

Technology and System Modernization: What Actually Keeps Systems Running?

Background

Digital and payment infrastructure — from real-time transfer rails to national switches, digital identity systems and interoperable APIs — increasingly underpins how banking agents, merchants and providers deliver services in low- and middle-income countries.

As mobile money, biometric onboarding and interbank switches scale, the operational stability of these systems (transaction success, downtime, processing speed and connectivity) becomes as consequential for financial inclusion as access itself.

Supply-side actors — agents, merchants, aggregators and providers — are the operational backbone through which these technologies reach end users, yet their experience of system reliability is comparatively under-examined relative to consumer-facing adoption research.

Scope of the Synthesis

This brief synthesises nine studies published between 2013 and 2024: one randomised controlled trial (Acimovic et al., 2019, Tanzania); one mixed-methods study (David-West et al., 2021, Nigeria); three quantitative survey and regression studies (Gupta & Singh, 2023, India; Coffie et al., 2020, Ghana; Torres Ortega et al., 2024, Colombia); two descriptive case-study reports (Riley & Kulathunga, 2017, multi-country; Buku & Meredith, 2013, Kenya); one econometric diffusion-forecasting study (Aduba & Asgari, 2022, Nigeria); and one expert-panel interpretive structural modelling study (Rana et al., 2023, India).

Sub-Saharan Africa is best represented, followed by South Asia, with single studies from South-East Asia and South America. Coverage across the four named sub-interventions is uneven: real-time transfer systems have the most direct evidence, digital identity integration has one substantive study, and national payment switches and API-based interoperability are addressed mainly incidentally within studies whose primary focus lies elsewhere.

1. Synthesis of Findings

1.1 Real-Time Transfer Payment Systems

Kenya's M-Pesa is the most extensively documented real-time system: by the end of 2011 it had 15.2 million active users and had moved over US\$1.4 trillion cumulatively, processing more domestic transactions than Western Union globally (Buku & Meredith, 2013). A complementary case study reports M-Pesa handling roughly two million transactions daily, equivalent to 90% of Kenya's mobile money transactions and 17% of GDP annually (Riley & Kulathunga, 2017).

Sri Lanka's eZ Cash, built by three mobile network operators sharing a single interoperable wallet platform, reached roughly 65% of the population and is described as the first

end-to-end interoperable mobile money system globally (Riley & Kulathunga, 2017).

At the agent level, a randomised trial in Tanzania targeting agents' cash and float rebalancing found that in-person training combined with a personalised daily recommendation reduced the probability of a float stockout by 2.1–3.9 percentage points and increased rebalancing frequency, with the effect concentrated among agents who had never used a bank to rebalance (Acimovic et al., 2019). This is the only experimental evidence in the cell.

1.2 National Payment Switches

Evidence directly addressing national switch infrastructure is limited to two single-country case narratives. Thailand operates one of three fully interoperable ATM networks in ASEAN via the National Interbank Transaction Management and Exchange, credited with lowering infrastructure costs

across banks, and Sri Lanka's national retail infrastructure provider LankaClear is described as moving toward a fully interoperable common switch (Riley & Kulathunga, 2017).

Both accounts are descriptive rather than outcome-evaluative. No study in this set measures switch-level reliability — uptime, settlement speed or failure rates — directly, so conclusions about national switches should be treated as provisional.

1.3 Digital ID Integration for Onboarding

A dedicated agent-level study in Himachal Pradesh, India (n = 301 banking agents) used ordered logistic regression to examine the continuity of agents operating on India's Aadhaar-enabled biometric authentication and Aadhaar Enabled Payment System. Prior exposure to financial technology was positively associated with intention to continue, poor internet connectivity significantly reduced it ($\beta = -0.866$, $p < 0.01$), and satisfaction with software-related technical support raised it ($\beta = 0.992$, $p < 0.01$) (Gupta & Singh, 2023).

Notably, the frequency of biometric-device and micro-ATM breakdowns — despite being reported as a high-frequency issue by over 95% of agents — was not a statistically significant predictor of agents' intention to continue. Perceived and operative drivers of attrition therefore diverge.

South Africa's SASSA programme, a biometric chip-based debit card used to disburse social grants and interoperable across any ATM or point-of-sale terminal, was issued to roughly 10 million beneficiaries and is reported to have generated approximately R2 billion in annual savings by eliminating duplicate or "ghost" accounts through biometric deduplication (Riley & Kulathunga, 2017).

1.4 API-Based Interoperability Between Banks and Fintechs

Only one study treats interoperability as a central, named finding. David-West et al. (2021), combining provider interviews, focus groups and survey data with unbanked populations in Nigeria, identify lack of integration in the ecosystem — limited interoperability between mobile money platforms and other sectors such as health, agriculture and government — as one of four primary drivers of non-diffusion.

An interpretive structural modelling analysis with 14 industry experts in India examined 19 barriers to mobile wallet adoption; lack of low-cost interoperable service providers was identified as a foundational, high driving-power barrier, with the authors noting that most wallets do not allow cross-platform fund transfers (Rana et al., 2023). Coffie et al. (2020) similarly observe that card payment adoption lagged mobile money among Ghanaian SMEs, partly attributable to limited point-of-sale and card acceptance infrastructure — interoperability-adjacent, but not a direct evaluation of bank-to-fintech APIs.

Table 1. Direction and basis of evidence by sub-intervention

Sub-intervention	Direction and basis
Real-time transfer systems	Positive; one RCT plus descriptive case narratives
Agent float rebalancing support	Positive (experimental, 2.1–3.9 pp reduction in stockouts)
National payment switches	Positive in description only; no reliability measurement
Digital ID integration	Mixed; one substantive regression study, one descriptive case
API-based interoperability	Negative on current gaps; no evaluation of achieved interoperability
Equipment reliability and agent continuity	Not significant (tested null)

Two of the four sub-interventions lack any study designed specifically to evaluate them.

2. Cross-Cutting Trends and Insights

Key cross-cutting trends and insights include:

- Connectivity and technical support outweigh device-level or hardware factors as drivers of system performance, shown directly in the agent-level Aadhaar study where connectivity and software support predicted agent continuation while equipment breakdown did not (Gupta & Singh, 2023).
- Interoperability gaps are referenced as an unresolved constraint wherever they are discussed — explicitly in Nigeria and as a secondary theme in India and Ghana (David-West et al., 2021; Rana et al., 2023; Coffie et al., 2020).
- No study in the set treats interoperability, or national switch performance, as its central object of investigation, so the evidence describes the gap rather than the effect of closing it.
- Shared platforms among competing providers appear repeatedly among the successful cases, in Sri Lanka's eZ Cash and Thailand's interbank ATM network alike.
- Perceived and operative reliability problems diverge: the most frequently reported fault was not the one that drove agents out.
- Most findings rest on single studies in single countries, which limits generalisation across regions.

3. What Works

- Combining in-person agent training with personalised, simple digital recommendations, which reduced float stockouts in a randomised trial and concentrated its effect among agents without prior bank access (Acimovic et al., 2019).

- b. Shared or pooled interoperable platforms among competing providers, such as three operators sharing one wallet in Sri Lanka, which achieved rapid national-scale reach — documented through descriptive case narrative rather than controlled comparison (Riley & Kulathunga, 2017).
- c. Biometric deduplication linked to a national identity system, associated with reported administrative savings from eliminating duplicate accounts, again via descriptive case account (Riley & Kulathunga, 2017).
- d. Responsive software and technical support for agents, which is significantly associated with intention to continue operating (Gupta & Singh, 2023).
- e. Interoperable acceptance infrastructure that allows a single instrument to work across terminals and networks (Riley & Kulathunga, 2017).

4. What Doesn't Work

- a. Notification-only or information-only guidance without in-person training or an explicit recommendation, which produced no significant improvement in reliability outcomes in the randomised trial — a genuinely tested null result rather than an absence of evidence (Acimovic et al., 2019).
- b. Treating hardware reliability as the primary lever: micro-ATM and biometric-device breakdowns did not significantly predict agents' intention to continue despite being their most frequently reported complaint (Gupta & Singh, 2023).
- c. Card-based payment infrastructure as a diffusion channel among Ghanaian SMEs, which underperformed mobile money, though this finding is secondary within a study focused on broader adoption determinants (Coffie et al., 2020).
- d. Deploying platforms without cross-sector integration, which was identified as one of four primary drivers of non-diffusion in Nigeria (David-West et al., 2021).

5. Challenges

- a. Several studies rely on self-reported Likert-scale perceptions of reliability rather than objective system logs, and the expert panel informing the India barrier hierarchy was small at 14 experts (Gupta & Singh, 2023; Rana et al., 2023).
- b. Rural connectivity and power-supply gaps constrain real-time system performance in agent-dependent contexts (Gupta & Singh, 2023; Acimovic et al., 2019).
- c. Agents' limited personal capital restricts how much cash and float they can hold, while the cost of delivering in-person training limits how quickly providers can scale it (Acimovic et al., 2019).
- d. Reliability is often difficult to observe directly: failed transaction attempts are typically unrecorded, forcing researchers to estimate rather than observe stockouts and failures (Acimovic et al., 2019).

- e. Raw fault-frequency counts do not necessarily reflect reliability as experienced by users, since agents can absorb faults through backup channels and responsive support (Gupta & Singh, 2023).
- f. Geographic concentration and single-study coverage for two of the four sub-interventions.

6. Areas for Further Research

- a. Replication of agent-level reliability interventions: the Tanzania trial is the only experimental evidence on improving agent-level system reliability, and replication across South Asian and additional Sub-Saharan African contexts is needed to assess generalisability (Acimovic et al., 2019).
- b. Dedicated empirical evidence on biometric and digital-identity onboarding, currently concentrated in one Indian study, with South Africa's SASSA case descriptive only and no controlled evaluation of the biometric system's reliability or downtime.
- c. Direct measurement of system performance gains once interoperability is achieved, and comparison of interoperable against siloed platforms on reliability indicators.
- d. Switch-level reliability measurement — uptime, settlement speed and failure rates — which no included study reports.
- e. Objective system-log data rather than agent-reported fault frequency, to separate perceived from experienced reliability.
- f. Evaluation of whether responsive technical support can substitute for hardware replacement, which the Indian null result implies but does not test.

7. Conclusion

Across a heterogeneous but geographically concentrated evidence base, real-time transfer systems are documented with the greatest depth, including one experimental study, while digital identity integration is supported by a single substantive quantitative study. National payment switches and API-based interoperability are addressed mainly as secondary observations within studies focused on other questions rather than as primary objects of investigation.

The clearest finding where the evidence is genuinely direct is that connectivity and technical support are the stronger predictors of system performance for supply-side actors — more so than the hardware faults agents most frequently report. That divergence between perceived and operative causes is itself a practical result: it suggests support arrangements deserve at least as much investment as equipment replacement.

Given that most findings rest on single studies in single countries, and that two of the four sub-interventions lack any study designed specifically to evaluate them, policymakers and funders should treat conclusions about national switches and interoperability as provisional, and prioritise

commissioning research that evaluates these two sub-interventions directly rather than incidentally.

About this Evidence Brief

This evidence brief is a cell-wise summary of studies of the cell “Technology and system modernization → System performance and reliability” from ICED’s Evidence and Gap Map of the Retail Finance Distribution Initiative.

For the full map, visit www.iced-eval.org/evidence-and-gap-maps

References

- Acimovic, J., Parker, C., Drake, D., & Balasubramanian, K. (2019). Show or tell? Improving agent decision making in a Tanzanian mobile money field experiment. Smeal College of Business, Pennsylvania State University.
- Aduba, J. J., & Asgari, B. (2022). Analysing and forecasting the diffusion of electronic payments system in Nigeria. *Technology Analysis & Strategic Management*, 34(10), 1215–1233.
- Buku, M. W., & Meredith, M. W. (2013). Safaricom and M-PESA in Kenya: Financial inclusion and financial integrity. *Washington Journal of Law, Technology & Arts*, 8(3), 375–400.
- Coffie, C. P. K., Hongjiang, Z., Mensah, I. A., Kiconco, R., & Simon, A. E. O. (2020). Determinants of FinTech payment services diffusion by SMEs in Sub-Saharan Africa: Evidence from Ghana. *Information Technology for Development*, 27(3), 539–560.
- David-West, O., Oni, O., & Ashiru, F. (2021). Diffusion of innovations: Mobile money utility and financial inclusion in Nigeria — Insights from agents and unbanked poor end users. *Information Systems Frontiers*. Advance online publication.
- Gupta, S., & Singh, P. (2023). Technology and financial inclusion: A study of technology’s role in the continuity of banking agents (pp. 225–248). Routledge.
- Rana, N. P., Luthra, S., & Rao, H. R. (2023). Assessing challenges to the mobile wallet usage in India: An interpretive structural modelling approach. *Information Technology & People*, 36(4), 1533–1554.
- Riley, T. A., & Kulathunga, A. (2017). Bringing e-money to the poor: Successes and failures. World Bank.
- Torres Ortega, J. M., Guzmán Murillo, H. J., & Blanco Troncoso, A. L. (2024). Assessing the impact of digital payment infrastructure accessibility on the social impact of microenterprises in Barranquilla, Colombia: An experimental study. *Journal of Infrastructure, Policy and Development*, 8(9), Article 6433.