
| RESEARCH ARTICLE

Mobile and Contactless Payment Innovations: The Future of POS Systems

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| ABSTRACT

Mobile and contact-free payment innovations are changing the point-of-sale system globally, causing significant changes in transaction paradigms in diverse market environments. The rapid adoption of digital payment methods is driven by several factors, including technological advancements, pandemic-induced shifts in consumer behavior, and evolving expectations around transaction efficiency and security. Near-field communication, QR code systems, biometric authentication, and digital wallet integration form the core technical framework driving this transformation. These technologies offer distinct benefits tailored to the needs of specific markets. These innovations deliver multifaceted benefits, including improved transaction processing efficiency, enhanced safety through operational cost reductions, and a richer, more seamless consumer experience. Despite these benefits, implementation challenges persist—ranging from data privacy concerns and regulatory complexity to technical fragmentation and socio-economic barriers to access. The projection of payment innovation indicates continuous development towards integrated intelligence, increased biometric security, and rapid, friction-free transactions, and it addresses inclusive requirements in diverse market contexts. The change of payment ecosystems not only represents technological progress but also establishes new benchmarks for fundamental reorganization, convenience, safety, and access to commercial interaction paradigms.

| KEYWORDS

Contactless payments, digital wallets, biometric authentication, payment security, financial inclusion.

| ARTICLE INFORMATION

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1. Introduction

There has been unprecedented change in the retail payment landscape, particularly in emerging economies like India, where digital payment transactions surged by 52.3% in volume during the financial year 2022–23 compared to the previous year, reflecting rapid adoption driven by technological advancement and evolving consumer behavior. UPI transactions alone surged dramatically in FY 2022–23, reaching ₹139 lakh crore in value across 8,375 crore transactions. This represents a year-over-year increase of approximately 121% in volume and 115% in value, underscoring UPI's pivotal role in India's digital payment transformation. Traditional cash-based transactions have declined significantly, with the currency-to-GDP ratio falling from 14.4% in FY 2020–21 to 11.8% in FY 2022–23. This shift reflects the rapid transition toward digital payment ecosystems across both urban and rural markets [1]. This shift has fundamentally transformed merchant-consumer interactions, with small businesses rapidly adopting QR-based solutions due to their low implementation costs and broad smartphone compatibility.

The COVID-19 pandemic served as a pivotal catalyst for contactless payment adoption, with health-safety concerns driving a 187% increase in contactless transaction volumes between March 2020 and December 2022 across Southeast Asian markets [2]. Longitudinal analysis of 27,486 consumers across six countries demonstrated that 73.8% of shoppers developed persistent preferences for contactless options even after pandemic restrictions eased, citing multiple factors beyond initial health concerns. Regression analysis identified significant correlations between contactless payment adoption and three key variables: perceived transaction security ($R^2=0.78$, $p<0.001$), processing speed ($R^2=0.83$, $p<0.001$), and integration with loyalty programs ($R^2=0.64$,

p<0.05) [2]. The research documented profound behavioral modifications, with contactless payment users completing 31.7% more transactions monthly and spending an average of 24.3% more per purchase compared to traditional payment users.

Near-field communication (NFC) technology has achieved remarkable penetration in developing markets, with data showing 84.7 million NFC-enabled devices actively processing payments in India by March 2023, representing a 342% increase from 2019 levels [1]. Simultaneously, biometric authentication systems integrated into payment ecosystems have delivered substantial security improvements, with studies reporting fraud reduction rates as high as 92.7% among participants using multi-factor biometric verification [2]. Controlled experiments comparing traditional PIN verification against biometric methods revealed dramatic improvements in both security metrics and user experience, with fingerprint and facial recognition authentication reducing transaction completion time by 64.3% while decreasing abandonment rates by 47.8% compared to traditional methods [2]. The integration of artificial intelligence into payment frameworks has significantly bolstered security, with AI-powered fraud detection systems across Indian payment networks successfully identifying and preventing 97.3% of attempted fraudulent transactions in FY 2022–23—safeguarding approximately ₹27,642 crore in potential losses [1].

2. Evolution of Payment Technologies

The historical progress of payment technologies reflects a continuous trajectory towards more efficiency, safety, and convenience. Central Bank Digital Currency (CBDC) represents the next limit in payment development, with 90% of central banks actively researching or developing CBDCs by 2022. Between 2014 and 2019, the share of cashless transactions rose from 55%, driven largely by the growth of e-commerce payments in advanced economies. Fast Payment Systems (FPS) also saw exponential adoption—while in 2015, global average processing times hovered around 60 seconds [3], by 2021, many systems achieved sub-10-second [3] processing speeds. That year, FPS platforms collectively processed over \$41 trillion in transactions worldwide. This shows the dramatic acceleration of how digital infrastructure has fundamentally represented 72% of all transactions in advanced economies, with digital payments fundamentally restructuring payments, and 42% in emerging markets.

Near-field communication (NFC) technology represents a major advancement in contactless payment infrastructure. In 2021, NFC-enabled payment transactions increased by 41%, reaching a global value of \$3.9 trillion. Contactless card penetration reached 88% in Europe, 71% in North America, and 63% in the Asia-Pacific region, with particularly strong adoption in Canada (93%), the UK (95%), and Australia (96%). The average transaction price for contactless payment increased from € 22.7 to € 33.8 in 2021, which reflects the growing consumer comfort with technology for large purchases [4]. Merchant acceptance has now supported contactless payments globally, with 82% of POS terminals adopting the technology. In 2019, the dramatic growth from 47% was driven by both consumer demand and regulatory mandate in many countries.

QR code payment systems have changed emerging market economies, with the number of transactions in China being more than 123 billion payments worth approximately \$ 18.7 trillion in 2021. Similarly, there has been an impressive growth in India, where the Integrated Payment Interface (UPI) has seen 38.74 billion QR-based transactions worth \$ 954.58 billion. This explosive growth is attributed to the minimal infrastructure requirements of the QR code system, an implementation cost of only \$ 29–50 per trader compared to \$ 300-500 for traditional POS terminals. This access has democratized digital payment acceptance, with QR-capable merchant accounts in India surpassing 2.1 million early in 2019 and expanding to over 50 million by the end of the year [3].

Biometric authentication and digital wallet integration represent the convergence of these payment innovations. Digital Wallets processed around \$ 15.9 trillion globally in 2021, with the Asia-Pacific sector accounting for 71% of this volume. The digital wallet transaction is estimated to reach \$ 38.6 trillion by 2026, which represents a mixed annual growth rate of 19.3% [4]. Biometric verification methods have demonstrated exceptional security metrics, with fraud rates of just 0.019% for biometric-secured transactions compared to 0.087% for conventional card payments, while simultaneously reducing checkout times by 53% [4].

Region	Penetration Rate (%)
Europe	88
North America	71
Asia-Pacific	63
Australia	93
Canada	95
UK	96

Table 1: Regional Variations in Contactless Card Implementation [3, 4]

3. Benefits of Contactless Payments

Adopting mobile and contactless payment technologies provides adequate benefits in many dimensions of retail transaction ecosystems. Contactless transactions have fundamentally changed consumer expectations. 83% of traders reported that payment flexibility has become the most important factor in consumer satisfaction. Contact-free-competent businesses experienced a 31% increase in visits from repeat customers and a decrease of 42% in checkout rates. Analysis of 17,835 traders in 38 countries suggests that contactless payment processing time averages 8.4 seconds for chip-and-pin transactions compared to 29.7 seconds, resulting in 72% throughput improvement during peak commercial hours [5]. This efficiency directly enhances operational capacity, with data showing that quick-service restaurants implementing contactless service models served 37 additional customers per hour during lunch—representing a 22% increase during peak business periods, all without requiring additional staffing.

Transaction security frameworks have been substantially reinforced through contactless implementation. EMV tokenization protocols have reduced payment fraud by 76% for participating merchants, with chargebacks declining by 54% in the first six months following contactless system deployment [5]. Key safety reforms have significantly reduced fraudulent activity, with hospitality merchants experiencing an 83% decrease in fraud-related transactions. Similarly, retailers reported a 71% reduction, highlighting the effectiveness of multi-layered fraud prevention strategies. On average, medium-sized retailers saved approximately \$27,300 annually in fraud-related costs following upgrades to their payment infrastructure—demonstrating strong returns on immediate investment beyond promotional incentives.

Longitudinal studies involving 3,842 consumers across diverse demographic segments indicate that users of contactless payment methods reported an average satisfaction score of 8.7 out of 10, compared to 6.4 for traditional payment users. The satisfaction gap was even more pronounced—at 3.1 points—among consumers under the age of 35 [6]. Businesses offering contactless options experienced 42.3% higher Net Promoter Scores and 27.8% improvements in customer loyalty metrics. Regression analysis identified significant correlations between contactless payment availability and three key variables: perceived transaction security ($R^2=0.73$, $p<0.001$), checkout efficiency ($R^2=0.81$, $p<0.001$), and overall shopping experience quality ($R^2=0.68$, $p<0.001$) [6].

From an operational perspective, businesses implementing comprehensive digital payment systems experienced 47.2% reductions in cash handling costs, 58.9% decreases in reconciliation discrepancies, and 31.5% reductions in labor hours dedicated to payment processing [5]. Merchants leveraging integrated payment data analytics reported 37.2% improvements in inventory forecasting accuracy, 43.8% enhancements in promotion targeting effectiveness, and 29.6% increases in customer basket analysis precision [6]. Controlled experiments demonstrated that personalized marketing initiatives informed by payment data analytics achieved conversion rates 2.7 times higher than traditional segmentation approaches, directly contributing to the 23.4% higher average transaction values observed among retailers effectively utilizing these capabilities.

Benefit Type	Improvement (%)
Cash Handling Cost Reduction	47.2
Reconciliation Discrepancy Reduction	58.9
Labor Hour Reduction	31.5
Fraud Reduction	76
Chargeback Reduction	54

Table 2: Operational Cost Reductions Through Digital Payment Systems [5, 6]

4. Challenges and Concerns

Despite the considerable benefits of mobile and contactless payment innovations, significant challenges persist that could hinder widespread adoption. Data privacy concerns represent a malignant barrier to consumers, with a survey of 12,783 consumers in 18 countries suggesting that 71.4% have significant apprehension about payment data security. Research indicates that 83.6% of consumers express concern over unauthorized exploitation of their personal data, while 76.8% remain uncertain about how their transaction patterns are analyzed to create behavioral profiles. Financial institutions experienced an increase of 37.2% in sophisticated fraud attempts between 2021 and 2023, with credential theft attacks increasing payment applications by 114.7% during this period [7]. The economic impact of these violations is sufficient, with an average cost of \$ 4.35 million per significant event and a decline of customer Trust Matrix at an average of 27.8% after the propagated data agreement.

Regulatory compliance presents extraordinary challenges for payment service providers, as organizations must navigate increasingly complex regulatory environments. Analysis of 339 privacy professionals across multiple sectors indicates that

financial technology companies allocate 21.4% of their compliance budgets specifically to payment data protection, a 47.2% increase since 2020 [8]. Organizations employ an average of 8.7 full-time compliance specialists focused exclusively on payment regulations—a figure that rises to 14.3 among multinational financial services providers. Alarming, 68.7% of surveyed firms report major challenges in reconciling conflicting regulatory requirements across jurisdictions, with 43.9% having delayed product launches due to compliance-related uncertainties [8].

Technological interoperability remains problematic, with payment ecosystem fragmentation directly impacting transaction reliability. Examination of 764,329 failed payment attempts identified technological incompatibility as the primary cause in 37.4% of cases, resulting in cart abandonment rates of 32.8% during such incidents [7]. This fragmentation disproportionately affects smaller merchants, who report implementation costs 72.6% higher than anticipated due to the necessity of supporting multiple payment platforms. The socioeconomic implications are equally concerning, as data indicates significant digital payment exclusion correlating strongly with demographic factors. Analysis reveals adoption gaps of 31.7 percentage points between the highest and lowest income quartiles, 26.4 percentage points between urban and rural populations, and 29.8 percentage points between consumers under 35 and those over 65 [8].

Security vulnerabilities persist despite technological advancements, with financial institutions detecting 14.7 billion suspicious transaction attempts in 2022 alone. Fraud analysis reveals that while overall payment fraud rates have declined by 18.3% since 2020, attack sophistication has increased dramatically, with 72.9% of successful breaches now employing advanced social engineering techniques rather than technical exploits [7]. Most concerning, research identifies a significant security awareness gap, with 64.3% of consumers unable to identify common payment fraud warning signs during simulated scenarios, suggesting that human factors remain the most vulnerable element within payment security frameworks despite substantial technological improvements.

Concern Type	Percentage of Consumers (%)
Payment Data Security	71.4
Unauthorized Data Exploitation	83.6
Uncertainty About Data Usage	76.8
Cannot identify Fraud Warning Signs	64.3

Table 3: Consumer Apprehensions Regarding Payment Data Protection [7, 8]

5. Industry Trends and Case Studies

Examination of contemporary industry trends reveals accelerating transformation within the payment technology landscape. Artificial intelligence integration represents the most significant evolutionary direction, with data indicating that 78% of financial institutions now consider AI implementation "mission-critical" for payment processing. Institutions leveraging AI-powered fraud prevention have experienced fraud reduction rates of 93% compared to 61% for those using traditional rule-based systems, translating to average savings of \$43.7 million annually for large financial institutions [9]. AI implementation has dramatically improved authentication experiences, with biometric verification reducing abandonment rates by 37% while simultaneously enhancing security metrics by 82%. Perhaps most significantly, 72% of consumers now expect predictive fraud protection as a standard feature, with 68% willing to switch payment providers to obtain enhanced security features, demonstrating how technological capabilities are fundamentally reshaping consumer expectations and competitive dynamics.

Case studies of financial institutions implementing comprehensive contactless payment transformations provide compelling evidence of successful implementation at scale. Analysis of DBS Bank's strategic deployment across Singapore demonstrates how intensive preparation directly correlates with implementation success rates. DBS achieved 96.7% staff proficiency in contactless system operation following their investment of 42,500 training hours, substantially exceeding the regional average of 57% proficiency for similar deployments [9]. This strategic preparation delivered exceptional outcomes—reducing transaction processing time by 71%, cutting payment processing costs by 38%, and achieving a remarkable 93.4% consumer activation rate within 90 days, far surpassing the industry average of 62.7%. Longitudinal analysis further demonstrates that DBS maintained these adoption rates, with contactless transactions representing 87% of total payment volume one year post-implementation, suggesting that well-executed deployments yield sustainable behavioral changes.

Analysis of digital payment adoption across seven Asian economies reveals distinctive implementation patterns in emerging markets. Comprehensive examination of transaction data from 923 million mobile payment accounts documents remarkable technological leapfrogging phenomena, with Vietnam experiencing mobile payment adoption growth from 19.3% to 76.8% between 2018 and 2023, dramatically outpacing card payment adoption, which reached only 41.3% [10]. Regression analysis

identifies three critical factors driving this accelerated adoption: smartphone penetration (correlation coefficient 0.83), limited legacy payment infrastructure (correlation coefficient 0.79), and supportive regulatory frameworks (correlation coefficient 0.74). Most notably, markets with smartphone penetration exceeding 85% but card penetration below 30% achieved mobile payment adoption rates 41.7 percentage points higher than markets with established card ecosystems, supporting the counterintuitive conclusion that infrastructure constraints paradoxically accelerate digital transformation.

Research offers particularly valuable insights into sector-specific implementation patterns, documenting that hospitality businesses demonstrate exceptional returns from contactless payment implementation. Examination of 3,187 restaurants across Indonesia, Thailand, Malaysia, and Vietnam reveals average table turnover improvements of 34.2% and total revenue increases of 27.6% following comprehensive deployment [10]. Granular analysis demonstrates that restaurants implementing integrated mobile payment systems reduced average payment processing times from 6.7 minutes to 1.8 minutes, increased server productivity by 31.5%, and most significantly, captured 28.3% more detailed customer preference data, enabling personalization initiatives that increased repeat visit frequency by 43.7%.

Metric	Improvement (%)
Table Turnover	34.2
Revenue Increase	27.6
Processing Time Reduction	73.1
Server Productivity Increase	31.5
Customer Preference Data Capture	28.3
Repeat Visit Frequency	43.7

Table 4: Operational Improvements in Hospitality Through Contactless Systems [9, 10]

6. Conclusion

The evolution of mobile and contactless payment technologies represents a fundamental transformation in financial transaction paradigms, transcending mere technological advancement to reshape commercial interactions across global markets. The remarkable acceleration in adoption rates, particularly in emerging economies, demonstrates how these innovations address critical pain points in traditional payment frameworks while simultaneously creating new possibilities for merchant-consumer engagement. The integration of artificial intelligence, biometric authentication, and tokenization protocols has established unprecedented security standards while paradoxically simplifying user experiences, resolving the historical tension between protection and convenience. "Particularly noteworthy is the phenomenon of technological leapfrogging in developing markets, where infrastructure limitations have paradoxically accelerated the adoption of advanced payment modalities—enabling these economies to bypass intermediate technological stages and embrace innovations such as mobile wallets, QR-based payments, and real-time transaction systems. "This pattern highlights the strategic advantages available to markets unburdened by legacy systems, allowing them to implement cutting-edge payment technologies directly—often leapfrogging more traditional, incremental adoption paths. Looking forward, the trajectory indicates continued convergence between physical and digital commerce environments, with payment technologies increasingly functioning not merely as transaction facilitators but as comprehensive commercial engagement platforms. The most successful implementations demonstrate the critical importance of thoughtful deployment strategies, particularly regarding staff training, consumer education, and integration planning. As these technologies continue evolving, their capacity to enhance operational efficiency, security, and accessibility will further transform commercial ecosystems, establishing new benchmarks for transaction convenience while addressing persistent challenges related to privacy, regulation, and financial inclusion.

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