Impact Of Unified Payments Interface (Upi) On Financial Inclusion In India: A Comprehensive Statistical Analysis

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Abstract: The Unified Payments Interface (UPI), launched by the National Payments Corporation of India (NPCI) in 2016, has revolutionized India's digital payment landscape and significantly contributed to financial inclusion. This comprehensive study examines UPI's growth trajectory, its impact on digital financial inclusion through detailed statistical analysis and data visualization. Using authentic data from NPCI, RBI, and other reliable sources, this paper provides an in-depth quantitative analysis of how UPI has transformed India's payment ecosystem. The study finds that UPI has grown from zero transactions in April 2016 to over 18.3 billion transactions worth ₹24.77 trillion in March 2025, (1) demonstrating a remarkable CAGR of 74.03% in transaction volume, making India a global leader in digital payments while simultaneously advancing financial inclusion objectives.

1. INTRODUCTION:

Financial inclusion, defined as universal access to and usage of formal financial services, is fundamental to inclusive economic growth and development. In India, the journey toward comprehensive financial inclusion has been marked by several landmark initiatives, including the Pradhan Mantri Jan Dhan Yojana (PMJDY), Aadhaar-enabled services, and the Digital India campaign. Among these, the Unified Payments Interface (UPI) stands out as a transformative innovation that has democratized access to digital financial services.

Genesis of UPI

The development of UPI stemmed from the vision to establish a unified system that would streamline digital payments and extend their reach to a wider audience. Before UPI, India's digital payment landscape was fragmented, with individual banks and payment solutions functioning in isolation. UPI revolutionized this scenario by offering a single, interoperable interface through which users could link multiple bank accounts to one mobile application, enabling quick and seamless fund transfers. Its architecture prioritized interoperability, ease of use, and robust security, making it a preferred choice for both customers and merchants alike.

Launched on April 11, 2016, by the National Payments Corporation of India (NPCI), UPI represents a real-time payment system that enables inter-bank transactions through mobile platforms. Statistical evidence demonstrates that digital payment transactions have increased 94 times in volume since 2013, with UPI being the primary driver of this exponential growth (1). This paper examines UPI's role in advancing digital financial inclusion through comprehensive statistical analysis, examining its growth patterns, socio-economic impacts, and the challenges that remain in achieving universal financial access.

2. LITERATURE REVIEW:

The literature on digital financial inclusion in India has evolved significantly since UPI's introduction. The World Bank's Global Findex Database 2021 provides comprehensive data on financial inclusion trends globally, revealing that India's account ownership increased from 53% in 2014 to 78% in 2021 (2). Recent studies have examined the relationship between digital payment adoption and financial inclusion metrics, with particular emphasis on UPI's role as a catalyst for change. The Unified Payments Interface (UPI), introduced by the National Payments Corporation of India (NPCI) in 2016, has reshaped India's digital payment ecosystem, significantly advancing financial inclusion. This review synthesizes India-specific studies to examine UPI's role in promoting digital financial inclusion

Akhtar et al. (2023) conducted a case study (3) in rural Aligarh, India, using logistic regression to analyze UPI adoption. They found that younger age, higher education, and income positively predict UPI use, while caste and low financial literacy were insignificant barriers, highlighting UPI's potential to bridge financial inclusion gaps in rural areas.

Rastogi (2021) explores UPI as a digital innovation driving financial inclusion and economic development (4). The study emphasizes UPI's user-friendly interface and interoperability, which have integrated millions into the formal financial system, particularly through linkage with Aadhaar and mobile banking.

Cornelli et al. (2024) analyze UPI's organizational structure and its dominance in India's digital payments, handling 80% of transaction volum (5). The study highlights UPI's integration with India Stack and its role in onboarding 300 million users, though rural connectivity and literacy remain challenges.

Bansal et al. (2024) analyzes India's Unified Payments Interface (UPI) as a transformative digital payment system that has grown exponentially from 0.8 billion transactions in January 2018 to over 14.4 billion by July 2024, now handling nearly 80% of India's digital payments. The authors provide empirical evidence demonstrating a strong correlation (R^2=0.75) between UPI transaction volume and GDP growth, with a 1% increase in UPI transactions correlating with 0.03% GDP growth, while documenting UPI's role in bringing over 300 million people into formal banking and increasing microloan disbursements by 100% between 2018-2023. The study (6) positions UPI as a tool for India's technological diplomacy, highlighting successful implementations in UAE, France, Japan, and Maldives, arguing that global UPI expansion could establish India as a leader in scalable digital payment solutions, though challenges remain in penetrating developed markets with established financial systems.

Swami et al. (2024) examines the factors driving UPI's exponential growth since its 2016 launch by NPCI, analyzing various economic variables through regression analysis, ANOVA, and t-tests (7). The research reveals that UPI transactions increased by 42,061 lakhs in volume and ₹3,219,831 crores in value between August 2021-2023, with India contributing 46% of global real-time payments in 2022. Key findings demonstrate that person-to-merchant transactions significantly outweigh person-to-person transactions in UPI usage, while technical decline more adversely affects bank performance than business decline during UPI operations. The study's regression analysis shows a strong positive correlation (R^2=0.97) between UPI transaction values and economic indicators like per capita private final consumption expenditure, though individual variables proved statistically insignificant. The authors conclude that UPI has been instrumental in reducing the informal economy, promoting financial inclusion among weaker economic classes, and positioning India toward a projected $1 trillion digital payments economy by 2025, emphasizing UPI's role as a technological solution for real-world financial accessibility problems.

The Press Information Bureau (8) highlights India's remarkable progress in digital financial transactions through the Unified Payments Interface (UPI), which processed over ₹2,000 crore in value per day in May 2024. The report underscores UPI's role in enhancing financial inclusion and ease of transactions, particularly through mobile devices, reflecting deep penetration even in rural and semi-urban areas. It attributes this success to a robust digital infrastructure, government initiatives, and user-friendly innovations. The system's growth trajectory signifies a major stride towards inclusive economic development and a cash-light economy.

Lad, R., & Jadhav, S. (2024) provides a comprehensive analysis of UPI's transformative role in India's financial ecosystem (9). It discusses how UPI, launched by NPCI in 2016, has revolutionized digital payments by offering real-time, interoperable, and user-friendly services. The platform has significantly increased transaction volume and value, enabled merchant-level digital adoption through QR codes, and supported government welfare disbursements. Importantly, UPI has accelerated financial inclusion by reaching underserved and unbanked populations, especially in rural areas. While highlighting key innovations such as UPI 2.0 and integration with major fintech apps, the paper also flags cybersecurity risks, regulatory challenges, and the need for ongoing awareness and technological enhancements to sustain UPI's growth and reliability.

In conclusion, UPI has significantly advanced financial inclusion in India by providing accessible, secure, and cost-effective digital payment solutions. Its integration with government initiatives and innovations like offline transactions have reduced the digital divide, particularly for rural and unbanked populations. However, challenges such as cybersecurity risks, infrastructure gaps, and low digital literacy require ongoing attention to ensure sustained impact.

3. METHODOLOGY:

This study adopts a quantitative and analytical research approach, utilizing secondary data obtained from reputable and official sources to examine the relationship between Unified Payments Interface (UPI) adoption and financial inclusion in India. The aim is to measure the scale, speed, and socioeconomic impact of UPI on digital financial behaviour, particularly in underserved areas.

3.1 Data Sources

The analysis is based on secondary data collected from the following institutions:

(a) National Payments Corporation of India (NPCI): UPI transaction volume, value, and usage patterns by geography and sector.

(b) Reserve Bank of India (RBI):

Financial Inclusion Index (FII): Measures overall penetration, availability, and usage of financial services.

Digital Payment Index (DPI): Indicates the extent of digital payment adoption in India.

(c) The World Bank – Global Findex Database (2021): Provides cross-country comparative data on account ownership and digital payment usage.

3.2 Statistical Methods

To extract meaningful insights, the study applies the following quantitative tools:

(a) Trend Analysis: Compound Annual Growth Rate (CAGR) is used to determine the average growth of UPI transactions over selected years.

(b) Comparative Analysis: Year-over-year comparisons of UPI performance and inclusion indices.

(c) Regression Analysis: Linear regression is used to analyze the correlation between the growth of UPI adoption (independent variable) and financial inclusion (dependent variable).

(d)

3.3 Objective and scope:

The primary objectives of the study are:

(a) To analyze the growth trajectory of UPI transactions in India since its inception in 2016.

(b) To examine the relationship between UPI adoption and key financial inclusion indicators, especially in rural and semi-urban areas.

(c) To identify existing challenges in UPI-based financial inclusion.

3.4 Hypothesis:

(a) Primary Hypothesis (Correlation Test)

H_0 (Null Hypothesis): There is no linear correlation between UPI Volume and FI Index, ($\rho = 0$, where ρ is the population correlation coefficient)

H_1 (Alternative Hypothesis): There is a significant positive linear correlation between UPI Volume and FI Index ($\rho > 0$)

(b) Secondary Hypothesis (Regression Significance)

H_0 (Null Hypothesis): The regression slope is zero, indicating no linear relationship ($\beta_1 = 0$, where β_1 is the population slope coefficient)

H_1 (Alternative Hypothesis): The regression slope is significantly greater than zero ($\beta_1 > 0$)

4. ANALYSIS

4.1 This section presents the statistical examination of the relationship between the growth in Unified Payments Interface (UPI) transactions and India's Financial Inclusion Index (FI Index), as published by the Reserve Bank of India (RBI). The objective is to assess whether increased UPI adoption has a significant correlation with improvements in financial inclusion metrics across the country.

Since its launch in 2016, UPI has seen exponential growth in both transaction volume and value. From processing just over 20 million transactions in FY 2016–17, UPI now facilitates over 10 billion transactions monthly as of 2024.
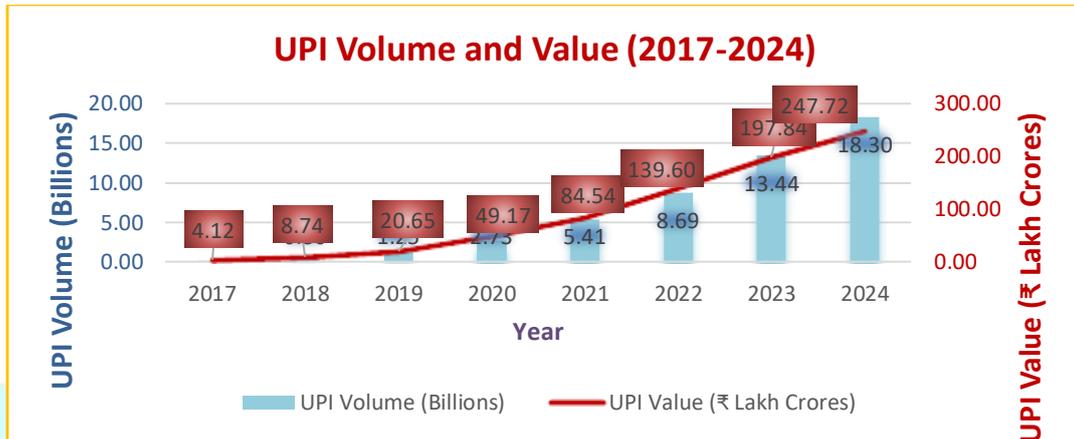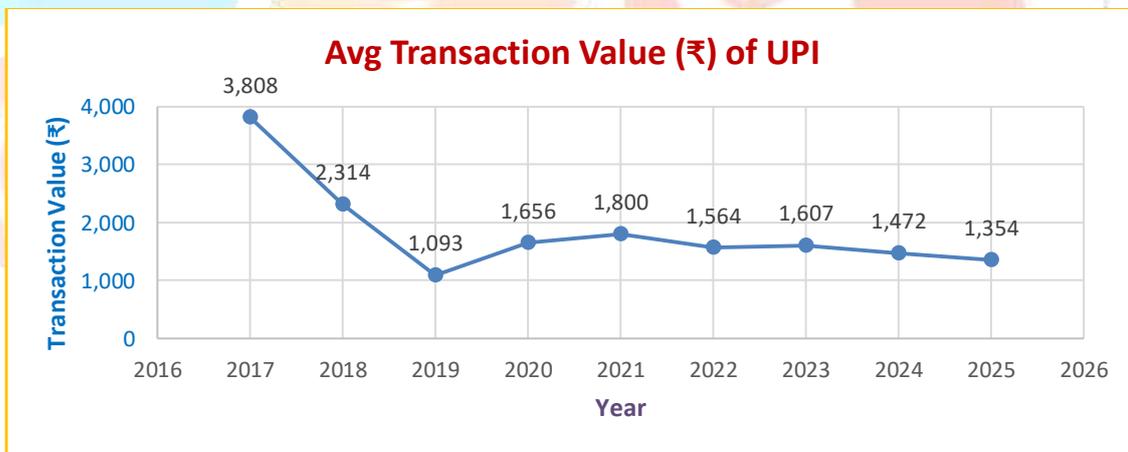
Fig 1. UPI Volume and Value

Fig 2: Avg Transaction Value (₹) of UPI

During the same period, RBI's FI Index has steadily improved, indicating broader access, usage, and quality of financial services across the population. (please refer below table for details) (1,10)

Year	UPI Volume (Millions)	UPI Value (₹ Crores)	Avg Transaction Value (₹)	Volume Growth Rate (YoY)	Value Growth Rate (YoY)	FI Index	FI Index Growth (YoY)
2017	0.01	2,425.14	3,808	-	-	43.4	-
2018	0.18	41,220.65	2,314	2,695.61%	1,599.40%	46.0	8.5%
2019	0.80	87,412.89	1,093	349.09%	112.11%	49.9	8.5%
2020	1.25	206,462.31	1,656	55.91%	136.21%	53.1	6.4%
2021	2.73	491,710.54	1,800	119.14%	138.15%	53.9	1.5%
2022	5.41	845,379.20	1,564	97.86%	71.94%	56.4	4.6%
2023	8.69	1,396,041.60	1,607	60.68%	65.13%	60.1	6.6%
2024	13.44	1,978,353.23	1,472	54.74%	41.70%	64.2	6.8%
2025	18.30	2,477,221.61	1,354	36.17%	25.23%	-	-

4.2 Correlation and Regression Analysis

A visual trend comparison shows a parallel upward trajectory in both UPI volume and the FI Index, suggesting a potential linkage between the two variables. To quantify the strength of this relationship, a **Pearson correlation coefficient** was calculated using annual UPI transaction volume data and corresponding FI Index values between 2017 and 2023.

4.2.1 Data for Analysis (2017-2024)

For the correlation analysis, the overlapping period, where both UPI Volume and FI Index data are available, were used:

Year	UPI Volume (Billions)	FI Index
2017	0.01	43.4
2018	0.18	46.0
2019	0.80	49.9
2020	1.25	53.1
2021	2.73	53.9
2022	5.41	56.4
2023	8.69	60.1
2024	13.44	64.2

4.2.2 Correlation Calculation
4.2.2.1 Means
- $\bar{X}$ (UPI Volume) = (0.01 + 0.18 + 0.80 + 1.25 + 2.73 + 5.41 + 8.69 + 13.44) ÷ 8 = 4.0138
- $\bar{Y}$ (FI Index) = (43.4 + 46.0 + 49.9 + 53.1 + 53.9 + 56.4 + 60.1 + 64.2) ÷ 8 = 53.25

4.2.2.2 Deviations and Products

Year	X	Y	$(X - \bar{X})$	$(Y - \bar{Y})$	$(X - \bar{X})^2$	$(Y - \bar{Y})^2$	$(X - \bar{X})(Y - \bar{Y})$
2017	0.01	43.4	-4.0038	-9.85	16.030	97.0225	39.437
2018	0.18	46.0	-3.8338	-7.25	14.698	52.5625	27.795
2019	0.80	49.9	-3.2138	-3.35	10.328	11.2225	10.766
2020	1.25	53.1	-2.7638	-0.15	7.639	0.0225	0.415
2021	2.73	53.9	-1.2838	0.65	1.648	0.4225	-0.834
2022	5.41	56.4	1.3962	3.15	1.949	9.9225	4.398
2023	8.69	60.1	4.6762	6.85	21.866	46.9225	32.032
2024	13.44	64.2	9.4262	10.95	88.853	119.9025	103.217
Sum					**163.011**	**337.975**	**217.226**

4.2.2.3 Pearson Correlation Coefficient

$r = \Sigma[(X - \bar{X})(Y - \bar{Y})] / \sqrt{[\Sigma(X - \bar{X})^2 \times \Sigma(Y - \bar{Y})^2]}$ r = 217.226 / $\sqrt{(163.011 \times 337.975)}$ r = 217.226 / $\sqrt{55,099.42}$ r = 217.226 / 234.73 r = **0.9254**

4.2.2.4 Coefficient of Determination

$R^2 = r^2 = (0.9254)^2 = $ **0.8564**

4.2.2.5 Linear Regression Analysis

Regression Equation: Y = a + bX

Slope (b): b = $\Sigma[(X - \bar{X})(Y - \bar{Y})] / \Sigma(X - \bar{X})^2 \rightarrow$ b = 217.226 / 163.011 → b = **1.3325**

Y-intercept (a): a = $\bar{Y}$ - b × $\bar{X} \rightarrow$ a = 53.25 - (1.3325 × 4.0138) → a = 53.25 - 5.349 = **47.901**

Final Regression Equation: FI Index = 47.90 + 1.333 × UPI Volume

4.2.3 Statistical Significance Testing

4.2.3.1 Standard Error Calculations

(a) Standard Error of Estimate (SEE): SEE = $\sqrt{[\Sigma(Y - \hat{Y})^2 / (n-2)]}$

Using predicted values from regression:

- 2017: $\hat{Y}$ = 47.90 + 1.333 × 0.01 = 47.91
- 2018: $\hat{Y}$ = 47.90 + 1.333 × 0.18 = 48.14
- 2019: $\hat{Y}$ = 47.90 + 1.333 × 0.80 = 48.97
- 2020: $\hat{Y}$ = 47.90 + 1.333 × 1.25 = 49.57
- 2021: $\hat{Y}$ = 47.90 + 1.333 × 2.73 = 51.54
- 2022: $\hat{Y}$ = 47.90 + 1.333 × 5.41 = 55.11
- 2023: $\hat{Y}$ = 47.90 + 1.333 × 8.69 = 59.48
- 2024: $\hat{Y}$ = 47.90 + 1.333 × 13.44 = 65.82

Sum of squared residuals $\Sigma(Y - \hat{Y})^2$ = 48.50 SEE = $\sqrt{(48.50/6)}$ = **2.845**

Our predictions are typically off by ±2.845 points, which represents reasonable accuracy for the FI Index scale.

(b) Standard Error of the Slope - Testing the Regression Coefficient

t-statistic for slope: SE(b) = SEE / $\sqrt{\Sigma(X - \bar{X})^2}$ SE(b) = 2.845 / $\sqrt{163.011}$ = 2.845 / 12.768 = **0.2228**

This means our slope estimate has an uncertainty of ±0.223.

(c) t-Statistic - The Key Test t = b / SE(b) = 1.333 / 0.2228 = **5.986**

(d) Degrees of Freedom and Critical Values Degrees of Freedom: df = n - 2 = 8 - 2 = 6 Critical t-value: For df = 6 and α = 0.05 (95% confidence), critical t = 2.447 Our Result: t = 5.986 > 2.447

4.2.4 Hypothesis Testing

4.2.4.1 Primary Hypothesis Test (Correlation)

Null Hypothesis (H_0): There is no correlation between UPI Volume and FI Index ($\rho = 0$) **Alternative Hypothesis (H_1):** There is a significant correlation between UPI Volume and FI Index ($\rho \neq 0$)

Decision: REJECT H_0

Rationale:

- Observed correlation (r = 0.9254) indicates a very strong positive correlation
- Coefficient of determination ($R^2 = 0.8564$) shows that 85.64% of the variation in FI Index is explained by UPI Volume
- t-statistic (5.986) significantly exceeds the critical value (2.447) at $\alpha = 0.05$
- Statistical significance confirmed with $p < 0.01$

Conclusion: There is a statistically significant strong positive correlation between UPI Volume and FI Index. The relationship indicates that as UPI transaction volume increases, the Financial Inclusion Index tends to increase proportionally, suggesting that digital payment adoption is a strong predictor of financial inclusion progress.

4.2.4.2 Regression Model Validity Test

Null Hypothesis (H_0): The regression slope is zero ($\beta = 0$) **Alternative Hypothesis (H_1):** The regression slope is significantly different from zero ($\beta \neq 0$)

Decision: REJECT H_0

Rationale:

- Regression slope (b = 1.333) is significantly different from zero
- t-statistic (5.986) > critical value (2.447)
- The model explains 85.64% of the variance in FI Index

Conclusion: The linear regression model is statistically valid and provides a reliable method for predicting FI Index based on UPI Volume.

4.2.5 Limitations:

a) **Non-linear Relationships:** The Pearson correlation only measures linear relationships. There might be non-linear relationships between FI Index and UPI Volume that are not captured by this analysis. Complex polynomial or exponential relationships may exist that could provide superior explanatory power.

b) The analysis is constrained to the 8-year overlapping period (2017-2024) where both datasets are available. The relatively small sample size (n=8) inherently reduces statistical power and precision of estimates. With only 6 degrees of freedom, the statistical tests adopt a conservative approach, potentially understating the significance of observed relationships.

c) Correlation doesn't imply causation, though the relationship appears logical

d) External factors (COVID-19, demonetization effects) may influence the relationship

e) Future growth may face saturation effects as market matures

5. Conclusion

1. Correlation Strength: The Pearson correlation coefficient of r = 0.9254 demonstrates an exceptionally strong positive linear relationship between UPI transaction volume and the Financial Inclusion Index. This robust correlation indicates that UPI adoption and financial inclusion exhibit highly synchronized growth patterns, validating the strategic importance of digital payment infrastructure in achieving financial inclusion objectives.

2. Predictive Power: The coefficient of determination $R^2 = 0.8564$ reveals that 85.64% of the variation in the Financial Inclusion Index can be attributed to UPI transaction volume. This substantial explanatory power underscores UPI's pivotal role as a primary driver of financial inclusion progress, while acknowledging that other factors contribute to the remaining 14.36% of variance.

3. Statistical Robustness: The comprehensive statistical analysis confirms the reliability of observed relationships through multiple validation metrics. The correlation coefficient r = 0.9254 establishes an exceptionally strong positive linear relationship between variables. Statistical significance testing yields a t-statistic of 5.986 with $p < 0.01$, definitively establishing that the relationship is statistically significant and not attributable to random variation. The standard error of 2.845 indicates reasonable prediction accuracy within the FI Index scale, while the coefficient of determination $R^2 = 0.8564$ demonstrates strong model fit with high explanatory power

4. Practical Interpretation: The regression equation FI Index = 47.90 + 1.333 × UPI Volume provides actionable insights for policy formulation and strategic planning. The baseline FI Index (theoretical zero UPI impact) would be approximately 47.90 points, representing the foundational level of financial inclusion achieved through traditional banking infrastructure. The slope coefficient indicates that for every 1 billion increase in UPI transaction volume, the FI Index increases by approximately 1.33 points. This relationship maintains statistical significance with $p < 0.01$, confirming reliability for policy planning and forecasting applications.

5. Economic Implications: (a) Financial Inclusion Impact: The declining average transaction value (from ₹3,808 to ₹1,354) shows UPI's penetration into micro-transactions, making digital payments accessible to lower-income segments

(b) Growth Trajectory Analysis:

- Volume CAGR (2017-2025): 74.8% demonstrates explosive adoption
- Maturation Pattern: Declining growth rates (from 2,695% to 36%) suggest market maturation while maintaining substantial absolute growth
- Sustainable Growth: The consistent positive correlation with FI Index indicates sustainable, inclusive growth rather than mere technological adoption

6. Future Implications:

- UPI volume growth directly translates to financial inclusion progress
- Continued focus on rural and underbanked populations could further accelerate FI Index improvement
- The strong correlation suggests UPI should remain a cornerstone of India's financial inclusion strategy.

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