency and growth of banks. Bibliometric analysis offers an objective approach that mitigates the subjectivity bias inherent in surveys and literature reviews (Fatima and Singh, 2023). This makes it a relevant and effective method for exploring the preliminary relationships between technical efficiency and growth in the banking sector. Bibliometric analysis also involves using statistical methods to analyse books, articles, and other publications. This approach helps identify trends, patterns, and the influence of research within a particular field. Innovative visualization techniques, such as VOSviewer, are often used to create visual representations of bibliometric data (Proaño-Rivera and Feria-Dominguez, 2024). The use of knowledge maps and network diagrams to visualize relationships and thematic similarities plays a crucial role in identifying emerging and underlying research interests (Lee and Chen, 2012). By examining scientific elements such as documents, authors, journals, and keywords, through co-occurrence and co-citation analyses, this research seeks to provide a comprehensive understanding of the evolution of the technical efficiency-growth relationship. Both co-occurrence and co-citation are helpful for researchers, but they focus on different things. Co-occurrence checks how often an item shows up in documents, while co-citation checks how often an item is cited in other documents (Dwivedi *et al*., 2023).

Further, the study is organized as follows: Section 2 reviews the literature, Section 3 details the methodology used in the study, Section 4 presents the results. Section 5 discusses the findings, Section 6 covers the implications, Section 7 concludes the study, and Section 8 outlines the limitations and future scope of the research.

Review of Literature

Peng *et al*. (2025) explored the tripartite relationship between financial outreach, bank deposits, and economic growth. They stated that financial outreach reduces cash holdings and increases bank deposits by lowering transaction costs, thereby boosting economic growth. Hu *et al*. (2025) showed a positive association between digital transformation and bank soundness. Digital transformation helps mitigate risk-taking behaviour and promotes diversification. Nguyen (2022) investigated the role of institutional quality in bank deposit growth, specifically in European transition economies. Their study highlighted that institutional quality strengthens the positive effect of deposit mobilization on bank deposit growth. Additionally, broad money supply and economic growth are critical factors influencing bank deposit growth.

Ferrier and Lovell (1990) use both econometric and linear programming techniques to evaluate the efficiency of 575 banks in 1984. They consider three inputs: the total number of employees, occupancy costs and expenditures on furniture and equipment, and expenditures on materials. The outputs include the number of demand deposit accounts, time deposit accounts, real estate loans, instalment loans, and industrial loans. Their analysis, using the non-stochastic production frontier, reveals an overall technical inefficiency of 16.04%. Contrary to other studies, they find that small banks (those with assets under $25 million) are the most efficient.

Earlier studies mainly look at how banks benefit from growing larger or offering more services. These studies assume that all banks are already working efficiently. The only previous study on bank inefficiency is by Sherman and Gold (1985), but it has a small sample size and doesn't separate inefficiency due to wasted resources from inefficiency due to not operating at the best scale (Rangan *et al*., 1988). Data Envelopment Analysis (DEA) is a popular method for evaluating how well banks perform using linear programming. Despite various methods to address banking efficiency, DEA is widely used. Several studies assess the efficiency and productivity of banks in different regions including USA, Europe, Canada, Latin America, and Asia. Abel *et al*. (2024) defined efficiency as the capacity to deliver desirable results with minimal input. They argued that financial institutions must allocate resources effectively to achieve efficiency. Their study evaluated bank efficiency in terms of capitalization levels, bank size, research costs, and automation. In the SADC region, banks were found to operate at only 40% efficiency. The authors recommended investments in adequate capitalization, asset base expansion, branch management, research and development, and automation to reduce inefficiency.

Halkos (2004) uses DEA to measure the performance of Greek banks and finds that larger total assets are linked to better efficiency. Fukuyama (2013) studies 269 Japanese Shinkin banks and finds that during economic downturns, these banks avoid new loans to reduce bad debts, reallocating capital for future recovery. Fukuyama (2015) also analyses Japanese commercial banks using a dynamic two-stage network model. They find that inefficiency in banks impacts the size of their asset portfolios. Phung et al. (2023) employ DEA to investigate US banks, finding that higher non-performing loans are associated with lower bank efficiency. Emrouznejad *et al*. (2022) review DEA applications across various industries, noting that a significant portion of DEA research focuses on the banking sectors in different countries and regions. Ngo (2012) utilizes a modified DEA window analysis to examine changes in Vietnamese banking performance from 1990 to 2010. In Tunisia, Tlig and Hamed (2017) apply fuzzy DEA to evaluate commercial banks, incorporating both precise and imprecise data.

Studies show that joint-stock commercial banks in China generally exhibit high and stable efficiency, while city commercial banks display more volatility. Additionally, the average technical efficiency of the Chinese banking industry is 0.797, indicating that many banks have room for improvement in managing their inputs (Jiang and He, 2018). Abu-Alkheil *et al*. (2012) examine the efficiency and productivity of Islamic and conventional banks in different regions. The DEA-efficiency scores serve as dependent variables in 'Ordinary Least-Squares' regression analysis to examine the impact of environmental factors, such as bank size and region, on bank performance (Vidyarthi, 2020). They recommend expansions within hybrid banking system growth model for Islamic banks. Persakis and Al-Jallad (2024) examined the influence of CSR on the financial performance of the banking industry. They highlighted the moderating role of social values in the CSR–bank performance relationship. Their findings indicate a positive association between CSR and bank performance, particularly in middle- and high-income countries. Social values such as higher indulgence, uncertainty avoidance, and long-term orientation enhance CSR effectiveness and positively impact bank performance.

Repková (2014) analyses Czech commercial banks' data from 2003 to 2012, finding that average efficiency under constant returns to scale is 70-78%, and 84-89% under variable returns to scale. Studies on banking efficiency look at factors like cost and profit efficiency, interest and operating expenses, revenue from interest and non-interest sources, loans, service quality, and systemic risk. To enhance their growth, banks should strategically expand by integrating both online and physical branches. By blending digital and in-person services, banks can significantly enhance customer satisfaction (Pennathur, 2001). Adhering to regulatory guidelines is essential for improving operational performance and accelerating growth (Badri *et al*., 2000). Leveraging advanced technologies further streamlines operations, making banks more efficient (Surekha *et al*., 2022). Ultimately, a strong focus on service improvement attracts a larger customer base and hence growth of the banks (Zeithaml, 2000).

Alghafes *et al*. (2024), in their study on the influence of ESG factors on the financial performance of banks, found that the overall ESG score does not significantly impact bank performance, but individual components do. Specifically, they demonstrated that the social factor positively affects several performance measures, governance impacts ROE, and the environmental factor correlates positively with Tobin's Q.

Hseih *et al*. (2024) highlighted the impact of bank age, diversity, and competition on return on assets, Tobin's Q, and liquidity creation in the developed world. Grishunin *et al*. (2024) explored the impact of age and gender diversity within boards of directors and CEOs on return on assets and Tobin's Q. Their results indicate that gender diversity within boards significantly negatively impacts Tobin's Q. However, no significant relationship was found between gender diversity and return on assets or Tobin's Q in developed countries.

Arnaudo *et al*. (2022) surveyed 280 Italian banks and examined digital transformation during 2017–2018. They identified indicators measuring the digital supply of financial services during this period and recorded higher growth associated with digital transformation. Innovations such as digital payments, digital channels for lending, and financial technology projects were highlighted. Their findings showed a positive correlation between the intensity of technological innovation and banking profitability, alongside a negative relationship between the number of physical branches, suggesting a substitution effect between physical branches and digital channels.

Methodology

This bibliometric analysis examines research articles on 'technical efficiency', (Du *et al*., 2013) 'growth', and 'banks' (Zainuldin & Lui, 2022) from the Scopus database. Bibliometric analysis is chosen for its quantitative nature, enabling systematic evaluation of scholarly literature. It helps identify trends, thematic trajectories, and latent patterns within the literature. The method provides an objective and replicable framework, enhancing the credibility of research findings. Explaining the rationale for using bibliometric analysis promotes transparency and scholarly rigor, strengthening the research's integrity and impact.

The study examines papers published since 1976 to present 2024, using the Scopus database (AlRyalat *et al*., 2019), a highly respected source in the scientific community. The study on technical efficiency and growth of banks embraced its publication in 1976; hence, this period is important for the seminal research. By searching for the term's 'efficiency', 'growth, 'banks', and 'technical' in article titles, we identify relevant papers. This approach enables us to explore the relationship between technical efficiency and growth across various languages. We conduct an independent keyword co-occurrence and cluster analysis on the collected articles. This step ensures that identifying 'growth' and 'technical efficiency' as top keywords accurately reflects their true significance in the literature, rather than merely our search strategy.

By searching for the terms "technical efficiency" and "growth" of "banks" in article titles, abstracts, and keywords, we identify relevant papers. This approach allows us to explore the relationship between technical efficiency and growth of banks also. Then, an independent keyword co-occurrence and cluster analysis on the collected articles has been performed. These techniques confirm that the terms are not only frequent but also central to discussions in the field, underscoring their analytical prominence. Figure 3 delineates our comprehensive search methodology (Aboelmaged *et al.,* 2024; Shahab et al., 2024). An extensive bibliometric analysis is undertaken on the entire documents, employing a variety of sophisticated tools. The number of publications and percentage, alongside citation metrics, are meticulously calculated in "Microsoft Excel" (de Araujo *et al*., 2021), with intricate graphical representations subsequently generated. Bibliometric networks are constructed and visualized through VOSviewer (Gandasari *et al*., 2024), leveraging Scopus data to elucidate the technical efficiency and growth trajectories of banks. The equations used to calculate Citation per paper, Citation per cited paper, the h-index, and the g-index are given below:

i. Citation per paper_= Total citation/Total paper
ii. Citation per cited paper_= Total citation/Total cited paper
iii. The h-index measures how many of an author's papers have been cited at least that many times (Norris & Oppenheim, 2010).
iv. The g-index gives more importance to highly-cited articles (Costas & Bordons, 2008).

VOSviewer offers three types of visualizations: Network, Overlay, and Density, their outputs have been presented in the results.

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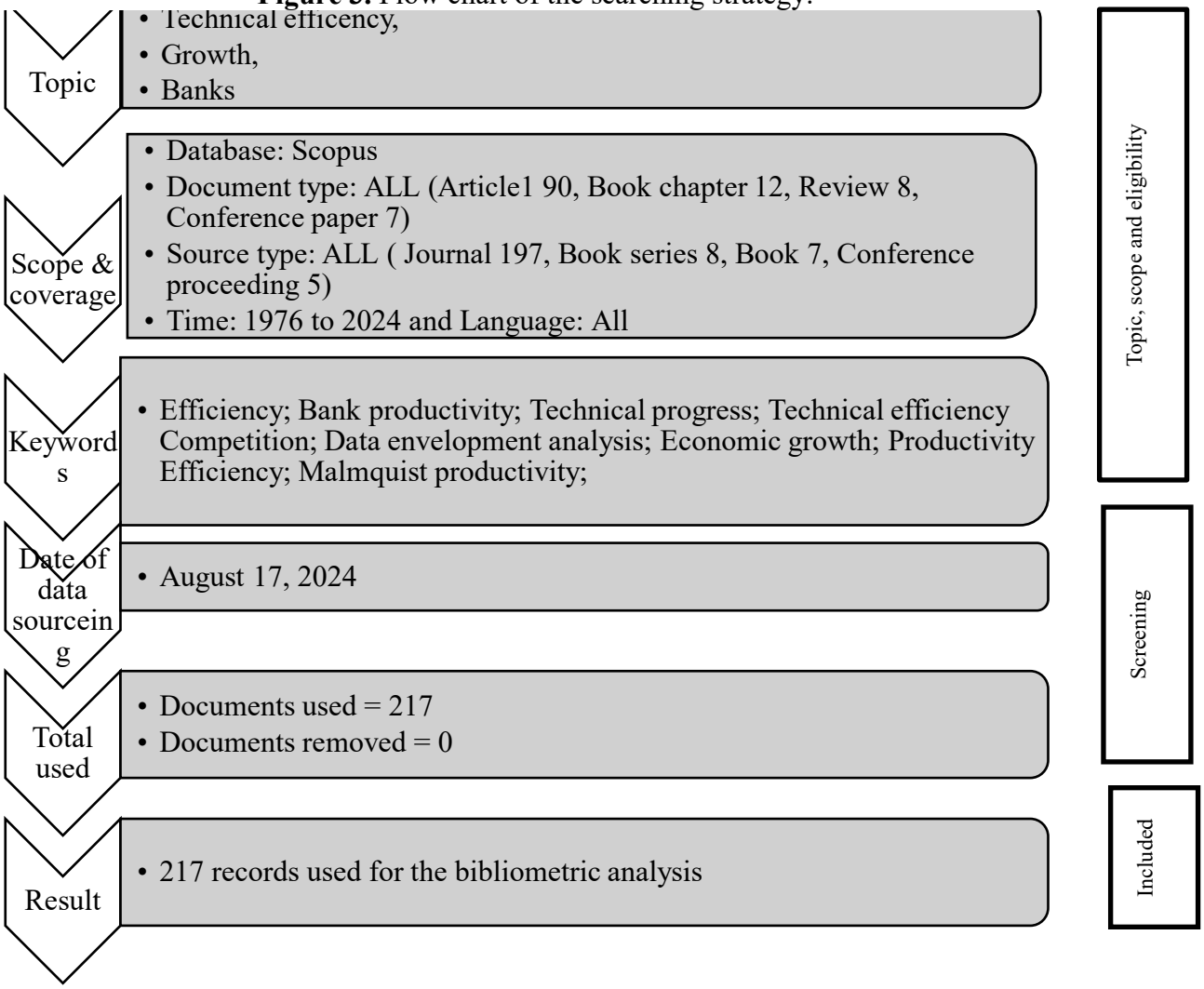
Figure 3. Flow chart of the searching strategy.



Results

The results present the findings of our study, which utilised the Scopus database covering the period from 1976 to August 2024. The very first publication was recorded in 1976; hence, this period has its own significance. They reveal trends and impacts of various publication types on the technical efficiency and growth of banking.

1.1. Year-wise publications and citations

Providing answer to our first question that is what is the annual and global patterns of publications and its popularity in terms of citations (Ellegaard and Wallin, 2015) of the TEF and growth nexus of banks? How the changes have been occurred in it over time (trend)? The Table 1 provides a summary of yearly publications on the development of technical efficiency and growth since 1976 to August 2024. The first study was conducted by Benko I. S. in 1976, as indicated by theScopus database. The table shows that the earlier 2000 mostly one paper per year has been published and since 2000 pace has been picked, in 2012 and 2020 two spikes of 17 papers have been published and most publications was in year 2022 (18, 8.29%). The most cited documents were from 2002, with a total of 468 citations on average. The theme TEF and growth of banks has the popularity of 101.27 average citation per year and 22.40 citation per publication.

Table 1. Year wise publication, percentage and citations

Y	TNP	PTG	CPG	NOCP	TC	ACPP	ACPCP
1976	1	0.46	0.46	1	1	1	1
1989	1	0.46	0.92	0	0	0	0
1990	1	0.46	1.38	1	66	66	66
1992	1	0.46	1.84	1	119	119	119
1993	1	0.46	2.3	1	1	1	1
1996	1	0.46	2.76	1	111	111	111
1997	1	0.46	3.23	1	136	136	136
1999	1	0.46	3.69	1	55	55	55
2000	2	0.92	4.61	2	79	39.5	19.75
2001	5	2.3	6.91	5	338	67.6	13.52
2002	2	0.92	7.83	2	468	234	117
2003	7	3.23	11.06	5	279	55.8	7.97
2004	4	1.84	12.9	4	248	62	15.5
2005	4	1.84	14.75	4	103	25.75	6.44
2006	5	2.3	17.05	4	267	66.75	13.35
2007	3	1.38	18.43	3	128	42.667	14.22
2008	8	3.69	22.12	8	189	23.625	2.95
2009	9	4.15	26.27	8	315	39.375	4.38
2010	8	3.69	29.95	8	216	27	3.38
2011	5	2.3	32.26	5	111	22.2	4.44
2012	17	7.83	40.09	15	331	22.067	1.3
2013	6	2.76	42.86	4	42	10.5	1.75
2014	9	4.15	47	7	228	32.571	3.62
2015	9	4.15	51.15	7	223	31.857	3.54
2016	12	5.53	56.68	11	157	14.273	1.19
2017	6	2.76	59.45	5	118	23.6	3.93
2018	12	5.53	64.98	12	110	9.167	0.76
2019	7	3.23	68.2	5	44	8.8	1.26
2020	17	7.83	76.04	16	161	10.063	0.59
2021	14	6.45	82.49	12	207	17.25	1.23
2022	18	8.29	90.78	16	83	5.188	0.29
2023	10	4.61	95.39	7	17	2.429	0.24
2024	10	4.61	100	3	8	2.667	0.27

Note (s): Year = Y, TNP = Total number of publications, PTG = Percentage, CPG = Cumulative percentage, NOCP = Number of cited publications, TC = Total citations, ACPP = Average citations per publication (Gök *et al*., 2016), ACPCP = Average citations per cited publication (Gök *et al*., 2016)

Source(s): Authors' computation

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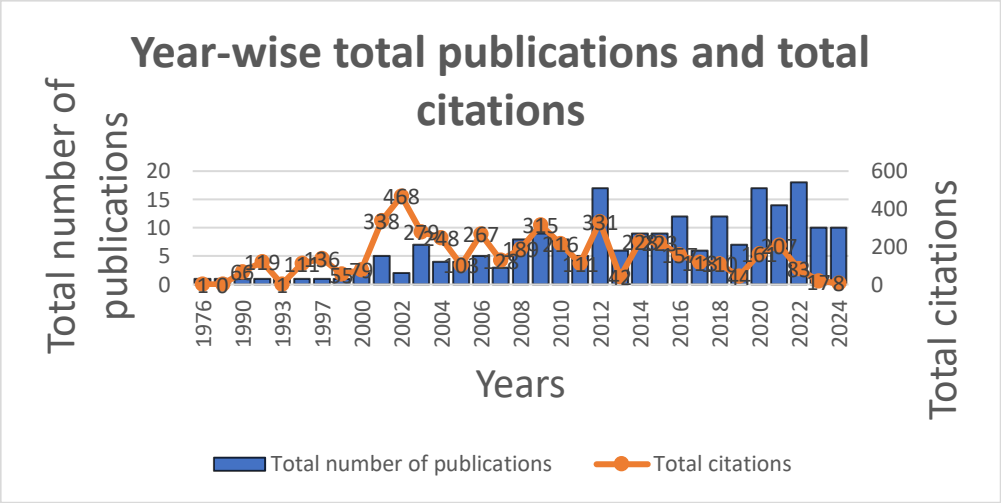
Figure 4. Year wise total publications and total citations



1.2. 4.2. Subject_ area

Table 2 categorizes publications across different subject areas. The table shows that 'Economics, Econometrics, and Finance' dominate with 117 publications, accounting for 32.68% of the total. 'Business, Management, and Accounting' follow with 70 publications, making up 19.55%. Social Sciences contribute 38 articles, representing 10.68%. 'Decision Science' and 'Engineering' fields are also significantly represented, with 30 and 21 publications respectively, comprising

Source(s): Authors' computation

8.38% and 5.57% of the total. 'Mathematics', 'Computer Science', 'Environmental Science', and 'Energy' have 17, 15, 12, and 10 publications respectively, accounting for 4.75%, 4.19%, 3.35%, and 2.79% respectively. The remaining categories, including 'Earth and Planetary Sciences', 'Multidisciplinary', 'Agricultural and Biological Sciences', 'Arts and Humanities', 'Medicine', 'Chemical Engineering', 'Psychology', 'Biochemistry, Genetics and Molecular Biology', 'Neuroscience', and 'Physics and Astronomy', collectively contribute 28 publications, representing approximately 8 % of the total, indicating a comparatively negligible publication count.

Table 2. Subject area

S.No.	Subject_ area	TNP	Percentage
1	'Economics, Econometrics and Finance'	117	32.68
2	'Business, Management and Accounting'	70	19.55
3	'Social Sciences'	38	10.61
4	'Decision Sciences'	30	8.38
5	'Engineering'	21	5.87
6	'Mathematics'	17	4.75
7	'Computer Science'	15	4.19
8	'Environmental Science'	12	3.35
9	'Energy'	10	2.79
10	'Earth and Planetary Sciences'	5	1.4
11	'Multidisciplinary'	5	1.4
12	'Agricultural and Biological Sciences'	4	1.12
13	'Arts and Humanities'	4	1.12
14	'Medicine'	3	0.84
15	'Chemical Engineering'	2	0.56

16	'Psychology'	2	0.56
17	'Biochemistry, Genetics and Molecular Biology'	1	0.28
18	'Neuroscience'	1	0.28
19	'Physics and Astronomy'	1	0.28
	Total	358	100

Note: Year = Y, TNP = Total number of publications

Source(s): Authors' computation

1.3. 4.3 Document type

1.4. The documents are categorised into four primary types, the articles (87.55%) being the most prevalent, then book chapters (5.53%). Followed by reviews and conference papers each contribute 3.68% and 3.22%, respectively (see Table 3).

Table 3. Document type, number of publications and percentage

S.No.	Document Type	TNP	PTG
1	Article	190	87.55
2	Book Chapter	12	5.53
3	Review	8	3.68
4	Conference Paper	7	3.22
	Total	217	100

Note (s): Year = Y, TNP = Total number of publications, PTG = Percentage,

Source(s): Authors' computation

1.5. 4.4 Language of publications

Understanding the current linguistic trends of the publications is crucial for identifying the nexus between technical efficiency and growth of the banks, the answer to our third research question that is which language is the most predominant (Shahab et al., 2024)? Table 4 shows, the primary language of publications in the journals is English (96.8%), several documents were published in multiple languages, including Russian (2), Spanish (2), German, Hungarian, and Undefined, each with one paper. However, these languages represent only a small fraction of the total publications.

Table 4. Language of published documents

S.NO.	Language	TNP	PTG
1	English	210	96.8
2	Russian	2	0.9
3	Spanish	2	0.9
4	German	1	0.5
5	Hungarian	1	0.5
6	Undefined	1	0.5
	Total	217	100

Note (s): Year = Y, TNP = Total number of publications, PTG = Percentage

Source(s): Authors' computation

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1.6. 4.5. Countries and their contributions

1.7. This section identifies the nations, their contributions and their impact in the area of TEF and growth of banks, Scopus database has been used for the analysis as well, this provides answer to our fifth research question that is which institute and countries have made important contributions **(Tang, 2013**; **van Eck *et al*., 2010)**? Only 63 countries have publications. **Table 5** shows most active Countries and their contribution to publications. The United States ranks first with 31 articles, followed by India with 30 articles, China with 29 articles, the United Kingdom with 21 publications, Malaysia with 16 publications, and both Australia and Taiwan with 12 publications each.

Table 5. Countries and their contribution to publications

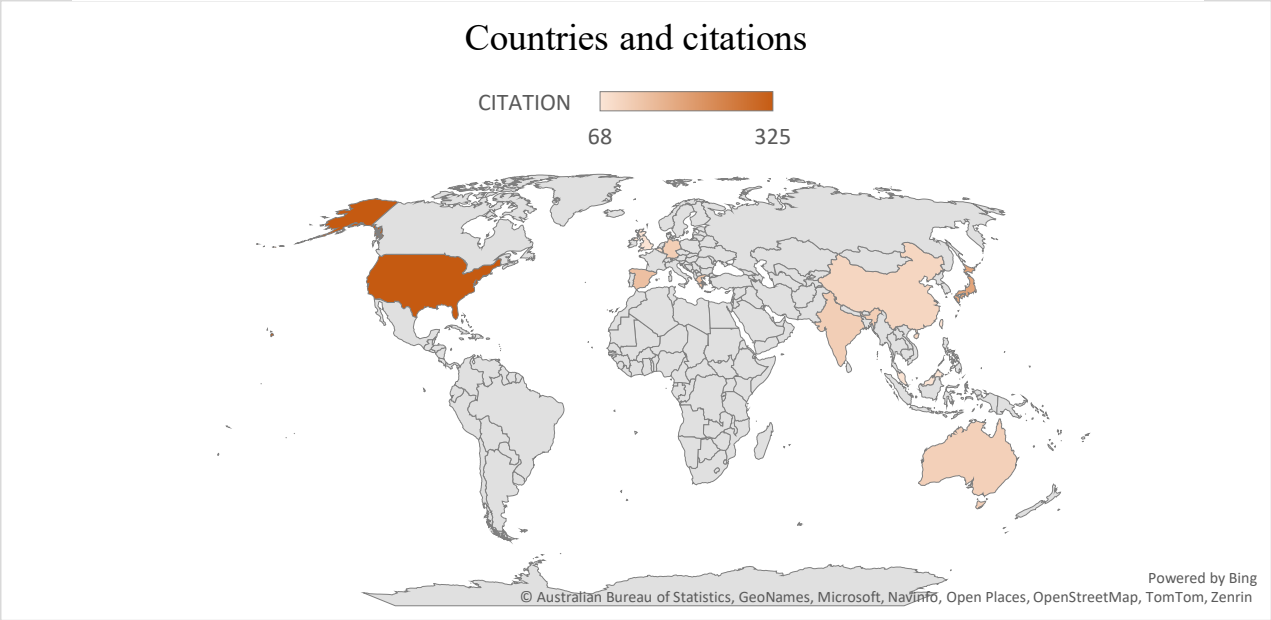
S.No.	Countries	TNP	NCP	TC	ACPP	ACPCP	h	g
1	United States	31	30	1862	60.06	62.07	19	17.74
2	India	30	25	452	15.07	18.08	7	12.85
3	China	29	23	384	13.24	16.7	11	11.27
4	United Kingdom	21	19	561	26.71	29.53	11	13.67
5	Malaysia	16	14	268	16.75	19.14	7	7.48
6	Australia	12	10	365	30.42	36.5	7	6.41
7	Taiwan	12	11	132	11	12	5	6.71

Note (s): TNP = Total number of publications, NCP = number of cited publications, TC = Total citations, ACPP = Average citations per publication, ACPCP = Average citations per cited publication, h = h-index, g = g-index

Source(s): Authors' computation

Figure 5, provides a visual representation of the research contributions from different countries to the global discussion on relationship between technical efficiency and growth of banks.

Figure 5. Global contribution on technical efficiency and growth



The Table 6, provides a comprehensive overview of source type of publications related to technical efficiency and growth of the banks. The predominant category is journal, which constitute 90.78% of all publications. Book series account for 3.69% with 8 papers, followed by books at 3.23% with 7 publications, and conference papers at 2.23% with 5 publications.

Table 6. Type of source

S.No.	Source Type	Total Publications	Percentage
1	Journal	197	90.78
2	Book Series	8	3.69
3	Book	7	3.23
4	Conference Proceeding	5	2.3
	Total	217	100
	Source(s): Authors' computation		

1.8. 4.6. Source titles of the publications

Table 7 outlines the top 11 journals publications on the theme of technical efficiency and the growth of banks. Moreover, the table provides details on each journal's publisher, number of publications, citation, CiteScore, SCImago Journal Rank (SJR), and Source Normalized Impact per Paper (SNIP). Elsevier Ltd. owns three journals, followed by Emerald and Springer with two each, and Taylor and Francis Ltd., Inderscience, Tamkang University, and John Wiley & Sons Ltd. each owning one. Among these journals, the Journal of Banking and Finance has most publications (11) and 1,566 citations. This journal focuses on issues in the banking field. The European Journal of Operational Research holds second most active journal (6 publications, 310 citations) focusing on operations issues such as technical efficiencies. Both journals belong to Elsevier. Managerial Finance (Emerald Publishing) ranks third (6 publications, 145 citations). It is followed by Applied Financial Economics (Taylor & Francis) with 4 articles and 163 citations. The 'International Journal of Productivity and Performance Management' of Emerald Publishing ranks fifth (4 articles, 33 citations). The 'Quarterly Review of Economics and Finance' of Elsevier Ltd. ranks sixth (8 publications, 80 citations). The Journal of Productivity Analysis (Springer Nature) ranks seventh with 3 articles and 20 citations. The International Journal of Information and Management Sciences (Tamkang University), the International Journal of Business Performance Management (Inderscience Publishers), the Annals of Operations Research (Springer Nature), and the African Development Review (John Wiley & Sons) each have 3 articles, with 8, 11, 53, and 105 citations respectively. Additionally, 132 publications have one article each.

By examining these journals' impact factors, Table 7 illustrates that the 'European Journal of Operational Research' has highest SJR score (2.321), followed by the 'Journal of Banking and Finance' (1.663), 'Annals of Operations Research' (1.019), 'International Journal of Productivity and Performance Management' (0.878), 'African Development Review' (0.829), Quarterly Review of Economics and Finance' (0.662), 'Journal of Productivity Analysis' (0.634), 'Managerial Finance' (0.439), 'Applied Financial Economics' (0.371), 'International Journal of Business Performance Management' (0.218), and 'International Journal of Information and Management Sciences' (0.159).

Table 7. Publications Source titles

S.No.	Source title	Publisher	TNP	NCP	Citations	Cite Scor_ 2023	SJR_ 2023	SNI_ 2023
1	'Journal of banking and finance'	Elsevier	11	11	1566	6.4	1.663	1.98
2	'Managerial finance'	Emerald publishing	6	5	145	3.3	0.439	0.81
3	'European journal of operational research'	Elsevier	6	6	310	11.9	2.321	2.58
4	'International journal of productivity and	Emerald publishing	4	4	33	7.9	0.878	1.5

	performance management'							
5	'Applied financial economics' (2015)	Taylor & Francis	4	4	163	1	0.371	1.33
6	'Quarterly review of economics and finance'	Elsevier	3	3	80	6	0.662	1.19
7	'Journal of productivity analysis'	Springer nature	3	3	20	3.1	0.634	1.46
8	'International journal of information and management sciences'	Tamkang university	3	3	8	0.9	0.159	0.21
9	'International journal of business performance management'	Inderscience publishers	3	2	11	1.9	0.218	0.42
10	'Annals of operations research'	Springer nature	3	3	53	7.9	1.019	1.39
11	'African development review'	John Wiley & sons	3	3	105	5.6	0.829	1.27

Note (s): TNP = Total number of publications, NCP = number of cited publications
Source(s): Authors' computation

1.9. 4.7. Most productive authors and their publications

This section in line with our fourth research questions Who are the most prolific authors (Lin, 2012; Zhuang *et al*., 2013)? Also, what are their h index, g index and parent institution? delves into the existing literatures on the relationship between technical efficiency and growth of the banks and identifies the most prolific authors and their key contributions to this field. As illustrated in Table 8, the top authors are Matousek, R., and Isik, I., each with four studies. In terms of overall citations, Isik, I., stands out as the most influential author with 705 citations, followed by Kumbhakar, S.C., with 252 citations. Moreover, 119 authors have contributed one paper each.

Table 8. Most productive authors and their publications

S.No.	Author's name	Affiliation	Country	TNP	NCP	TC	ACPP	ACPCP	h	g
1	Matousek, R.	'School of Business, Management and Economics, The University of Sussex'	United Kingdom	4	4	239	59.8	59.8	4	7.06
2	Isik, I.	'Department of Accounting and Finance, Rowan University, Glassboro'	USA	4	4	705	176.3	176.3	4	7.68

3	Weber, W.L.	'Department of Economics, Southeast Missouri State University, Cape Girardeau'	USA	3	3	230	76.7	76.7	3	4.63
4	Tsionas, M.G.	'Lancaster University Management School'	U.K	3	3	29	9.7	9.7	2	3.08
5	Managi, S.	'Graduate School of Environmental Studies, Tohoku University'	Japan	3	3	228	76	76	3	6.11
6	Kumbhakar, S.C.	'Department of Economics, State University of New York'	Norway	3	3	252	84	84	3	6.6
7	Gulati, R.	'Department of Humanities and Social Sciences, (IIT) Roorkee'	India	3	3	35	11.7	11.7	3	2.87
8	Grifell-Tatjé, E.	'Departament d'Economia de l'Empresa, Universitat Autbnoma de Barcelona'	Spain	3	3	148	49.3	49.3	2	3.88
9	Feng, G.	'Department of Econometrics, Monash University'	Australia	3	3	148	49.3	49.3	3	4.76
10	Chen, X.	'China Academy of Financial Research, Zhejiang University of Finance & Economics'	China	3	3	15	5	5	1	3.122
11	Barros, C.P.	'Instituto Superior de Economia e Gestão, Technical University of Lisbon Rua Miguel Lupi'	Portugal	3	3	47	15.7	15.7	3	1.55

Note (s): TNP = Total number of publications, NCP = number of cited publications, TC = Total citations, ACPP = Average citations per publication, ACPCP = Average citations per cited publication, h = h-index, g = g-index
Source(s): Authors' computation

1.10.4.8 Publications by institutions

This section analyses the leading institutions contributing to research on the connection between technical efficiency and growth of the banks (see table 9). The University of New Orleans, USA, emerges as the most influential institution in this field, with 577 citations. Rowan University, USA, and Southeast Missouri State University, USA, follow closely with 280 and 230 citations, respectively. Notably, the Indian Institute of Technology Roorkee is the sole Indian institution represented in the top institutions, with 31 citations.

Table 9. Most productive institutions with a minimum of three publications.

S	Affiliations	Country	TNP	NCP	TC	ACPP	ACPCP	h	g
1	Universiti Utara Malaysia	Malaysia	3	3	123	41	41	3	4.9
2	Rowan University	USA	3	3	280	93.33	93.33	3	5.32
3	International Islamic University Malaysia	Malaysia	3	3	25	8.33	8.33	1	1.96
4	Southeast Missouri State University	USA	3	3	230	76.67	76.67	3	4.84
5	University of New Orleans	USA	3	3	577	192.33	192.33	3	6.66
6	Universitat Autònoma de Barcelona	Spain	3	3	24	8	8	2	1.66
7	Indian Institute of Technology Roorkee	India	3	3	31	10.33	10.33	3	2.87
8	Zhejiang University of Finance and Economics	China	3	3	15	5	5	1	3.12

9	Lancaster University Management School	United Kingdom	3	3	29	9.67	9.67	2	3.08
10	University of Ghana Business School	Ghana	3	3	46	15.33	15.33	3	3.12

Note (s): TNP = Total number of publications, NCP = number of cited publications, TC = Total citations, ACPP = Average citations per publication, ACPCP = Average citations per cited publication, h = h-index, g = g-index
Source(s): Authors' computation

1.11.4.9 Citation matrices

Table 10 summarizes the citation metrics for documents published between 1976 and 2024. During this 48-year period, 217 papers were published, averaging 101 citations per year. On average, each paper received 22.4 citations, and each author contributed to 30.3 citations. Additional metrics include papers per author (1.36), authors per paper (0.74), h-index (39), and g-index (38.33). These data provide valuable insights into the research output and impact in this field.

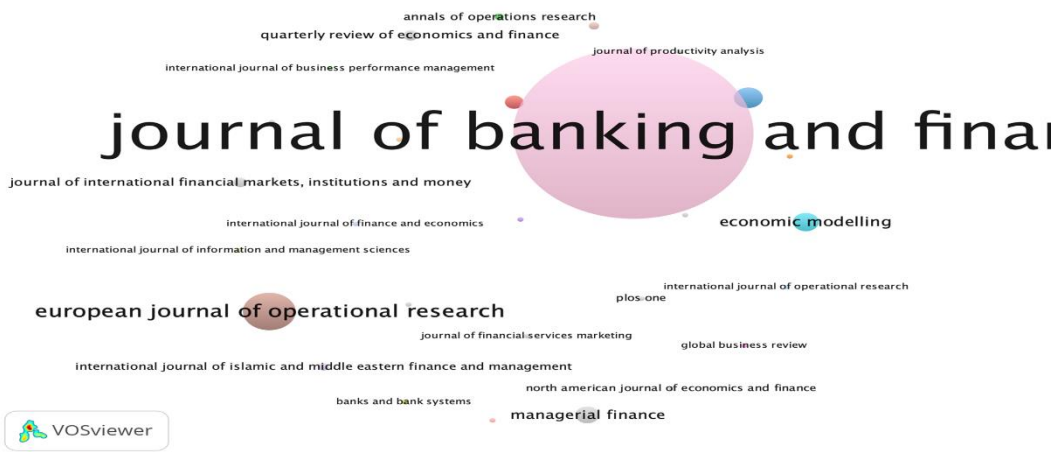
Table 10. Publications' Citations metrics_

S.No.	Metrics	Data
1	Papers_	217
2	Number_ of Citations	4861
3	Years	48
4	Citations_ per Year	101.27
5	Citations_ per Paper	22.40
6	Citations_ per Author	30.38
7	Papers_ per Author	1.36
8	Authors_ per Paper	0.74
9	h-index_	39
10	g-index_	38.33

Source(s): Authors' computation

Figure 6 presents a citation analysis of research on the relationship between technical efficiency and growth of the banks, visualized using VOSviewer. The journals are clustered based on their source, with box sizes indicating their relative importance (Van Eck & Waltman, 2020).

Figure 6. Citation by source title's Network visualization map



Source(s): Authors' work

The color-coded clusters reveal that the literature on this topic is primarily published in journals within the fields of Economics, Econometrics and Finance, and Business, Management, and Accounting.

1.12.4.10 Top cited documents

This section provides answer to our second research question that is which papers and publications are most influential and impactful (Wallin, 2005; Waltman *et al*., 2012)? Among the publications listed in Table 11 on the relationship between technical efficiency and growth of the banks, 'Technical, Scale, and Allocative Efficiencies of the Turkish Banking Industry' by Isik I. and Hassan M.K. (2002) stands out as the most cited article, receiving 325 citations with an average of 14.77 citations per year. The second most cited article is 'Financial Deregulation and Total Factor Productivity Change: An Empirical Study of Turkish' by Isik I. and Kabir Hassan M. (2003), with 198 citations and an average of 9.43 citations per year. Overall, this list of publications offers a comprehensive overview of research trends and interests in the field of technical efficiency and growth of the banks. It highlights a growing interest in this topic over time and underscores its significance.

Table 11. Twenty most cited articles

S.NO	Authors	Title	Year	Source title	Cited by	Cites per Year
1	Isik I.; Hassan M.K.	'Technical, scale and allocative efficiencies of Turkish banking industry'	2002	'Journal of Banking and Finance'	325	14.77
2	Isik I.; Kabir Hassan M.	'Financial deregulation and total factor productivity change: An empirical study of Turkish commercial banks'	2003	'Journal of Banking and Finance'	198	9.43
3	Fujii H.; Managi S.; Matousek R.	'Indian bank efficiency and productivity changes with undesirable outputs: A disaggregated approach'	2014	'Journal of Banking and Finance'	187	18.7
4	Mukherjee K.; Ray S.C.; Miller S.M.	'Productivity growth in large US commercial banks: The initial post-deregulation experience'	2001	'Journal of Banking and Finance'	172	7.48
5	Park K.H.; Weber W.L.	'A note on efficiency and productivity growth in the Korean Banking Industry, 1992-2002'	2006	'Journal of Banking and Finance'	172	9.56
6	Grifell-Tatjé E.; Lovell C.A.K.	'The sources of productivity change in Spanish banking'	1997	'European Journal of Operational Research'	136	5.04
7	Koutsomanoli-Filippaki A.; Margaritis D.; Staikouras C.	'Efficiency and productivity growth in the banking industry of Central and Eastern Europe'	2009	'Journal of Banking and Finance'	131	8.73
8	Tybout J.R.	'Linking trade and productivity: New research directions'	1992	'World Bank Economic Review'	119	3.72
9	Lang G.; Welzel P.	'Efficiency and technical progress in banking:	1996	'Journal of Banking and Finance'	111	3.96

		Empirical results for a panel of German cooperative banks'				
10	Shanmugam K.R.; Das A.	'Efficiency of Indian commercial banks during the reform period'	2004	'Applied Financial Economics'	110	5.5
11	Kumbhakar S.C.; Lozano-Vivas A.; Knox Lovell C.A.; Hasan I.	'The effects of deregulation on the performance of financial institutions: The case of Spanish savings banks'	2001	'Journal of Money, Credit and Banking'	108	4.7
12	Feng G.; Serletis A.	'Efficiency, technical change, and returns to scale in large US banks: Panel data evidence from an output distance function satisfying theoretical regularity'	2010	'Journal of Banking and Finance'	106	7.57
13	Sahoo B.K.; Tone K.	'Decomposing capacity utilization in data envelopment analysis: An application to banks in India'	2009	'European Journal of Operational Research'	100	6.67
14	Shair F.; Shaorong S.; Kamran H.W.; Hussain M.S.; Nawaz M.A.; Nguyen V.C.	'Assessing the efficiency and total factor productivity growth of the banking industry: do environmental concerns matters?'	2021	'Environmental Science and Pollution Research'	96	32
15	Kumbhakar S.C.; Wang D.	'Economic reforms, efficiency and productivity in Chinese banking'	2007	'Journal of Regulatory Economics'	78	4.59
16	Gheeraert L.; Weill L.	'Does Islamic banking development favor macroeconomic efficiency? Evidence on the Islamic finance-growth nexus'	2015	'Economic Modelling'	77	8.56
17	Chang T.-P.; Hu J.-L.; Chou R.Y.; Sun L.	'The sources of bank productivity growth in China during 2002-2009: A disaggregation view'	2012	'Journal of Banking and Finance'	75	6.25
18	Krishnasamy G.; Ridzwa A.H.; Perumal V.	'Malaysian post-merger banks' productivity: Application of malmquist productivity index'	2004	'Managerial Finance'	70	3.5
19	Matthews K.; Zhang N.X.	'Bank productivity in China 1997-2007: Measurement and convergence'	2010	'China Economic Review'	70	5

20	Rezitis A.N.	'Efficiency and productivity effects of bank mergers: Evidence from the Greek banking industry'	2008	'Economic Modelling'	68	4.25

Source(s): Authors' computation

1.13.4.11. Highly used Keywords

This section is in line with our sixth research question that is what are the keywords used frequently (Song and Zhao, 2013)? What networks have been emerged based on the authors' keyword? Table 12 presents the most frequently used keywords in research on the relationship between technical efficiency and growth of the banks. The dominant keywords are 'technical efficiency,' 'data envelopment analysis,' 'efficiency,' 'productivity,' and 'banking,' reflecting a strong focus on the connection between technical efficiency and bank performance. This keyword analysis highlights the critical role of technical efficiency in the banking sector, underscoring its significance within the broader fields of finance and economic growth.

Table 12. Top 20 author's keywords

S.No.	Authors	Author Keywords	Cited by	Percentage
1	Isik I.; Hassan M.K.	Cost efficiency; Ownership and control; Turkish banks	325	12.95
2	Isik I.; Kabir Hassan M.	DEA; Deregulation; Efficiency; Liberalization; Productivity; Technology; Turkish banks	198	7.89
3	Fujii H.; Managi S.; Matousek R.	Bank; DEA; Efficiency; India; Non-performing loan	187	7.45
4	Mukherjee K.; Ray S.C.; Miller S.M.	Bank productivity; D24; Deregulation; G21; Malmquist index	172	6.85
5	Park K.H.; Weber W.L.	Bank efficiency; Bank productivity; Korean banks	172	6.85
6	Grifell-Tatjé E.; Lovell C.A.K.	Banking; Efficiency; Malmquist index; Productivity	136	5.42
7	Koutsomanoli-Filippaki A.; Margaritis D.; Staikouras C.	Banking efficiency; Directional distance functions; Luenberger productivity indicator; Stochastic frontier analysis; Transition economies	131	5.22
8	Tybout J.R.		119	4.74
9	Lang G.; Welzel P.	Banking; Economies of scale; Economies of scope; Technical progress; Translog cost function	111	4.42
10	Shanmugam K.R.; Das A.	Efficiency; Indian commercial banks;	110	4.38
11	Kumbhakar S.C.; Lozano-Vivas A.; Knox Lovell C.A.; Hasan I.	Deregulation; performance; financial institutions:	108	4.3
12	Feng G.; Serletis A.	Productivity decomposition; Translog output distance function	106	4.22
13	Sahoo B.K.; Tone K.	Capacity utilization; DEA; Optimal idle capacity; Technical efficiency	100	3.98
14	Shair F.; Shaorong S.; Kamran H.W.; Hussain M.S.; Nawaz M.A.; Nguyen V.C.	Competition; Data envelopment analysis; Generalized method of moments; Malmquist productivity index; Risk	96	3.82
15	Kumbhakar S.C.; Wang D.	Deregulation; Efficiency; Input distance function; Productivity; Stochastic frontier; Technical change	78	3.11

16	Gheeraert L.; Weill L.	Aggregate productivity; Economic growth; Efficiency; Financial development; Islamic finance	77	3.069
17	Chang T.-P.; Hu J.-L.; Chou R.Y.; Sun L.	Banking; China; Efficiency change; Input slack-based productivity index; Productivity growth; Technical change	75	2.99
18	Krishnasamy G.; Ridzwa A.H.; Perumal V.	Accounting research; Acquisitions and mergers; Banking; Malaysia; Productivity rate	70	2.79
19	Matthews K.; Zhang N.X.	Bank efficiency; Bootstrap; China; Malmquist; Productivity	70	2.79
20	Rezitis A.N.	Efficiency; Malmquist productivity; Mergers; Translog distance function	68	2.71

Source(s): Authors' computation

Figure 7. Network visualization of the author's keywords

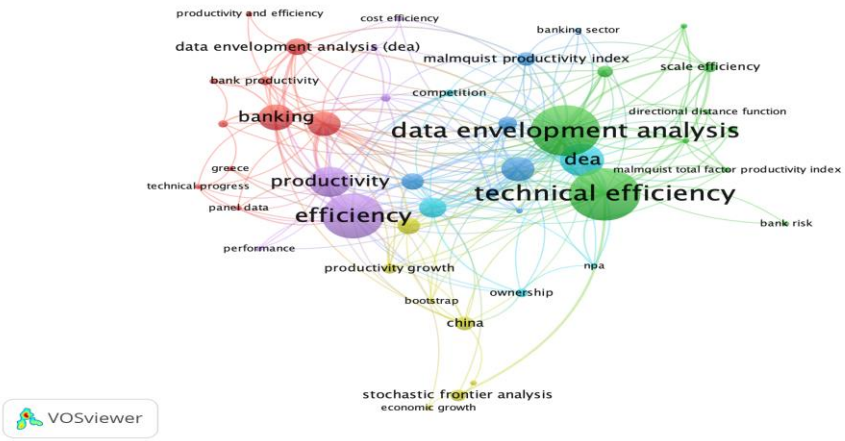


Figure 8. Overlay visualization of the author's keywords

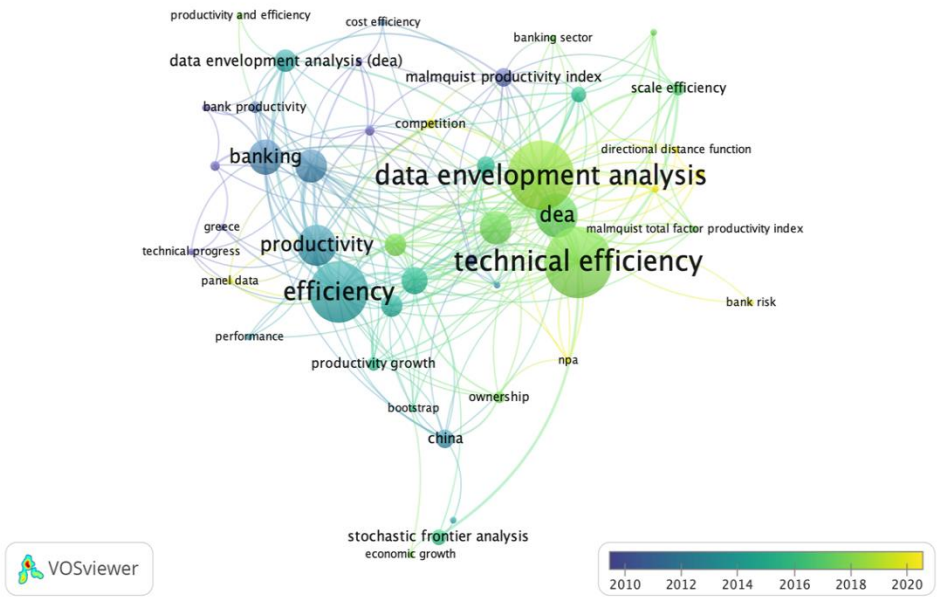


Figure 9. Themes of research based on author's keywords (the hotspot of the findings)

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1.14.4.12. Analysis of Co-occurrence

Co-occurrence analysis of author's keywords

This section presents the answer to our last question that is what are the patterns of author keyword co-occurrence and co-citation (Shahab and Nayan, 2024)? The author's keyword analysis significantly influences the content of the piece (Ali *et al*., 2022). Co-occurring keywords, which appear together in the article, indicate related topics. To answer the final research question, we utilized VOSviewer for keyword and co-occurrence analysis. VOSviewer, a tool for creating and visualizing bibliometric networks, was used to map keywords within each document. Figures 10, 11, and 12 present different visualizations of a term co-occurrence network based on all keywords: network visualization, overlay visualization, and density visualization.

These graphics illustrate the strength of connections between terms using colour, circle size, font, and line thickness, with related keywords often grouped by colour. The analysis identified 13 significant clusters within the research on the relationship between technical efficiency and growth of the banks using the author's keywords. For instance, the diagram demonstrates that 'technical efficiency' (green), 'efficiency' (red), 'Malmquist productivity index' (red), 'total factor productivity' (yellow), and 'banks' (yellow) are strongly related and frequently appear together.

Figure 10. Network visualization of a term co-occurrence network based on all keywords

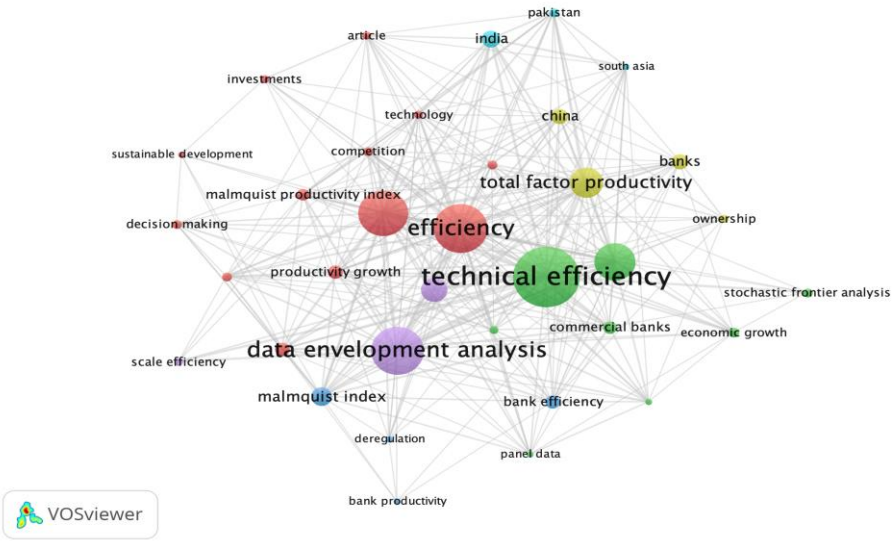

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Figure 11. Overlay visualization of a term co-occurrence network based on all keywords

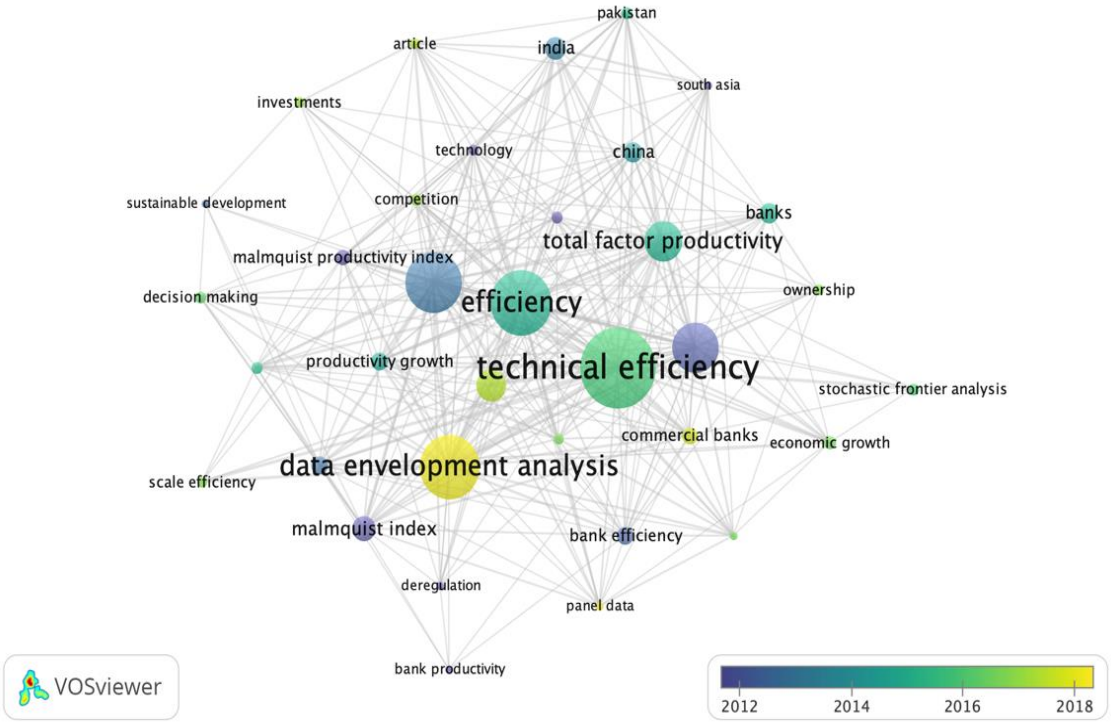
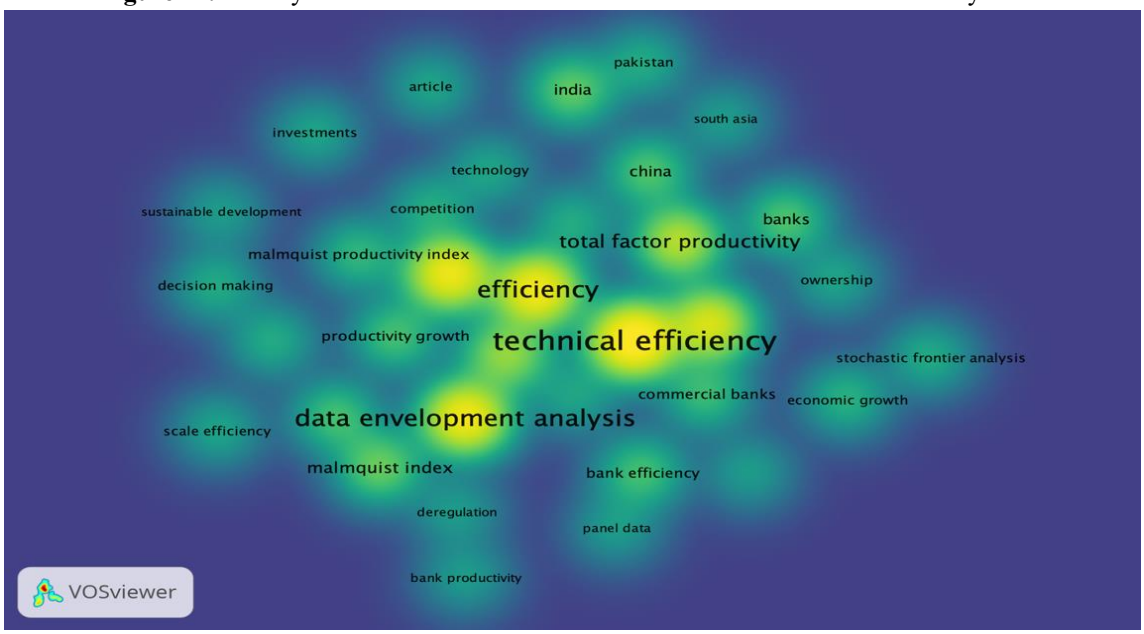


Figure 12. Density visualization of a term co-occurrence network based on all keywords



4.13 Citation analysis

1. Citation analysis by authors

Citation analysis measures the frequency with which a document is cited, reflecting its prominence in a particular field (Aria & Cuccurullo, 2017). Authors' citation analysis involves gathering data on how often their works are cited by others. This data helps calculate metrics like total citation count, h-index, and g-index, which compare the impact and influence

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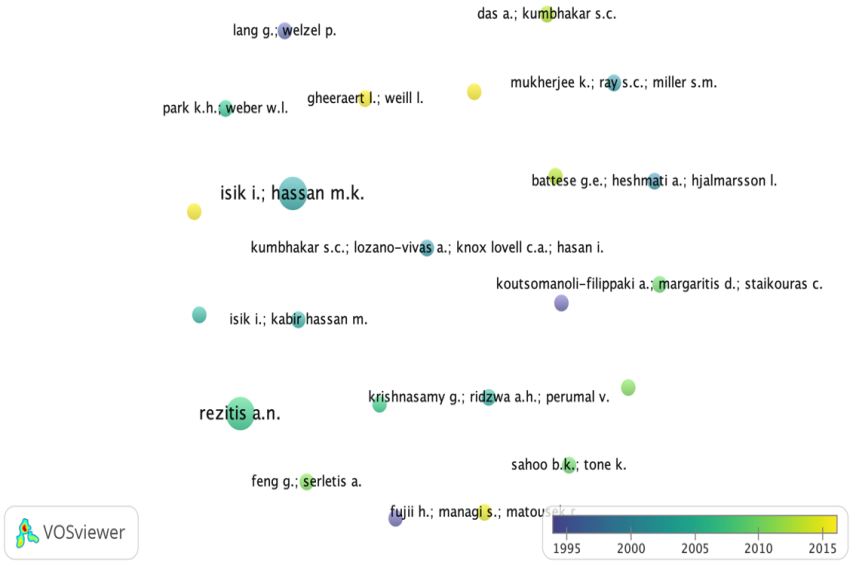
of different authors and identify key works or authors in a field (Mester, 2022). Figures 13 and 14 show network and overlay visualization maps of author citations, respectively.

Figure 13. Network visualization map of the citation by authors

These maps reveal 20 significant clusters of papers cited by others, detailing the structure of frequent citations in the field of technical efficiency and growth of the banks.

Figure 14. Overlay visualization map of the citation by authors



2. Co-citation analysis by authors

Co-citation analysis is essential for understanding the literature on the relationship between technical efficiency and growth of the banks. This analysis helps readers comprehend the evolution and popularity of articles in this field (Bhattacharjee *et al*., 2023; Zhu *et al*., 2021). Figure 15 presents a network visualization map of co-citation analysis by authors, illustrating the co-citation network for literature on technical efficiency and growth of the banks. Research clusters

emerge when multiple authors co-cite the same pairs of papers, often indicating recurring themes among the co-cited works. These clusters, combined with single-link clustering, highlight specialized study areas and the broader landscape of scientific research.

Figure 15. Network visualization map of co-citation analysis by authors

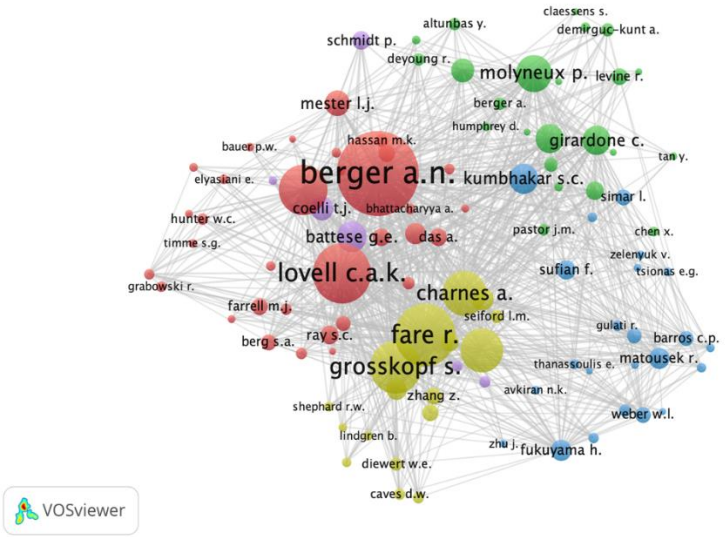


Figure 16. Density visualization map of co-citation analysis by authors

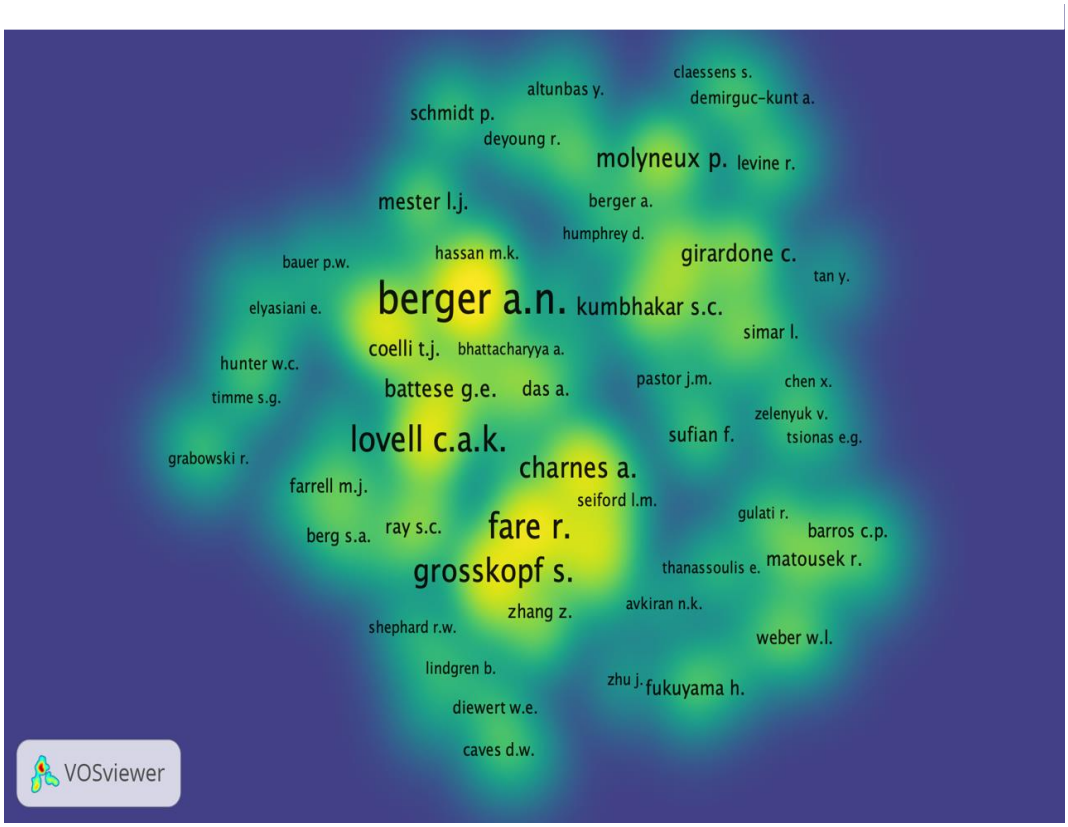


Figure 16, a density visualization map of co-citation analysis by authors, provides a visual representation of the interconnectedness and clustering of research within the field of technical efficiency and growth of the banks.

5. Discussion

The study's initial research question aimed to identify current patterns in the technical efficiency and growth of banks. To achieve this, a bibliometric analysis was conducted, focusing on the trend of research in this area. Bibliometric analysis, as noted by Fanea-Ivanovici and Siemionek-Ruskań (2023) and Mansour *et al*. (2022), is a valuable tool for evaluating the productivity of research and publications within a specific field. Gu (2004) highlighted that bibliometric data can be instrumental in comparing the outputs and inputs of scientific research, assessing the effectiveness of a study field, and aiding academic institutions in regulating funding-related policies. Furthermore, the results of bibliometric research can provide researchers with deeper insights into the variables that contribute to the field's research output, as discussed by Akhavan *et al*. (2016). This study specifically examined papers related to the technical efficiency and growth of banks, sourced from the Scopus database. A predetermined search query was employed, resulting in the identification of 217 relevant documents.

Benko (1976) published a seminal paper titled "Internal Over voltages and Protective Devices in EHV Compensated Systems-Series Capacitors and Shunt Reactors," which marked the beginning of this research area. However, a more pertinent paper by Obben (1993), titled "Cost Structure and Technical Change in Rural Banking," has been identified as particularly significant according to documents gathered from the Scopus database. The number of publications in this field saw a gradual increase until 2008. Since then, the volume of research on the technical efficiency and growth of banks has continued to rise and remains robust to this day.

This study highlights the most productive authors in the field of technical efficiency and growth of banks. The Journal of Banking and Finance stands out as the most productive journal, with 11 publications, 1,566 total citations, and a cite score of 6.4. The most influential article, authored by Isik and Hassan (2002), titled "Technical, Scale, and Allocative Efficiencies of the Turkish Banking Industry," has garnered 325 citations and an average of 14.77 citations per year. Matousek R. is the second most prolific author, with 4 publications and 238 citations. Articles constitute more than 87.55% of all publications, and 96.8% of these are written in English. The top five countries contributing to research on the technical efficiency and growth of banks are the United States, India, China, the United Kingdom, and Malaysia. Research in the fields of Economics, Econometrics and Finance, and Business, Management and Accounting predominantly focuses on technical efficiency and growth of banks. The University of New Orleans in the USA is the most productive academic institution in this area. Moreover, Scopus database records 577 citations overall. Research on the impact of technical efficiency on the growth of banks has received 4,861 citations over 48 years, averaging 101.27 citations per year, 22.40 citations per paper, and 30.38 citations per author, with h and g indices of 39 and 38.33, respectively.

The keyword, title, and summary analyses conducted using VOSviewer reveal the key components of this field. Frequently used terms include "technical efficiency," "data envelopment analysis," "efficiency," "productivity," and "banking." The Scopus database was the primary source of documents for this investigation. Although Scopus is one of the largest databases for scientific studies, it does not encompass all published sources (Ahmi and Mohamad, 2019). Future research could benefit from incorporating additional databases such as Google Scholar, Web of Science, and others, potentially yielding more comprehensive and valuable results. Despite its limitations, this study enhances our understanding of the relationship between technical efficiency and growth of the banks by highlighting recent research trends in this area. By employing bibliometric methods, it contributes to the existing body of knowledge on this topic.

While bibliometric analysis has unique characteristics, the study also has certain limitations that should be noted to aid readers' comprehension and support further research. The results primarily focus on specific phrases, particularly "technical efficiency" and "growth of banks," which frequently appear in document titles, abstracts, and keywords. Some researchers might focus solely on titles, abstracts, or keywords, making screening necessary before data analysis. Future studies could address this issue. Researchers in this field may find this study useful for understanding the existing literature and generating ideas for further research on the nexus between technical efficiency and growth of the banks.

6. Implications

The research on technical efficiency and growth of banks provides profound insights for researchers, academics, practitioners, and society at large. First and foremost, the increasing trend in research indicates a growing academic interest in the field of technical efficiency and the growth of banks. High citation rates observed in the early 2000s suggest that key research in this area has significantly influenced subsequent studies. Banking professionals can leverage insights from technical efficiency and growth (TEFG) studies to enhance operational efficiency and strategic planning. The historical

analysis of TEFG in banking enables practitioners to benchmark their institutions against global trends and best practices. Since research interest has intensified post-2000, it is essential for practitioners to stay updated on the latest findings to integrate new strategies into their operations. Research on technical efficiency and growth contributes to more efficient banking systems, ultimately benefiting consumers through improved financial services. A deeper understanding of efficiency and growth in banks supports financial stability, which is crucial for broader economic development. Policymakers can use these insights to design regulations that enhance bank efficiency, promote financial inclusion, and strengthen economic resilience.

Second, the strong representation of research in Business, Management, and Accounting suggests that practitioners can apply these insights to improve financial decision-making and strategic management. Additionally, studies in Computer Science and Engineering indicate that artificial intelligence (AI), machine learning, and fintech innovations are increasingly relevant to banking efficiency. The high percentage of journal articles ensures that practitioners have access to well-vetted, peer-reviewed research that can inform decision-making in banking efficiency and growth. The dominance of peer-reviewed articles ensures credible research findings, minimizing misinformation. However, the limited presence of book chapters and conference papers suggests that academic findings may not be reaching wider audiences, including policymakers and the general public. The presence of review articles allows policymakers and institutions to leverage synthesized knowledge to create evidence-based policies that enhance banking efficiency and economic growth.

Third, the prevalence of English in publications underscores its role as the primary language of communication, but this also presents a barrier for non-English-speaking researchers, limiting their ability to contribute and access key studies. This highlights a gap that needs to be addressed. The predominance of English in financial research may restrict access in regions where English proficiency is lower, limiting financial literacy and informed decision-making. Encouraging multilingual research publications and translations can help ensure that banking efficiency and growth studies benefit a more diverse audience, including policymakers, businesses, and consumers worldwide. Policymakers in non-English-speaking countries may struggle to access and implement research findings, highlighting the need for localized research or translated policy briefs.

Fourth, the dominance of major economies like the U.S., China, India, and the U.K. in technical efficiency and banking growth research suggests that nations with strong academic and financial sectors play a crucial role in shaping the field. However, a significant portion of the world remains underrepresented, indicating potential gaps in regional insights and financial system analyses. Countries in Africa, the Middle East, and Latin America could collaborate more actively to bridge this research gap. Universities and financial research institutions in leading countries may influence global perspectives on banking efficiency, shaping the methodologies and frameworks used worldwide. Banking professionals in less-represented countries can analyse findings from leading contributors such as the U.S., India, China, and the U.K. to adopt best practices and improve technical efficiency. While research from these nations provides valuable insights, financial institutions must consider local economic and regulatory conditions before implementing global strategies. The growing interest in banking efficiency research in emerging markets—as evidenced by contributions from India, Malaysia, and Taiwan—offers valuable lessons for developing economies.

Fifth, the dominance of publishers such as Elsevier, Springer, Emerald, Taylor & Francis suggests that a limited number of reputable journals ensure academic credibility in the field. Leading journals like the Journal of Banking and Finance and the European Journal of Operational Research highlight the significant focus on banking and efficiency studies. Financial professionals and policymakers can rely on these journals for well-researched insights into banking efficiency and growth strategies. The prominence of operational research journals highlights the importance of efficiency measurement tools, optimization models, and performance analysis in banking operations. Practitioners seeking applied insights may prioritize research from journals such as Managerial Finance and Applied Financial Economics, Benchmarking: An International Journal etc., which focus on financial management and performance evaluation. However, the low representation of region-specific journals—except for the African Development Review—suggests that studies on banking efficiency may not adequately reflect regional financial systems, highlighting the need for localized research. Financial professionals and policymakers can utilize research from leading institutions to optimize financial strategies and improve decision-making processes. Banks and financial institutions can also benchmark their operational performance against global best practices using insights from top academic institutions.

Sixth, the identification of prolific authors like Matousek, R., and Isik, I. provides a reference point for researchers seeking foundational studies and methodologies in banking efficiency and growth. Isik, I., has had a significant impact, serving as

a cornerstone for further research. Kumbhakar, S.C., also holds considerable academic influence. Scholars can identify leading authors and their affiliated institutions to establish research collaborations and benefit from their expertise.
Seventh, the dominance of institutions such as the University of New Orleans, Rowan University, and Southeast Missouri State University highlights their significant contributions, making them valuable sources for academic collaboration. The concentration of research in U.S.-based institutions suggests a regional focus, presenting opportunities for scholars from other countries to contribute diverse perspectives. With only one Indian institution (Indian Institute of Technology Roorkee, among the top contributors, there is potential for more participation from emerging economies, particularly in regions where banking efficiency is crucial for economic development. Practitioners can explore partnerships with universities for industry-driven research and training in financial efficiency methodologies.
Finally, an average of 101 citations per year and an h-index of 39 indicate the strong academic relevance and impact of research in technical efficiency and banking growth. The clustering of publications in fields such as Economics, Econometrics, Finance, Business, and Management highlights the interdisciplinary nature of the research. There are opportunities for expansion into related areas. The frequent use of keywords like "technical efficiency," "data envelopment analysis," "efficiency," "productivity," and "banking" indicates the key areas of focus in banking and finance research. Future studies can explore how improvements in technical efficiency impact various aspects of bank performance and growth. The identification of 13 significant research clusters and the mapping of co-occurring keywords reveal central themes and emerging trends in technical efficiency and bank growth studies. Researchers can explore these clusters further to understand areas of convergence and divergence in the literature. For practitioners in the banking sector, co-occurrence analysis provides an overview of the most relevant topics associated with TEFG. This can help practitioners enhance productivity and adopt efficiency-improving strategies. Recognizing co-occurring themes such as "banks," "efficiency," and "technical efficiency" allows banking professionals to adopt best practices and implement strategies aligned with these key areas. This may include embracing new methodologies for assessing and improving efficiency or focusing on specific productivity measures gaining traction in the literature. Policymakers in leading research nations have access to more data-driven insights, enabling them to craft effective banking policies compared to underrepresented regions.

7. Conclusion

The study investigates current trends in the technical efficiency and growth of banks through a bibliometric analysis, using data sourced from the Scopus database. The literature reveals ambiguity regarding the impact of technical efficiency on bank growth, highlighting the need to clarify this relationship. The objective of our study is to identify and examine most prominent publications, authors, academic affiliations, source title, countries, language, document type, subject area and citation matrix in the field. Also, to offer insights for future research directions in technical efficiency and growth of banks. The study encompasses 48 years of literatures and publications in Scopus database. The research identifies 217 relevant documents related to bank efficiency and growth, using a systematic search query. Notably, the work of Obben (1993) is the first significant contributor to this field.
The ‘Journal of Banking and Finance’ standing out as the most productive journal. Isik I. and Hassan M.K.’s (2002) article on the Turkish banking industry is the most influential, with 325 citations. The study identifies the most countries contributing to this research area, with the United States, India, China, the UK, and Malaysia leading the way. Using VOSviewer for keyword analysis, the study finds that terms such as "technical efficiency," "data envelopment analysis," "efficiency," and "productivity" are central to this research field. This study provides directions to future research to unearth the relationship between technical efficiency and the growth of banks across various global regions.

8. Limitations and future scope of the research

The study contributes to the understanding of technical efficiency and growth of the banks, emphasizing the value of bibliometric methods in uncovering research trends. However, the paper highlights certain limitations, particularly the narrow focus on specific keywords and phrases. Future research should expand on this by using systematic literature reviews (Gunasekaran *et al*., 2020) and meta-analyses and empirically testing the relationship between technical efficiency and growth of the banks across different regions globally.
While Scopus served as the primary source of data, the study acknowledges limitations in relying solely on this database and recommends future research incorporate additional databases like Google Scholar and Web of Science for a broader scope. Further, future research could focus on the relationship between technical efficiency and bank growth by comparing

different types of banks—local, global, foreign, national, and regional—across various regions. This will help identify ways to enhance efficiency and productivity hence, the growth of the banks.

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