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Socio-Economic Implications of Unified Payment Interface (UPI) Adoption in Agricultural Markets: Evidence from Azadpur Mandi, Delhi

Mehak Lal[1], Prof. Ashok Purohit[2]
[1]Research Scholar Institute of Business Management and Commerce Mangalayatan University, Aligarh
[2]Professor Institute of Business Management and Commerce Mangalayatan University, Aligarh

ABSTRACT
This study examines the socio-economic implications of UPI adoption in Azadpur Mandi, Asia's largest wholesale fruit and vegetable market located in Delhi, India. Through a mixed-methods approach combining surveys, interviews, and transaction data analysis, we investigate how digital payment infrastructure has transformed market operations, trader-farmer relationships, and economic outcomes for various stakeholders. Our findings reveal significant improvements in transaction efficiency, reduced cash handling costs, and enhanced financial inclusion, while also highlighting persistent challenges related to digital literacy, infrastructure gaps, and the informal credit economy that characterizes agricultural markets.

INTRODUCTION:

The Unified Payment Interface (UPI), launched by the National Payments Corporation of India (NPCI) in 2016, has revolutionized digital payments in India. By December 2023, UPI processed over 11 billion transactions monthly, representing a paradigm shift in how Indians conduct financial transactions. Agricultural markets (mandis), traditionally characterized by cash-intensive operations and informal credit systems, represent a critical yet understudied domain of this digital transformation.

Azadpur Mandi, spread over 80 acres in North Delhi, handles approximately 4,000-6,000 metric tons of fruits and vegetables daily, with an estimated annual turnover exceeding ₹8,000 crores (approximately $1 billion USD). The mandi serves as a critical node in Delhi-NCR's agricultural supply chain, connecting farmers from Punjab, Haryana, Uttar Pradesh, and Himachal Pradesh to retailers, wholesalers, and institutional buyers.

Research Questions

This study addresses the following research questions:

1. What is the extent and pattern of UPI adoption among different stakeholder groups (farmers, commission agents, traders, laborers) in Azadpur Mandi?
2. How has UPI adoption affected transaction costs, efficiency, and transparency in market operations?
3. What are the implications for financial inclusion and access to formal credit for marginalized stakeholders?
4. What barriers impede broader UPI adoption, and what policy interventions could address these challenges?

Significance

Understanding UPI's impact on agricultural markets is crucial for several reasons:

- **Policy relevance**: The Government of India's Digital India initiative and the push for a less-cash economy require evidence-based assessment of digital payment adoption in rural-urban linkages.
- **Financial inclusion**: Agricultural markets serve as critical financial intermediaries for millions of farmers, many of whom remain unbanked or underbanked.
- **Market efficiency**: Digital payments could potentially reduce transaction costs, improve price discovery, and enhance market transparency.
- **Scalability**: Insights from Azadpur Mandi can inform digital payment interventions in the 7,000+ regulated markets across India.

Literature Review

Digital Payments and Economic Development

The relationship between digital financial services and economic development has been extensively documented. Jack and Suri (2014) demonstrated how M-Pesa in Kenya improved household resilience and lifted women out of poverty. Subsequent studies have shown that digital payments can reduce corruption (Muralidharan et al., 2016), improve tax compliance (Okunogbe & Pouliquen, 2022), and enhance business formalization (Bachas et al., 2021).

In the Indian context, research has focused on the impact of demonetization (November 2016) on digital payment adoption. Crouzet et al. (2020) found that demonetization led to a sharp increase in digital transactions, though the

effects were heterogeneous across regions and sectors. However, agricultural markets have received limited scholarly attention despite their economic significance.

Agricultural Markets in India

India's agricultural marketing system, structured around the Agricultural Produce Market Committee (APMC) Act, has been criticized for inefficiency, high intermediation costs, and lack of transparency (Chand, 2012). Studies estimate that farmers receive only 25-35% of the final retail price, with the remainder consumed by transportation, handling, and intermediary margins (Acharya, 2004).

Recent reforms, including the e-NAM (National Agriculture Market) platform and the controversial 2020 farm laws (later repealed), attempted to modernize agricultural markets. However, research on the intersection of digital payments and agricultural market reform remains sparse.

UPI and Financial Technology in India

UPI's unique architecture—enabling interoperable, real-time payments through a single mobile application—has been studied primarily from a technological and adoption perspective. Sengupta and Bezbaruah (2021) analyzed factors influencing UPI adoption using TAM (Technology Acceptance Model) framework, identifying perceived usefulness and ease of use as key drivers.

However, most UPI research focuses on urban consumers and retail transactions. The agricultural context presents distinct challenges: variable smartphone penetration, limited digital literacy, unstable internet connectivity, and deeply entrenched informal credit relationships.

Research Gap

While existing literature provides valuable insights into digital payments, agricultural markets, and UPI adoption separately, there is a paucity of research examining their intersection. This study fills this gap by providing empirical evidence on how UPI is transforming one of India's most critical agricultural markets.

Historical Development

Azadpur Mandi was established in 1977 to consolidate Delhi's fragmented wholesale fruit and vegetable trade. It operates under the Delhi Agricultural Produce Marketing Committee (APMC) regulations and serves as the primary wholesale market for Delhi-NCR's 25+ million residents.

Market Structure and Stakeholders

The mandi ecosystem comprises multiple stakeholder groups:

Commission Agents (Arhatias): Approximately 2,000 licensed commission agents act as intermediaries between farmers and buyers, earning a 6-8% commission on transaction value. They provide critical services including price information, storage, and informal credit.

Farmers/Sellers: Daily arrivals include 3,000-5,000 farmers and farmer representatives (primarily from surrounding states), selling produce ranging from seasonal vegetables to exotic fruits.

Traders/Buyers: Wholesale buyers, retail chain representatives, and large retailers purchase produce for redistribution across Delhi-NCR and neighboring states.

Laborers: 15,000-20,000 daily wage laborers handle loading, unloading, sorting, and transportation, forming the backbone of physical operations.

Support Services: Banks, transporters, packaging suppliers, and weighing scale operators constitute the auxiliary ecosystem.

Traditional Payment Systems

Historically, Azadpur Mandi operated almost exclusively on cash transactions. Large-value payments (above ₹1-2 lakhs) occasionally used checks, but these were cumbersome and subject to clearance delays. The informal credit system, wherein commission agents extend credit to farmers and buyers, has been integral to market functioning for decades.

Methodology

Research Design

This study employs a mixed-methods approach combining quantitative surveys, qualitative interviews, and secondary data analysis to provide a comprehensive understanding of UPI adoption and its implications.

Data Collection

Survey Data: Between August 2024 and December 2024, we conducted structured surveys with 600 respondents:

- 200 farmers/farmer representatives
- 150 commission agents
- 150 wholesale buyers/traders
- 100 laborers

Sampling employed stratified random sampling to ensure representation across produce categories (vegetables, fruits, regional specializations) and business scales.

Qualitative Interviews: 45 in-depth semi-structured interviews were conducted with:

- 15 commission agents (varying business scales)

- 10 farmer representatives
- 10 traders
- 5 APMC officials
- 5 representatives from banks and payment service providers

Secondary Data: Transaction data was obtained from three major payment service providers operating in the mandi, covering January 2022 to December 2024. APMC administrative records provided arrival and price data.

Analytical Approach

Quantitative analysis employed logistic regression to identify determinants of UPI adoption, and difference-in-differences estimation to assess the impact on transaction efficiency among early vs. late adopters. Qualitative data was analyzed using thematic coding to identify emergent patterns and contextual nuances.

Limitations

Several limitations should be noted:

- Self-reported data may be subject to social desirability bias
- Transaction data from payment providers represents only digital transactions, potentially underestimating cash usage
- The study's cross-sectional design limits causal inference
- Generalizability to other mandis may be constrained by Azadpur's unique characteristics (size, proximity to urban center)

Findings

Adoption Patterns

Overall Adoption Rates: Our survey reveals that 67% of commission agents, 43% of farmers/representatives, 71% of traders, and 28% of laborers have conducted at least one UPI transaction in Azadpur Mandi within the past year.

However, adoption frequency varies significantly. Among those who have used UPI:

- 45% use it for more than 50% of their transactions
- 32% use it for 25-50% of transactions
- 23% use it for less than 25% of transactions

Temporal Trends: Transaction data shows exponential growth in UPI adoption post-COVID-19 pandemic. In January 2022, UPI accounted for approximately 8% of traceable transactions (by value). By December 2024, this increased to 34%, representing a more than four-fold increase.

Stakeholder-Specific Patterns:

Commission Agents: Early adopters, primarily driven by convenience for large-value transactions. Agents handling fruits (higher value, lower volume) showed higher adoption (78%) compared to vegetable specialists (61%).

Farmers/Representatives: Adoption concentrated among younger representatives and those from Punjab and Haryana (states with higher smartphone penetration). Small-scale farmers (selling <₹50,000/visit) showed significantly lower adoption (31%) compared to large-scale farmer representatives (63%).

Traders: Highest adoption rates, particularly among retail chain buyers and institutional purchasers who prefer digital payment trails for accounting purposes.

Laborers: Lowest adoption, constrained by smartphone access (only 41% own smartphones), irregular earnings, and preference for immediate cash wages.**Transaction Efficiency and Costs**

Transaction Time: Time-motion studies conducted on 120 transactions revealed:

- Average cash transaction (including counting, verification, change-making): 8.3 minutes
- Average UPI transaction: 2.1 minutes
- Time savings: 75%, statistically significant at $p<0.001$

For large transactions (>₹1 lakh), time savings were even more pronounced:

- Cash/check transactions: 23.7 minutes (including bank verification for checks)
- UPI transactions: 2.8 minutes
- Time savings: 88%

Aggregate Savings: Based on estimated average daily transactions of ₹30 crores at Azadpur Mandi, and 34% UPI penetration, we estimate aggregate daily savings of approximately ₹1.12 lakhs, or ₹4.1 crores annually for the market ecosystem.

Transparency and Record-Keeping

Digital Trail Benefits: 73% of traders and 68% of commission agents reported that UPI's automatic digital records simplified accounting and tax compliance. This was particularly valued during:

- GST filing
- Income tax assessment
- Business loan applications
- Dispute resolution

Price Transparency: Interestingly, we found limited evidence that UPI adoption directly improved price

transparency for farmers. While digital payments create traceable records, the opacity of commission agent deductions and market fees remained largely unchanged. 58% of farmers surveyed were still unclear about exact deductions from their payment.

Dispute Resolution: UPI's digital trail proved valuable in payment disputes. APMC officials reported a 34% reduction in payment-related complaints between 2022-2024, attributing much of this to transaction traceability.

Financial Inclusion Implications

Bank Account Linkage: UPI requires bank account linkage, which has driven financial inclusion. Our data shows:

- 89% of UPI users in the mandi have active bank accounts
- 67% of these reported increased engagement with formal banking (checking balances, using other banking services)
- 23% opened bank accounts specifically to use UPI

Access to Formal Credit: One of the most significant findings concerns access to formal credit. Among commission agents:

- 42% of regular UPI users (>50% of transactions) had successfully obtained formal business loans from banks, compared to only 18% of non-users
- The digital transaction record was cited as a key factor in creditworthiness assessment
- Average loan amounts were also higher for UPI users (₹18.7 lakhs vs. ₹11.2 lakhs)

However, this also revealed an unintended consequence: 34% of commission agents expressed concern that digital transaction trails could increase tax scrutiny, creating a disincentive for full digitalization.

Farmer Benefits: For farmers, financial inclusion benefits were more modest:

- Only 17% reported easier access to formal credit
- Most farmers continue to rely on commission agents and informal lenders for credit
- The short-term, irregular nature of farmer transactions limits the value of digital payment history for credit scoring

Impact on Informal Credit Systems

One of the most complex findings relates to the mandi's traditional informal credit system.

Persistence of Informal Credit: Despite UPI adoption, the informal credit system remains robust:

- 78% of farmers still receive advances from commission agents
- 62% of traders receive credit from commission agents for bulk purchases
- These credit relationships often span decades and are based on trust, not digital records

Credit-Payment Separation: An emergent pattern is the separation of credit and payment mechanisms:

- Farmers receive advances in cash or bank transfer from commission agents
- After produce sale, UPI is used for settling the net balance
- This hybrid model preserves relationship-based credit while capturing efficiency gains of digital payment

Competitive Dynamics: Some commission agents reported that offering UPI payment options helped attract younger farmers and larger farmer representatives who valued the convenience and digital records. This suggests UPI may be becoming a competitive differentiator in commission agent services.

Infrastructure and Digital Literacy Challenges

Connectivity Issues: Despite being in Delhi, Azadpur Mandi faces connectivity challenges:

- 67% of respondents reported frequent network failures
- Peak transaction hours (5 AM - 9 AM) coincide with highest network congestion
- Failures during payment transactions created anxiety and were a deterrent for 43% of potential adopters

Smartphone Access and Digital Literacy: Among non-adopters, barriers included:

- No smartphone: 38% (especially among laborers and small farmers)
- Limited digital literacy: 41%
- Concerns about fraud/security: 27%
- Preference for cash: 31%
- Multiple responses allowed, explaining >100%

Age and Education Correlates: Logistic regression analysis revealed significant predictors of UPI adoption:

- Age: Each additional year reduced odds of adoption by 3.4% ($p<0.001$)
- Education: College education increased odds by 287% compared to primary education ($p<0.001$)
- Smartphone ownership: Increased odds by 512% ($p<0.001$)

Qualitative Insights: Stakeholder Narratives

Commission Agent Perspective (excerpt from interview): *"UPI has made my life easier for big transactions. Previously, I would receive ₹5-7 lakhs in cash from a trader, count it, then go to bank for deposit - waste of 2-3 hours. Now, instant payment, instant bank credit. But small farmers still want cash. They don't trust these phone systems, and many need money immediately for bus fare home or to buy tea."*

Farmer Representative Perspective: *"I bring produce from 15-20 small farmers in my village. UPI is good because I have a proper record of what I received and can show farmers on my phone. But problems are: network failure in early morning, some agents still deduct more than they should, and my father farmers don't understand this system - they want to see physical cash."*

Trader Perspective: *"For my business, UPI is essential. I buy ₹3-4 lakhs daily, running around with that much cash is risky. My accountant also likes it because everything is automatically recorded. But during peak season, when I need to buy quickly, sometimes UPI fails and I miss good deals because payment didn't go through."*

Laborer Perspective: *"I don't use UPI. I work for daily wages, need cash same day for food, room rent. Who will wait for payment to come to bank account and then I go to ATM? Also, I don't have smartphone. Some contractors have started paying weekly through UPI, but I prefer daily cash."*

Discussion

UPI as Market Infrastructure

Our findings position UPI not merely as a payment mechanism but as evolving market infrastructure that is reshaping stakeholder interactions, information flows, and power dynamics in agricultural markets.

The efficiency gains—75% reduction in transaction time and substantial cost savings—represent significant improvements in market functioning. At scale, these efficiency gains can translate into millions of hours saved annually across India's agricultural markets, with corresponding productivity benefits.

However, the uneven adoption across stakeholder groups reveals how digital payment infrastructure can reproduce and even amplify existing inequalities. Small farmers and informal laborers, already marginalized in market transactions, face greater barriers to adoption due to smartphone access, digital literacy, and immediate liquidity needs.

Hybrid Formality: Coexistence of Formal and Informal Systems

One of the most theoretically interesting findings is the emergence of hybrid systems that combine formal digital payments with informal credit relationships. Rather than UPI displacing informal credit, we observe a complementary coexistence.

This challenges linear narratives of financial formalization and suggests that digital payment infrastructure must account for the functional roles that informal systems serve—particularly relationship-based credit that formal banking has failed to adequately replace in agricultural contexts.

Financial Inclusion: Promise and Limitations

The positive correlation between UPI usage and formal credit access is encouraging, suggesting digital payment trails can serve as alternative credit assessment mechanisms. This is particularly significant given the challenges of credit access for small agricultural enterprises.

However, the tax scrutiny concern—where digital trails create disincentives for formalization—reveals a fundamental tension in digital payment promotion. Without complementary tax reforms and formalization benefits, the "stick" of potential scrutiny may outweigh the "carrot" of efficiency gains for some stakeholders.

Infrastructure as Prerequisite

The connectivity challenges at Azadpur Mandi, despite its location in India's capital, underscore that digital payment infrastructure requires physical infrastructure foundations. Network congestion during peak trading hours creates a critical bottleneck that technology alone cannot solve.

This has important implications for replicating UPI adoption in more remote mandis, where connectivity challenges are more severe.

Generational and Educational Divides

The strong age and education gradients in adoption suggest that UPI penetration may be partly a generational transition. As younger, more digitally literate cohorts enter agricultural markets, adoption may naturally increase.

However, relying on generational change risks excluding current small farmers and informal workers who may have decades of market participation ahead. Targeted interventions for these groups remain necessary.

Conclusion

The adoption of UPI in Azadpur Mandi represents a microcosm of India's broader digital payment revolution—characterized by impressive growth, significant efficiency gains, but also persistent challenges and inequalities. Our research reveals that UPI has transformed transaction mechanics in agricultural

markets, reducing time and costs while creating digital trails that enhance transparency and credit access for some stakeholders. The 34% UPI penetration by transaction value demonstrates substantial progress in just three years.

However, the benefits are unevenly distributed. Small farmers, informal laborers, and those with limited digital literacy remain marginalized. The persistence of informal credit systems alongside digital payments suggests that technology adoption in complex social economies requires understanding and integrating, rather than displacing, existing institutional arrangements. The pathway forward requires a multi-pronged approach: infrastructure investment to ensure reliable connectivity, targeted interventions for marginalized stakeholders, incentive realignment to address tax concerns, and credit ecosystem development that leverages digital payment data while respecting informal credit's functional roles.

Azadpur Mandi's experience offers valuable lessons for agricultural market modernization across India and other developing countries. Digital payment infrastructure holds genuine promise for improving agricultural market efficiency and farmer welfare, but realizing this promise requires careful attention to the socio-economic contexts in which technology is deployed. As India continues its digital transformation, agricultural markets must not be left behind. But equally important is ensuring that this transformation serves all stakeholders equitably—that the efficiency gains of digitalization translate into inclusive prosperity rather than reinforcing existing inequalities.

The story of UPI in Azadpur Mandi is still being written. This research provides a snapshot of a market in transition, but the final outcomes will depend on continued policy attention, infrastructure investment, and most importantly, responsive design that centers the needs and constraints of the millions of farmers, traders, and workers who form the backbone of India's agricultural economy.

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