

# Payment Systems and Financial Infrastructure

Theme I: Digital Market Design

**Research Question:** How should payment infrastructure evolve to balance efficiency, competition, and financial stability?

PhD Seminar in Digital Finance

## Network Externalities

User  $i$ 's value from network  $N$ :

$$u_i(N) = \alpha \cdot |N| + \beta \cdot f(N) - c_i$$

where  $f(N)$  = connectivity function.

## Critical Mass Problem

- Adoption requires  $|N| > N^*$
- Chicken-and-egg: Users wait for merchants
- Subsidies needed to bootstrap

## Interchange as Coordination

Three-party model:



Interchange fee  $f$  balances:

$$\text{Issuer margin} = f - c_I$$

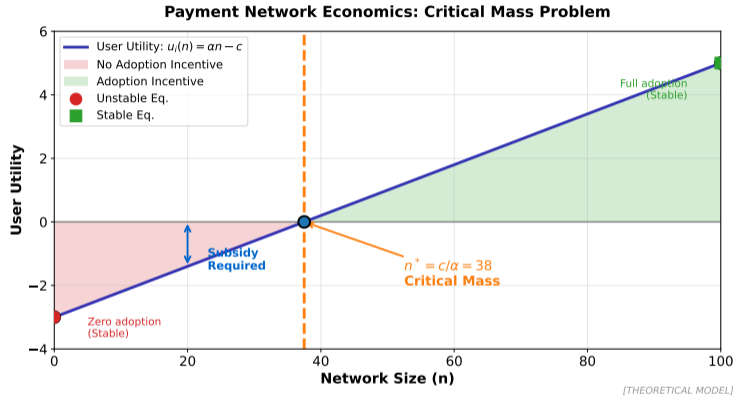
$$\text{Acquirer margin} = m - f - c_A$$

## Proposition

*Socially optimal  $f^*$  equates marginal network benefits across sides.*

Baxter (1983), "Bank Interchange of Transactional Paper" – foundational theory

# Payment Network Critical Mass



Network utility exhibits threshold dynamics; adoption accelerates after reaching critical mass.

## System Characteristics

System	Launch	Speed
UK Faster Payments	2008	< 2 hrs
India UPI	2016	Real-time
EU TIPS	2018	10 sec
US FedNow	2023	Real-time
Brazil PIX	2020	Real-time

## Adoption Drivers

- Central bank mandate
- Mobile-first economies
- Competition from fintechs

## Economic Impact

BIS Working Paper 1228 (2024):

- Transaction costs: -40% to -80%
- Financial inclusion: +15% unbanked access
- Working capital: 2-3 day improvement

## Network Effects Evidence

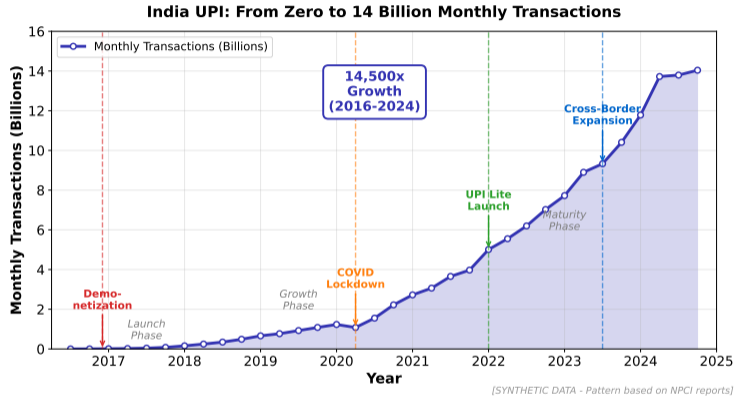
India UPI growth:

- 2016: 0.1M transactions/month
- 2024: 14B transactions/month
- S-curve adoption pattern

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BIS Working Paper 1228 (2024), "Retail fast payment systems as a catalyst for digital finance"

# India UPI: Real-Time Payments at Scale



UPI demonstrates fastest payment network adoption in history, reaching 14B monthly transactions.

## Current Architecture

- SWIFT: Messaging (11,000 banks)
- Correspondent banks: Settlement
- Nostro/Vostro accounts: Liquidity

	Component	Share
<b>Cost Structure</b>	FX spread	40%
	Correspondent fees	30%
	Compliance (AML/KYC)	20%
	Other	10%

Average cost: 6.4% (remittances)

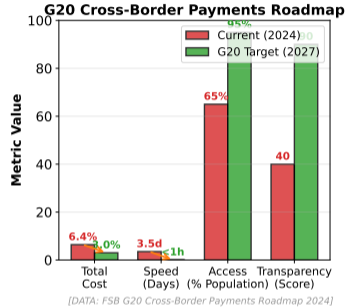
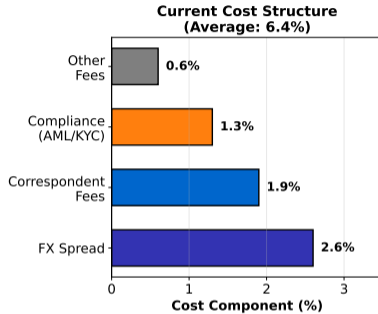
## Inefficiency Sources

- ④ **Fragmented liquidity:** Pre-funded accounts
- ② **Sequential processing:** 2-5 day settlement
- ③ **Opacity:** Uncertain fees, timing
- ④ **De-risking:** Compliance costs

## G20 Roadmap Targets (2027)

- Cost: < 3% (from 6.4%)
- Speed: < 1 hour (from 2-5 days)
- Access: Universal coverage
- Transparency: Full fee disclosure

# Cross-Border Payment Costs: G20 Roadmap



G20 targets reducing remittance costs from 6.4% to 3% by 2027; technology enables but regulation constrains.

## Public Infrastructure

- Central bank operated
- Universal access mandate
- Cost-recovery pricing
- Examples: RTGS, FedNow

## Private Networks

- Profit-maximizing
- Selective access
- Network effects capture
- Examples: Visa, PayPal

## Competition Framework

Public rail as outside option:

$$\pi_{private} \leq u_{user}(public)$$

## BIS “Finternet” Vision (2024)

Carstens & Nilekani propose:

- Unified ledger architecture
- Programmable money
- Cross-network interoperability
- Central bank as backbone

## Key Question

Where is the boundary between utility and competitive layer?

## Natural Experiment: India Demonetization (2016)

86% of currency invalidated overnight.

Outcome	Short-run	Long-run
Digital payments	+300%	+150%
GDP growth	-2%	+0.5%
Informal sector	-15%	-8%
Tax compliance	+25%	+15%

## Chodorow-Reich et al. (2020)

District-level analysis shows persistent digitization effects.

## Key Findings

- Shock accelerated adoption 3-5 years
- Network effects amplified over time
- Heterogeneous by prior infrastructure

## Mechanism

Coordination game: Shock moved economy to new equilibrium.

$$u(\text{digital} | n_{\text{digital}}) > u(\text{cash})$$

when  $n_{\text{digital}} > n^*$

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Chodorow-Reich et al. (2020), "Cash and the Economy," QJE

## Smart Contract Payments

Conditional transfers:

```
if (delivery_confirmed) {  
  transfer(amount, seller);  
} else if (timeout) {  
  refund(amount, buyer);  
}
```

## Use Cases

- Trade finance: Auto-release on shipment
- Payroll: Streaming wages
- Government: Conditional transfers

## Design Challenges

- ④ **Oracles:** External data verification
- ② **Finality:** Reversal capabilities
- ③ **Privacy:** Transaction visibility
- ④ **Scalability:** Throughput limits

## Tokenized Deposits (BIS, 2024)

Banks issue programmable deposits on shared ledger:

- Atomic settlement
- Interoperable across banks
- Central bank money backing

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Project Mariana (BIS, 2023): Cross-border CBDC proof-of-concept using AMMs

## Publishable Research Directions

### ① Optimal Payment System Design

- RQ: What is the welfare-maximizing mix of public/private rails?
- Method: Structural model with network externalities
- Gap: No unified framework for infrastructure competition

### ② Real-Time Payments and Credit

- RQ: Does instant payments reduce or increase demand for credit?
- Method: Exploit staggered rollout (FedNow, PIX)
- Gap: Theory unclear; liquidity vs. float effects

### ③ Cross-Border Infrastructure Coordination

- RQ: What governance structure enables multi-CBDC interoperability?
- Method: Game theory of international coordination
- Gap: Emerging policy area with limited academic analysis

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Payment infrastructure is understudied relative to its economic importance

## Mathematical

Model a payment network with adoption externalities:

$$u_i = \alpha n - c$$

- Find critical mass  $n^*$
- Derive optimal subsidy  $s^*$
- Analyze platform vs. public provision

**Due:** Week 4 – Empirical exercise uses publicly available data

## Empirical

Using BIS CPMI data:

- 1 Compare instant payment adoption curves
- 2 Test for S-curve dynamics
- 3 Identify adoption determinants

Data: BIS Red Book, CPMI Statistics

## Research Proposal

Draft 1-page proposal:

- “FedNow and Small Business”
- Hypothesis: Working capital effects
- Identification strategy
- Data sources

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BIS provides excellent cross-country payment statistics

## Core Papers (Read Before Class)

- 1 **BIS Working Paper 1228** (2024). “Retail fast payment systems as a catalyst for digital finance.”
  - Focus: Sections 2-4, country case studies
- 2 **Chodorow-Reich et al.** (2020). “Cash and the Economy: Evidence from India’s Demonetization.” *QJE*, 135(1), 57-103.
  - Focus: Identification strategy, Tables 3-5

## Supplementary

- BIS Finternet Paper (2024): Future infrastructure vision
- FSB Cross-Border Roadmap (2020): Policy targets
- Baxter (1983): Interchange theory – classic

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**BIS publications provide excellent policy-relevant research**