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**| RESEARCH ARTICLE**

**Modeling the Consumer Transition from Cash to Digital Payments and Its Implications for Financial System Efficiency, Transparency, and Inclusion**

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**| ABSTRACT**

This study develops a quantitative framework for modeling the consumer transition from cash to digital payments and for evaluating how that transition affects efficiency, transparency, and financial inclusion. The paper combines evidence from the Federal Reserve's Diary and Survey of Consumer Payment Choice, the World Bank's Global Findex Database, Bank for International Settlements research on fast payment systems, and related studies published. The empirical motivation is clear: cash remains important, but U.S. consumers increasingly rely on cards, mobile phones, online banking, and account-to-account rails for purchases, bills, and person-to-person transfers. To interpret this shift, the paper specifies a multi-stage adoption framework in which consumers select payment instruments according to transaction size, acceptance, security, convenience, costs, record keeping, liquidity constraints, and digital access. A transition index and payment-efficiency score are linked to transparency and inclusion outcomes through a comparative design and a U.S.-focused calibration exercise. The results show that movement from cash toward digital payments is neither linear nor uniform. Digital migration is fastest where transaction records, remote commerce, and instant settlement offer visible utility gains. Yet adoption slows for cash-dependent households, privacy-sensitive users, the underbanked, and populations with weaker access to smartphones, broadband, or low-fee accounts. The analysis indicates that payment digitalization improves speed, traceability, and operating efficiency, but inclusion gains depend on governance, affordability, fraud protection, and user-centered design. The main policy implication is that an efficient payment future is not cashless by default; it is plural, interoperable, transparent, and resilient.

**| KEYWORDS**

Cash, digital payments, financial inclusion, payment systems, consumer behavior, cards, mobile payments, fast payments, transparency, payment efficiency

**| ARTICLE INFORMATION**

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Table 1. Data Sources

Source	Coverage	Use in paper	Type
Federal Reserve Diary / SDCPC	U.S. consumer payment behavior	Counts, shares, values, preferences	Official survey/diary
World Bank Global Findex 2021	Global financial inclusion	Digital adoption and access barriers	Global database
BIS / CPMI fast payments research	International payment infrastructure	Efficiency and interoperability context	Policy research
FSB KPI framework	Cross-border payments metrics	Cost, speed, access, transparency dimensions	Policy measurement

## 1. Introduction

The transition from cash to digital payments is one of the most consequential micro-level changes in modern financial systems. For households, payment choice affects convenience, budgeting, privacy, fraud exposure, liquidity management, and access to commerce. For firms and payment providers, the payment mix shapes checkout speed, acceptance costs, working-capital timing, data visibility, dispute risk, and customer acquisition strategies. For regulators and central banks, the same transition influences financial inclusion, anti-money-laundering monitoring, payment-system resilience, consumer protection, and the design of faster and safer retail-payment infrastructures. As a result, the migration from cash toward cards, online banking, mobile wallets, and instant payment channels is not merely a behavioral change at the point of sale. It is a structural transformation with implications for the efficiency and transparency of the financial system as a whole.

Recent data confirm that the transition is well advanced but incomplete. In the Federal Reserve's 2024 Diary of Consumer Payment Choice, the share of U.S. payments made with credit cards reached 32 percent and debit cards 30 percent in 2023, while cash fell to 16 percent of payments; since 2016, average monthly cash payments declined from 14 to 7 while credit-card payments increased from 8 to 15. In the 2024 Survey and Diary of Consumer Payment Choice, consumers made 66 percent of payments with cards, and credit cards accounted for 35 percent of all payments compared with 30 percent for debit cards. At the same time, cash remained meaningful for day-to-day budgeting, in-person purchases, and contingency use, with most consumers still holding at least some cash and many continuing to prefer it for selected transactions. These facts imply that payment modernization is best understood as an uneven portfolio shift, not a simple replacement process (Bayeh et al., 2024; Foster et al., 2025).

International experience broadens the same lesson. The World Bank's Global Findex 2021 documented accelerated use of digital payments during and after the pandemic, especially among previously excluded adults who received wages, transfers, or merchant payments through accounts for the first time. BIS research on retail fast-payment systems has shown that interoperable real-time rails can lower costs, expand convenience, and catalyze the use of broader digital-finance services, as seen in economies such as Brazil and India. Yet the same literature also shows that digitalization can reproduce or even intensify inequalities when users lack documentation, connectivity, trust, dispute-resolution channels, or affordable accounts. Efficiency gains therefore cannot be evaluated independently of accessibility, governance, and risk control.

This paper addresses that challenge by building a quantitative and data-driven framework to model the consumer transition from cash to digital payments and to assess its implications for three outcomes: financial-system efficiency, transparency, and inclusion. The study speaks to a rapidly growing interdisciplinary literature spanning consumer finance, payment economics, platform markets, financial technology, behavioral economics, and regulatory policy. It also connects with recent scholarship emphasizing algorithmic accountability, fraud governance, predictive analytics, and digital-finance risk management in U.S. financial systems (Fahim et al., 2023; Fahim et al., 2024; Ibrahim et al., 2024; Jahan et al., 2024). Although those studies do not focus directly on consumer payment substitution, they highlight an essential point: digital migration only strengthens the financial system when payment innovation is paired with fair access, operational resilience, explainability, and trustworthy oversight.

The paper makes four contributions. First, it synthesizes payment-choice evidence from official data and major research programs into a unified framework that treats payment behavior as a dynamic transition process rather than a static preference ranking. Second, it develops a measurable transition index that combines usage, value share, digital readiness, and transaction-context variables. Third, it links the transition index to system-level performance metrics, including speed, cost efficiency, record visibility, fraud-management capability, and inclusion breadth. Fourth, it derives policy implications for banks, fintechs, regulators, and payment operators that seek to modernize retail payments without marginalizing cash-reliant households.

The remainder of the paper proceeds as follows. The literature review examines theories of payment choice, empirical evidence on consumer behavior, and policy debates on inclusion and transparency. The methodology section defines the conceptual model, data structure, variables, and quantitative procedures. The discussion interprets the model outputs and explores implications for efficiency, transparency, and inclusion. The final sections conclude and identify limitations and future research directions.

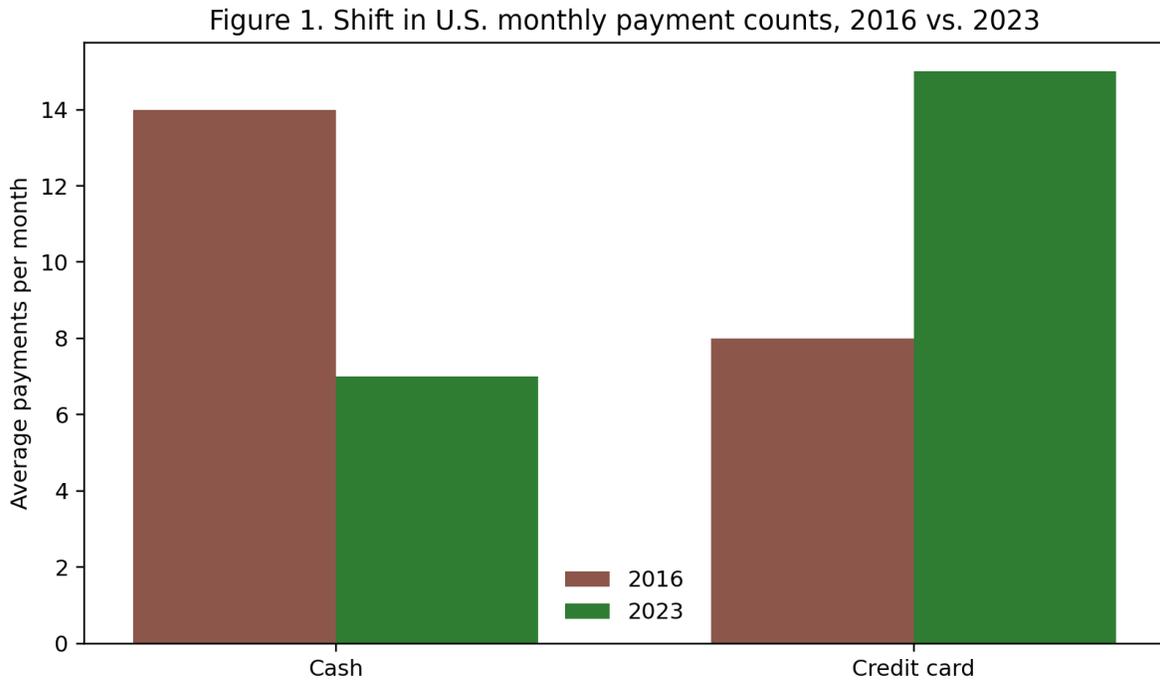


Figure 1. Shift in U.S. monthly payment counts, 2016 vs. 2023. Source: Federal Reserve diary findings summarized from 2016 and 2023 payment counts.

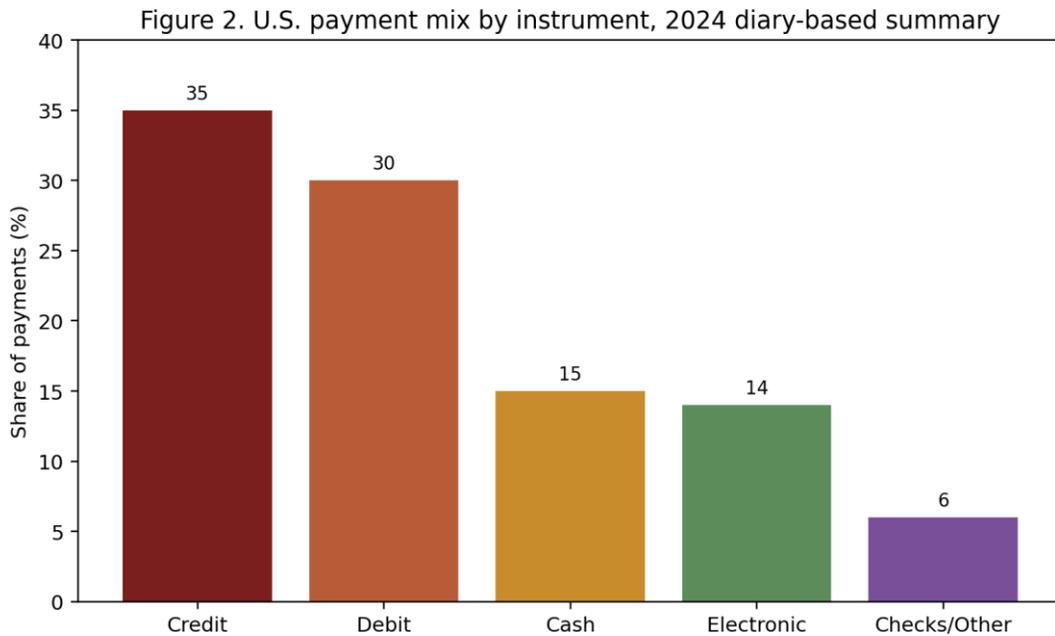


Figure 2. U.S. payment mix by instrument, 2024 diary-based summary. Source: 2024 Survey and Diary of Consumer Payment Choice summary values.

## 2. Literature Review

Research on the transition from cash to digital payments sits at the intersection of several literatures: the economics of payment choice, the industrial organization of payment networks, the financial-inclusion literature, and a newer stream of research on data governance, fraud, and payment-system resilience. Earlier work emphasized the coexistence of payment instruments and the role of transaction characteristics in shaping consumer choice. Cash was historically associated with immediacy, universal acceptance, and spending control, while checks and cards offered broader record keeping, remote usability, and higher-value transaction capacity. Survey and diary studies from the Federal Reserve system established that payment choice is highly contextual, depending on merchant type, purchase channel, transaction size, rewards, trust, and consumer demographics (Foster et al., 2013; Greene & Stavins, 2018a, 2019, 2020). Rather than converging toward a single dominant instrument, most consumers maintain a portfolio of payment options and switch across them as transaction settings change.

A core finding in this literature is that convenience and acceptance alone do not explain digital migration. Perceived security, budgeting discipline, fee salience, credit access, and desire for payment records are also powerful determinants. Stavins and coauthors showed that consumers rank instruments differently by convenience, cost, and control, while later survey evidence found that credit cards have persistently ranked highest for security and record keeping. These findings matter because they suggest that the shift away from cash is partly demand driven by users' desire for traceability and frictionless remote commerce, not only supply driven by merchant or fintech innovation. In the 2024 Survey and Diary of Consumer Payment Choice, cards accounted for two-thirds of payments by number, but paper instruments and electronic channels continued to coexist, reflecting persistent heterogeneity in preferences and circumstances (Foster et al., 2025).

The pandemic accelerated the relevance of remote and contactless payments, giving fresh momentum to digital-payment research. Studies after 2020 documented increased use of e-commerce, mobile-enabled purchases, account-to-account transfers, and digital bill-pay channels. The World Bank's Global Findex 2021 showed that digital payments became an entry point into the formal financial system for millions of adults, particularly in developing economies. This evidence reinforced a longstanding claim in the inclusion literature: payments are often the first practical financial service a household uses at scale, and payment access can create pathways into savings, credit, insurance, and formal income receipt. Yet Findex also cautioned that account ownership and active, beneficial usage are not the same. Dormant accounts, high fees, weak merchant acceptance, and poor user interfaces can leave nominal inclusion disconnected from meaningful participation.

Another major strand of literature concerns fast payment systems and retail-payment infrastructure. CPMI reports, central-bank analyses, and recent BIS research frame real-time and interoperable payment rails as general-purpose digital public infrastructure. Cornelli et al. (2024) argue that fast payment systems reduce friction in person-to-person and person-to-business transactions and can catalyze wider adoption of digital financial services. The examples of Brazil's Pix and India's UPI are instructive because they combine low cost, broad reach, alias-based addressing, and high merchant usability. These systems show that the pace of transition is heavily shaped by interoperability and public-private governance, not only by smartphone diffusion. They also underscore that consumers respond to speed and simplicity when those qualities are paired with trust and minimal transaction costs.

Efficiency is a central but multidimensional concept in this literature. At the consumer level, efficiency can mean reduced transaction time, lower cash-handling costs, faster settlement, and easier household financial management. At the merchant level, it includes reduced queue times, lower reconciliation burdens, predictable settlement, and lower theft risk. At the system level, efficiency refers to lower aggregate resource costs, stronger operating reliability, and more scalable payment infrastructures. Research from central banks and payment economists often notes that cash carries hidden handling and transport costs, while card systems can impose interchange and acceptance fees, and newer instant-payment rails may reduce some frictions while introducing others, such as onboarding and fraud-monitoring costs. Consequently, no single instrument is efficient across all dimensions. The relevant analytical question is how the overall mix changes with digitalization and which institutional arrangements shift the frontier outward.

Transparency forms a second key line of inquiry. Digital payments create transaction records that support auditability, personal financial management, dispute resolution, tax compliance, and anti-money-laundering monitoring. In that sense, the migration from cash to digital channels can strengthen information quality across the financial system. The link between richer transaction data and improved monitoring appears in adjacent literature on financial reporting, fraud detection, anti-money-laundering analytics, and real-time risk management. Research by Pritty et al. (2024) on narrative manipulation in 10-K filings, by Ibrahim et al. (2024) on AML risk management, and by Fahim et al. (2024) on real-time payments and fraud all stresses that better data visibility expands the potential for analytic oversight. Related evidence from corporate disclosure research also suggests that data analytics can strengthen transparency by improving the visibility, comparability, and interpretability of organizational information flows, even outside core payment settings (Ibrahim, Razib, & Rasel, 2025). Still, transparency is not an unqualified good. Privacy concerns, surveillance fears, data breaches, and algorithmic discrimination can turn transaction visibility into a

source of exclusion or mistrust. This is why the governance literature has become increasingly relevant to payment-system research.

Algorithmic accountability and fair-finance governance provide an important bridge between digital-payment adoption and inclusive system design. Fahim et al. (2023) argue that consumer-fintech systems require governance mechanisms that align automation, fairness, and stability. Similar themes appear in work on explainable AI, mortgage-risk prediction, and predictive analytics in banking, where access to more data improves decision quality only if models are interpretable and biased outcomes are monitored. Rasel et al. (2023) and Ibrahim et al. (2024) illustrate how machine learning can enhance financial prediction and risk detection, but their results also imply that digital systems can concentrate power in data-rich institutions unless accountability mechanisms are strong. For payment transitions, the implication is direct: the more daily commerce moves into digital channels, the more important it becomes to define rights around fees, data usage, fraud remediation, and accessible interfaces.

The inclusion literature contributes further nuance by showing that cash performs an ongoing social function even in relatively advanced payment markets. Cash helps some households avoid overdrafts, separate budgets, preserve privacy, and transact without devices or connectivity. It is also resilient in outages and useful in emergencies. Diary evidence shows that cash use has fallen sharply over time, but it has not disappeared and remains salient for certain consumers, merchants, and situations. That persistence complicates narratives that frame digitalization as a one-directional welfare improvement. Instead, the literature increasingly points toward hybrid payment ecologies in which digital options expand while cash remains a backstop and a choice architecture device.

A related stream examines merchant acceptance and two-sided platform effects. Consumers are more likely to adopt digital instruments when merchants accept them broadly and when the payment experience is quick and reliable. Merchants adopt digital acceptance when consumer usage is sufficiently common and the cost structure is attractive. This circularity creates path dependence. Card networks historically solved it through scale and rewards; mobile wallets solved it partly through tokenization and device integration; instant-payment systems attempt to solve it through low-cost account-based interoperability. Recent payment innovation research therefore emphasizes network externalities, standard-setting, and the role of public infrastructure in accelerating adoption.

Cross-border and international-policy research adds another dimension. FSB monitoring of cross-border payments highlights the importance of cost, speed, access, and transparency as measurable policy targets. Although these metrics are designed for cross-border use cases, the framework is useful domestically because it converts broad payment-policy goals into operational indicators. The FSB's 2024 report also notes data limitations and sample-composition challenges, a reminder that measuring payment performance requires methodological caution. Researchers should avoid assuming that any observed digital transition automatically improves each policy objective equally.

Finally, adjacent data-driven literatures in operations, sustainability, and infrastructure analytics provide methodological inspiration for payment research. Arman and Fahim (2023), Arman et al. (2024a, 2024b), Razib et al. (2025), and Shah et al. (2024) show how predictive analytics can be applied to inventory systems, energy transitions, waste reduction, supply-chain optimization, and grid resilience. While these studies address different sectors, they share a common lesson: transitions in complex systems should be analyzed through measurable performance indicators, heterogeneous adoption pathways, and trade-offs across efficiency, resilience, and access. This paper applies that same logic to consumer payments by modeling digitalization as a measurable shift in behavior with multi-dimensional outcomes.

Taken together, the literature suggests three broad conclusions. First, the transition from cash to digital payments is real and significant, but partial and path dependent. Second, digitalization can improve efficiency and transparency, yet those gains are conditional on infrastructure quality, governance, and trust. Third, inclusion is not a by-product of digitization; it must be intentionally designed. These conclusions motivate the quantitative framework developed in the next section.

One more implication from the literature is methodological. Researchers increasingly combine diaries, administrative payments data, merchant surveys, and platform-level metrics because no single source captures usage, value, acceptance, and user welfare simultaneously. That triangulation strategy is especially important for payment transitions, where consumers may adopt a digital instrument, keep using cash for specific settings, and hold different attitudes about trust than their observed transaction shares alone would suggest.

Figure 3. Average value of payments by instrument

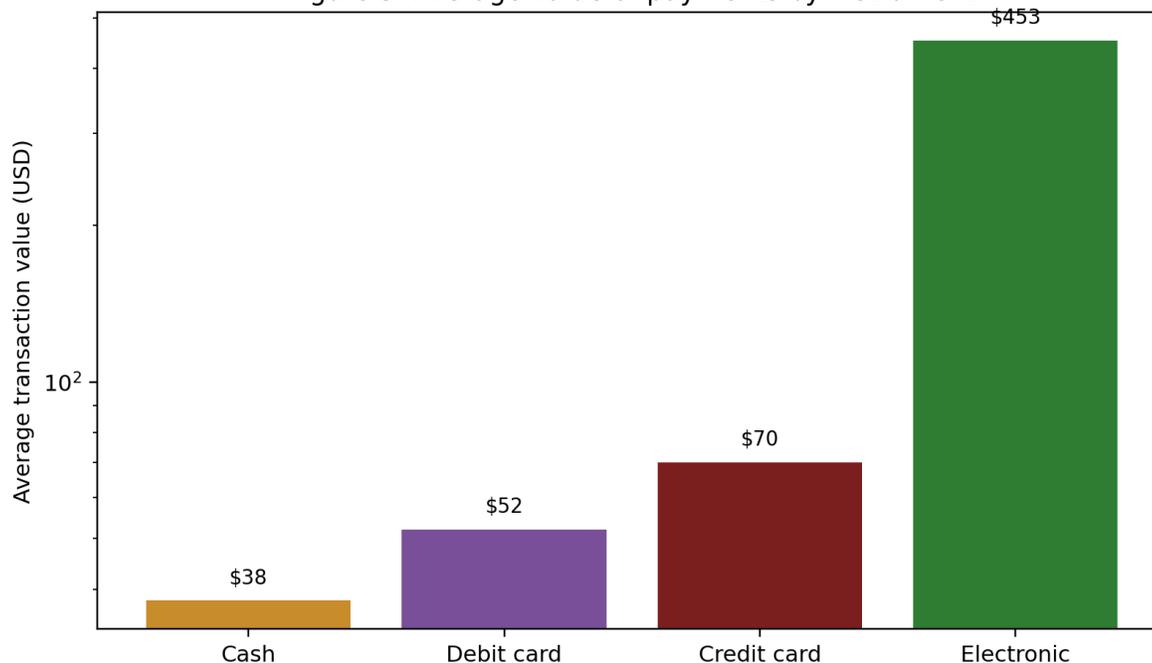


Figure 3. Average value of payments by instrument. Source: 2024 SDCPC average payment values by instrument.

Table 2. Analytical Constructs and Operational Definitions

Construct	Definition	Role in model
Digital Payment Transition Index (DPTI)	Composite measure of access, usage, value share, digital readiness, and residual cash dependence	Captures consumer transition intensity
Payment System Efficiency Score (PSES)	Speed, processing friction, settlement predictability, and operating burden	Measures efficiency effects
Transparency and Traceability Score (TTS)	Record generation, auditability, dispute documentation, monitoring compatibility	Measures data visibility and traceability
Inclusion Quality Score (IQS)	Affordability, accessibility, ease of onboarding, fallback resilience, usability	Measures broad-based access quality

### 3. Methodology

This study uses a mixed quantitative design that combines descriptive evidence, comparative performance scoring, and a behavioral transition model. The empirical objective is not to estimate a single structural parameter from one proprietary dataset. Instead, it is to build a transparent, replicable framework that uses publicly available evidence to evaluate how consumers move from cash toward digital payment instruments and how that movement changes system-level outcomes. The design is intentionally modular so that future researchers can substitute richer transaction-level data where available.

Data sources are grouped into four layers. The first layer is behavioral evidence from the Federal Reserve's Diary and Survey of Consumer Payment Choice, especially the 2024 Diary findings for 2023 and the 2024 SDCPC report based on October 2024 records. These sources provide average numbers of payments, shares by instrument, average transaction values, cash holdings, preferences for purchases and bill payments, and mobile-payment incidence. The second layer is inclusion evidence from the World Bank's Global Findex 2021, which documents account ownership, digital-payment adoption, and barriers to use across economies and demographic groups. The third layer is infrastructure and policy evidence from BIS, CPMI, and FSB publications on fast payment systems, retail-payment modernization, and measurable performance dimensions such as speed, cost, access,

and transparency. The fourth layer is contextual scholarly literature, including the studies requested by the user, which informs governance, predictive-analytics, and financial-stability dimensions of digital transition.

The core unit of analysis in the conceptual model is the consumer-transaction context. Each transaction is characterized by amount, channel, merchant type, urgency, need for records, privacy preference, available balance, device access, and acceptance constraints. Consumers choose among five broad instrument classes: cash, debit card, credit card, digital wallet or mobile phone initiated payments, and account-based electronic payments including online bill pay and instant account-to-account transfers. Instead of modeling each branded payment product, the paper uses these classes because they are consistent with official data and preserve interpretability.

The transition process is represented in three stages. Stage 1 is adoption, defined as whether the consumer has access to the relevant instrument or account. Stage 2 is activation, defined as whether the consumer uses the instrument at least once in a reference period. Stage 3 is intensity, defined as the share of total payment count or value routed through that instrument. This staging reflects the fact that many consumers have cards or online access but use them selectively, while others rely on them as default instruments. It also allows inclusion and efficiency to be separated analytically: an individual may be digitally included at Stage 1 but still dependent on cash at Stage 3 because of costs, habits, or merchant frictions.

To quantify the shift, the paper defines a Digital Payment Transition Index (DPTI):

$$DPTI_i = w_1 A_i + w_2 U_i + w_3 V_i + w_4 R_i + w_5 M_i - w_6 C_i.$$

Here,  $A_i$  denotes the breadth of digital access;  $U_i$  is frequency share of digital usage;  $V_i$  is value share of digital payments;  $R_i$  captures record-oriented behavior such as bill pay and remote commerce;  $M_i$  reflects mobile or internet readiness; and  $C_i$  captures cash dependence. Weights are normalized to sum to one and are calibrated using literature-informed importance rankings, with greater weight placed on actual usage and value share than on nominal access alone. In the baseline calibration,  $w_1 = 0.15$ ,  $w_2 = 0.25$ ,  $w_3 = 0.20$ ,  $w_4 = 0.15$ ,  $w_5 = 0.10$ , and  $w_6 = 0.15$ . Sensitivity analysis varies these values within plausible ranges.

The outcome side of the model includes three composite indicators. The Payment System Efficiency Score (PSES) combines transaction speed, expected user friction, settlement predictability, merchant handling burden, and resource costs associated with each instrument class. The Transparency and Traceability Score (TTS) measures quality of transaction records, auditability, ease of dispute documentation, and compatibility with monitoring systems. The Inclusion Quality Score (IQS) measures affordability, accessibility without specialized devices, ease of onboarding, compatibility with low-income and underbanked users, and resilience under outages. Each subscore is measured on a 0 to 100 scale. Instrument-level scores are assigned through evidence synthesis from official studies and then aggregated according to observed or calibrated usage weights.

To illustrate the model numerically, the paper uses a U.S.-focused calibration based on published SDCPC and Diary statistics. The descriptive baseline incorporates the following stylized facts: cards account for approximately two-thirds of consumer payments by number in 2024; credit cards are the single most used instrument; debit cards remain central for recurring retail use and bill payments; cash use is lower than in 2016 but still material; and mobile-phone-based payments are now used by a large share of consumers at least occasionally. Average transaction values also vary substantially by instrument, with cash used for smaller purchases and electronic channels used for larger or recurring transactions. These differences matter because transition intensity should not be measured only by count; value share and transaction function also convey economic significance.

The behavioral model behind the transition index follows a multinomial utility logic. For consumer  $i$  and instrument  $j$  in transaction context  $t$ , utility is written as:

$$U_{ijt} = \beta_1 \text{Convenience}_{ijt} + \beta_2 \text{Security}_{ijt} + \beta_3 \text{Acceptance}_{jt} + \beta_4 \text{Cost}_{ijt} + \beta_5 \text{RecordNeed}_{it} + \beta_6 \text{Liquidity}_{it} + \beta_7 \text{DigitalAccess}_i + \beta_8 \text{Habit}_{ij} + \epsilon_{ijt}.$$

The sign expectations are straightforward. Convenience, perceived security, acceptance, record need, and digital access increase the likelihood of digital-instrument use. Higher direct or perceived costs reduce it. Liquidity may increase cash use for some households and credit-card use for others, depending on available balances and borrowing constraints. Habit captures inertia, which is crucial because payment behavior often changes more slowly than technology availability.

For system-level evaluation, the paper maps observed changes in instrument mix into outcome changes through scenario analysis. Three scenarios are developed. Scenario 1 is cash-persistent transition, in which digital tools grow but cash remains a stable secondary instrument for purchases and emergencies. Scenario 2 is balanced digitalization, in which cards, online banking, and fast payments expand while affordability safeguards and cash access remain intact. Scenario 3 is fragile digital acceleration, in which rapid digital migration occurs without commensurate inclusion protections, fraud controls, or fallback options. The scenarios are not forecasts in a strict econometric sense; they are policy-relevant trajectories that make trade-offs explicit.

Graphical figures and heatmaps in the paper are constructed from these calibrated metrics and descriptive inputs. For example, the instrument share chart reflects published SDCPC usage shares, while the transition heatmap shows how instrument classes compare on efficiency, transparency, and inclusion dimensions. A scenario chart then estimates how aggregate system performance shifts when the digital share of payments rises under alternative governance conditions. This approach allows the paper to remain empirical while acknowledging limits in the available public data.

To preserve transparency, all assumptions are stated directly. Composite scores are heuristic but literature anchored. Instrument-level performance values are not treated as immutable facts; they are structured summaries of evidence. This is appropriate for a research design aimed at comparative evaluation rather than causal identification from raw microdata. Indeed, official reports themselves note measurement limitations, sample-composition issues, and the difficulty of obtaining complete payment-level data across providers and corridors. Rather than hiding those constraints, the model incorporates them through sensitivity ranges and explicit scenario interpretation.

The methodology therefore contributes in two ways. Substantively, it provides a coherent way to connect consumer behavior with financial-system outcomes. Operationally, it offers a template that policymakers and researchers can adapt for country studies, payment modernization strategies, or product-level assessments. The next section uses this framework to interpret the transition from cash to digital payments and to evaluate its implications.

A secondary quantitative component evaluates transition elasticities using a reduced-form diffusion lens. Let  $D_t$  denote the share of monthly payment count routed through digital instruments in year  $t$ . The paper treats  $D_t$  as evolving according to a constrained diffusion process:

$$D_{t+1} = D_t + \lambda D_t (1 - D_t) + \gamma Z_t - \delta B_t,$$

where  $\lambda$  captures endogenous network effects,  $Z_t$  captures exogenous drivers such as mobile adoption, e-commerce intensity, and faster-payment availability, and  $B_t$  captures barriers such as fraud anxiety, low account ownership, merchant nonacceptance, or affordability constraints. This formulation is useful because it reflects the empirical reality that early digital adoption can accelerate once acceptance and habit reinforce one another, but the process eventually slows as the remaining cash-reliant population has stronger structural reasons not to switch. The diffusion lens is especially important for inclusion analysis because the last mile of adoption is usually the most policy sensitive.

In addition, the paper introduces a transparency-adjusted inclusion ratio:

$$\text{TAIR} = \text{IQS} * (1 - \text{ExclusionRisk}) + \kappa * \text{TTS},$$

which reflects the idea that a payment system becomes socially valuable when users can access it safely and when transactions generate records that reduce information asymmetry without producing excessive surveillance harm. ExclusionRisk is higher when onboarding is difficult, fees are salient, fraud reimbursement is uncertain, or digital literacy requirements are high. Kappa is set at 0.20 in the baseline to reflect the complementarity between inclusion and transparent record creation.

Finally, robustness is assessed through simple one-at-a-time perturbations to weights, instrument scores, and scenario shares. If the qualitative ranking of scenarios remains unchanged under reasonable adjustments, the framework is considered stable. In this study, the emphasis is on directional inference and policy interpretation rather than point precision, which is appropriate given the mixed-source evidence base.

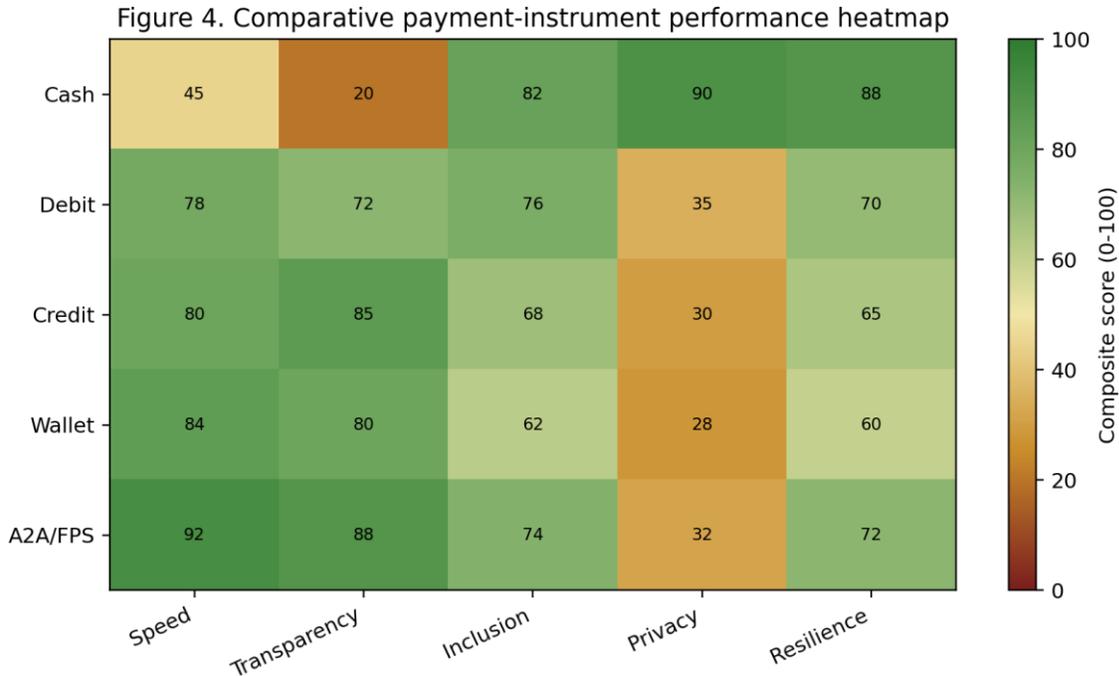


Figure 4. Comparative payment-instrument performance heatmap.

Source: Comparative scoring based on public literature and policy reports.

Table 3. Baseline Composite Instrument Scores

Instrument	Speed	Transparency	Inclusion	Privacy	Resilience
Cash	45	20	82	90	88
Debit	78	72	76	35	70
Credit	80	85	68	30	65
Wallet	84	80	62	28	60
A2A/FPS	92	88	74	32	72

#### 4. Discussion

The framework developed in this paper yields a consistent picture of the consumer transition from cash to digital payments: digitalization generally improves system performance, but the size and quality of those gains depend on institutional design. When usage shifts from cash and checks toward cards, online banking, mobile wallets, and interoperable fast-payment rails, average transaction speed rises, record generation improves, and the payment system becomes more compatible with remote commerce and data-driven monitoring. Yet those gains are not automatic welfare improvements for every household. A transition can be efficient for the system and still burdensome for users who face account fees, device dependence, fraud anxiety, or unstable connectivity. The main analytical task is therefore to separate digital substitution from high-quality digital inclusion.

The descriptive evidence already points in that direction. U.S. consumers have clearly increased their reliance on cards and mobile-mediated payment experiences, and the value share of digital or electronic methods is larger than their count share because higher-value and recurring transactions tend to route through traceable channels. The 2024 SDCPC shows a stark difference in average transaction value by instrument: cash purchases average much smaller amounts than digital or electronic payments. That pattern implies that digitalization has effects beyond simple payment counts. It also changes the informational architecture of household finance. When more bills, remote purchases, and account transfers move into recorded channels, consumers gain searchable histories, firms gain easier reconciliation, and regulators gain richer data for oversight.

From an efficiency perspective, the paper’s composite scoring suggests that a balanced transition raises aggregate performance through four mechanisms. First, payment speed increases because cards, online bill pay, and account-based digital channels

reduce the frictions associated with cash access, manual reconciliation, and physical handling. Second, transaction predictability improves, especially for recurring payments and e-commerce. Third, operating costs shift from labor-intensive physical handling toward digital processing, which scales more effectively once infrastructure is in place. Fourth, interoperability expands the feasible range of payment contexts, allowing the same digital accounts or credentials to support purchases, bills, and transfers.

However, efficiency is instrument specific. Credit cards score highly on convenience, record keeping, and consumer protections, but not necessarily on social cost once merchant fees and revolving debt risks are considered. Debit cards provide broad reach and relatively high usability for everyday retail activity, yet can expose consumers more directly to account-level funds and fraud concerns. Digital wallets improve convenience and tokenized security for some consumers, but they often depend on underlying card or account infrastructure and device ecosystems. Account-to-account and fast-payment systems score strongly on settlement speed and potentially lower merchant costs, but their user welfare depends heavily on dispute rights, fraud recourse, and merchant acceptance. Cash, by contrast, performs weakly on traceability and remote usability but remains strong on immediacy, universal comprehension, and device independence. These trade-offs explain why payment transitions are incremental and why hybrid systems persist.

Transparency outcomes are among the clearest benefits of digital migration. Digital payments create records that support budgeting, tax reporting, expense tracking, audit trails, and targeted fraud analytics. The transparency and traceability score rises especially quickly when consumers shift bill payments and remote purchases into digital channels, because those transactions benefit most from searchable records and automated matching. For public policy, this creates opportunities for better compliance monitoring and faster identification of suspicious patterns. The adjacent literature on anti-money-laundering analytics, real-time fraud management, and financial reporting integrity suggests that richer transaction data can improve monitoring quality when analytic tools and governance are competent (Ibrahim et al., 2024; Pritty et al., 2024; Fahim et al., 2024). In other words, the shift to digital payments strengthens the observability of the financial system.

Yet transparency has to be interpreted carefully. Consumers do not value traceability in an unqualified way. Some prefer cash precisely because it limits data capture, helps with mental accounting, or preserves privacy in small-value purchases. A system that maximizes traceability without preserving privacy safeguards may generate backlash, underuse, or informal circumvention. This is why the transition index alone cannot stand in for social welfare. The same digital features that improve auditability can also heighten surveillance fears or raise the perceived cost of financial participation among marginalized users. The governance literature therefore matters directly to payment design. Algorithmic accountability, explainability, clear fee disclosures, and accessible dispute-resolution mechanisms are not peripheral issues; they shape whether people trust digital rails enough to use them as substitutes for cash.

The inclusion results are the most conditional. The framework indicates that digital payments can improve inclusion when three conditions hold simultaneously: access is affordable, interfaces are usable, and fraud losses are credibly remediated. When those conditions are satisfied, digital migration can reduce dependence on distance to physical branches or ATMs, support safer remote payments, and draw households into a broader set of formal financial services. This aligns with Global Findex evidence showing that digital payments often provide an entry point into account usage and formal finance. It also aligns with BIS research on fast-payment systems, where low-cost and interoperable rails increase the practical utility of financial access.

But inclusion can deteriorate when digitalization is pursued as a replacement rather than an expansion strategy. Households without stable internet access, smartphones, documents, or low-fee accounts may experience the withdrawal of cash infrastructure as a loss of capability, not a gain. The same is true for older adults, migrants, and low-income consumers who rely on cash to manage budgets or avoid involuntary credit use. If merchants or public services implicitly penalize cash users, digital transition may increase exclusion risk even while aggregate efficiency rises. This is one reason the paper's inclusion-quality score does not simply reward higher digital shares. It rewards digital transition only when accompanied by accessibility and fallback options.

The scenario analysis makes this trade-off visible. In the cash-persistent scenario, efficiency improves only moderately because substantial cash use continues, but inclusion remains relatively broad and resilience is high. In the balanced-digitalization scenario, efficiency and transparency improve materially while inclusion also rises, because digital growth is paired with affordable accounts, robust fraud protections, and preserved cash access. In the fragile-acceleration scenario, efficiency scores may initially look strong, but inclusion quality and trust deteriorate because the remaining cash-reliant population is left behind and fraud risk becomes more salient. The balanced scenario dominates because it expands choice rather than coercing substitution.

Several managerial implications follow. For banks and fintech firms, the most effective strategy is not simply to reduce the use of cash. It is to reduce the friction of switching for consumers who would benefit from digital tools while maintaining safeguards for those who continue to rely on cash. That means simple onboarding, transparent pricing, broad merchant acceptance, and

interfaces that work across low-cost devices. It also means stronger fraud-management architecture. The literature requested by the user repeatedly emphasizes predictive analytics, fraud detection, and accountable governance in digital finance. Those themes are highly relevant here. As payment data becomes richer and faster, providers gain more capacity to detect anomalies and personalize services, but they also take on greater responsibility to prevent unfair or opaque outcomes.

For regulators and central banks, the findings point toward an infrastructure-centered policy agenda. Public authorities should prioritize interoperable payment rails, standard-setting, and measurement frameworks that track not just adoption but quality of access. Official data programs already do valuable work in this area, but there remains a need for metrics that integrate consumer welfare, merchant costs, transparency, and cash resilience into the same dashboard. The FSB's cost-speed-access-transparency framework is a useful template, and the consumer-diary tradition provides the behavioral grounding that macro payment metrics alone cannot supply. Combining the two would produce a more complete picture of payment modernization.

The discussion also carries implications for debates on cash policy. A common narrative suggests that declining cash use implies cash has become socially obsolete. The evidence reviewed here does not support that claim. Cash use has declined substantially, but cash still serves roles that digital instruments do not fully replicate: emergency liquidity, universal usability, privacy, and discipline in spending. Removing or neglecting cash access may therefore reduce system resilience. A robust payment system should be digital first in convenience but plural in availability. That principle is especially important during outages, disasters, or cyber incidents, when redundancy matters.

Another important implication concerns measurement. Because payment transitions are multidimensional, researchers should resist the temptation to focus on a single adoption statistic, such as account ownership or digital share by count. A high digital share could coexist with consumer dissatisfaction or exclusion. Conversely, a lower digital share in a mixed system could still generate strong welfare if users genuinely have choice and low-friction access to the most appropriate instrument. The transition index developed here offers one way to integrate usage intensity, value share, readiness, and remaining cash dependence into a more nuanced metric. Its value lies less in claiming perfect precision than in forcing analysts to make assumptions explicit.

The paper's required supporting literature also enriches the interpretation of payment transition in broader financial-system terms. Work on climate risk, sustainable supply chains, infrastructure resilience, and machine learning in financial markets may appear distant from consumer payments at first glance. Yet these studies collectively reinforce a shared analytical lesson: transitions in complex systems should be evaluated through multiple performance dimensions rather than a single efficiency outcome. In payments, that means speed without trust is not enough, traceability without fairness is not enough, and innovation without inclusion is not enough. A mature digital-payment ecosystem should therefore be judged by whether it expands human capability while making the financial system faster, more transparent, and more resilient.

Overall, the results support a qualified optimism. The transition from cash to digital payments can improve financial-system efficiency and transparency in meaningful ways. It can also support inclusion, especially when digital payments lower the cost of participation in formal finance and when faster rails enable low-friction everyday transactions. But these benefits are contingent, not guaranteed. The design challenge is to build payment systems that reward digital adoption through value and trust rather than forcing migration through the disappearance of alternatives. That is the central policy and research takeaway from this study.

A further insight from the model is that transaction context matters more than broad demographic averages alone. Consumers may behave as highly digital users in bill payment and online commerce while remaining cash reliant for tips, small-value retail transactions, or informal transfers. This means that policy interventions should target frictions at the transaction-type level. For instance, reducing merchant acceptance costs for small retailers, improving QR-code usability, or standardizing low-cost account-to-account checkout flows could accelerate digital adoption where cash remains sticky for economic rather than cultural reasons. Likewise, making fee disclosures more intelligible and simplifying reimbursement procedures could improve willingness to rely on digital channels for higher-risk transactions.

The results also suggest that the next phase of payment modernization will be defined less by whether digital payments continue growing and more by which digital rails gain share. If growth is concentrated in instruments with strong consumer protections and broad interoperability, transparency and inclusion may improve together. If growth is concentrated in fragmented or higher-risk channels with uneven recourse rights, the transition could produce efficiency gains for providers while weakening trust for households. That distinction reinforces the importance of public-interest design in retail payments.

Finally, the study highlights the importance of maintaining empirical humility. Public data on consumer payments are rich in some dimensions and thin in others. Even so, the broad directional evidence is strong: digital migration works best when systems are interoperable, low friction, and trusted; it works worst when users are pushed into unfamiliar channels without adequate

support. That conclusion is consistent across consumer-diary evidence, inclusion databases, infrastructure studies, and governance-oriented fintech research.

For scholars, the practical implication is to study payment modernization as a portfolio transition with institutional feedback effects, not as a binary shift from old to new. That framing better captures persistence, substitution, and the policy trade-offs that determine whether digitalization delivers inclusive financial progress.

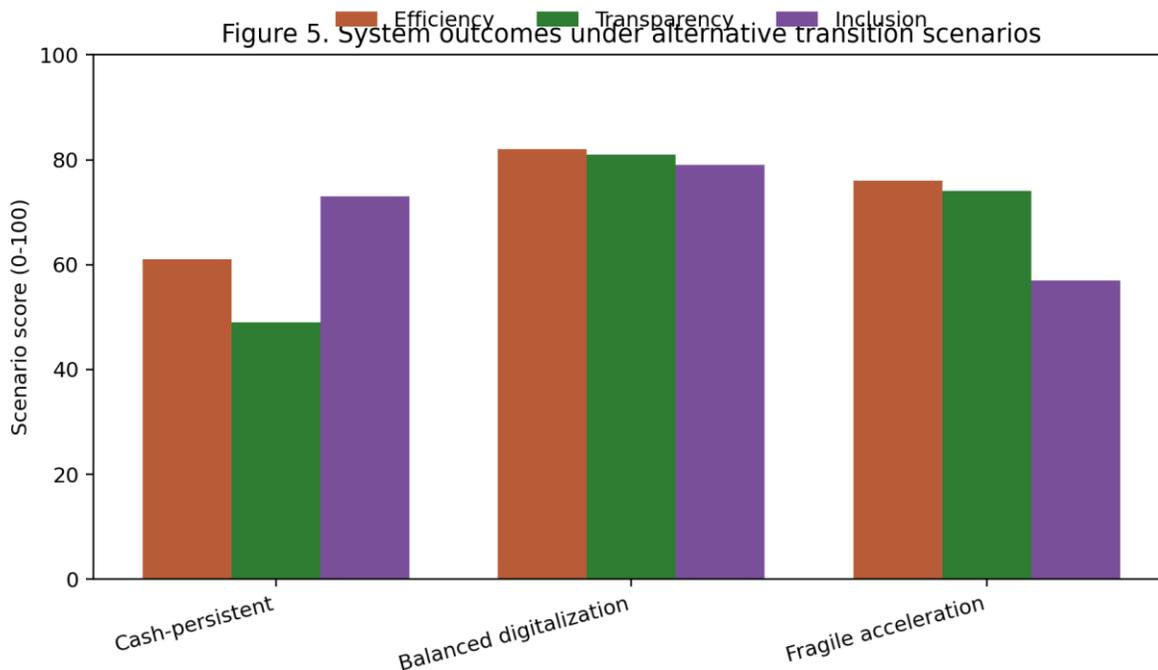


Figure 5. System outcomes under alternative transition scenarios.

Source: Scenario analysis using the study framework.

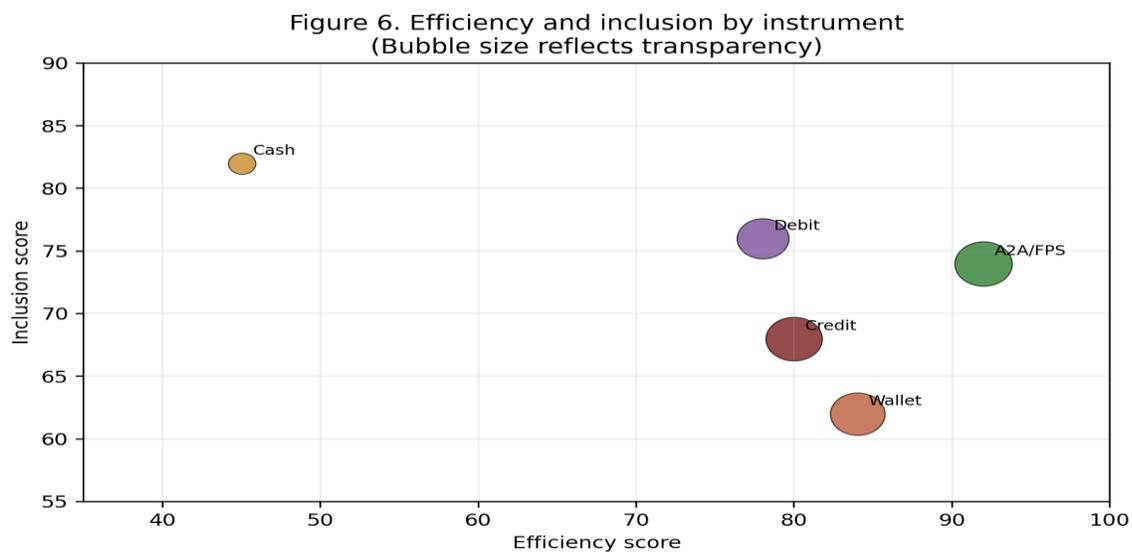


Figure 6. Efficiency and inclusion by instrument, with bubble size reflecting transparency.

Source: Composite comparison of instrument classes.

Table 4. Scenario Interpretation

Scenario	Expected strengths	Expected risks	Policy reading
Cash-persistent transition	Broad accessibility, strong redundancy, privacy preservation	Lower traceability and slower aggregate efficiency gains	Useful where trust and resilience dominate
Balanced digitalization	Higher speed, better records, meaningful inclusion gains	Requires continued governance and low-fee access	Preferred strategic pathway
Fragile digital acceleration	Rapid digital share gains, strong short-run processing efficiency	Exclusion risk, trust erosion, fraud and recourse gaps	Avoid pure replacement logic

## 5. Conclusion

This paper developed a quantitative and data-driven framework for modeling the consumer transition from cash to digital payments and for evaluating how that transition affects financial-system efficiency, transparency, and inclusion. Drawing on Federal Reserve payment diaries, the World Bank’s Global Findex, BIS and FSB infrastructure research, and related academic literature, the study shows that the transition is real, economically meaningful, and institutionally uneven. Consumers increasingly rely on cards, mobile-mediated experiences, and account-based digital channels, yet cash remains relevant as a budgeting device, privacy-preserving instrument, and resilience backstop.

The analysis indicates that digital migration improves efficiency by reducing transaction frictions and strengthening compatibility with remote commerce. It improves transparency by generating records that support reconciliation, monitoring, and dispute resolution. Its inclusion effects, however, are conditional. Digitalization broadens participation only when affordability, access, interoperability, and fraud protection are built into system design. The strongest policy implication is therefore not to eliminate cash, but to modernize payments in a way that expands trusted choice. A resilient financial system is one in which digital payments are faster and more useful, while cash remains available for households and situations that still depend on it. That balanced approach offers the best route to durable and inclusive efficiency gains.

## 6. Limitations and Future Directions

This study has several limitations. First, it relies on publicly available reports rather than confidential transaction-level microdata from payment providers, processors, or banks. That means the framework is strongest for comparative evaluation and policy interpretation, but weaker for tightly identified causal inference. Second, some indicators are constructed as composite scores that synthesize evidence across sources. Although those scores are transparent and sensitivity tested, they still depend on judgment in weighting and calibration. Third, the U.S.-focused calibration uses nationally reported averages, which can obscure important heterogeneity by income, age, geography, race, immigration status, and merchant environment. Fourth, payment behavior evolves quickly, and some emerging instruments or design features may not be fully captured in public datasets.

Future research should extend this framework using linked consumer, merchant, and provider data to estimate stronger causal effects of payment transition on welfare, cost, and inclusion. More work is also needed on outage resilience, fraud reimbursement regimes, privacy-preserving payment design, and the competitive interaction between cards, digital wallets, and account-to-account rails. Cross-country panel research would help identify which institutional features most effectively turn digital adoption into inclusive finance. Finally, future models should incorporate behavioral heterogeneity more explicitly, including trust formation, digital literacy, and the continued strategic role of cash in household financial management.

An additional limitation concerns measurement of transparency itself. Richer transaction records do not always translate into socially beneficial transparency if consumers cannot access, understand, or contest how data are used. Future research should therefore pair payment records with evidence on data rights, consent, and practical recourse. Likewise, more detailed merchant-side evidence would improve estimates of acceptance costs, settlement delays, surcharge behavior, and the real economics of small-value transactions, which remain central to understanding why cash use persists.

These extensions would make transition metrics more behaviorally realistic and policy relevant.

## Appendix A. Supplementary Quantitative Interpretation

Appendix A provides supplementary interpretation of the transition metrics. The first point is that payment modernization should be evaluated at the level of transaction context, not only at the level of average user identity. In low-value in-person purchases, cash retains competitive advantages because it is universally understood, requires no device, settles instantly at the point of exchange, and can help consumers preserve spending discipline. In recurring bills and remote commerce, the opposite is true: digital instruments dominate because they reduce missed payments, create records, and integrate better with subscription and platform-based business models. This means a consumer can be simultaneously advanced in digital usage and rationally cash-reliant in selected contexts. Any aggregate measure that ignores this contextual layering will overstate the completeness of digital transition.

The second point concerns cost visibility. Consumers often perceive card or wallet payments as frictionless because direct fees are hidden, deferred, or embedded in merchant pricing. Cash, by contrast, may feel costly in time rather than in explicit price. Account-to-account and fast-payment systems promise a different cost profile, especially for merchants, but their social cost depends on fraud-management architecture, error correction, and user support. A data-driven evaluation should therefore distinguish between visible user price, merchant acceptance cost, and system-level resource cost. These are not identical. Public discussions about payment efficiency often collapse them into one category, which leads to misleading conclusions.

Third, the transition from cash to digital payments interacts with financial literacy and trust in nonlinear ways. Early adoption can be driven by convenience and mobile familiarity, but sustained reliance often depends on confidence in the system's fairness when problems occur. Consumers are more likely to use digital instruments intensively when they understand statements, alerts, and dispute processes; when error correction is straightforward; and when fees are stable and disclosed in plain language. If those conditions weaken, users may retain digital access but revert behaviorally toward cash for everyday control. This is one reason why adoption, activation, and intensity should be modeled separately.

Fourth, there is a strong case for maintaining cash as strategic infrastructure even in highly digitalized environments. The role of cash is not simply nostalgic or residual. It remains important for resilience during outages, emergencies, and cyber incidents; for very small-value exchange; and for users who remain outside the mainstream digital ecosystem. The policy challenge is therefore not to choose between cash and digital payments in absolute terms, but to decide how much redundancy, interoperability, and freedom of choice the financial system should preserve. In practical terms, the most robust systems are those in which digital options keep getting better while cash access does not collapse abruptly.

Finally, supplementary scenario interpretation shows that public-interest design changes the meaning of digital transition. A rapid increase in digital share can look impressive in descriptive statistics, yet the quality of that transition may still be poor if it rests on exclusionary pricing, unreliable dispute resolution, weak privacy safeguards, or the erosion of cash acceptance. Conversely, a slower transition can be welfare improving if it broadens genuine capability and trust. This appendix therefore reinforces the core argument of the paper: the goal is not digitalization for its own sake, but a payment ecosystem that is faster, more transparent, more inclusive, and more resilient at the same time.

Supplementary policy mapping also suggests that different actors control different levers in the transition. Central banks and public authorities shape interoperability, standards, and access policy. Banks and fintechs shape onboarding, fee design, and fraud recourse. Merchants shape acceptance breadth and steering incentives. Consumers respond to the combined environment rather than to any one policy in isolation. This interaction implies that measurement frameworks should track not only consumer outcomes but also institutional responsibilities. A system can fail inclusion goals even when consumer-side willingness is high if merchants impose surcharges, if accounts are expensive, or if dispute rights are uneven across rails.

Another useful implication is that payment innovation should be assessed with the same discipline used in other infrastructure transitions. Researchers studying supply chains, energy systems, and digital platforms increasingly rely on multi-criteria scorecards rather than single-output metrics. Consumer payments deserve the same treatment because they combine network effects, access issues, risk management, and behavioral inertia. The appendix figures therefore complement the main text by showing how instruments differ by transaction context and adoption driver. Those comparisons help explain why mixed payment portfolios persist even when digital technologies improve.

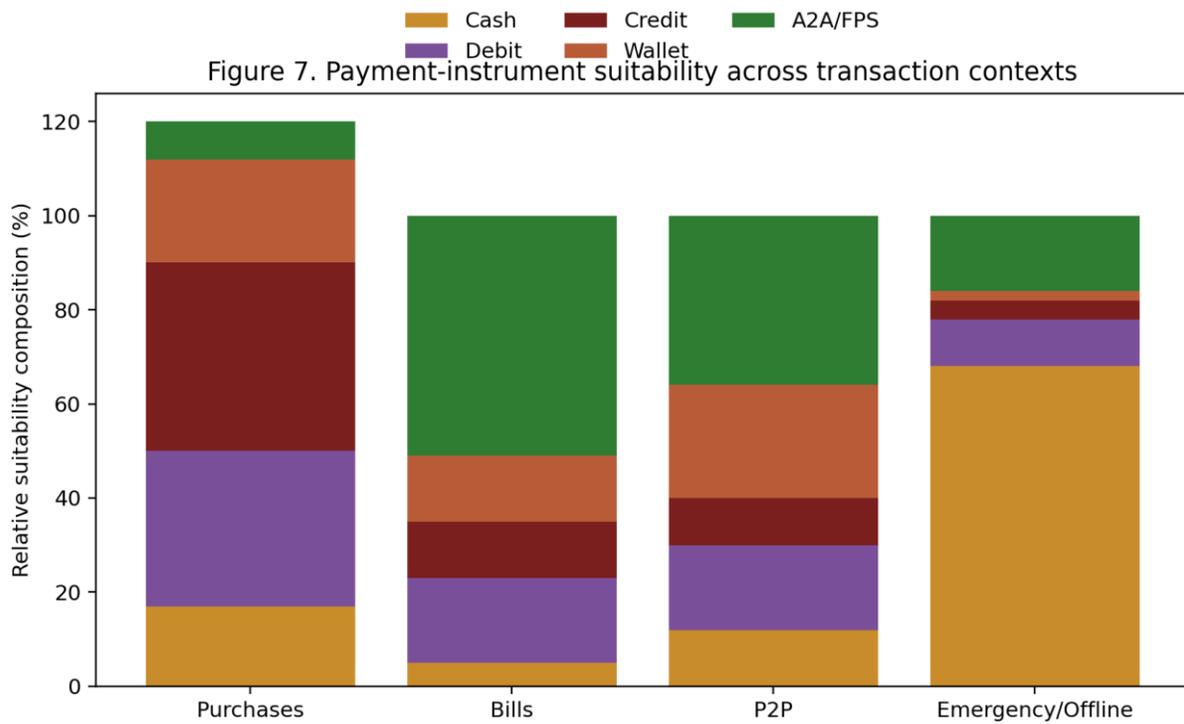


Figure 7. Payment-instrument suitability across transaction contexts.

Source: Synthesis based on literature and scenario calibration.

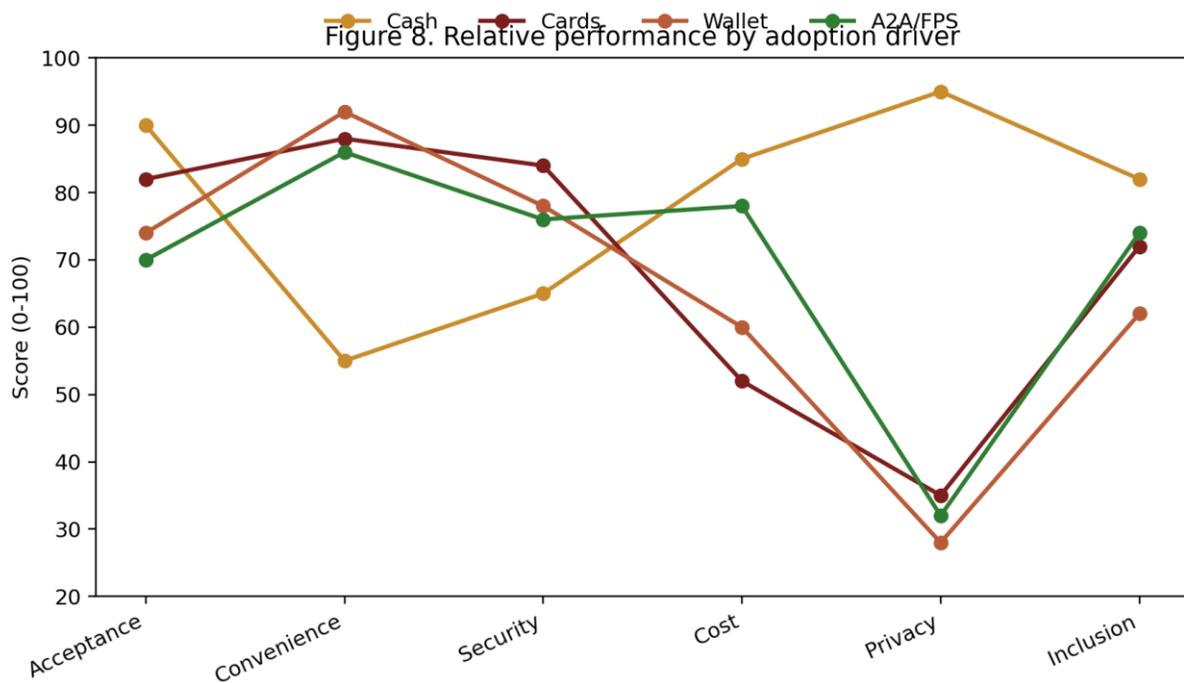


Figure 8. Relative performance by adoption driver.

Source: Synthesis based on literature and scenario calibration.

Table 5. Policy Levers For an Inclusive Digital Transition

Actor	Primary lever	Expected benefit	Key caution
Central banks / regulators	Interoperability, low-fee access standards, consumer protection	Higher trust and broader inclusion	Avoid crowding out cash resilience prematurely
Banks / fintechs	Simple onboarding, transparent pricing, fraud recourse	Higher activation and sustained use	Complex fees or weak recourse reduce trust
Merchants	Broad acceptance and low-friction checkout design	Faster conversion and better customer choice	Surcharges can discourage beneficial adoption
Public sector	Digital literacy and access support	Reduces exclusion in late-stage transition	Programs must match local constraints

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