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FINANCIAL TECHNOLOGY (FINTECH) INNOVATIONS: TRANSFORMING FINANCIAL SERVICES IN THE DIGITAL ERA A Data-Driven Research Paper

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Abstract

The use of technology in finance has caused a major disruption in financial services. First, services were delivered through technology silos controlled by finance institutions. Now, services are offered through integrated, data-centered platforms. Purpose: In this study, we examine the disruptive effects of FinTech in the context of the Indian financial services ecosystem. We focus on digital payments, financial inclusion, increased operational flexibility, and the potential risks this disruption may cause. Data and methodology: This study uses a quantitative secondary data design based on the National Payments Corporation of India Unified Payments Interface data and the Reserve Bank of India Financial Inclusion and Digital Payments indices for the five financial years of March 2021 to March 2025. This study uses a combination of descriptive statistics, year-to-year changes, compound annual growth rate (CAGR) and exploratory Pearson correlation. This quantitative analysis is framed and guided by a review of published official and peer-reviewed literature. Results: The UPI transaction volume grew by a factor of 8.32. Financial inclusion and digital payments indices improved. Volume and financial inclusion are strongly correlated ($r = 0.991$, $p = 0.001$). Average transaction value declined, indicating that the UPI was used to satisfy retail payments. Conclusion and Implications: Convenience and reach are the three main effects. This study cannot support a robust multivariable framework for the economic payment model due to the extremely limited number of observations.

Keywords: *FinTech; digital banking; Unified Payments Interface; financial inclusion; artificial intelligence; digital payments; financial regulation*

Introduction

Financial technology or FinTech, includes the technology modern systems employ to assist in payments and exchanges of money, saving, lending, insuring, investing and regulatory practices and their additions and subtractions to current technology systems. Currently, instead of integrating systems with other financial systems, FinTech combines intermediation using mobile devices, APIs, cloud technology, artificial intelligence, distributed ledgers and real-time payment systems and technologies. FinTech is changing the structure of the production, validation and exchange of financial information rather than representing yet another category of start-ups (Thakor, 2020; Boot et al., 2021; Barroso & Laborda, 2022).

FinTech is the result of new technology and changing markets, especially in the discovery and provision of data to the public. In India, the new public digital infrastructure encouraged market innovations and new financial products and services. The introduction of Aadhar-enabled identification, payment systems, and technology to bank accounts and mobile phones that allow inter-operability and reduced transaction friction and enabled banks and non-bank financial institutions to offer services via Application Programming Interfaces (APIs). The UPI system is a prime example. UPI permits inter-operability of bank accounts and payment systems and instant payments without the need for a proprietary wallet. The Model set forth by the National Payments Corporation of India (NPCI) and the Reserve Bank of India (RBI) showed impressive transaction growth during and after the pandemic, and the RBI Digital Payment Index (RBI-DPI) and Financial Inclusion (FI)-Index indicated a concurrent and rapid advancement of payment system digitization and financial inclusion.

The changes being made go beyond just payment systems. Automated digital lending and underwriting using alternative data; open finance made possible by data aggregators and consent-based data sharing; InsurTech and WealthTech innovations reduce great barriers to distribution and regulation; central bank retail digital currency pilots explore tokenized state currency; and AI technologies improve service and personalization of credit assessments and fraud detection, among other things. Yet, all of these technologies have downsides as well, such as opacity, bias, and model governance issues with AI, and barriers to entry and volatility with crypto and blockchain technologies, among others, such as the public cryptocurrency volatility. (Goodell et al., 2021; Allen et al., 2022; RBI, 2022e).

The main research problem is not the growth of digital finance, but the growth of digital finance and the resulting benefits for the general public in the form of affordable and reliable financial services. Prior studies have focused on the intent to use digital finance, individual digital finance platforms, or cross-country studies on FinTech credit. There are fewer studies that incorporate India's official payment and financial inclusion indices. Moreover, most studies have set a limitation on the amount of statistical inference that can be drawn from short time spans of national data. This study attempts to fill this gap by analyzing the 2020-2025 validated indices, making a distinction between adoption and intermediation, and describing the types of inclusion supported by the data. It seeks to understand which of these innovations are truly groundbreaking and the nature of the changes in adoption, if the growth observed aligns with inclusion of all people in global finance, what risks to consumers and the economy may emerge, and what governance frameworks may exist to make digital finance more sustainable and inclusively integrated.

The order of India's policies is as important. Annual reports of RBI denote a pathway from pandemic induced digital persistence towards scaling digital payments & enacting rules on digital lending, as well as developing Account Aggregators, and experimenting with CBDC and step-up cyber supervision (RBI, 2021a, 2022a, 2023a, 2024a, 2025a). This pathway exemplifies the need for innovation and regulation to work synergistically, as public interoperable frameworks can increase market participation and can simultaneously support regulatory and consumer confidence frameworks. Similar conclusions are drawn in multiple international assessments. In order for sustainable Fintech to innovate, develop and thrive, the right balance and integration of infrastructure, competition, data management, and regulation is critical, otherwise rapid innovation may create a technology gap that negatively impacts consumers with predatory, unstable and exclusionary practices (Arner et al., 2020; World Bank, 2022a).

Table 1. Major FinTech innovations, applications and principal risks

Segment	Core technologies	Transformation mechanism	Principal risk
Digital payments	UPI, QR, IMPS, tokenisation	Instant interoperable transfers and merchant acceptance	Fraud, outages, concentration
Digital lending	e-KYC, alternative data, automated underwriting	Faster origination and lower processing cost	Over-indebtedness, opaque scoring
Open finance	APIs and account aggregators	Consent-based data portability and product comparison	Consent fatigue, third-party risk
AI and RegTech	Machine learning, NLP, anomaly detection	Fraud detection, service automation, compliance	Bias, explainability, model drift
WealthTech/InsurTech	Robo-advice, embedded insurance	Lower distribution cost and wider access	Mis-selling, suitability failures
Blockchain/CBDC	Distributed ledgers, tokenised money	Programmable settlement and shared records	Interoperability, privacy, cyber risk

Source: Author synthesis based on RBI (2022e, 2022f, 2025d), World Bank (2022b), FSB (2024), and peer-reviewed literature.

Critical Review of Literature

2.1 Digital intermediation and platform competition

The consensus positions FinTech as reducing transaction and information costs, skewing competitive advantages toward data, interfaces, and network effects. Thakor (2020) separates innovations that complement banking from those that disintermediate banking functions. Boot et al. (2021) argue that while abundant data and AI enhance platforms that match users to subsidized services, they do not diminish the need for trust, balance sheets, and regulatory frameworks. Barroso and Laborda (2022) find that digital transformation in their systematic

review changes banks' organizational capabilities and customer journeys, beyond supporting improvements in delivery channels. Collectively, these mean a regulated future where banks provide regulated balance sheet capacity and competitive customer interfaces and information processing come from FinTech, tech firms, and public sector infrastructure.

2.2 Payments, adoption and financial inclusion

In the digital payments literature, key customer adoption drivers include perceived benefits and costs, trust, and the influence of others. Sahi et al. (2021) point out the fragmented evidence across different technologies and contexts makes institutional design essential. In the case of India, to reduce the costs of consumer/merchant switching, payment systems have introduced open-loop, interoperable rails and systems, while low-value, feature phone products have been introduced to extend access beyond a focus on the smartphone. The Global Findex measures the increase in digital payments as a result of the COVID-19 pandemic and claims that account ownership does not ensure active, safe, and functional systems (Demirgüç-Kunt et al., 2022). The RBI FI-Index is an example of an inclusion framework measuring access, use, and quality, as opposed to account ownership.

2.3 Digital credit, alternative data and algorithmic risk

FinTech lends to customers who hitherto have only limited formal credit histories by leveraging transaction data and data on the customer's behavior. Berg et al. (2020) show that digital data can be informative, and Cornelli et al. (2023) relate digital credit expansion with economic growth, more investor interest, and flexible regulations. Predictive ability is not predictive fairness. Bartlett et al. (2022) note that while technology has the ability to mitigate certain kinds of discrimination, price inequalities are likely to endure, and Fuster et al. (2022) argue that gains in machine-learning techniques may be unevenly distributed to the creditworthy. As a result, the digital lending framework in India emphasizes direct lending and repayment, transparency, data minimization, grievance mechanisms, and accountability of regulated entities (RBI, 2022d, 2025d). Innovation is welcome, but the literature does not support the transfer of accountability to the algorithms and lending service providers.

2.4 Artificial intelligence, cyber resilience and regulation

In finance, AI is being applied in many areas such as risk assessment, modeling and quantification of fraud, customer interactions, trading, and compliance. Goodell et al. (2021) recognize rapid growth and increased interest, but also the multitude of isolated methods and poor consideration of governance. In the FSB (2024), the combination of cyber threats, herding, and reliance on third parties, and correlated models serve as potential channels for a loss of financial stability. India's responsible AI focuses on safety, fairness, and transparency, and adds accountability and privacy protection (NITI Aayog, 2021). Digital Personal Data Protection Act sets the bar for the legal and responsible processing of data (Government of India, 2023). Regulatory sandboxes can lessen uncertainty by allowing temporary controlled experiments, but will not replace the need for licensing, proper oversight, or ex post consumer protection (SEBI, 2020; RBI, 2024d).

Research Gap

There are three main gaps. Firstly, many of these growth narratives conflate payment activities with inclusion. In fact, inclusion takes account of access, use, and quality. Secondly, there is a lack of adequate measures related to cost, failure, and processing times,

yet many authors assume efficiency from adoption. Thirdly, studies on the national annual series often subject them to over-parameterized regressions, despite limited samples and common trends. This study attempts to address these gaps. Firstly, it has used the confirmed data of UPI, FI-Index, and RBI-DPI, and has provided clear and transparent descriptive and correlational analyses, and has avoided the use of multivariable regressions in cases when the degree of freedom was insufficient.

Another gap that will be addressed relates to developmental impacts. Some cross-country studies show that digital financial inclusion and the reduction of payment frictions can contribute to economic growth. However, the benefits are largely dependent on the level of the institutions and the use of the services, as opposed to digital access (Khera et al., 2021). The same concerns are seen in the sustainability literature. These contradictions of digital finance justify a design that incorporates the scale of transactions and provides governance and inclusion, as opposed to treating the adoption of FinTech as an unrestricted welfare gain.

Conceptual and Theoretical Framework

Integration of technology acceptance logic with diffusion, transaction cost and financial intermediation theories is employed in this framework. User adoption occurs when services are perceived to be useful, easy, trusted and built on a sufficient infrastructure. Diffusion is rapid when the benefits of the network, acceptance by merchants, and interoperability of the services render them more valuable with growing participation. From a transaction cost perspective, automated onboarding, real-time settlement and reusable digital identity credentials will reduce search, verification and processing costs. Financial intermediation theory asserts that while technology alters the processes of screening and distribution, it does not eliminate the functions of liquidity, maturity transformation, conduct and systemic risk. Hence, the effects of FinTech innovations on inclusion are indirect and occur through the adoption and use of the services, where digital skills, connection, cyber security, regulation and consumer awareness act as intermediary barriers (Sahi et al., 2021; Boot et al., 2021; World Bank, 2022b).

Figure 1. Conceptual framework linking FinTech innovation with financial-service outcomes

FinTech innovation →	**Digital-service adoption** →	**Outcomes**
Payments, APIs, AI, DLT	Usage, trust, frequency	Access, affordability, efficiency, inclusion
Moderators: digital literacy, connectivity, cybersecurity, consumer awareness and regulatory support		

Source: Author-developed framework informed by Boot et al. (2021), Sahi et al. (2021), and World Bank (2022b).

Research Methodology

The methodology used in this study is a quantitative, descriptive, and design-based approach of secondary data that is comparative and correlational. The main unit of analysis is the Indian financial year ending in March, which is a set of five matched cross-sectional data for

the years 2020-21 to 2024-25. Information on the volume and value of UPI is obtained from NPCI retail payment statistics and the Economic Survey. Financial Inclusion is represented through the RBI FI-Index, which combines the dimensions of access, usage and quality. Payment digitization is via the RBI-DPI, which is a composite index of payment digitization, with March 2018 as the base year. The analytical window is set between March 2021 and March 2025, as the FI-Index is available from March 2021 and up to March 2025, is the most current year in the study (Ministry of Finance, 2025; NPCI, 2025a, 2025b; RBI, 2021b, 2021c, 2022b, 2022c, 2023b, 2023c, 2024b, 2024c, 2025b, 2025c).

The data were collected in their published units, then cross-checked across all source tables and were consolidated by financial year. UPI value is provided in INR billion and UPI transaction volume is provided in millions. Average ticket size is equal to UPI value in INR billion multiplied by 1000, divided by UPI transaction volume in millions. Data transformation was done to compute year-on-year growth, which equals the ratio of the value from the current year compared to the value from the previous year minus one. The four time periods of compound annual growth were also computed. Other descriptive statistics computed include mean, median, minimum, maximum, sample standard deviation and sample variance, and coefficient of variation. As the variables were continuous and almost linear for all the years, Pearson correlation with two-tailed p-values was carried out at a 5% significance level.

The correlation analysis is primarily exploratory. Due to an n = 5, common time trends can produce a high coefficient, and the sample cannot provide strong constraints for the control, the tests for stationarity, or a meaningful multiple regression. A three-predictor model would provide just a single residual degree of freedom and would result in coefficient instability with a false sense of precision. Therefore, no multiple regression is computed. H01 is examined by the association of UPI volume and the FI-Index. H02 is concerned with a measurable efficiency outcome that could be cost per transaction, processing time, or failure-adjusted service productivity. Due to the absence of a series on annual basis, H02 could not be evaluated. H03 is beyond the scope of a significance test and is evaluated qualitatively.

The research is based on aggregated data, and since no personal or confidential data are present, formal ethics approval for research on human subjects was not required. However, ethical analyses go beyond formal requirements and consider the obligations for responsible interpretation of data. These interpretations include measurement of system growth independent from the growth of system use, refraining from making claims on causal relations, and considering the reported fraud. The main limitations are the short time series, the change in granularity of data, the composite measures of FI-Index and RBI-DPI, and the absence of measures for cost of transactions and customer satisfaction for concurrent years.

Table 2. Variables, definitions, units and sources

Indicator	Unit	Analytical role	Period	Source
UPI volume	Million transactions	FinTech/payment adoption	FY2020-21–FY2024-25	NPCI retail statistics
UPI value	INR billion	Payment intensity	FY2020-21–FY2024-25	NPCI; Economic Survey

Average ticket	INR per transaction	Retail-use proxy	Derived	Author calculation
FI-Index	0–100 composite	Financial inclusion	March 2021–2025	RBI
RBI-DPI	March 2018 = 100	Payment digitisation	March 2021–2025	RBI

Note: Indicators are aligned to the financial year ending March. Date accessed: 25 July 2026; only observations through March 2025 are analysed.

Results

5.1. Growth and transaction structure

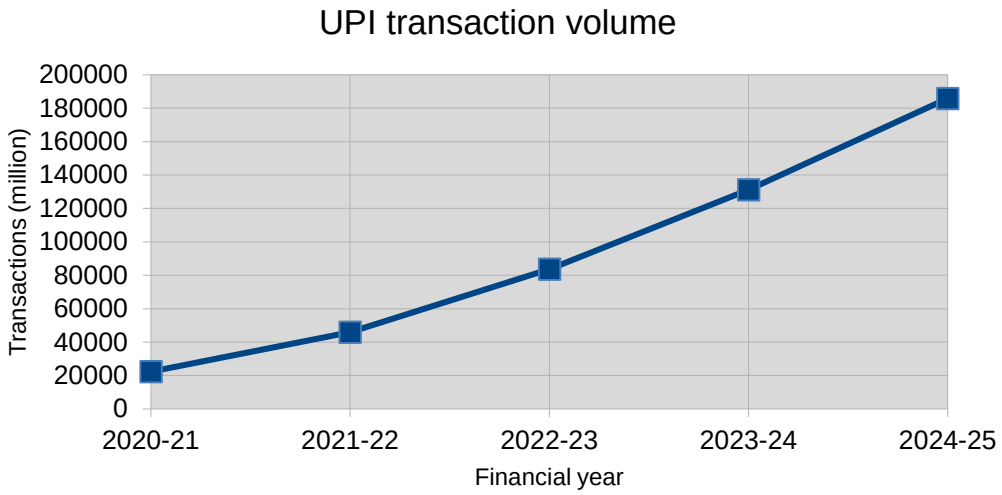
In the instance of Unified Payments Interface (UPI), the transaction volume from FY2020–21 to FY2024–25 rose from 22.331 billion transactions to 185.866 billion transactions. This resulted in an 8.32-fold volume increase and an annual compound growth of 69.85%. The transaction value rose from INR 41.036 trillion to INR 260.570 trillion representing a 6.35-fold monetary increase and an annual compound growth of 58.74%. Growth was decelerating as the base was enlarged, however growth remained positive. For FY2021–22 to FY2024–25, transactions volume growth decelerating from 105.85% to 41.70% and value growth from 105.13% to 30.37%. This is in line with the early stage of mass-market growth and not a contraction as evidenced (NPCI, 2025a; Ministry of Finance, 2025).

Table 3. UPI transaction indicators and Financial Inclusion Index, FY2020–21 to FY2024–25

Financial year	UPI volume (billion transactions)	UPI value (INR trillion)	Average ticket (INR)	FI-Index
2020-21	22.33	41.04	1838	53.9
2021-22	45.97	84.18	1831	56.4
2022-23	83.75	139.21	1662	60.1
2023-24	131.16	199.87	1524	64.2
2024-25	185.87	260.57	1402	67.0

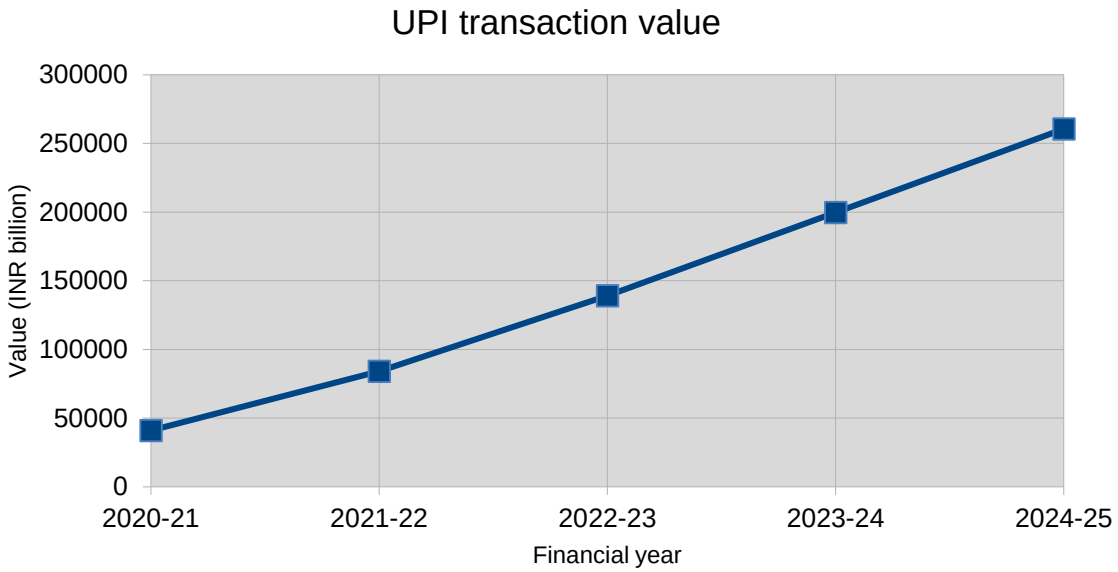
Sources: NPCI (2025a, 2025b), Ministry of Finance (2025), RBI (2021b, 2022b, 2023b, 2024b, 2025b); calculations by the author. Year-on-year growth is reported separately in Table 6.

Figure 2. Growth of UPI transaction volume, FY2020–21 to FY2024–25



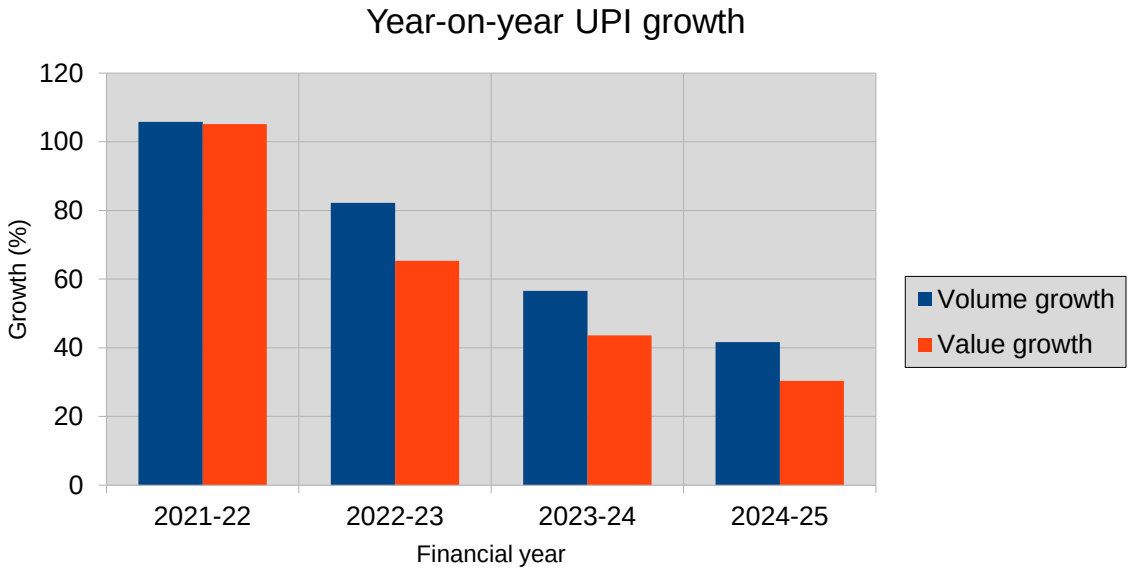
Source: NPCI (2025a); unit: million transactions. Chart is an editable embedded chart.

Figure 3. Growth of UPI transaction value, FY2020–21 to FY2024–25



Source: NPCI (2025a); unit: INR billion. Chart is an editable embedded chart.

Figure 4. Year-on-year growth in UPI volume and value



Source: Calculated from NPCI (2025a) annual totals. Chart is an editable embedded chart.

5.2 Digitization, inclusion and transaction size

Between March 2021 and March 2025, the RBI-DPI jumped from 270.59 to 493.22, a growth of 82.28%, compared to the FI-Index which increased from 53.9 to 67.0, a 13.1 point improvement, or a 24.30% increase. Progress was reported for both indices every year. The RBI-DPI progressing at a more rapid rate shows that the payment infrastructure and its performance are capable of being scaled more rapidly than the overall access, use, and advantages of the complete suite of financial services. Thus, the digitization of transactions occurs at a much faster rate than financial services inclusion. It must be noted that beyond the availability of a payment account, the digitization and inclusion of other services such as

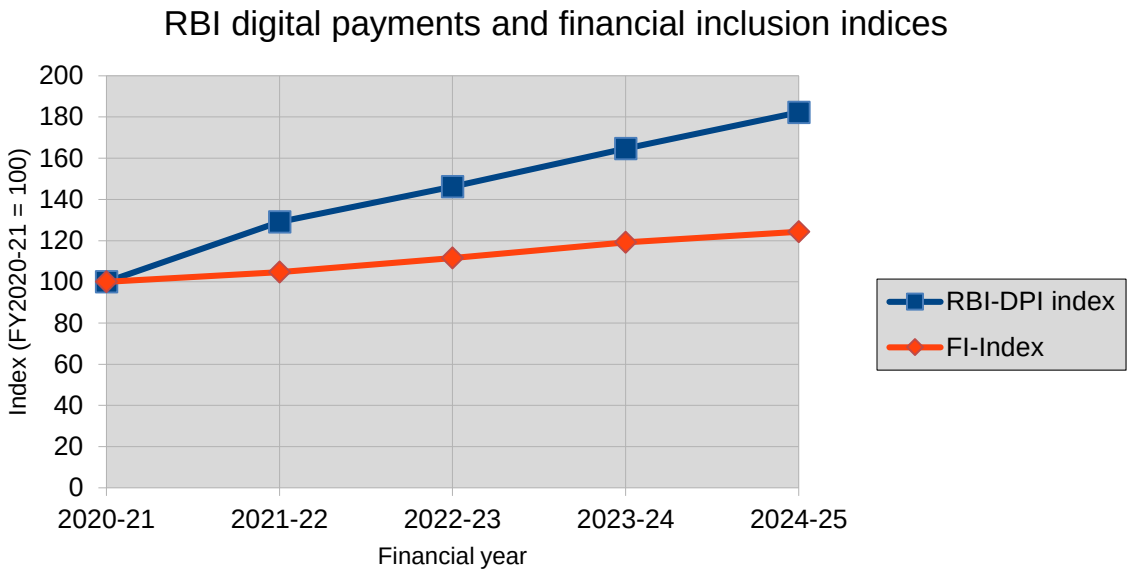
credit, insurance, pensions, and the capability and quality of service, still remain essential (RBI, 2021b, 2021c, 2022b, 2022c, 2023b, 2023c, 2024b, 2024c, 2025b, 2025c).

Table 4. RBI digital-payment and financial-inclusion indices

FY ending March	RBI-DPI	FI-Index	UPI volume index (2020–21=100)
2020-21	270.59	53.9	100.0
2021-22	349.30	56.4	205.8
2022-23	395.57	60.1	375.0
2023-24	445.50	64.2	587.4
2024-25	493.22	67.0	832.3

Sources: RBI index releases, 2021–2025; UPI volume index calculated from NPCI data.

Figure 5. Indexed growth of RBI-DPI and FI-Index (FY2020–21 = 100)



Source: Author calculations using RBI index releases. Chart is an editable embedded chart.

The average size of UPI transactions fell by 23.7%, from INR 1,838 to INR 1,402. Strong growth in total transaction value means that this can be analyzed as UPI users expanding usage to smaller transactions, as opposed to a decline in UPI usage. The growth in smaller transactions is consistent with the rapid growth of QR code payments and the use of immediate transfer systems for small retail transactions in the economy. The variation also illustrates a scale effect, as the coefficient of variation for UPI transactions is equal to 70.24%, and for the average transaction size it is 11.56%. This indicates that transaction counts were much larger than the value of the average transaction in the system compared to previous transactions..

Table 5. Descriptive statistics of selected indicators (n = 5)

Indicator	Mean	Median	Minimum	Maximum	Sample SD	Sample variance	CV (%)
UPI volume (million)	93,816.17	83,751.14	22,331.00	185,866.02	65,895.69	4.34e+09	70.24
UPI value (INR billion)	144,971.06	139,206.78	41,036.00	260,569.55	87,903.83	7.73e+09	60.64
Average ticket (INR)	1,651.33	1,662.15	1,401.92	1,837.62	190.82	36,410.83	11.56
FI-Index	60.32	60.10	53.90	67.00	5.39	29.08	8.94
RBI-DPI	390.84	395.57	270.59	493.22	86.14	7,419.35	22.04

Source: Author calculations. Monetary and transaction units are as defined in Table 2.Table 6. Growth rates and average transaction value

FY	UPI volume YoY (%)	UPI value YoY (%)	Average ticket (INR)
2020-21	—	—	1,838
2021-22	105.85	105.13	1,831
2022-23	82.19	65.38	1,662
2023-24	56.61	43.58	1,524
2024-25	41.70	30.37	1,402

Note: Volume CAGR = 69.85%; value CAGR = 58.74% over four annual intervals.

5.3 Correlation and hypothesis assessment

The exploratory correlations are uniformly strong because all major scale indicators trend upward over the same five years. UPI volume and FI-Index show r = .991 (p = .001), and UPI value and FI-Index show r = .998 (p < .001). RBI-DPI and FI-Index are also closely associated (r = .985, p = .002). The negative correlation between average ticket size and FI-Index (r = −.988, p = .002) supports the interpretation that inclusion and payment deepening coincided with more frequent low-value transactions. H01 is rejected at the 5% level, but the decision establishes association only. H02 and H03 remain statistically untested because no valid annual efficiency or customer-accessibility outcome was available. No regression coefficients are reported because the sample is inadequate for a defensible multivariable specification.

Table 7. Exploratory Pearson correlations and hypothesis decisions

Relationship	r	Two-sided p	Interpretation
UPI volume–FI-Index	0.991	0.001	Very strong positive
UPI value–FI-Index	0.998	<0.001	Very strong positive
RBI-DPI–FI-Index	0.985	0.002	Very strong positive
UPI volume–RBI-DPI	0.969	0.006	Very strong positive

Average ticket–FI-Index	-0.988	0.002	Very strong negative

Note: n = 5. P-values are exact for Pearson correlation. Shared time trends and the small sample limit inference.

Table 8. Hypothesis-testing summary

Null hypothesis	Evidence/test	Result	Decision
H01: No relationship between FinTech adoption and inclusion	Pearson: UPI volume vs FI-Index	r=.991; p=.001	Reject H01; association is positive, not causal
H02: No effect on service efficiency	No consistent efficiency series	Not tested	Inconclusive
H03: No improvement in accessibility/convenience	No respondent-level accessibility series	Not tested	Qualitative support only; no statistical decision

Source: Author analysis. "Not tested" prevents unsupported significance claims.

Discussion

The findings show that transformation arises from scale, interoperability, and transaction-frequency deepening. The growth in UPI's transaction volume outpaced the growth in transaction value, associated with a decline in the average transaction value. This has an important meaning: a payment system becomes socially incorporated and embedded when ordinary transactional activities are conducted, as opposed to the system being only used to conduct infrequent, value-laden transfers. Interoperability minimizes the need for merchants and customers to join the same closed-loop proprietary network, and standard QR code acceptance reduces the cost of requiring customers to use an accepting system. Each of these factors resonates with transaction-cost theory and with FinTech literature that views the evolution of systems as a reshaping of the information and distribution networks, rather than the substitution of unregulated entities for regulated intermediaries (Thakor, 2020; Boot et al., 2021).

The observed UPI activity and FI-Index relationship is strong and supports the argument that digital payment systems offer new inclusion opportunities. However, the payment system growth and RBI-DPI vs. FI-Index disparity show that the growth of payment systems does not mean that financial inclusion has been achieved. While the building blocks for scalable payments systems are identity, bank accounts, and point-of-sale systems, the extensive use of financial services (i.e., savings, credit, insurance, and pensions) requires various economic, financial, and regulatory conditions. The World Bank illustrates the distinction between having an account and actively using it for productive purposes (Demirgüç-Kunt et al., 2022). Thus, policy frameworks must identify the new economic opportunities afforded by digital payment systems rather than focusing on the mere increased volume of transactions.

FinTech tools supply banks with a unique mix of strategic and operational advantages. Implementing machine learning, cloud-based infrastructures, APIs, and automation increases

the velocity and efficiency of service. However, the competitive landscape resulting from the use of these tools threatens banks' customer relationships. The FinTech community is using the banking infrastructure, digital identity, and regulated payment systems to build innovative services. These systems create a framework of cooperative competition. Within this framework, collaboration exists in the building of a shared infrastructure and distribution networks, whereas competition exists over the quality of interfaces and data. The dependency on technology is particularly evident during periods of disruption. The integration of technology provides a competitive advantage and demonstrates the value of investment in infrastructure (Pierri and Timmer (2022)).

Digital lending exemplifies the push and pull of access and behavior. Thin file borrowers have increased access to credit through the use of alternative data (Berg et al., 2020). However, the race to innovate further entrenches existing biases and inequities (Bartlett et al., 2022; Fuster et al., 2022). The RBI framework creates a necessary shift of responsibility to the service providers, requires transparency, and restricts the use of data (RBI, 2022d, 2025d). The innovation of lending services should be measured against the customer experience that is derived (e.g. approval, clarity and fairness in costs, ease of repayment and frictionless customer support) and should not be measured against the volume of credit issued.

These technologies will further elevate governance demands. AI-enabled solutions can be integrated to conduct real-time fraud detection, automate customer service via conversational agents, and facilitate compliance with competition laws via user-controlled data-sharing frameworks. However, using the same infrastructure (e.g. cloud, data-sharing frameworks, and AI foundation models) creates correlated risks and reduces the reliability of competitive markets. Also, poorly controlled models and excessive user-consent pop-ups create the illusion of self-regulation. The FSB (2024), NITI Aayog (2021) and the data-protection framework advocate for "layered governance" involving data restriction, security-by-design, model oversight, human-in-the-loop, logging and monitoring, external audits and clear assignment of responsibility.

CBDC and the movement towards tokenisation represent a new challenge. Unlike private crypto-assets, a CBDC is a liability of the central bank, and therefore, can be designed to incorporate finality of settlement guarantees, and programmable or offline transaction capabilities. The BIS design envisions a tokenised, central-bank money integrated with a fully programmable ledger of commercial bank money and assets. However, the implications of privacy, bank runs, and system operational risk, among others, will slow down such designs (Bank for International Settlements, 2023). This is further supported by the RBI's (2022e) observation to favour technology trials.

Table 9. Comparative assessment of major FinTech segments

Segment	Adoption stage in India	Primary contribution	Priority constraint
Digital payments	Very high	Immediate, interoperable mass usage	Fraud resilience and sustainable economics
Digital lending	High but uneven	Faster onboarding and alternative underwriting	Conduct, pricing and over-indebtedness
InsurTech	Moderate	Digital distribution and claims automation	Suitability and exclusion
WealthTech	Moderate	Low-cost access and automated portfolios	Risk disclosure and advice quality
RegTech	Growing	Automated monitoring and reporting	Model validation and integration cost
Blockchain/CBDC	Experimental/selective	Programmable settlement and tokenised assets	Interoperability, privacy and governance

Source: Critical synthesis of RBI annual reports, RBI (2022e, 2022f), and World Bank (2022b).

Major Challenges

The first challenge is cyber and operational resilience. Legitimate transactions can be as slow as service outages, phishing, account takeovers, social engineering, mule accounts, and data breaches. The second challenge is consumer protection. Providers can gain efficiencies from opaque transaction costs, dark patterns, mis-selling, lending to an overextension of instant-credit and poor grievance redress mechanisms, while exposing households to greater risks. Digital exclusion is the third challenge. Connectivity, accessibility, and a lack of support for disabilities, as well as language barriers and gaps in financial literacy create exclusion. The fourth challenge is data-intensive models causing concerns about privacy, bias and the ability to explain data-intensive models. The fifth challenge is concentration of payment applications, cloud providers, identity services, and data intermediaries creating single points of failure along the value chain and systemic concentration risks. The sixth challenge is tokenized assets and cross-border applications creating a (lack of) settlement finality and anti-money laundering compliance across jurisdictions (Government of India, 2023; FSB, 2024; OECD, 2023; RBI, 2025a).

Figure 6. Qualitative risk-impact matrix for the Indian FinTech ecosystem

Likelihood / Impact	Low impact	Moderate impact	High impact
High likelihood	Minor service errors	Phishing and mis-selling	Account takeover and systemic outages
Moderate likelihood	Local integration delays	Algorithmic bias and data misuse	Third-party/cloud concentration
Low likelihood	Limited pilot failure	Cross-border disputes	Systemic cyber event

Source: Author assessment based on FSB (2024), RBI (2022d, 2025d) and Government of India (2023). The matrix is qualitative, not a probability estimate.

Risk-control register (supplementary)

Risk	Potential consequence	Priority mitigation
Cyber fraud and outages	Loss, distrust, contagion	Strong authentication, behavioural monitoring, redundancy and rapid recovery
Opaque digital lending	Mis-selling and over-indebtedness	Key-fact statements, cooling-off, affordability tests and accountable regulated entities
Algorithmic bias	Unequal approval/pricing	Bias testing, explainability, human review and appeal
Data misuse	Privacy and identity harm	Purpose limitation, minimisation, encryption and consent logs
Digital divide	Exclusion of rural/low-literacy users	Assisted channels, feature-phone access, vernacular and accessible design
Third-party concentration	Common-mode operational failure	Exit plans, portability, concentration limits and supervisory testing

Source: Author synthesis; supplementary operational register, not counted as an analytical results table.

Recommendations

To begin, regulators and operators are encouraged to abandon transaction-growth targets. Instead, the measurement of inclusion needs to assess active use, affordability, failure rates, complaint resolution, and customer financial health. Payment resilience should also be viewed as critical infrastructure. Payment service providers should have multi-region redundancy, continuous fraud resilience, recovery objectives, and contingency with communication during incidents. Finally, digital lending should enforce accountability for all outsourcing along the service value chain, requiring key fact statements, consent, affordability, and limits to dark patterns and active cool-off and complaint mechanisms.

The use of Responsible AI in financial services means having a model inventory, independent validation of models, controlled drift, explainability, human-in-the-loop, and borrower appeal. Data protection needs to use the principles of privacy by design, purpose limitation, encryption, short retention, and verified deletion, instead of unnecessary lengthy consent. For inclusion, mandated funding for connectivity, assisted digital services, clear digital pathways, local-language interfaces, disability access, and ongoing financial literacy services is a given. Combining a good digital infrastructure with financial literacy, an understanding of fraud, and consumer rights as shown by the OECD/INFE evidence (OECD, 2023) is a good and positive approach.

Seventh, open finance and account aggregator ecosystems require common API standards, consent dashboards, and liability and service-level frameworks so that portability does not result in unmanaged third-party risk. Eighth, regulatory sandboxes should specify test results and criteria for leaving, to enable learning for all market participants and to avoid permanent regulatory forbearance. Ninth, public-private coordination should focus on infrastructure that is inter-operable, not on exclusive platforms. Lastly, the economics of instant retail payments should be sustainable. This means innovation should be maintained and cross-subsidies should not be hidden, but fraud and disputes should maintain a quality level of service. Seventh, transparent pricing is critical for blockchain infrastructure. Portability and innovation should not be achieved through hidden subsidization.

Eighth, open finance and account aggregator ecosystems require common API standards, consent dashboards and liability and service level frameworks to ensure that portability does not create unmanaged third party risk. Eighth, regulatory sandboxes should specify test results and criteria for exit, to enable learning for all market participants and avoid permanent regulatory forbearance. Ninth, public-private coordination should focus on interoperable, not exclusive, infrastructure. Finally, the economics of instant retail payments should be sustainable. This means innovation should be maintained and cross-subsidation should be avoided, but fraud and disputes should maintain a quality level of service.

Implementation should be supported by a public measurement dashboard that reports transactional success, outages, fraud and the time it took to resolve complaints, as well as rural use, accessibility and savings, insurance, and credit use. Disaggregated indicators would allow regulators to see if there was digital growth masking regional and demographic exclusion. Frequent independent assessments should compare sandboxes' claims and AI model's.

Limitations and Future Research

The analysis is based on aggregated secondary data and a matched five-observation annual series. Composite indices obscure variability across regions and demographic segments, under-reporting of fraud may occur, and reporting standards across FinTech segments vary. There is a risk of common trends affecting the observed relationships, and these relationships do not imply causation. There was a lack of comparable annual data for mobile-banking users, digital-credit, processing data on cost, success, and satisfaction. Future studies should explore bank- or state-level panels and transaction data and quarterly data on the quality of transactions along with anonymized customer surveys. These studies should also focus on the rural and gender gaps, CBDC adoption and platform concentration, and the over-

indebtedness gap by applying the longitudinal studies and other gaps of concern by applying the same designs.

Conclusion

It is evident that FinTech has transformed Indian financial services by making account-to-account payments seamless, instantaneous, and integrated into everyday transactions. From FY2020–21 to FY2024–25, the UPI volume increased more than eight times. Payment systems became more digitized, and the FI-Index improved. The average transaction value also decreased, showing a greater level of engagement by the general public. UPI use and financial inclusion also improved (although it was more advanced). The analysis suggests that the major innovations include: the seamless integration of payments, APIs, artificial intelligence, digital lending, RegTech, and tokenization. It also suggests that financial inclusion progresses at a pace that is less than the advancement of payment innovations. The next step should focus on developing responsible digital credit systems and AI, as well as safeguarding the privacy of users and providing effective systems for financial literacy and redress. The long-term impact of FinTech should be evaluated on the ability to deliver secure and affordable financial services across all social and geographical segments of society rather than focusing on the total number of transactions.

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