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Transforming Transactions: The Evolution of Fintech in Indian Banking Sector

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Abstract

The payment systems in the Indian banking sector have undergone a remarkable transformation over the past few decades, evolving from traditional cash-based transactions to digital platforms. This research article explores the evolution of payment systems in India, tracing the journey from the early days of barter and cash transactions to the latest advancements in digital payment systems. The study highlights the key milestones, technological advancements, regulatory frameworks, and the impact of these changes on the economy and banking sector. The findings reveal that while technological innovations have greatly enhanced efficiency and convenience, challenges such as cybersecurity and regulatory compliance still remain. Future prospects indicate continuous growth and integration of advanced technologies like blockchain and artificial intelligence, promising further improvements in the payment landscape.

Keywords: *Fintech; Banking Revolution; Information Technology; Payment System*

1. Introduction

The Indian banking sector has seen significant transformation in its payment systems, driven by technological innovations, regulatory reforms, and shifting consumer preferences. Payment systems are essential to any economy's financial infrastructure, enabling the transfer of funds among individuals, businesses, and government entities. In India, these changes reflect the country's broader economic and technological advancements.According to the RBI, "Digital Transaction is a payment conducted in a system where cash is not needed for at least one party, whether the payer, the receiver, or both. This includes transactions made through digital or electronic methods, where both the sender and the recipient use digital mediums to send or receive money" [1] Following globalization, financial liberalization ande conomic reforms over the past three decades, Indian banks have adopted various E-banking techniques to enhance their financial position. The RBI reports that in the last two decades, electronic payment modes have outpaced physical systems, underscoring the impact of electronic payments in the Indian banking sector. The overall payment system in India is divided into three categories: large value payment systems, retail payment systems, and retail electronic systems [2] The RBI has been instrumental in developing India's payment and settlement systems for both large-value and retail payments. In the 1980s, the central bank led the automation of the paper-based clearing system. During the 1990s, it introduced the Electronic Funds Transfer system (EFT) and Electronic Clearing Services (ECS Credit and Debit). In April 2003, the Special Electronic Fund Transfer (SEFT) system was launched but was

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discontinued in March 2006 following the implementation of the National Electronic Fund Transfer (NEFT) system in November 2005. Additionally, the Real-Time Gross Settlement (RTGS) system was introduced in March 2004 [3]. The Reserve Bank of India (RBI) supports the growth of the FinTech sector during the FinTech 3.0 era. Over recent years, India has developed a robust FinTech incubation and growth network. The Indian Stack, which includes JAM (Jan Dhan, Aadhaar, and Mobile) and the digital locker, has significantly boosted FinTech companies. Banks and financial institutions leverage technology internally and through partnerships to enhance business processes, exemplified by NPCI. This combined with the Aadhaar Enabled Payment System(AEPS), Bharat Interface for Money(BHIM), Unified Payment Interface(UPI), India Quick Response(QR), Immediate Payment Service(IMPS), National Automated Clearing House(NACH), Bharat Bill Payment System(BBPS), National Electronic Toll Collection(NETC), and USSD, constitutes one of the world's largest interoperable payment systems. Following the GST rollout, digital adoption among companies, particularly SMEs, has increased [4]. India’s share of digital transactions is relatively low compared to other emerging markets like China, yet the Indian fintech sector is experiencing significant growth. A Boston Consulting Group report from March 2021 values the Indian fintech market at US$31 billion, with projections to reach US$84 billion by 2025 [5]. Moreover, the value of fintech transactions in India is expected to increase from US$66 billion in 2019 to US$138 billion by 2023 [6]. The Reserve Bank's primary focus will be on expanding digital banking nationwide. With over 54% of the population under 25, India is one of the world's youngest nations. This tech-savvy demographic of India signals a promising future for digital banking in the country [7].

2. Background and Significance of Payment Systems in India

In earlier times, India's payment system heavily relied on cash. Physical branches were central to financial transactions which basically were traditional banking methods [8]. In 1935 the Reserve Bank of India (RBI) was established which played a key role in overseeing and regulating these early financial systems [9]. Following which non-cash transactions like cheques and demand drafts came into picture. These processes required more physical interventions and were slower. The introduction of electronic payment systems marked a significant moment in India's financial evolution. During the 1980s, with the introduction of Automated Teller Machines (ATMs) technology began to shape the banking sector [10]. The commencement of the Electronic Clearing Service (ECS) in the 1990s enabled efficient processing of repetitive payments [10]. From the 2000s onward, India experienced rapid growth and modernization in its payment systems. In 2005, the introduction of the National Electronic Funds Transfer (NEFT) system streamlined transactions, further improving efficiency and speed [11]. This was accompanied by the Real-Time Gross Settlement (RTGS) system, which enabled instant fund transfers of high values. For real-time interbank payments, Immediate Payment Service (IMPS) was introduced in 2010 which further enhanced convenience in transactions [12]. With the rise of smartphones and widespread internet access a revolution in digital and mobile payments got triggered. The Unified Payments Interface (UPI) launch in 2016 revolutionized fund transfers via mobile devices with its user-friendly interface and inter-bank interoperability [13]. This significantly boosted adoption rates of digital payment. To promote UPI usage among the general public Bharat Interface for Money (BHIM) app was introduced. Simultaneously, e-wallets and mobile banking apps also gained acceptability [14]. Digital payment adoption has streamlined transaction records, enhancing transparency which reduces the cash handling risks and costs. This shift was driven by government initiatives like Digital India, supported by penetration of smartphones and affordable high-speed internet, making digital transactions accessible and convenient for consumers nationwide [15]. Payment systems are vitally important to the economy, ensuring smooth, secure, and prompt fund transfers that are vital for both personal and business transactions [16]. These

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advancements promote financial inclusion, extending bank services to unbanked populations.The RBI oversees regulations to ensure the security, reliability, and alignment of payment systems with global standards, increasing trust in electronic transactions. Further, a robust legal framework reinforced transparency and accountability in financial transactions. This research paper presents the evolution of payment systems in India over the last 25 years, from 2000 to 2024 demonstrating significant advancements in technology, regulatory measures, and policy initiatives.The paper is structured as follows: The next section discusses the historical development of Banking & payment systems, followed by an exploration of technological advancements. The subsequent sections delve into the introduction and impact of the Unified Payments Interface (UPI), the regulatory framework, and the effects on the banking sector and economy. Finally, the paper concludes by exploring future prospects and summarizing key findings and insights.

3. Developments of Banking in India

The transformation of the Imperial Bank of India into the State Bank of India (SBI) in July 1955 aimed to expand branch networks nationwide to bolster banking activity. This policy continued with the nationalization of 14 major banks in 1969 and an additional six banks in 1980, all aimed at supporting the needs of India's growing economy (Bansal and Raj 2021). In response to an unprecedented fiscal crisis in 1991, the Government of India opted to liberalize the economy, which included reforms in the banking sector. This liberalization effort was informed by recommendations from three significant banking reform committees: the Committee on Financial System of 1991, the Committee on Banking Sector Reforms of 1998, and the Standing Committee on International Financial Standards Codes of 1999 (Rezvanian et al. 2008). Following nationalization, the number of bank branches surged significantly, rising from 8,262 in 1969 to 60,220 by 1991, with rural branches increasing from 1,833 to 35,206. This expanded network notably boosted rural credit availability. The implications of this nationalization and branch expansion had substantial effects on the operations and dynamics of the RBI (Bansal and Raj 2021). Furthermore, the adoption of recommendations from the Committee on Banking Sector Reforms, as proposed by the Narasimham Committee-II in 1998, significantly advanced reforms in the banking sector. The Narasimham Committee-II report was pivotal in shaping public policy regarding the Indian banking sector (Yoo 2005).

4. Historical Development of Payment Systems

Figure 1 showing the historical developments of the payment system started with barter and cash to the latest innovative technological upgradation.

4.1. Early Payment Systems: Barter and Cash

The earliest payment method in India, like in other regions, was the barter system, where goods and services were directly exchanged without monetary involvement. This system faced challenges such as the requirement for a double coincidence of wants and difficulties in determining the value of exchanged items [8]. Around the 6th century BC, metallic coins were introduced, initiating a monetary economy. These coins were made of metals like silver, gold, and copper, making a uniform standard of value. Various Indian dynasties also issued their own currency because of their widespread use. The introduction of paper currency marked a remarkable advancement in payment systems. In 1935 paper currency was standardized, with the establishment of the Reserve Bank of India (RBI), formalizing cash transactions. compared to metal coins, paper money was a more convenient and portable medium of exchange [9].

4.2. Traditional Banking Instruments: Cheques and Demand Drafts

During the 19th and 20th centuries, with the banking institution evolution, traditional instruments like cheques and demand drafts gained popularity for their secure transaction capabilities which reduced the risks of carrying large sums of cash. Demand drafts which are especially used for transactions of higher-value, added an additional layer of security [17]. Magnetic Ink Character Recognition (MICR) technology which uses special ink and characters readable by both humans and machines, streamlining cheque processing with speed and accuracy was introduced by the Reserve Bank of India (RBI) which

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is also a significant technological advancement in these instruments [17]. Initially implemented in major cities, MICR standardized formats and ink, ensuring consistency across banks. The establishment of MICR clearing houses and investment of banks in MICR-enabled equipment notably reduced cheque clearance times, which further enhanced efficiency in the overall banking system.

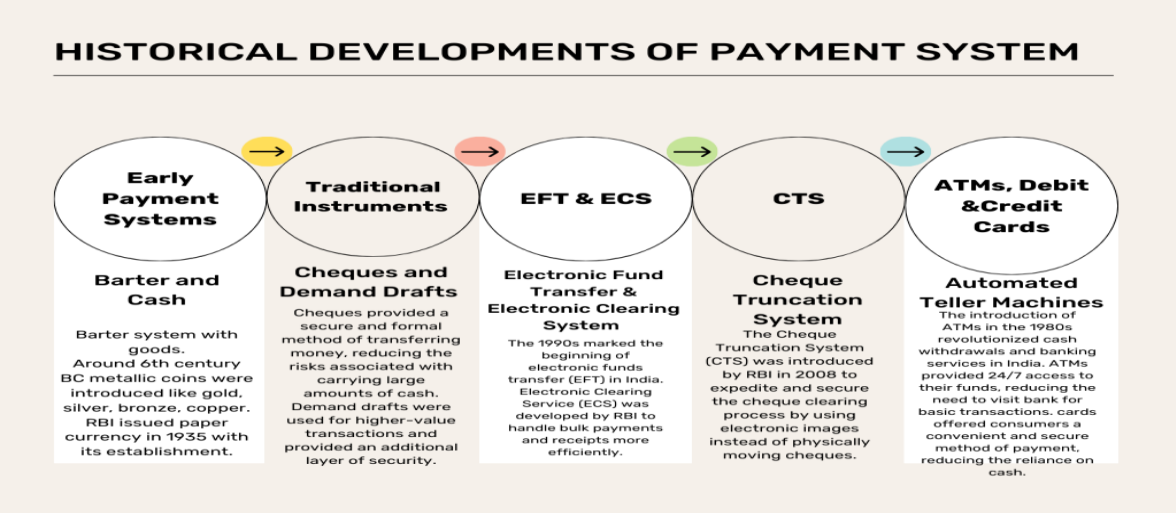

Figure 1 Historical Developments of Payment System
Source: Author

4.3. Electronic Funds Transfer (EFT) & Electronic Clearing System (ECS) in the 1990s

India saw the coming of electronic funds transfer (EFT) systems in the 1990s and Electronic Clearing Service (ECS) was introduced by the RBI which was designed to efficiently streamline bulk payments and receipts. It facilitates electronic transfers between bank accounts for recurring transactions like salaries, dividends, interest payments, and utility bills. ECS includes ECS Debit for bulk collections and ECS Credit for bulk payments, which was initially implemented in major urban centers before expanding to wider geographical areas. By reducing reliance on physical payment, ECS minimized operational expenses and accelerated transaction processing times, guided by RBI regulations ensuring transactional security and reliability.

4.4. Cheque Truncation System (CTS)

In 2008 the Cheque Truncation System (CTS) was introduced by the RBI to modernize and secure the cheque clearing process using electronic images instead of physical cheques. Its grid-based clearing model facilitated faster settlement within regions, supported by standardized cheque formats incorporating mandatory security features. CTS significantly accelerated cheque clearance, reduced fraud risks associated with physical cheques, and enhanced overall efficiency in India's payment and settlement systems. This advancement eliminates the need to physically transport cheques across bank branches, except under exceptional circumstances for clearing purposes [16].

5. Technological Advancements in Payment Systems

Figure 2 demonstrates the development after ATM and Card money. These innovations are very capable to smoothen the transactions.

5.1. Automated Teller Machines (ATMs)

Revolution in cash withdrawals and banking services across India came with the introduction of Automated Teller Machines (ATMs) in the 1980s. ATMs offered customers 24/7 services which reduced reliance on physical branches for routine transactions. The subsequent increase in ATMs from 75,645 in 2010 to 218,815 in 2024 shows nearly threefold growth,

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driven by efforts to extend banking services to a large geographical area including rural and semi-urban populations [18]. The widespread availability of ATMs has enhanced convenience and accessibility, enabling individuals to conveniently manage their finances and promote financial inclusion. During this period ATM functionalities saw remarkable technological advancements. Modern ATMs have evolved to provide diversified services other than cash withdrawals, such as cash deposits, fund transfers, bill payments, and biometric authentication [19]. These enhancements have significantly increased the utility of ATMs, making them a vital component in the banking ecosystem.

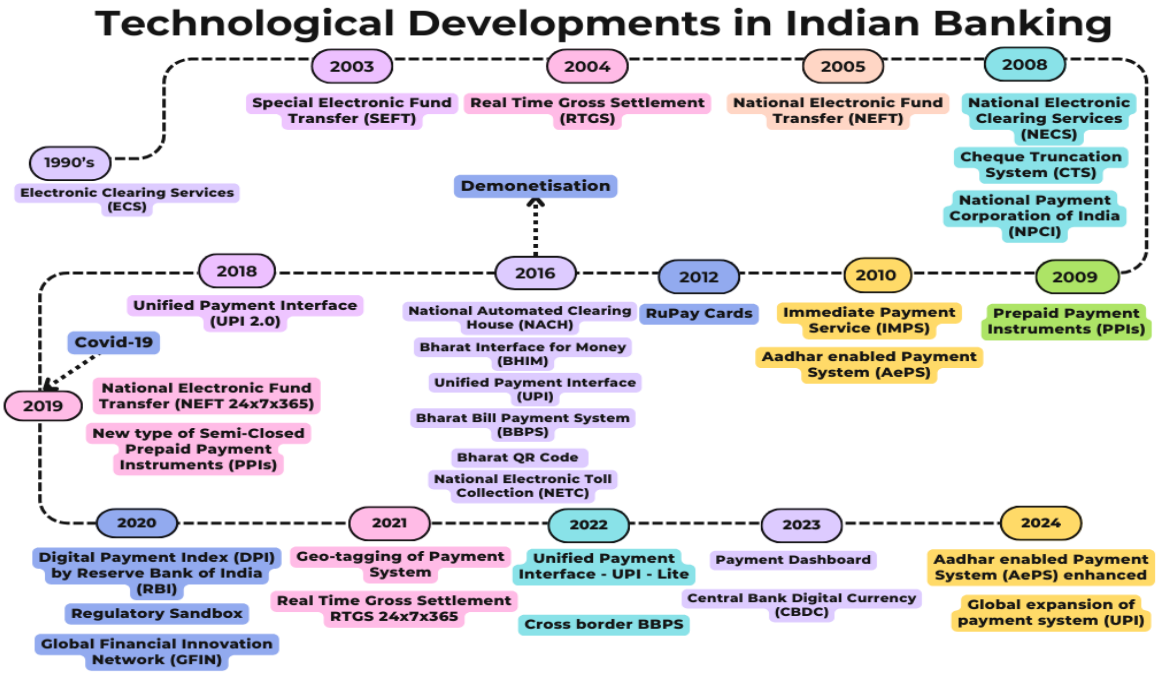

Figure 2 Technological Developments of Payment System
Source: Author

5.2. Credit and Debit Cards

In the 1990s, credit and debit cards gained widespread adoption in India, providing consumers with convenient and secure payment options which reduced dependence on cash. Credit cards offered credit facilities, whereas debit cards provided direct access to bank funds. Therefore, the expansion of Point of Sale (POS) terminals nationwide supported the growth of card-based payments [20]. The substantial growth in India's debit card numbers, rising from 230 million in 2011 to nearly 965 million by March 2024, reflects the success of digital banking and financial inclusion initiatives [18]. This exponential increase emphasizes significant efforts to enhance accessibility in banking services across the country whereas From 2011 to 2024, the significant growth in credit card issuance in India, increased from 17.8 million to 180 million by March 2024 which shows the growing acceptance and adoption of credit-based transactions among consumers in India [18]. This tenfold rise shows a dynamic shift in consumer behavior and the evolving landscape of financial services in India. Technological advancements led to the advent of secure and user-friendly online banking platforms and mobile applications have simplified the process of application for and management of credit cards. Therefore, enhanced security measures, such as EMV chip technology and two-factor authentication, have increased trust of consumer in credit card transactions [21]. The expansion of e-commerce has also increased the demand for credit cards, as they are often the preferred mode of payment for online

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purchases. RBI also prioritized customer security by implementing strict measures. Like in 2015, RBI issued directives for the replacement of all magnetic stripe cards with EMV chip and PIN-based cards by March 2018, ensuring enhanced security standards across payment transactions [22].

5.3. Internet Banking

In India, internet banking emerged as a transformative force in the early 2000s. The convenience and accessibility of internet banking led to its rapid adoption, fundamentally reshaping customer-bank interactions. It empowered customers to conduct a wide range of online banking activities, from fund transfers to bill payments and management of accounts. The substantial growth from approx. 14.9 million NEFT transactions in 2011 to 79.4 million in 2024 shows more than five fold increase which was primarily driven by technological advancements that have enhanced the accessibility and convenience of electronic fund transfers for individuals and businesses both [18]. The rise in NEFT transactions reflects a shift towards digital banking in India, as consumers and businesses increasingly favor electronic payments over traditional methods of transactions. The COVID-19 pandemic further accelerated this shift by amplifying demand for contactless payment solutions. Additionally, the increase in the e-commerce sector and the proliferation of online services have contributed to NEFT's growing utility across various payment needs. Similarly, the increase from approximately 3.3 million RTGS transactions in 2011 to over 12.2 million in 2024 indicates nearly a fourfold rise [18]. This growth mirrors the expanding economy's demand for swift and secure payment mechanisms for high-value transactions. RTGS real-time function has become integral to the financial infrastructure, facilitating efficient inter-bank settlements and urgent need for customer payments.

5.4. Mobile Banking

The proliferation of smartphones and mobile internet in the late 2000s was a key instrument in popularizing mobile banking. These apps have empowered customers with convenient access to banking services on-the-go, featuring real-time fund transfers, bill payments, and proactive account alerts, thereby solidifying mobile banking's role within the broader payment ecosystem [23]. In January 2014, a Technical Committee on Mobile Banking was constituted under the chairmanship of Shri B. Sambamurthy which explored how to use India's widespread mobile phone usage to enhance financial inclusion and to find ways to make payment transactions more affordable and accessible for consumers. From 2011 to 2024, the remarkable growth in mobile banking transactions illustrates a significant technological advancement within the banking sector. Starting with 1,081,921 transactions in 2011, mobile banking was initially niche but rapidly expanded to 1,286,557,836 transactions by 2024, indicating its widespread adoption and integration into mainstream banking operations [18]. This 1200-fold exponential growth, reflects advancements in mobile technology, network infrastructure, and banking software. Mobile banking applications have evolved to offer exclusive services beyond basic transactions, encompassing bill payments, fund transfers, investments, and customer support, all accessible from smartphones or tablets. Enhanced security measures, including biometric authentication and encryption, have significantly improved the security and reliability of mobile banking, enhancing consumer trust.

5.5. Digital Wallets and Payment Apps

As per the annual reports of RBI, in the 2010s, the emergence of digital wallets and payment apps has changed the global payment landscape. Paytm, PhonePe, and Google Pay and similar kinds of platforms have introduced digital wallets, allowing users to store money digitally and perform transactions conveniently via smartphones and internet. These wallets featured QR code payments for swift transactions, peer-to-peer transfers among users and the integration with numerous merchants for both online and offline payments. After that the introduction of Unified Payments Interface (UPI) app changed digital payments within India. Apps such as SBI YONO, PhonePe, Google Pay (G-Pay), BHIM Axispay, WhatsApp Pay, imobile etc.facilitated a effortless fund transfers between bank accounts using mobile numbers or UPI IDs. The Reserve Bank also permitted small value transactions in UPI through an

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on-device wallet in UPI App to facilitate safe and secure payments where users can transfer a upto rupees 2,000 to UPI Lite wallet. This interoperability across banks and platforms significantly accelerated the adoption of digital payments nationwide, promoting financial inclusion and reducing dependency on cash transactions. These advancements in digital wallets and UPI apps have not only revolutionized transaction methods for individuals and businesses but also propelled the growth of India's digital economy [1]. Further discussion on this topic is covered in the next section (UPI).

5.6. Unified Payments Interface (UPI)

In 2016, the Unified Payments Interface (UPI) was introduced by NPCI, a transformative payment instrument which revolutionized digital transactions in the country. National Payments Corporation of India (NPCI) was established by the Reserve Bank of India (RBI) in collaboration with the Indian Banks Association (IBA), Under the framework of 'The Payments and Settlements System Act, 2007' [1].

5.6.1. Introduction and Features of UPI

Figure 3 shows the features of UPI as a payment system. NPCI was established to oversee retail payments and settlement systems within India's payment ecosystem [1]. UPI is the single largest retail payment system in India in terms of volume of transactions and has become one of the most inclusive modes of payment in India. It enabled instant, round-the-clock transfers between bank accounts through a single mobile application. It provided a seamless and interoperable platform connecting various banks and payment service providers, facilitating diverse banking operations and retail business payments across member banks. UPI initially was launched with 21 banks as a pilot program, allowing users to manage multiple bank accounts through any UPI-enabled app [24]. It supported various payment methods, including Virtual Payment Address, Mobile Number, Account Number & IFSC, Aadhaar, and QR Code, for sending or requesting money. The core drivers behind UPI's success are its emphasis on Simplicity, Innovation, Adoption, Security, and Cost-effectiveness (SIASC).

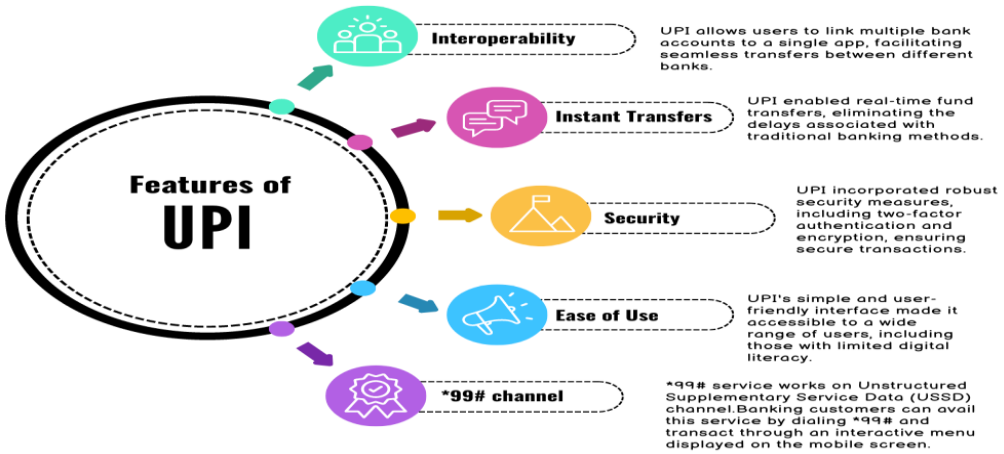

Figure 3 Features of UPI
Source: Author

UPI provided several features which contributed to its rapid adoption:

Interoperability: UPI allows users to connect several bank accounts to a single app, making it easy to transfer funds across different banks.

Instant Transfers: UPI allows real-time transactions, eliminating the delays like traditional banking methods.

Security: Features like two-factor authentication and encryption strengthened its security, ensuring that transactions are safe and protected.

Ease of Use: UPI's intuitive and user-friendly interface allows access, catering to users with varying levels of digital literacy. Similarly, the *99# service uses the USSD channel, allowing banking customers to perform transactions simply by dialing *99# and

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following the interactive menu on their mobile screens.

5.6.2. Growth and Adoption of UPI

Figure 4 shows the growth of UPI adoption by using the transaction value and volume. That clearly shows the upward trend of use of this technology.

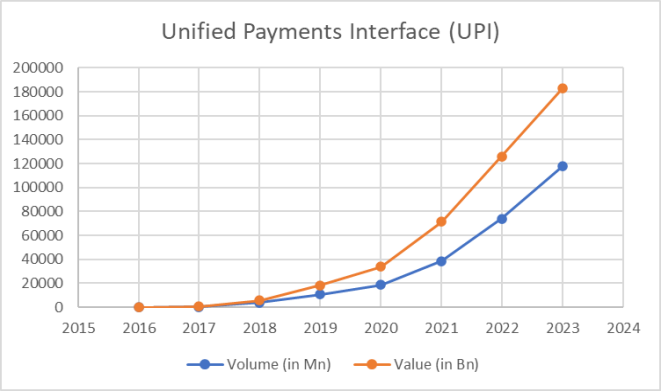

Figure 4 UPI Statistics
Source: Author

Since its inception, UPI has seen considerable growth, outpacing traditional digital payment methods by 2020. This rise in UPI transactions can be attributed to several key factors [25]:

Government Initiatives: Through initiatives like Digital India which played a crucial role in driving the widespread adoption of UPI. The Indian government put efforts to promote digital payments leading to a cashless economy.

Merchant Acceptance: Merchants across various platforms, both online and offline, embracing UPI has significantly enhanced its convenience and utility for consumers.

Innovation and Integration: Continuous innovation and integration with various services, such as bill payments, e-commerce, and peer-to-peer transfers, have enriched the functionality and appeal of UPI. Figure 5 demonstrates the glimpse of UPI in contact to growth, adoption, and usage.

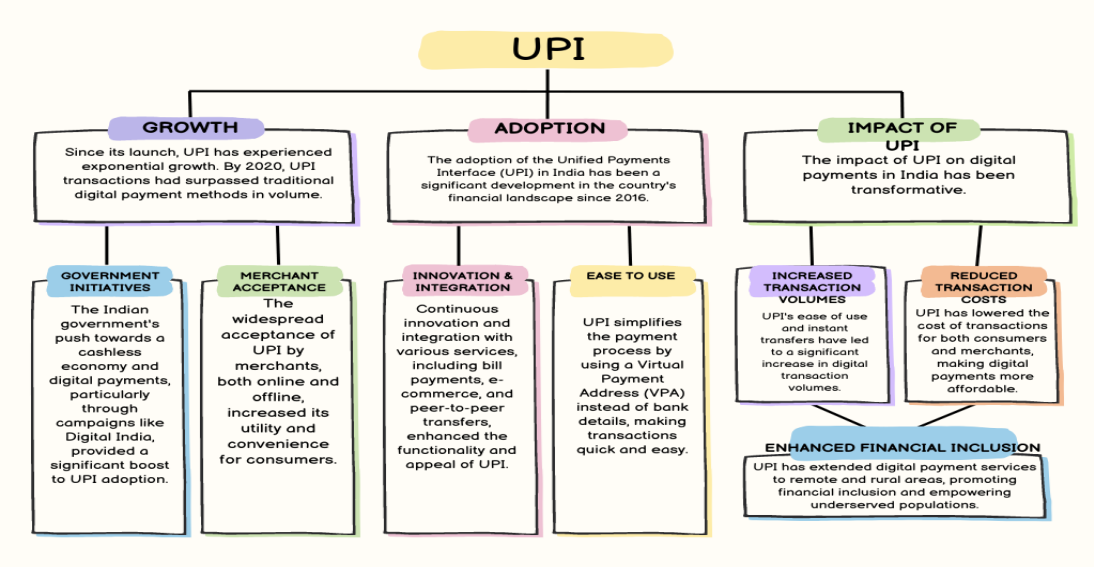

Figure 5 Overall Analysis of UPI
Source: Author

5.6.3. Impact of UPI on Digital Payments

The impact of UPI on digital payments in India has been transformative [26]. It includes:

Transaction Volumes: UPI's user-friendly interface and instant transfer capabilities have led to a substantial increase in digital transaction volumes.

Financial Inclusion: UPI has extended digital payment services to remote and rural areas, encouraging financial inclusion and empowering underserved populations.

Transaction Costs: UPI has reduced the cost of transactions for both merchants and consumers, making digital payments more affordable.

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6. Role of the Government & Reserve Bank of India (RBI)

The Reserve Bank of India (RBI) has played an important role in shaping India's payment systems landscape. As the central regulatory authority, the RBI has consistently issued guidelines and frameworks to ensure the security, interoperability, and innovative payment systems. The enactment of the Payment and Settlement Systems Act, 2007 provided a robust legal foundation for the regulation and oversight of payment systems in India [27]. This legislation empowered the RBI to effectively supervise and regulate payment systems, thereby enhancing their reliability and efficiency. Figure 6 shows various aspects of regulators and the government towards this technology development. RBI's policy initiatives for promoting digital payments have evolved significantly to foster a resilient and inclusive financial ecosystem in India [28]. Beginning with the introduction of the Bharat Bill Payment System (BBPS) in 2014, RBI focused on streamlining bill payments through diverse channels. BBPS was extended in September 2019 to include all categories of billers who raise recurring bills except prepaid recharges as eligible participants, on a voluntary basis. The landmark introduction of the Unified Payments Interface (UPI) in 2016 revolutionized digital transactions by enabling seamless and instantaneous fund transfers using mobile devices. Subsequent revisions to Prepaid Payment Instruments (PPI) guidelines in 2016 were instrumental in enhancing the security and interoperability of digital wallets. The RBI's authorization of Payment Banks in 2017 further bolstered digital payment adoption, particularly in rural regions. The introduction of data localization guidelines in 2018 ensured that customer data remains protected within India's borders. Frameworks introduced for tokenization of card transactions in 2018 and interoperability of PPIs in 2019 which can be loaded/re-loaded only from a bank account and/or a credit card and can be issued based on essential minimum details sourced from the customers, significantly strengthened payment security and user convenience [29].

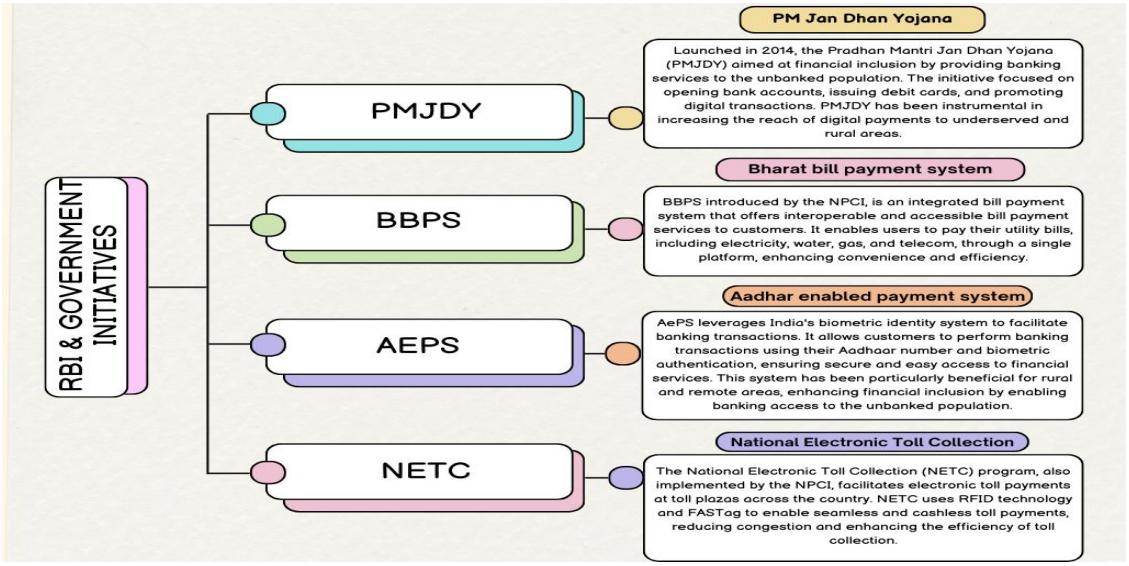

Figure 6: RBI & Government Initiatives
Source: Author

The RBI's proactive stance on technology developments ensures continuous enhancement and adaptation to evolving technological landscapes. Recent stringent security controls for digital payments in 2021 underscore RBI's commitment to fostering secure, efficient, and inclusive digital payment systems nationwide. Campaigns like "Digital India" played a crucial role in transforming India into a digitally empowered society and knowledge economy [30]. By focusing on digital

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infrastructure, service delivery, and promoting digital literacy, this campaign improves awareness and supports the adoption of digital payments throughout the country. The increase in ATMs can be attributed to supportive policies and infrastructure developments by both the RBI and the government. Initiatives like the Pradhan Mantri Jan Dhan Yojana (PMJDY) have incentivized banks to expand their ATM networks, particularly in underserved areas. Improvements in telecommunications and power infrastructure have further facilitated the installation and operation of ATMs nationwide. Supportive policies and initiatives by the Reserve Bank of India (RBI) and the government have been instrumental in promoting NEFT. Enhancements such as increasing settlement cycles and making NEFT operational 24/7 from December 2019 have made it a preferred method for various financial transactions. Financial inclusion initiatives have also expanded NEFT's user base. Similarly, the RBI has promoted RTGS by making it available 24/7 from December 2020, lowering the minimum transaction limit, and reducing fees. These measures, along with efforts to enhance financial literacy, have encouraged wider adoption of RTGS among customers and businesses. The RBI also launched the Mission 'Har Payment Digital' on the occasion of the Digital Payments Awareness Week (DPAW) in 2023 with campaign theme "Digital Payment Apnao, Auron ko bhi Sikhao". As part of the initiative, PSOs have pledged to adopt 75 villages across the country under the '75 Digital Villages' programme with a vision to convert them into digital payment enabled villages. The Indian government has also launched several initiatives to promote digital payments and enhance the payment infrastructure.

6.1. Prime Minister's Jhan Dhan Yojana (PMJDY)

Pradhan Mantri Jan Dhan Yojana (PMJDY), launched in 2014 as a financial inclusion strategy to open bank accounts for poorer households, particularly those who are related to direct benefit transfers beneficiary and casual laborers. This significantly expanded the base of account holders [31]. PMJDY aimed to provide banking services to the unbanked population by focusing on opening bank accounts, issuing debit cards, and promoting digital transactions. It has been instrumental in extending the reach of digital payments to underserved and rural areas, resulting in a significant increase in the number of account holders, effectively doubling the figures from before the initiative.

6.2. Bharat Bill Payment System (BBPS)

The Bharat Bill Payment System (BBPS), introduced by NPCI, is an integrated platform offering interoperable and accessible bill payment services. It allows users to pay utility bills such as electricity, water, gas, and telecom and other bills like credit card, insurance premium, education fee and many more through a single platform, enhancing convenience and efficiency. Earlier the scope of BBPS included all categories of recurring bills but later The RBI expanded its scope to include all categories of payments and collections, both recurring and non-recurring in nature. The BBPS guidelines were issued in November 2014, with NPCI setting up the system under the PSS Act, 2007. BBPS addresses the inconvenience of using multiple payment options provided by different billers [29]. NPCI's authorization as the Bharat Bill Payment Central Unit (BBPCU) and the establishment of Bharat Bill Payment Operating Units (BBPOUs) were completed during 2015-16.

6.3. National Electronic Toll Collection (NETC)

Toll payments, largely done in the form of cash payments, is an important area where financial technology needs to be incorporated as this service is very vast all over India, and has seen least efforts towards electronic payment adoption. There is a push to migrate to interoperable electronic toll systems pan-India. The National Electronic Toll Collection (NETC) program by NPCI facilitates electronic toll payments using RFID technology and FASTag, enabling seamless, cashless transactions. This initiative aims to reduce congestion and enhance toll collection efficiency.

6.4. Aadhaar-enabled Payment System (AePS)

The Aadhaar-enabled Payment System (AePS) leverages India's biometric identity to facilitate secure banking transactions using Aadhaar numbers and biometric authentication. AePS enables transactions like cash withdrawals, balance inquiries,

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and money transfers through biometric authentication. In India, various sources are there to provide these services. This system has significantly enhanced financial inclusion, particularly in rural and remote areas, where banking services are less in comparison to urban areas, by providing banking access to the unbanked [32]. AePS has seen a substantial rise in transaction volumes, from 12.98 billion in 2017 to 25.83 billion in 2024, reflecting its growing acceptance and convenience [18]. Main intermediary of this service is Bank Mitra, a small intermediary who does these transactions on behalf of the bank and makes banking services more accessible. This surge underscores AePS's critical role in promoting financial inclusion and enhancing India's digital payments ecosystem. Various countries like Mauritius, UAE, Sri Lanka and Nepal have adopted India's technologies like RuPay cards, UPI connectivity and QR code-based payments for enabling cross border payments. RBI policies, and government initiatives have profoundly impacted India's banking system, fostering a more efficient, inclusive, and transparent financial ecosystem. These efforts have driven economic growth and stability, with digital payments becoming a cornerstone of India's financial infrastructure, advancing the digitized economy.

6.5. Central Bank Digital Currency (CBDC)

CBDC is a perfect example of the use cases of DLT in banking & finance. CBDC (e₹) has been implemented in both wholesale and retail pilot phases, showcasing evolving use cases. The Reserve Bank introduced a new application through the e₹-Wholesale (e₹-W) pilot in October 2023 to facilitate interbank call money trades [29]. Traditionally settled via RTGS, these trades can now be processed in real time within the e-Kuber system, bypassing the RTGS application. Balances in e₹-W are synchronized with NPCI in real time, paving the way for potential migration to a distributed ledger technology (DLT) platform.

7. Impact on the Banking Sector and Economy

The banking sector is undergoing significant transformations driven by technological advancements, impacting competition, operational efficiency, and customer service through innovations such as internet banking, ATMs, and mobile banking. Technology enhances operational efficiency, asset/liability management, and enables anytime, anywhere banking. Payment systems have evolved with electronic transactions like card payments and EFT, reducing reliance on physical cash [33].

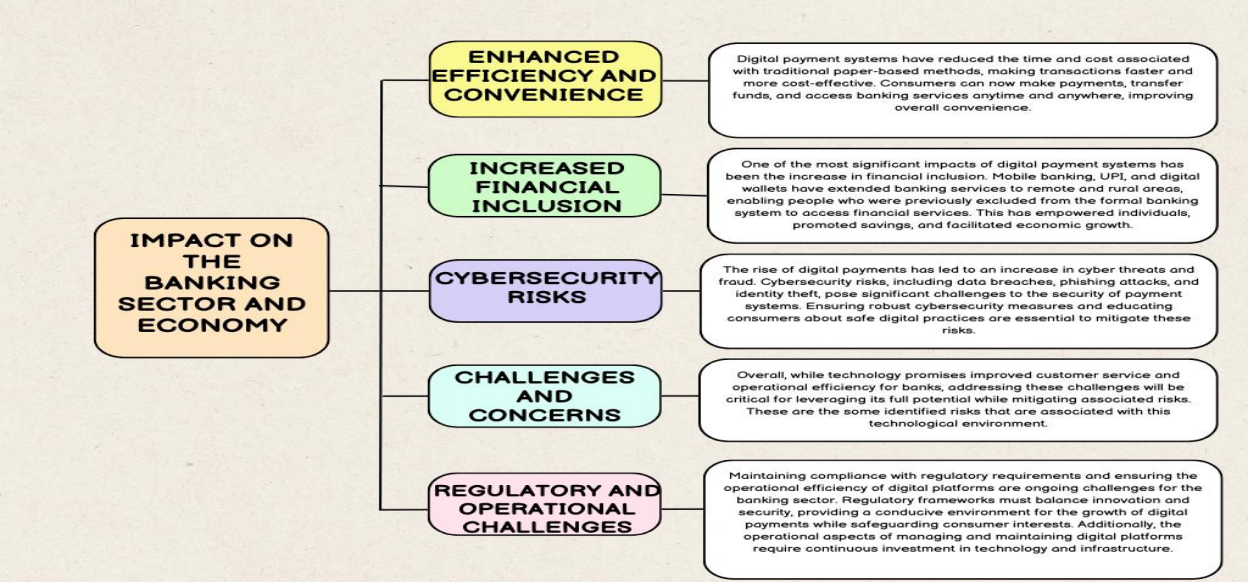

Figure 7 Impact on Banking Sector
Source: Author

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However, these advancements bring challenges, including the need for standardized hardware, software, and security measures to ensure seamless inter-bank communication and cyber protection. Implementing technology requires robust Business Process Reengineering (BPR) to align procedures with new technologies effectively [34]. Figure 7 showing the overall impact of these technological developments in the payment system of the banking sector including some regulatory challenges. Efficient banking enhances a country's economic capabilities by improving productivity, capital allocation, and financial inclusion. It enables quicker transaction processing, reduces costs, and expands access to financial services, supporting businesses with easier financing and better cash management tools. This contributes to economic stability, resilience against financial crises, and facilitates international trade and investment. Efficient banking systems bolster economic growth, job creation, and prosperity by optimizing resource allocation and empowering individuals and businesses to participate more fully in the formal economy.

7.1. Enhanced Efficiency and Convenience

The evolution of payment systems has considerably increased the efficiency and convenience of financial transactions in India. Digital payment systems have cut the time and cost associated with traditional paper-based methods, making transactions faster and more economical [34]. Consumers now enjoy the ability to make payments, transfer funds, and access banking services anytime and anywhere, enhancing overall convenience.

7.2. Financial Inclusion

Digital payment systems have significantly boosted financial inclusion. Mobile banking, UPI, and digital wallets have expanded access to banking services in remote and rural areas, integrating previously excluded individuals into the formal banking system [30]. This inclusion has empowered individuals, promoted savings, and driven economic growth.

7.3. Challenges and Concerns

While technology offers enhanced customer service and operational efficiency for banks, addressing associated challenges is crucial to fully leverage its potential and mitigate risks. These risks must be carefully managed to ensure a secure and efficient technological environment.

7.3.1. Cybersecurity Risks

As the wide use of information technology in the banking sector, the surge in digital payments has also heightened vulnerabilities to cyber threats and fraud. Main challenges such as data breaches, phishing attacks, and identity theft underscore the critical need for strong cybersecurity measures and consumer education on safe digital practices to safeguard payment systems. RBI continuously discussed these issues and the potential and preventive measures in their reports [29].

7.3.2. Regulatory and Operational Challenges

RBI ensures that the operations in the new era must be regulated so that in every report of RBI mentioned the new challenges, so that the solution of these challenges can be found. But ensuring compliance with regulatory standards and optimizing the operational efficiency of digital platforms remain persistent challenges in the banking sector [35]. AS the new technology introduced in the sector the regulations need to be reviewed. Regulatory frameworks need to balance between fostering innovation and ensuring security, creating an environment that supports the expansion of digital payments while protecting consumer interests, so that effectively managing and enhancing digital platforms necessitates ongoing investments in technology and infrastructure.

8. Initiatives for Future

Figure 8 showing the future of these technological innovations which includes blockchains, distributed ledger technology, artificial intelligence and various technologies to more robust and efficient use of technology.

8.1. Cloud Computing

The Reserve bank of India discussed Cloud in the year 2013, when banks use information technology (IT) infrastructure by banks, there is a need to examine the issue of shared IT resources in order to optimize costs while maintaining the desired levels of efficiency and security [29]. Indian Financial Technology and Allied Services (IFTAS), a subsidiary wholly owned by the Reserve Bank, boasts over eight years of expertise in managing its

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dedicated cloud platform and delivering diverse cloud services. This platform supports hosting for IFTAS projects, the Reserve Bank, and its subsidiaries, particularly for SFMS member interface operations. Given the escalating data volumes handled by Indian banks and financial institutions, exploring options with various public and private cloud providers necessitates conducting thorough business technology risk assessments before engaging their services.

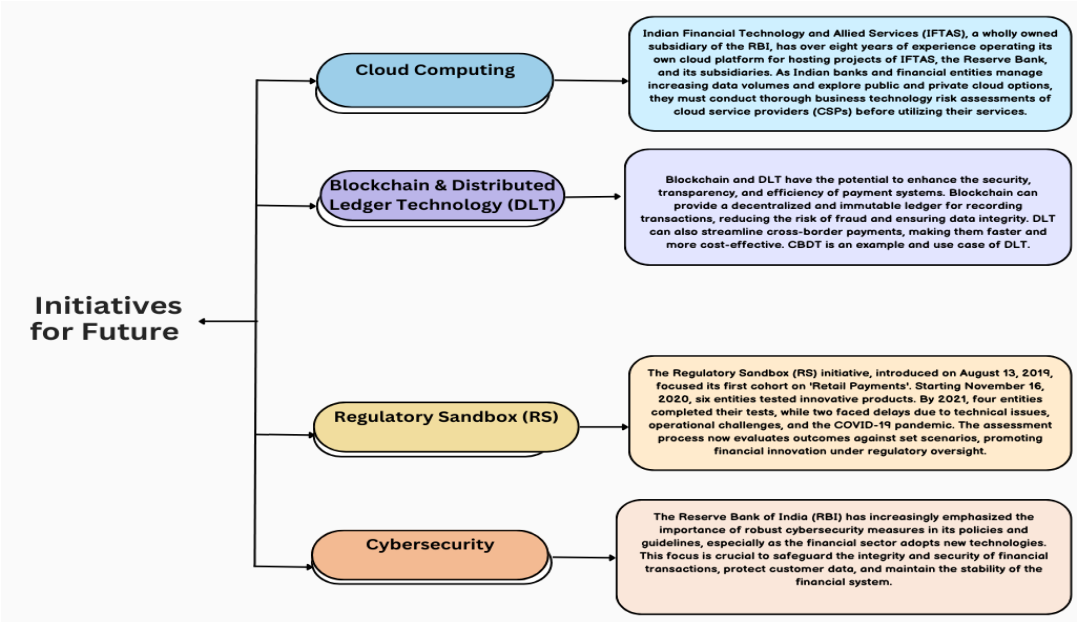

Figure 8 Future Initiatives
Source: Author

8.2. Block Chain and Distributed Ledger Technology (DLT)

The RBI discussed distributed ledger technology in the annual report of 2017. Blockchain and distributed ledger technology (DLT) offer robust solutions to enhance payment system security, transparency, and efficiency [29]. By establishing decentralized and immutable transaction ledgers, blockchain mitigates fraud risks and maintains data integrity. DLT systems, exemplified by CBDT, also streamline cross-border payments, improving their speed and cost-effectiveness.

8.3. Regulatory Sandbox (RS)

2021 was the era of fitechs where every fintech company got their funding from investors and their growth began. Meanwhile, the RBI was working to regulate fintech firms as well as banks that deployed the technology to provide services, both of them. The Regulatory Sandbox (RS) initiative, introduced with an Enabling Framework on August 13, 2019, which was discussed in the annual report of 2020, focused its first cohort on the theme of 'Retail Payments'. Commencing from November 16, 2020, the testing phase involved six entities selected to trial innovative products [29]. By the year 2021, four entities successfully concluded their test phases, while the remaining two faced delays attributed to technical issues, operational challenges, and disruptions exacerbated by the COVID-19 pandemic. The assessment process now evaluates outcomes against predetermined test scenarios, ensuring adherence to stipulated conditions and fostering an environment supportive of financial innovation under regulatory oversight.

8.4. Cybersecurity

After reviewing the report of the Reserve bank of India it can be concluded that the Reserve Bank of India (RBI) has increasingly prioritized robust cybersecurity measures in its policies, particularly with the adoption of new financial technologies [33].

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This focus is critical for safeguarding transaction integrity, securing customer data, and maintaining financial system stability. Ongoing initiatives include issuing guidelines, forming committees, and establishing working groups to fortify infrastructure across financial entities [36]. Continuous regulatory backing is crucial for advancement of payment systems in India. The RBI and government is expected to support innovations while ensuring stringent security and regulatory adherence. Streamlining regulations, promoting interoperability, and enhancing consumer protection are pivotal in fostering a more efficient and secure payment environment in the Indian banking system [29].

Conclusion

The transformation of payment systems in India's banking sector illustrates how technological innovation, regulatory reforms, and market demands are constantly changing. The shift from cash-based transactions to a vibrant online payment system has been powered by such landmark introductions of ATMs, credit or debit cards, internet banking and mobile banking. The transformation of financial transactions in the recent past has been facilitated by recent advancements such as UPI and digital wallets leading to improved convenience, speed and security where the Reserve bank of India (RBI) plays a proactive role and is supported by governmental policies. RBI's regulatory framework, alongside initiatives like Digital India and PMJDY, has laid a solid foundation for digital payment growth. These efforts not only improve efficiency in the banking sector but also promote financial inclusion by integrating millions of consumers into the formal financial system. Despite many advances in banking technology, there are some challenges especially cybersecurity and compliance matters that it is still grappling with. With digital transactions used more frequently, there is a need for heightened security against cyber crimes to keep customer's information safe hence building confidence among people who use these banks. For policymakers, striking a balance between innovation and regulatory supervision remains central. Future research should investigate the effect of the latest technologies such as blockchain and the DLT on the safety and efficiency of transactions. Additionally, it should also assess how effective government policies have been in encouraging electronic payments plus financial inclusion, providing improved safety measures for cyber threats today. These are key areas that need attention for understanding issues that arise while the changing mode with digital towards e-payments landscape development. India's future payment systems promise enhanced convenience and accessibility through advanced technologies like blockchain and AI, supported by robust regulatory frameworks. Ensuring strong cybersecurity and overcoming operational challenges will be vital to sustain and secure the growth of digital payments.

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