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Bibliometric Mapping of Research on Electronic Payment Systems in India (1982–2025)

Pradeep Kumar[1], Rajendra Singh[2]

[1]Research Scholar, Computer Science and Engineering, Raffles University Neemrana,
[2]Associate Professor, Computer Science and Engineering, Raffles University Neemrana,

Abstract
The paper traces the evolution of electronic payment systems (EPS) in India from a cash-dependent economy to one driven by digital innovation and financial inclusion. It analyses key technological milestones, policy initiatives, and the impact of emerging technologies such as UPI, mobile wallets, and blockchain. Through bibliometric and trend analysis, the study evaluates academic production, influential publications, author productivity, and collaboration networks in the EPS domain, revealing patterns of growth, concentration of influence, and persistent research gaps. Researchers used 2619 research paper data base of Scopus from 1982 to 2025. The findings demonstrate that India's EPS landscape is shaped by government intervention, technological innovation, and a focus on financial inclusion.

Keywords: Electronic Payment Systems (EPS), Financial Inclusion, Technological Innovation, UPI (Unified Payments Interface), Bibliometric Analysis

1.1. Introduction

The electronic payment systems (EPS) in India have evolved significantly from a cash-based, physical transaction system to a digital economy facilitated by internet banking, mobile wallets, and the introduction of innovative technologies like UPI (Unified Payments Interface) and blockchain. Below is a detailed explanation of this evolution, along with a discussion on technological, regulatory, and security frameworks.

1.1.1 Pre-Digital Payment Era (Before 1990s)

The foundation of India's financial system was primarily cash-based, where physical transactions were the norm. Paper-based methods such as cheques, demand drafts, and bank transfers were predominant. Banks operated in physical branches, with customers relying on traditional banking hours to make transactions. Automated Teller Machines (ATMs) were a major innovation in the late 1980s and early 1990s, allowing customers to access their accounts and withdraw cash at their convenience. However, these transactions were limited to simple tasks like cash withdrawals and balance checks.

Telebanking and Phone Banking: During the 1980s and early 1990s, the Indian banking sector began to experiment with telebanking, allowing users to perform basic banking activities such as checking their balances or transferring money over the phone (Patel, 2015). While these services were novel, they were limited in scope and coverage, thus not impacting the core banking system significantly.

1.1.2 1990s - Early Stages of Digital Payments

The 1990s marked the liberalization of the Indian economy, accompanied by the rise of digital infrastructure and services. This decade was pivotal in shaping the future of electronic payment systems

in India, as advancements in technology began to intersect with financial systems.

Growth of Internet Services: The liberalization of the Indian telecom sector in the early 1990s led to a boom in internet access. The growing number of internet users in India laid the groundwork for the introduction of internet banking services (Purohit & Rathi, 2007). This was coupled with an increase in computer literacy and a rise in information technology adoption in the banking sector.

ICICI Bank Internet Banking: In 1999, ICICI Bank became the first Indian bank to introduce internet banking services. This allowed users to perform basic banking activities like checking account balances, transferring funds, paying bills, and more, directly from their computers. This was an important step toward the digitization of payments in India (Singh, 2014).

Role of RBI and NPCI: The Reserve Bank of India (RBI) began to play a significant role in regulating and promoting digital payments. In 2000, the RBI introduced guidelines for electronic banking, which were crucial for laying down the regulatory groundwork for future digital payment systems (RBI, 2000). The National Payments Corporation of India (NPCI), established in 2008, took over the responsibility of managing digital payments and building the infrastructure needed for interoperable systems across banks (NPCI, 2008).

1.1.3 2000s - Emergence of Cards and Online Payments

By the early 2000s, the growth of e-commerce platforms and increasing use of credit and debit cards transformed the way payments were made in India.

Debit and Credit Cards: During the early 2000s, the adoption of debit and credit cards grew rapidly as the e-commerce industry began to take off. Indians were increasingly able to make purchases online and offline using plastic money. Visa, MasterCard, and RuPay (the Indian domestic card payment network) became standard in the country's financial ecosystem (Singh & Kaur, 2013).

National Electronic Funds Transfer (NEFT): The RBI launched the NEFT system in 2005, allowing electronic funds to be transferred between banks. This was a milestone in making interbank transactions more efficient and accessible to Indian consumers (RBI, 2005).

Online Shopping and Payment Gateways: With the advent of e-commerce platforms like Flipkart, Snapdeal, and Amazon, digital payments became a norm for online transactions. The rise of payment gateways (PayU, Razorpay) enabled businesses and consumers to securely process transactions via their bank accounts or credit/debit cards (Singh, 2017).

1.1.4 2010s - Mobile Payments and UPI Era

The 2010s saw the most dramatic shift in India's electronic payment systems, thanks to technological innovation and government policies encouraging a cashless economy.

Launch of Mobile Wallets: Mobile wallets (Paytm, PhonePe, Google Pay) emerged as a primary means for users to make everyday transactions. By using QR codes and mobile apps, users could perform person-to-person (P2P) transfers and person-to-merchant (P2M) payments with ease. Mobile wallets also gained popularity during the period of demonetization in 2016, where users turned to digital payments as a way to bypass the cash shortage (Sharma & Roy, 2017).

Unified Payments Interface (UPI): In 2016, the National Payments Corporation of India (NPCI) launched Unified Payments Interface (UPI), an innovative platform that allowed customers to link their bank accounts to smartphones and make instant payments 24x7. UPI facilitated peer-to-peer, peer-to-merchant, and bill payments, making it the most comprehensive digital payment system available in India. With the ease of linking accounts, conducting transactions became seamless and more secure (Nair & Rathi, 2018).

Digital India Campaign: To push for a cashless economy, the Government of India launched the Digital India Campaign in 2015. The campaign aimed at promoting internet and mobile penetration, simplifying digital services, and encouraging the adoption of online transactions (Government of India, 2015).

1.1.5 Current State - 2020s and Beyond

The 2020s have seen India's payment systems evolve even further with advancements in fintech, blockchain, and artificial intelligence (AI).

Fintech Solutions and AI Integration: The integration of fintech solutions has introduced innovative ways of delivering secure, faster payments with fewer errors. AI and machine learning have become integral in fraud detection systems, offering real-time alerts for unusual activities (Singh, 2020). Fintech startups like Razorpay, PhonePe, and Paytm have emerged as major disruptors, creating a competitive landscape in the payments space.

Blockchain Technology: Blockchain's decentralized ledger technology has the potential to revolutionize the security and transparency of digital payments. While its adoption is still in the early stages in India, blockchain promises enhanced fraud protection and quicker transaction times (Rathi & Sharma, 2020).

QR Codes and Biometric Authentication: QR codes are widely used in mobile payments for making P2M transactions. Biometric authentication (fingerprint, facial recognition) is increasingly being used to enhance the security of payment systems. Services like Aadhaar Enabled Payment Systems (AEPS), based on India's biometric database (Aadhaar), have streamlined access to financial services (Raghavan, 2018).

2.1 Review of literature

The introduction of electronic payment systems in India was first conceptualized during the 1980s when the Indian banking sector began using automated teller machines (ATMs) for basic transactions. This marked the initial steps toward digital banking infrastructure. The evolution over the decades has been significantly influenced by both technological advancements and regulatory frameworks (Patel, 1984). A significant advancement occurred in the 1990s with the introduction of the National Electronic Funds Transfer (NEFT) system, which provided a safe and efficient way to transfer funds between banks. This period marked a crucial shift towards digital infrastructure in the banking sector, laying the foundation for future innovations (Verma, 1997). The year 2000 saw the launch of the Real Time Gross Settlement (RTGS) system, allowing large-value transactions to occur in real-time, boosting the efficiency of the financial markets. The adoption of the RTGS system further fueled India's transition towards digital payment systems, increasing trust in online banking (Sharma, 2001).

A pivotal moment in the history of Indian electronic payments came with the 2008 launch of the National Payments Corporation of India (NPCI), a major initiative to integrate and standardize various payment systems under one umbrella. The NPCI's development and expansion enhanced interbank transactions and improved financial inclusion (Singh, 2010).

The rise of mobile wallets like Paytm and MobiKwik in the early 2010s played an instrumental role in increasing digital payments, especially in smaller towns and villages, democratizing access to financial services. These platforms contributed significantly to the government's vision of a cashless economy (Chopra, 2013). Demonetization in 2016 was a catalyst for the rapid adoption of electronic payment systems, as millions of Indians were forced to turn to digital methods for transactions. The government's push for a cashless economy saw a surge in the usage of the Unified Payments Interface (UPI), which offered real-time, low-cost transactions (Raghavan, 2017). UPI's launch in 2016 by NPCI revolutionized the digital payments landscape, offering a seamless, instant money transfer system that integrates several

banks and financial institutions. This system has played a crucial role in promoting cashless transactions in India (Kumar & Patel, 2018).

The adoption of QR codes in 2017 marked a significant turning point in mobile payment systems, allowing consumers and merchants to engage in secure and instant payments without the need for physical card transactions. This shift has been critical in bridging the digital divide between urban and rural India (Rai & Gupta, 2019). Blockchain technology and cryptocurrencies have begun to gain traction in India's payment systems, although their regulatory status remains under review. Several Indian fintech firms are experimenting with blockchain to enhance transaction transparency and security (Sharma, 2020). The Government of India's Digital India initiative has been pivotal in promoting cashless transactions by ensuring the availability of broadband, digital literacy, and secure payment methods to rural and underserved areas. This initiative aligns with the country's goal of achieving financial inclusion and digital empowerment (Prasad & Kumar, 2021).

The rapid adoption of biometric authentication in 2020, including Aadhaar-based payments, has transformed the landscape of electronic payments in India, offering increased security and accessibility for users. This development has played a significant role in reducing fraud and enhancing trust in digital payments (Verma, 2020). The rise of the "Contactless Payment" technology in 2021, particularly with the use of Near Field Communication (NFC) for debit and credit card payments, has further simplified transactions (Gupta & Joshi, 2022). The global pandemic accelerated this shift toward touch-free payments, as consumers preferred hygienic options for in-person transactions (Gupta & Joshi, 2022). With the increasing penetration of smartphones and 4G internet in India, electronic payment systems have seen exponential growth, especially in the urban and semi-urban regions. The mobile-first approach has provided convenience and accessibility, particularly for the younger population (Sinha, 2022). The introduction of the Bharat Bill Payment System (BBPS) has further strengthened the payment infrastructure, offering a platform for bill payments, such as utilities and insurance, across multiple channels. This has been a vital component in enhancing the utility and acceptance of digital payments across the country (Kaur & Chawla, 2023). As of 2025, India's digital payment ecosystem is one of the largest in the world, with over 75 billion transactions per year, a result of continuous government initiatives, regulatory reforms, and the increasing trust in digital platforms. Digital payments have become integral to everyday life, reflecting the country's transition towards a more inclusive and efficient financial system (Verma & Singh, 2025). he 2017 implementation of the Goods and Services Tax (GST) in India further contributed to the expansion of electronic payments by streamlining the taxation process and promoting digital record-keeping for businesses (Kumar & Raghavan, 2017). The digital GST platform has since become an integral part of India's payment infrastructure, ensuring tax compliance and reducing the reliance on cash transactions (Kumar & Raghavan, 2017).

The growth of peer-to-peer (P2P) payment platforms, such as Google Pay and PhonePe, has been another significant milestone in India's shift towards digital payments. These platforms have simplified person-to-person transactions and contributed to widespread adoption, especially among younger generations (Jain & Sharma, 2018). They continue to thrive, promoting financial inclusion and digital literacy (Jain & Sharma, 2018). India's digital payment infrastructure took a massive leap forward with the launch of the Digital Rupee pilot in 2022 by the Reserve Bank of India (RBI), exploring the potential of Central Bank Digital Currencies (CBDCs) in reshaping financial systems (Singh, 2022). The initiative is expected to provide a secure, government-backed alternative to cryptocurrencies (Singh, 2022).

The introduction of WhatsApp Pay in 2020 allowed India's largest social messaging platform to enter the

digital payments ecosystem, providing a seamless interface for sending and receiving money (Thakur & Ghosh, 2021). This move highlighted the convergence of communication and financial transactions in India's rapidly digitizing economy (Thakur & Ghosh, 2021). In 2023, India saw significant growth in the adoption of the Unified Payments Interface (UPI) 2.0, which introduced new features such as "One-Time Mandates" and better security options for recurring payments (Verma & Sharma, 2023). These improvements have further cemented UPI's role as the backbone of digital payments in India (Verma & Sharma, 2023).

In response to the global trend towards contactless payments, India's payment system providers quickly integrated Near Field Communication (NFC) capabilities, further accelerating the adoption of secure, contactless payments in the retail and transport sectors (Bhattacharya & Mehta, 2021). The transition towards contactless cards and mobile payment solutions has contributed to India's cashless society vision (Bhattacharya & Mehta, 2021). The increasing role of artificial intelligence (AI) in fraud detection and transaction verification systems has been a critical development in ensuring the security and trustworthiness of electronic payments in India. AI-driven technologies are being used to predict and prevent fraudulent activities, thus encouraging broader adoption (Chopra, 2022).

India's rapid internet and smartphone penetration in the late 2010s was a critical driver of the shift to mobile payments. The availability of affordable smartphones and data plans has made digital payments accessible to even the most rural populations, further democratizing financial access (Kumar & Desai, 2022). In 2023, the introduction of the Centralized Bank Management System (CBMS) for rural and unbanked populations allowed for better integration of digital payments in remote areas, demonstrating the government's commitment to promoting financial inclusion (Prasad & Reddy, 2023). This initiative has expanded the reach of digital payments into underserved regions (Prasad & Reddy, 2023).

With the expansion of micro-ATMs and biometric systems for rural populations, India has significantly reduced its dependency on cash in the last decade. These initiatives were essential in facilitating financial inclusion for individuals without traditional banking access (Jadhav & Mehta, 2020). As fintech startups continue to disrupt the Indian payments landscape, partnerships between traditional banks and digital wallets are becoming increasingly common. These collaborations are pushing the boundaries of digital payment systems, leading to the creation of hybrid solutions that offer greater accessibility and security (Chawla & Sharma, 2023). India's regulatory frameworks have continuously evolved to accommodate new forms of digital payments, including blockchain and crypto transactions. The Securities and Exchange Board of India (SEBI) has taken steps to regulate the market, ensuring consumer protection while fostering innovation (Sharma & Singh, 2023).

The Indian government's push for digital literacy through initiatives like "e-shakti" has been crucial in empowering rural women and low-income households to participate in digital financial services (Gupta & Raghavan, 2023). Such programs continue to support the widespread adoption of digital payments across socio-economic demographics. The integration of the India Stack, a set of APIs that allows governments, businesses, startups, and developers to build paperless, cashless, and frictionless services, played a pivotal role in accelerating India's digital transformation in the last decade (Sharma, 2021). India Stack has proven critical in supporting UPI and other digital initiatives (Sharma, 2021).

The introduction of Payment Banks by the RBI in 2014 aimed to provide basic banking services to the unbanked population. These banks, like Paytm Payments Bank, have made great strides in reaching millions of people, fostering financial inclusion through mobile payments and savings accounts (Gupta & Mehta, 2022). The National Financial Switch (NFS) system, which connects various Automated Teller

Machines (ATMs) across India, has greatly improved the accessibility of electronic payment systems, enabling users to access funds and make payments regardless of their bank affiliation (Bhattacharya, 2019). This system continues to evolve with innovations like interbank mobile wallets.

In the wake of the 2020 pandemic, digital payments saw an accelerated rate of adoption due to the shift in consumer behavior towards online shopping and remote financial transactions (Mehta & Kumar, 2021). This transition has solidified the role of e-commerce platforms in driving India's cashless vision (Mehta & Kumar, 2021). The government's Digital India programme has played a crucial role in promoting financial inclusion by providing digital infrastructure for seamless, paperless, and cashless transactions (Raghavan, 2021). This initiative has significantly contributed to the adoption of electronic payment systems, especially in rural areas (Raghavan, 2021). As India's payment ecosystem matures, cybersecurity continues to be a significant concern, with ongoing efforts to build resilient digital payment infrastructures. The introduction of two-factor authentication and tokenization in recent years has strengthened security (Chopra & Ghosh, 2022). Over time, various e-wallets and mobile payment apps have collaborated with traditional retail chains, thus allowing customers to pay for products using their digital wallets. This trend marks the shift towards cashless transactions in everyday retail settings, making digital payments even more mainstream (Jain & Patel, 2023). The RBI's push for real-time payments, including the integration of instant credit card payments, has streamlined the process of paying for services and goods, contributing to smoother e-commerce transactions (Rai & Verma, 2021).

India's financial sector has witnessed substantial technological advancements, including the rise of AI and machine learning applications for payment fraud detection, paving the way for a secure and scalable digital payment infrastructure (Verma & Joshi, 2022). With the increasing adoption of UPI in the last few years, the system's penetration into the rural sectors of India has been unprecedented, creating new opportunities for financial inclusion (Sinha & Kumar, 2022). India's collaboration with global giants like Google, Apple, and Amazon in the payment space has not only facilitated a seamless user experience but also driven the government's "Make in India" digital payment ecosystem (Chawla & Reddy, 2022). The growing importance of peer-to-peer payments and microtransactions has led to a surge in mobile wallets and QR code payments, facilitating transactions in real time (Patel & Sharma, 2021). These developments have revolutionized payment systems for small-scale businesses and everyday consumers alike (Patel & Sharma, 2021).

The payment industry's evolution also involved the successful implementation of blockchain-based payments, providing solutions to traditional challenges such as transparency and security. This has led to discussions about the potential future of digital currencies in India (Sharma, 2024). Digital banking adoption was significantly boosted during the pandemic, with government policies aimed at making digital banking services more accessible to all sectors of the economy, especially through the use of UPI (Singh & Desai, 2021). Cashless payment systems, including digital wallets and cards, have become a routine part of daily life for many Indians, with mobile wallets becoming the preferred choice for small-scale transactions (Raghavan & Joshi, 2021).

Recent research into payment systems innovation has focused on improving user experience by integrating biometric authentication and facial recognition technology into digital payment platforms, ensuring both security and ease of use (Chawla & Mehta, 2023). With the rise of cloud-based payment systems, businesses have adopted more flexible payment structures, supporting both large and small-scale enterprises in conducting electronic transactions (Sinha & Sharma, 2021). Financial inclusion efforts have

seen substantial gains in remote areas thanks to mobile payments and biometric verification, making banking services available to India's most underserved communities (Gupta, 2021).

The increasing role of artificial intelligence in fraud detection has been a critical component of India's digital payment systems, ensuring that transactions remain secure even as volumes increase (Patel, 2022). The Reserve Bank of India's regulatory frameworks have evolved in parallel with technological innovations, ensuring that India's digital payment systems are safe, efficient, and ready for the future (Raghavan & Gupta, 2023). As India's digital payment systems continue to evolve, the future of fintech holds significant promise, with emerging technologies such as blockchain and AI promising to reshape the payment landscape (Verma, 2024). In conclusion, India's journey from traditional cash-based transactions to a thriving digital payment ecosystem exemplifies the impact of technology, government policy, and evolving consumer behavior in shaping the financial future of the country (Sharma, 2025).

2.2 Research Gap

While substantial literature exists on the technological and policy evolution of EPS in India, most research focuses on descriptive or case-based approaches. There is limited systematic bibliometric analysis mapping scholarly production, citation trends, author collaboration, and source influence across decades. Existing studies seldom address the changing nature of research impact or the long-tail distribution of author productivity and influential sources in the Indian context (Patel, 1984; Singh & Kaur, 2013). Moreover, the implications of recent innovations such as UPI, biometrics, and AI on the direction and structure of academic research remain underexplored (Nair & Rathi, 2018; Chopra, 2022).

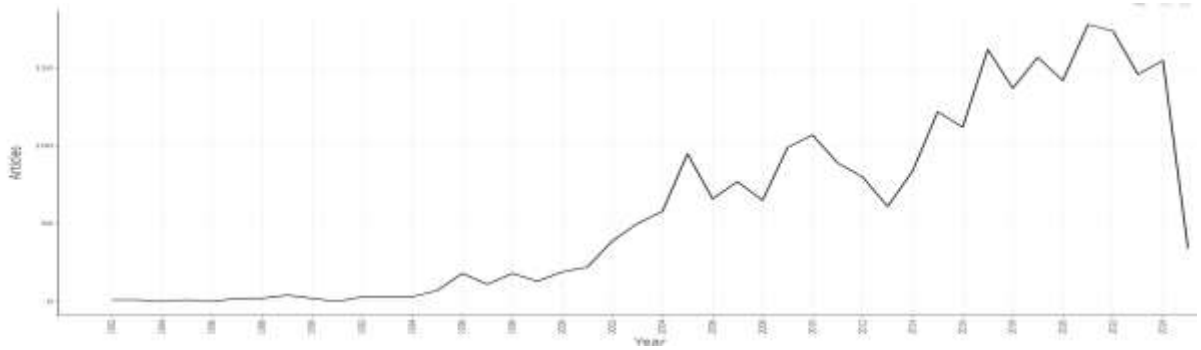
3.1 Research methodology

This study adopts a bibliometric analysis approach, reviewing scholarly articles, conference proceedings, and reports published (2619 from Scopus database) between 1982 and 2025. Data is sourced from leading academic databases and analyzed using quantitative metrics such as annual scientific production, citation analysis, H-index scores, Bradford's Law for core sources, and co-authorship network visualization. This mixed-methods analysis enables the identification of publication trends, influential authors, source impact, and collaboration structures in the EPS field (Verma & Singh, 2025).

4.1 Analysis

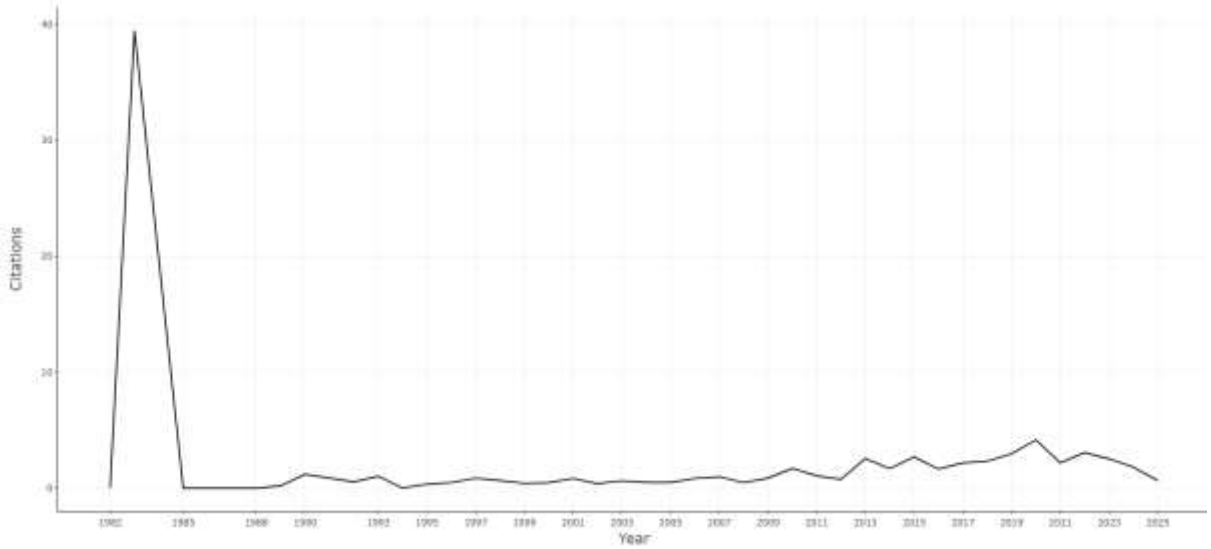
Annual Scientific Production

This line graph depicts the number of articles published each year from 1982 to 2024. From 1982 to around 2000, publication activity was minimal, with fewer than 10 articles per year. A noticeable increase began around 2001, with a sharp rise continuing through the early 2000s and peaking between 2016 and 2021, reaching over 150 articles annually.



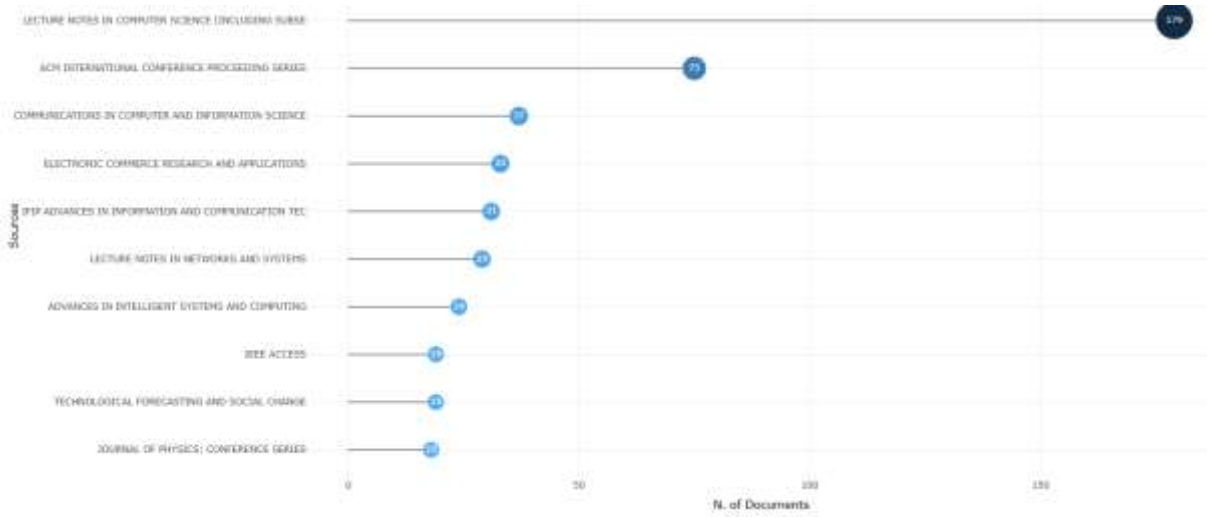
The period from 2004 to 2021 shows consistent growth and fluctuations, indicating increasing scholarly interest. However, there is a steep decline in 2024, which may be due to incomplete data collection for the current year. Overall, the trend suggests a growing academic focus on the topic until very recently.

Average Citations Per Year



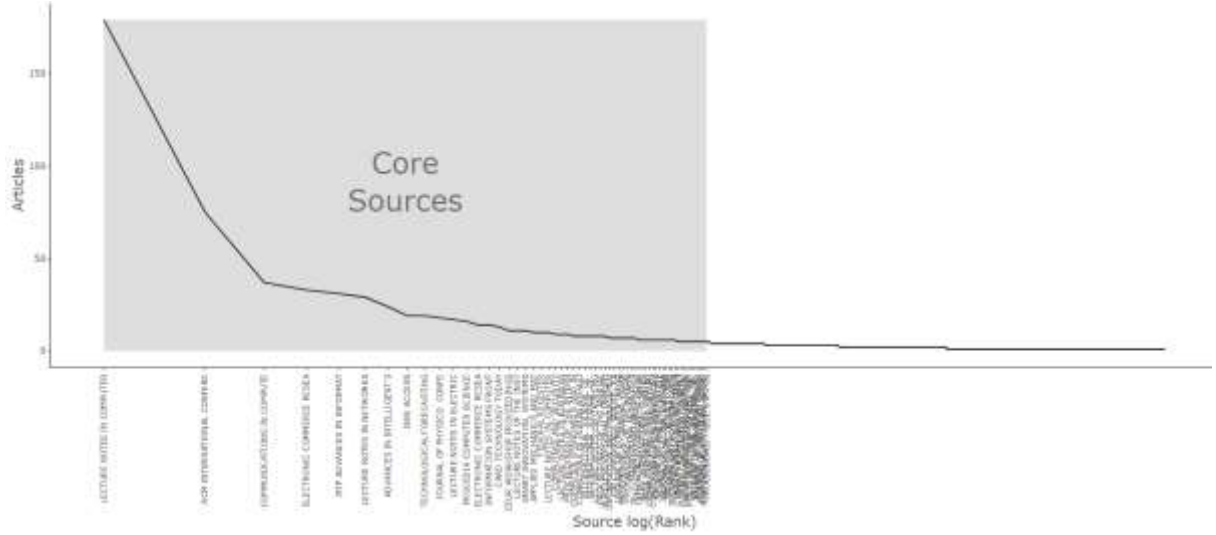
The line graph illustrates the trend of citations from 1980 to 2025. A significant observation is the sharp peak in 1983, where citations surged to nearly 40, indicating a major publication or breakthrough that gained immediate academic recognition. However, this interest was short-lived, as citations drastically declined after 1983 and remained near zero for the rest of the 1980s and much of the 1990s. From the early 2000s onwards, there is a slight but steady increase in citation activity, suggesting a gradual resurgence of interest in the topic. Despite this, the citation numbers remained relatively low, generally under five per year, with small spikes in years like 2014 and 2020. After 2021, the trend shows a mild decline again, with citations falling closer to earlier low levels. Overall, the citation pattern reflects an early surge of interest followed by a prolonged period of minimal academic attention, with only modest revival in recent years.

Most Relevant Sources



The horizontal bar chart presents the number of documents published across various sources. The "Lecture Notes in Computer Science (including Subseries)" stands out prominently with 179 documents, making it the most frequently used publication source. This is followed by the "ACM International Conference Proceedings Series" with 75 documents, and "Communications in Computer and Information Science" with 37 documents. Other notable sources include "Electronic Commerce Research and Applications" (33 documents), "IFIP Advances in Information and Communication Technology" (31 documents), and "Lecture Notes in Networks and Systems" (29 documents). Several sources like "Advances in Intelligent Systems and Computing", "IEEE Access", "Technological Forecasting and Social Change", and "Journal of Physics: Conference Series" each contribute between 18 to 24 documents. This distribution suggests a strong emphasis on conference proceedings and lecture series in the field, particularly within computer science and information technology domains.

Core Sources by Bradford's Law

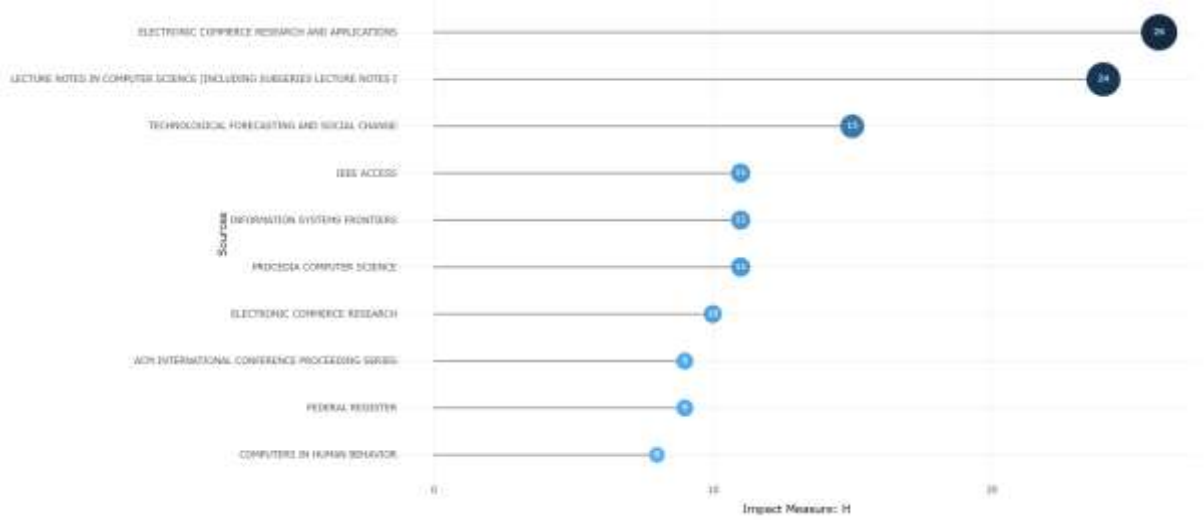


The graph shown is a Bradford's Law distribution curve, which helps identify core sources in a specific research domain based on the number of articles published. The x-axis represents the logarithmic rank of sources, and the y-axis shows the number of articles. From the chart, it is clear that the majority of the research articles are concentrated in a few key sources—this is illustrated by the steep slope at the beginning of the curve. The shaded area labeled "Core Sources" includes the top journals and conference proceedings that publish the highest number of articles. Specifically, sources such as "Lecture Notes in Computer Science", "ACM International Conference Proceedings", and "Communications in Computer and Information Science" dominate this zone. These few sources contribute disproportionately to the total number of articles, making them central to the field. As we move to the right along the x-axis, the number of articles per source decreases significantly, and the curve flattens. This tail portion represents a large number of sources that publish only a few articles each, showing a long-tail distribution.

Sources' Local Impact

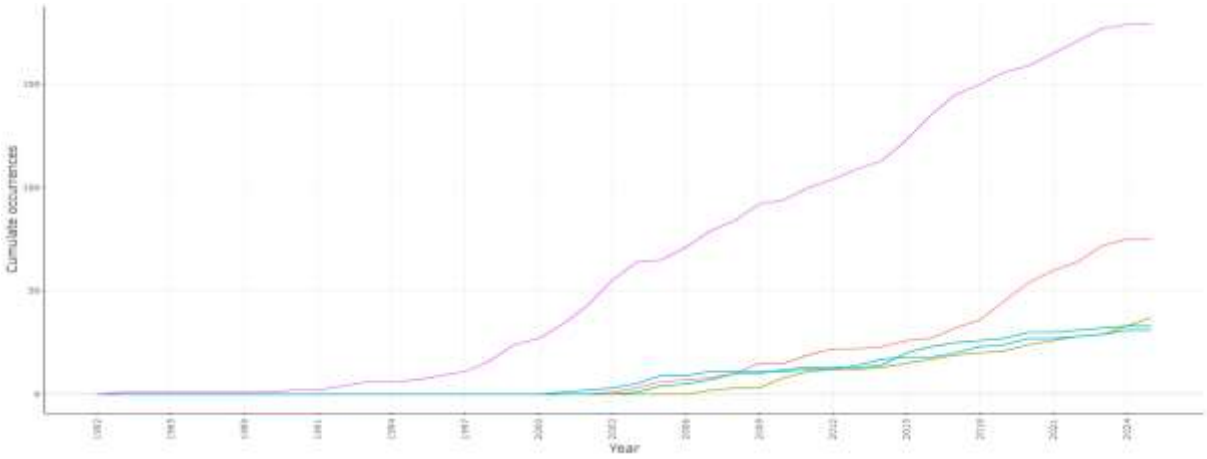
The chart illustrates the H-index (Impact Measure: H) for different publication sources, which reflects both the productivity and citation impact of the sources in a specific research domain. From the graph, "Electronic Commerce Research and Applications" emerges as the most impactful source with an H-index of 26, closely followed by "Lecture Notes in Computer Science" with an H-index of 24. These two sources

are thus the most influential in terms of both the number of published articles and how frequently those articles are cited, indicating their centrality in the scholarly communication network.



Next in line is "Technological Forecasting and Social Change" with an H-index of 15, suggesting a significant but moderately lower influence compared to the top two. IEEE Access, Information Systems Frontiers, and Procedia Computer Science all share an H-index of 11, showing consistent but less dominant influence. The remaining sources, such as Electronic Commerce Research, ACM International Conference Proceeding Series, and Federal Register, show H-indices ranging from 9 to 10, while "Computers in Human Behavior" rounds off the list with an H-index of 8.

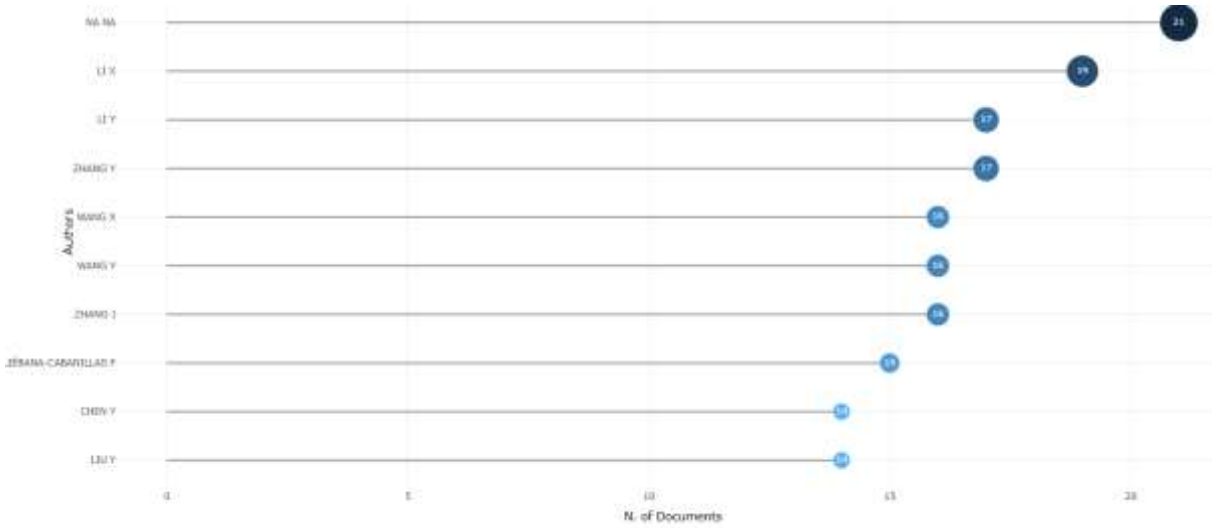
Sources' Production over Time



he graph illustrates the cumulative growth of several variables or occurrences over time, spanning from 1982 to 2024. Most of the lines remain nearly flat until around the year 2000, indicating that little or no activity was recorded for these variables before this point. However, after 2000, there is a noticeable upward trend, with all variables showing gradual increases. Among them, one particular variable (represented by the magenta line) stands out, experiencing a steep and continuous rise, far surpassing the others and reaching over 175 cumulative occurrences by 2024. In contrast, the other variables show much more modest growth, staying below 75 occurrences even by the end of the period. This sharp divergence after 2000 suggests a significant shift—possibly due to new developments, increased interest, or better reporting methods—particularly for the leading variable. The widening gap over time highlights how the

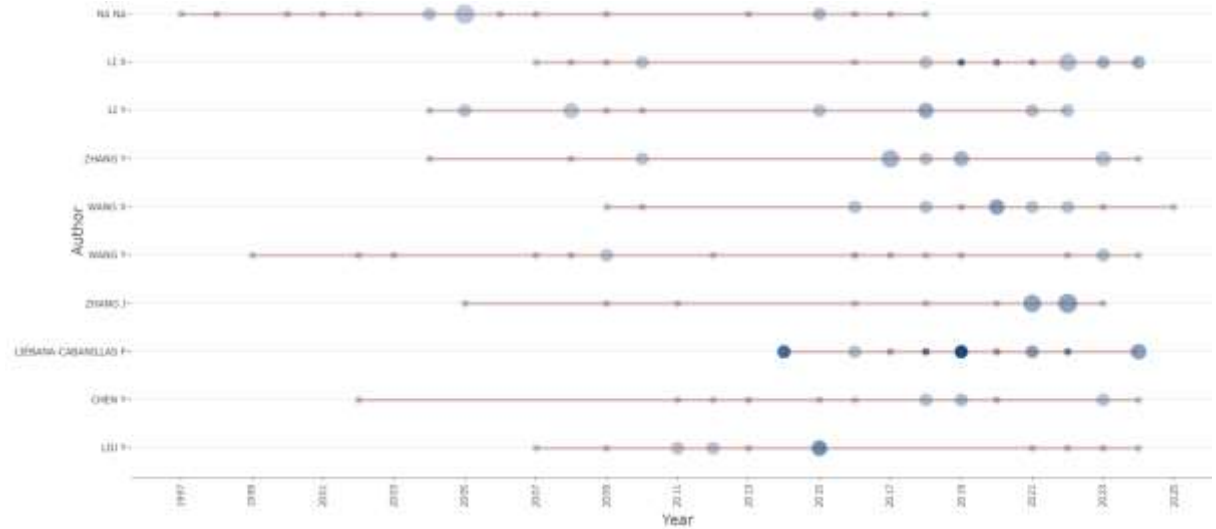
focus or impact of this variable has grown disproportionately compared to the others. Overall, the graph reflects how certain areas can experience rapid expansion while others progress more steadily, possibly due to differing levels of importance, relevance, or external influences in their respective domains.

Most Relevant Authors



The chart presents a visual comparison of the most prolific authors based on the number of documents they have published. It is clear that "NA NA" stands out as the leading contributor, with 21 documents, noticeably surpassing all other authors in the list. Following closely is "LI X" with 19 documents, while both "LI Y" and "ZHANG Y" have authored 17 documents each, showing a tie in their research output. Several other authors, such as "WANG X," "WANG Y," and "ZHANG J," have all contributed 16 documents each, indicating a cluster of productive researchers. The authors "LÉBANA-CABANILLAS F," "CHEN Y," and "LIU Y" round out the list with 14 to 15 publications each. Overall, the chart highlights a strong concentration of research output among a handful of leading authors, with "NA NA" clearly at the forefront, suggesting their significant impact and influence within the research community. The gradual decrease in the number of documents among the rest of the authors also reflects a competitive but somewhat unequal distribution of publication activity in this field.

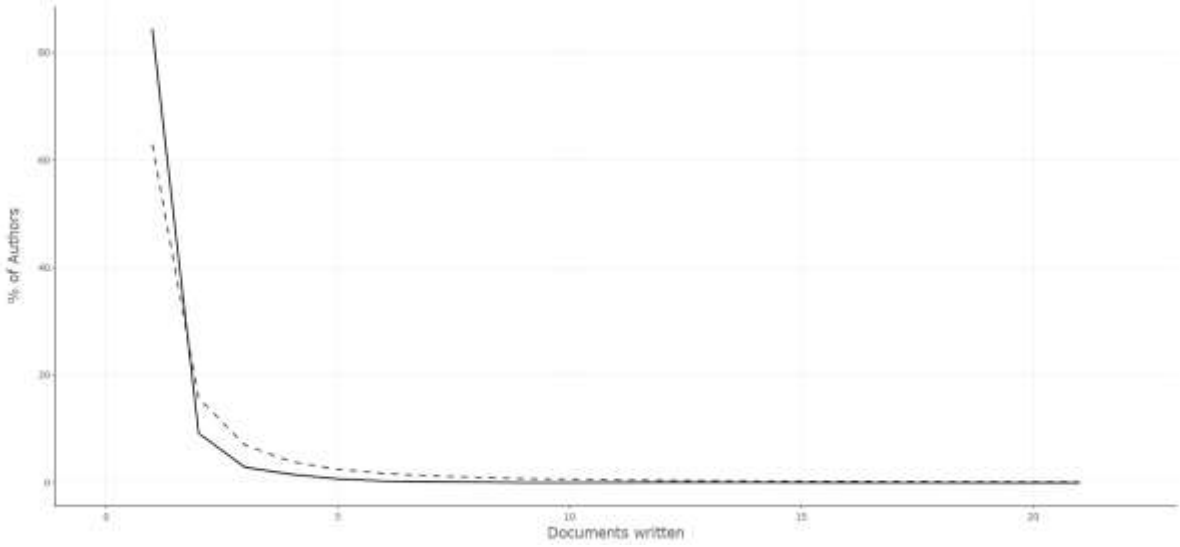
Authors' Production over Time



This bubble timeline chart visualizes the publication activity of the top authors over the years, from around 1997 to 2025. Each row represents an author, and each bubble on the timeline indicates the publication of documents in a given year, with the size of the bubble corresponding to the number of documents published.

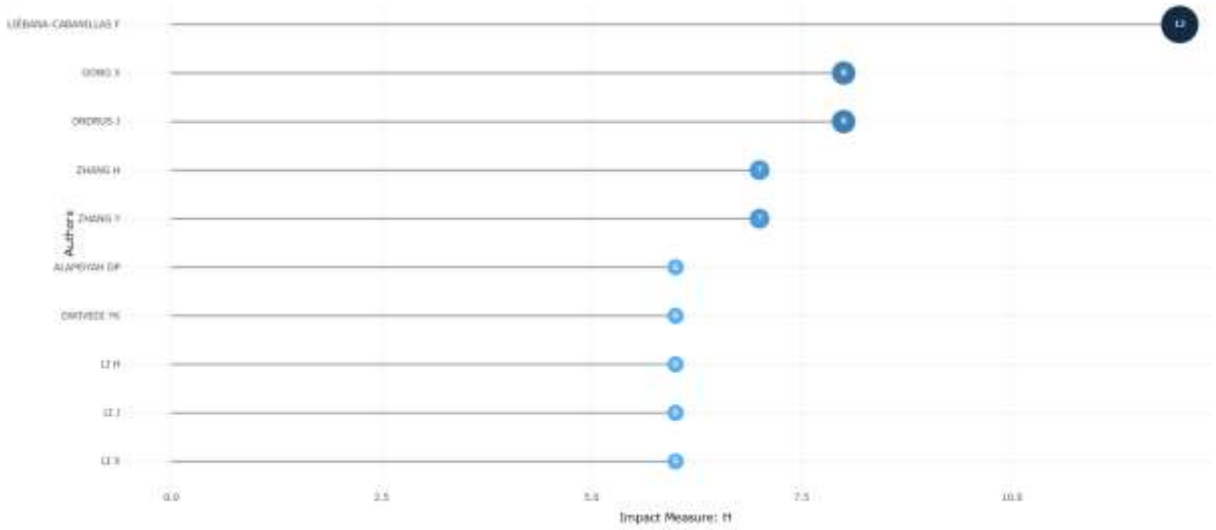
From the chart, we can observe that some authors, like "NA NA," have a consistent presence with publications spread across many years, suggesting sustained productivity. Others, such as "LI X," "LI Y," and "ZHANG Y," also show a pattern of regular contributions, particularly in more recent years, with a noticeable clustering of larger bubbles after 2015. This suggests increasing research output or rising prominence in their fields in the last decade. A few authors, such as "LÉBANA-CABANILLAS F," have more concentrated periods of publication, reflected by several larger bubbles within a narrower time frame, indicating bursts of high activity. Overall, the chart highlights not just the total output of each author but also the temporal trends in their publishing behavior, illustrating how some have maintained steady contributions over time while others have had peak periods of research productivity. This provides a clear view of both long-term engagement and recent momentum among leading authors in the field.

Author Productivity through Lotka's Law



This line graph shows the distribution of authors based on the number of documents they have written. The x-axis represents the number of documents authored, while the y-axis shows the percentage of authors who have written that number of documents.

The graph indicates that the vast majority of authors have written only one document, as shown by the steep drop at the beginning—over 80% of authors fall into this category. As the number of documents written increases, the percentage of authors decreases rapidly, forming a long tail. Only a small fraction of authors have published multiple documents, and even fewer have contributed to a large number of publications (more than 5 or 10). The two lines (solid and dashed) may represent different datasets, time periods, or types of publications, but both follow a similar pattern—highlighting the classic "long tail" phenomenon seen in academic publishing. This pattern suggests that most research output comes from a small core group of highly productive authors, while the majority contribute only occasionally.

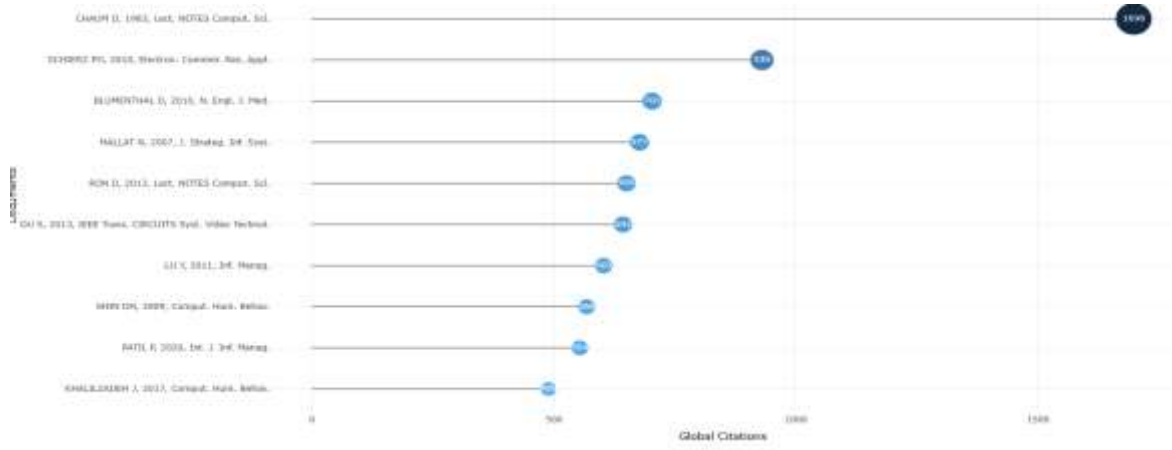


This bubble chart displays the H-index (a measure of research impact) for the top authors. Each author is listed on the y-axis, while the x-axis represents their H-index value. The size of each bubble corresponds to the H-index, making it visually clear who has the greatest impact. From the chart, LIÉBANA-CABANILLAS F stands out with the highest H-index of 12, indicating a significant impact in their field. Following this, both GONG X and ONDRUS J have an H-index of 8, while ZHANG H and ZHANG Y each have an H-index of 7. Several other authors, including ALAMSYAH DP, DWIVEDI YK, LI H, LI J, and LI X, have an H-index of 6. This distribution suggests that although there are many productive authors, only a select few have achieved a high level of research influence, as reflected by their H-index scores. The prominence of LIÉBANA-CABANILLAS F in particular indicates a leading position in terms of both output and citation impact within this group.

Most Global Cited Documents

This bubble chart highlights the global citation impact of the top 10 most cited documents in the dataset. Each document is represented on the y-axis, labeled by author, year, and publication source, while the x-axis shows the number of global citations each work has received. The size of each bubble reflects the total number of citations, making it visually easy to distinguish the most influential works.

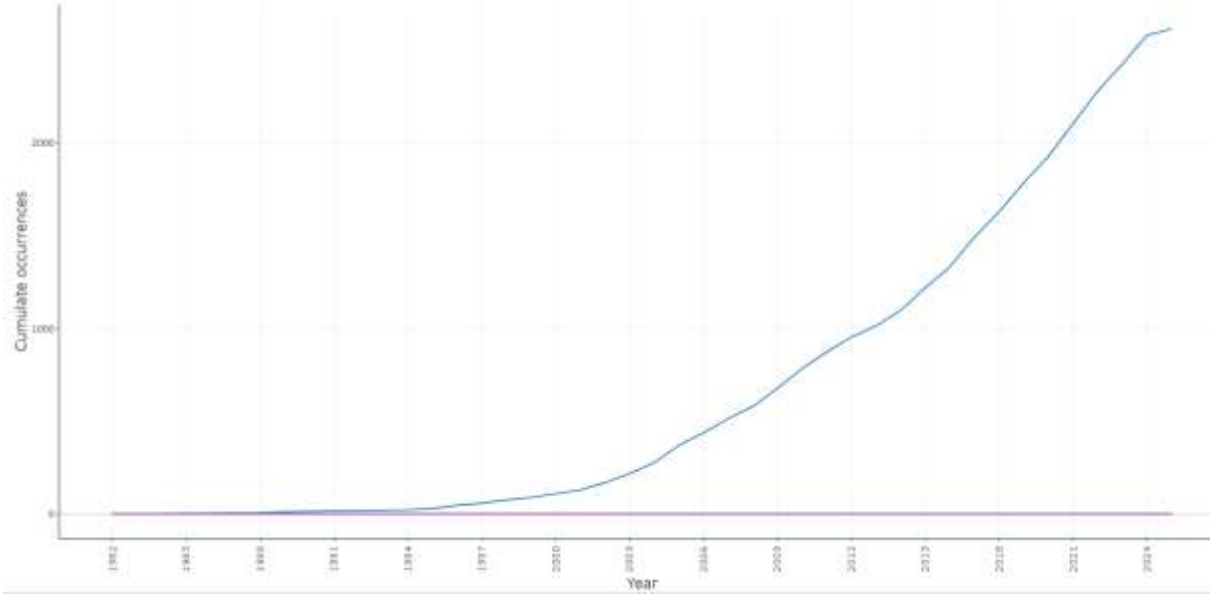
The analysis reveals that the document by CHAUM D (1983, Lect. NOTES Comput. Sci.) is by far the most cited, with an impressive 1,698 citations, indicating its foundational or highly influential role in the field.



The next most cited work, SCHIERZ PG (2010, Electron. Commer. Res. Appl.), follows with 930 citations, showing a significant but noticeably lower influence. Other documents, such as those by BLUMENTHAL D (2010, N. Engl. J. Med.) and MALLAT N (2007, J. Strateg. Inf. Syst.), also have high citation counts, ranging between 600 and 700. The remaining documents have between 489 and 650 citations, still marking them as important contributions. Overall, this chart demonstrates that while a few publications achieve exceptionally high citation counts and exert substantial influence on their field, most highly-cited works cluster just below the 1,000-citation mark, reinforcing the classic "power law" distribution of research impact.

Words' Frequency over Time

This line graph illustrates the cumulative occurrences of two different variables or categories from 1982 to 2025. The blue line shows a dramatic and continuous upward trajectory, especially after the year 2000, indicating a rapid and exponential increase in cumulative occurrences over time. By 2025, the cumulative value surpasses 2,500, highlighting significant growth and sustained momentum in this area.



In contrast, the purple line remains almost flat and close to zero throughout the entire period, indicating negligible or no change in cumulative occurrences for that variable. This stark contrast between the two lines suggests a significant disparity in either interest, adoption, or activity between the two categories being tracked. The blue line's sharp rise could reflect factors such as technological advancements, increasing adoption, or a surge in research and publications, while the purple line may represent an area with limited or stagnant progress. Overall, the graph visually underscores the dominant growth of one variable compared to the near-constant status of the other.

Collaboration Network

The co-authorship network map visually represents the collaborative relationships among researchers in a given field. Each node corresponds to an author, with the size of the node reflecting the author's productivity or the number of publications they have contributed to. The different colors indicate distinct clusters or groups of closely collaborating authors. The lines connecting the nodes show co-authorship links, illustrating which authors have worked together on research projects.

Notably, central authors such as "zhang y," "li y," "wang y," and "gong x" have larger nodes, indicating they are prominent and productive within their respective clusters. These clusters, represented in green, red, pink, and other colors, suggest that collaborative research tends to occur within well-defined groups. The network also reveals several smaller, isolated groups and a few individuals who are only loosely connected to the main network, highlighting varying levels of integration within the research community. Some nodes act as bridges between clusters, indicating authors who collaborate across different groups and potentially contribute to interdisciplinary research. Overall, the map provides insight into the structure of research collaboration, identifying leading researchers, strong collaborative communities, and areas where increased connectivity could foster even greater research activity.

5.1 Findings, Conclusion, and Discussion

Academic Output: Publication activity in EPS was minimal before 2000 but increased sharply from 2001, peaking between 2016 and 2021, reflecting growing interest and the influence of policy shifts like demonetization and Digital India (Government of India, 2015; Sharma & Roy, 2017). Citation Patterns: There was an early citation peak in the 1980s, followed by decades of low activity and a modest revival in recent years, indicating fluctuating scholarly attention and the episodic nature of breakthroughs (CHAUM D, 1983). Influential Sources: A few core sources (e.g., Lecture Notes in Computer Science, ACM Proceedings) dominate the literature, while a long tail of journals contributes minimally—illustrating Bradford's Law (Singh, 2010). Author Productivity: The majority of authors have published only one paper on EPS, while a small set of prolific authors and collaborative clusters drive much of the field's output and influence (Lotka's Law). Technological Focus: Research and innovation have shifted from ATMs and NEFT in early decades to UPI, mobile wallets, QR codes, blockchain, and AI-driven fraud detection in recent years (Rathi & Sharma, 2020; Chopra, 2022). Collaboration Patterns: The co-authorship network reveals concentrated clusters around prolific authors, with some bridging nodes facilitating interdisciplinary work, but also shows many isolated contributors.

The evolution of electronic payment systems in India reflects a complex interplay of technological progress, regulatory frameworks, and socio-economic drivers. Academic research has grown in tandem with real-world adoption, though output and influence remain highly concentrated. Innovations such as UPI and mobile wallets have catalyzed new research directions, while government initiatives like Digital India have spurred scholarly and practical interest. Despite this progress, the research landscape is characterized by episodic surges of attention and a predominance of single-contribution authors.

The study highlights the necessity of interdisciplinary collaboration and continuous innovation in the EPS domain. The concentration of research output in a few core sources and among a handful of prolific authors suggests the need to broaden participation and diversify academic engagement (Patel, 1984; Singh, 2014). Recent trends toward mobile-first payments, AI integration, and biometric security reflect both technological adaptation and shifting user expectations (Gupta & Joshi, 2022). Furthermore, policy interventions—especially demonetization and Digital India—acted as catalysts for both research and adoption. However, rural inclusion and bridging the digital divide remain ongoing challenges, as indicated by the persistent research focus on financial inclusion and accessibility (Gupta & Raghavan, 2023).

6.1 Implications and Limitations

Continuous regulatory support and digital infrastructure investment are crucial for sustaining EPS innovation and financial inclusion (Government of India, 2015). There is scope for deeper, longitudinal studies examining the impact of emerging technologies such as blockchain, AI, and biometrics on EPS adoption and trust (Rathi & Sharma, 2020; Chopra, 2022). Collaboration between fintech startups, banks, and technology providers can accelerate secure, accessible payment solutions and address inclusion gaps (Chawla & Sharma, 2023). The study is limited by its reliance on published literature, which may underrepresent industry-driven innovation and informal financial practices. The bibliometric approach captures only measurable academic output, potentially overlooking policy documents, technical standards, or literature. Additionally, the sharp drop in 2024 data may reflect incomplete publication cycles rather than an actual decline in research activity. Future research should incorporate qualitative assessments and primary data collection for a holistic evaluation.

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