Stablecoins as Tokenized Money *

Lin William Cong[†] Gordon Liao[‡] Eswar Prasad[§] Tony Zhang[¶]

Abstract

We document five facts about payment stablecoins using granular blockchain data from 2020 to 2025. First, stablecoins are functioning as a transaction currency: their onchain transaction volume now exceeds Bitcoin's despite a far smaller outstanding supply, their velocity has risen sharply, and their transaction-size distribution has shifted toward small-value transfers. Second, we develop a Bayesian refinement of the standard visitor-share attribution methodology that uses transaction-timing data to help geolocate individual wallets. This approach shows that stablecoin activity is distributed broadly across the Americas, Europe, and Asia, but that standard methods substantially overstate the cross-regional share of flows. Third, we estimate a structural model of cash management on stablecoin transaction data and find that the typical stablecoin wallet operates on quantitative terms comparable to traditional cash holdings in terms of wallet replenishment opportunities and estimated transaction costs. Fourth, stablecoins are becoming the settlement currency for a rapidly expanding onchain credit market in which lending terms are enforced by rule-based smart contracts rather than by intermediary discretion; balance-sheet accounting disciplined by reserve and currency data indicates that stablecoins' growth reallocates rather than destroys credit. Fifth, stablecoins support programmable, machine-initiated payments: smart contracts participate in roughly a third of stablecoin transactions and over two-thirds of transfer volume on Ethereum, and early agentic-payment protocols such as x402 demonstrate machine-to-machine commerce at sub-cent transaction sizes. Together, these facts suggest that stablecoins are behaving as tokenized money. We discuss implications for traditional financial markets and the design of regulatory frameworks.

JEL classification: E41, E42, E51, G21, G23, O33.

Keywords: Stablecoins, digital payments, cash management, money demand, decentralized finance, onchain credit, blockchain, programmable payments, agentic commerce

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[†]Nanyang Technological University, ABFER, CEPR, and NBER. Email: will.cong@ntu.edu.sg.

[‡]Circle LLC. Email: gordon@circle.com.

[§]Cornell University. Email: eswar.prasad@cornell.edu.

[¶]Arizona State University, W.P. Carey School of Business. Email: tony.zhang@asu.edu.

1 Introduction

Stablecoins are digital currencies recorded on blockchains that maintain a stable value relative to a unit of account, typically fiat currencies such as the U.S. dollar. Unlike volatile cryptocurrencies such as Bitcoin and Ether, stablecoins are designed to serve as a store of value and a medium of exchange on public blockchains, effectively functioning as tokenized money. Their programmability also gives them a central role in the growing decentralized finance (DeFi) ecosystem.

Our focus in this paper is on fiat-backed stablecoins, which have gained significant traction in recent years. Fiat currency-backed stablecoins are backed by reserves of safe, liquid assets denominated in major fiat currencies.[1] As of December 2025, the two largest such stablecoins had a combined market value exceeding US$260 billion. These stablecoins are USDT, which is issued by Tether, and USDC, which is issued by Circle. Because fiat-backed stablecoins do not pay interest and maintain their value at par relative to fiat currency, they are often used solely for payments.

This paper represents the first comprehensive analysis of stablecoin usage patterns using wallet-level blockchain data from 2020 to 2025. The richness of this dataset allows us to classify transactions by size and function, and to compare stablecoin performance against traditional payment methods on dimensions such as cost and turnover.

A central question in the public discourse is whether stablecoins serve a legitimate economic purpose beyond cryptocurrency speculation. Prior work has documented a decline in the speculative use of stablecoins and an increase in their use as general-purpose tokenized money (Liao, Hadeed, and Zeng 2023). We extend this analysis by presenting new facts about the growth in use cases, geographic reach, and financial infrastructure emerging around stablecoins. A second ques-

[1] Other varieties include algorithmic stablecoins, whose supply adjusts algorithmically to maintain their peg, and commodity-backed stablecoins backed by assets such as gold and bitcoin.

tion concerns displacement: whether money migrating onto blockchain rails drains bank deposits and shrinks the credit they fund. The balance-sheet accounting developed in Fact 4 addresses this concern directly and finds little support for it.

We document five facts about the stablecoin market:

1. **Stablecoins are functioning as a transaction currency.** Stablecoin onchain transaction volume now exceeds Bitcoin's despite a far smaller outstanding supply, and stablecoin velocity has risen sharply while Bitcoin's has remained flat. The transaction-size distribution has also shifted: by 2025, 36 percent of stablecoin transactions were below one dollar, a pattern that coincided with sharply lower transfer costs on Ethereum and on lower-cost layer-2 networks and alternative chains; the same cost decline underpins the machine-scale payment applications documented in Fact 5. Wallet composition has shifted in parallel toward payment-oriented users and away from exchange-affiliated and trading wallets.

2. **Stablecoins have a global geographic footprint.** Stablecoin transaction volume is broadly distributed across the Americas, Europe, and Asia, with each major region accounting for roughly a third of wallet-to-wallet flows. Using a Bayesian refinement of the standard visitor-share geographic attribution methodology that incorporates circadian transaction timing patterns, we show that the industry-standard approach overstates the cross-regional share of flows by 15–22 percentage points. The corrected estimates indicate that the majority of volume flows within regions, consistent with domestic payments and savings use cases. The data also reveal a persistent hub-and-spoke pattern in which the Americas is a net sender of stablecoins to both Europe, Middle East, and Africa (EMEA) and Asia Pacific (APAC), alongside a pronounced migration of stablecoin balances toward APAC: APAC's share of end-of-month balances rises from 16 percent in 2022 to 42 percent in 2025, while the Americas' share falls from 58 to 31

percent.

3. **Stablecoin wallet usage resembles traditional cash management.** Stablecoin wallet behavior closely resembles traditional cash management: owners hold balances to meet liquidity needs, periodically deposit funds when balances run low, and maintain precautionary reserves. Estimating the structural cash-management model of Alvarez and Lippi 2009 at quarterly frequency, we find that stablecoin owners are gaining more frequent and cheaper access to onchain payment rails since 2023.

4. **Onchain credit markets denominated in stablecoins are expanding.** Stablecoins serve as the settlement currency for a rapidly growing onchain credit market: outstanding loans on secured lending protocols have roughly quadrupled over the past two years, and unsecured onchain lending to institutional borrowers, though smaller, has grown even faster. Tokenization supplies credit through two channels familiar from traditional finance: collateralized lending against tokenized assets, and market-based credit provision in which risk is priced by market forces. Lending terms are enforced by rule-based smart contracts rather than by intermediary discretion, which reduces the scope for moral hazard in credit intermediation when protocol rules are set appropriately. A one-dollar balance-sheet exercise further shows that issuance relabels deposits rather than destroying them; bounds disciplined by reserve disclosures and by currency-in-circulation data imply deposit effects that are economically negligible and, at central readings, mildly positive.

5. **Stablecoins enable programmable, machine-initiated payments.** Because stablecoins settle on programmable ledgers, payments can be initiated by software as well as by people. In 2025, 35 percent of Ethereum stablecoin transactions and 69 percent of transfer volume involved a

smart contract such as an automated market maker, a lending protocol, or a custody and settlement contract, and half of all active stablecoin wallets transacted with a contract during the year. These contracts are overwhelmingly financial: lending protocols, the credit infrastructure of Fact 4, account for a third of contract-involved volume, while payments-and-commerce contracts account for just 0.1 percent, so the programmable layer has so far automated finance rather than commerce. On top of this programmable base, agentic-payment protocols such as x402 begin to fill that gap, extending machine-initiated payments to autonomous AI agents transacting at sub-cent denominations, a use case that conventional payment rails cannot serve and whose relevance is rising with the spread of agentic AI workflows.

These five facts together suggest that stablecoins are emerging as a form of tokenized money. We close with a discussion section that situates the empirical findings in two broader contexts: the implications of stablecoin growth for traditional financial markets, particularly bank deposit funding and the short-dated U.S. Treasury market; and the design of regulatory frameworks across jurisdictions, where recent legislative developments such as the GENIUS Act in the United States and the EU's Markets in Crypto-Assets (MiCA) regulation have begun to define the scope of permissible stablecoin issuance and reserve composition.

1.1 Related Literature

A growing literature examines cryptocurrencies and digital assets, though much of it focuses on volatile cryptocurrencies as an asset class and their price dynamics. Rogoff 2017 offers a critical perspective on the long-term viability of cryptocurrencies given their inherent volatility and the lack of a stable monetary anchor. Cong, Tang, and Zhao n.d. documents segmentation across token categories and explains the cross-section of cryptocurrency returns through a 4-factor model.

Makarov and Schoar 2022 examine the extent to which cryptocurrencies facilitate cross-border capital movements and the associated regulatory implications.

Research on stablecoin design and peg stability has advanced rapidly. Lyons and Viswanath-Natraj 2023 study the mechanisms that maintain Tether's price stability, finding that migration to Ethereum and decentralization of issuance enhanced arbitrage efficiency and reduced peg deviations. Gorton and Zhang 2023 draw parallels between stablecoins and nineteenth-century bank notes, arguing that stablecoins face similar challenges and proposing regulatory options to mitigate stability risks. Gorton, Ross, and Ross 2022 develop a framework for understanding how privately issued instruments acquire "moneyness," demonstrating that most stablecoins remain distant from true no-questions-asked status due to redemption frictions and issuer risk. Liu, Makarov, and Schoar 2023 provide a detailed account of the Terra-Luna collapse, showing how the failure of an algorithmic stablecoin resembled a traditional bank run. Ante et al. 2023 provide a systematic review of empirical research on stablecoins, identifying key themes including peg stability, safe-haven characteristics, and interconnections with other crypto assets.

Several papers examine the financial stability implications of stablecoins. Anadu et al. 2023 show that stablecoins, like money market funds, are prone to runs and flight-to-safety behavior, with investors selling riskier stablecoins and moving into those backed by safer assets during periods of crypto market stress. Ma, Zeng, and Zhang 2025 find that stablecoins rely on a centralized arbitrage structure and demonstrate a trade-off: expanding the set of arbitrageurs improves price stability but makes panics more likely. Aldasoro et al. 2025 explore how stablecoins respond to shocks from both cryptocurrency markets and monetary policy, finding that stablecoin market capitalization shrinks when monetary policy tightens. An important insight from this literature is that stablecoin stability depends critically on reserve composition and the functioning of the primary issuance and

redemption market, rather than solely on secondary market trading dynamics.

Our analysis of the geographic distribution of stablecoin activity relates to research on cross-border crypto flows and currency competition. Graf von Luckner, Reinhart, and Rogoff 2023 use peer-to-peer Bitcoin trading data to study the geographic determinants of crypto vehicle transactions, finding that local financial market conditions—including the structure of cross-border payment systems—are associated with adoption patterns. Reuter 2025 traces the geography of stablecoin transactions, finding strong use for remittances and dollar access in Latin America and Africa, with North America showing consistent net outflows. Murakami and Viswanath-Natraj 2025 model the macroeconomic implications of stablecoin adoption in emerging market economies, finding welfare effects that depend on local monetary conditions and the degree of currency substitution. Cong and Mayer 2025 study currency competitions, including strategic digitization of fiat money using stablecoins. Most directly related to our cross-border findings, Du, Huang, and Scharfstein 2026 compare the cost and speed of cross-border payments across three competing rails—correspondent banking and SWIFT, non-bank money transmitters such as Wise and Remitly, and stablecoins—and assess whether stablecoin rails can match or undercut the existing payments architecture.

The impact of stablecoins on traditional finance has also received attention. Liao and Caramichael 2022 analyze how stablecoin adoption could affect the banking system, considering scenarios ranging from a two-tiered system that supports stablecoin issuance to a narrow banking model. They find that a two-tiered approach can maintain credit intermediation, while the replacement of physical cash with tokenized cash stablecoins could crowd in deposits to the banking system. Cong 2025 extends this analysis by examining how regulated stablecoins under frameworks like the GENIUS Act may complement rather than disrupt banking, finding that deposit erosion risks depend criti-

cally on underlying economic frictions such as deposit-rate stickiness and search costs. A parallel quantitative literature asks whether competition from central bank digital currency disintermediates banks and finds that the answer hinges on deposit market power and on banks' funding responses (Chiu et al. 2023; Whited, Wu, and Xiao 2023); we draw on this literature in Fact 4. The balance-sheet benchmark we develop there also connects to older monetary economics, including the inside–outside money distinction (Lagos 2006), classic analyses of banks and money substitutes (Tobin 1963), and equivalence results for private and public money (Brunnermeier and Niepelt 2019); the incidence of digital competition on deposit pricing echoes the deposits-channel evidence of Drechsler, Savov, and Schnabl 2017. Liao, Hadeed, and Zeng 2023 present evidence that stablecoin usage has shifted decisively away from speculative activities: the speculative trading ratio of payment stablecoins like USDC is substantially lower than that of fiat currencies used in traditional asset trading. Kosse et al. 2023 analyze the stablecoin market's evolution and find that while fiat-backed stablecoins have been less volatile, temporary deviations from par can occur during periods of secondary market stress.

Finally, because stablecoins can be viewed as a tokenized form of cash, our analysis connects to the classical literature on money demand (Tobin 1956; Baumol 1952; Baumol and Tobin 1989) and more recent work estimating cash demand in the context of technological innovation (Alvarez and Lippi 2009; Alvarez and Lippi 2014).

2 Institutional Background

This section describes the key institutional features of the stablecoin market before turning to the data used in our analysis.

Stablecoins facilitate real-time domestic and cross-border payments between consumers, businesses, and financial institutions. They serve both traditional finance applications and decentralized finance (DeFi), where blockchain technology enables transactions without traditional financial intermediaries. Stablecoins also act as a bridge between these two domains, allowing users to move seamlessly between conventional banking and onchain activity.

To maintain their peg, fiat backed stablecoin issuers hold reserves that enable redemptions at par. The composition of these reserves varies substantially across issuers, a distinction that has important implications for stability and run risk (Liao and Caramichael 2022). USDC reserves are held in two components: approximately 80 to 90 percent in short-dated US Treasuries and Treasury reverse repos, managed through the Circle Reserve Fund (an SEC-regulated government money market fund), and approximately 10 to 20 percent in cash deposits at globally systemically important banks and settlement banks.[2] This reserve structure is described in detail by (Liao, Hadeed, and Zeng 2023). Tether's reserves are more diversified: as of September 2025, approximately 77 percent is held in cash and cash equivalents (primarily US Treasury bills), with the remainder allocated to precious metals (7 percent), secured loans (8 percent), Bitcoin (5 percent), and other investments.[3] US dollar-linked stablecoins remain dominant, although stablecoins pegged to other currencies such as euros, Mexican pesos, and Australian dollars are also in circulation.

The stability of a stablecoin's peg depends on both the soundness of its reserves and the functioning of its primary market—the direct issuance and redemption channel between the issuer and authorized participants. In the secondary market, where stablecoins are traded on exchanges, temporary price deviations from par can occur, particularly during periods when the primary market

[2]See https://www.circle.com/en/transparency. USDC reserves do not contain any other assets of different risk profiles.

[3]See https://tether.to/en/transparency. Tether's reserve composition has shifted substantially toward US Treasuries in recent years.

is non-operational (e.g., outside banking hours). However, these deviations tend to be small and short-lived when the issuer's reserves are composed of highly liquid assets and the primary market functions efficiently (Liao, Hadeed, and Zeng 2023).

Similar to traditional payment networks, transaction costs on blockchain networks are not free. Transaction costs on blockchain networks take the form of "gas" fees, which are per-transaction charges that fluctuate with network congestion. These fees vary substantially across blockchains: on Ethereum, gas fees can range from a few cents to several dollars per transaction, while Layer 2 networks and alternative blockchains such as Solana and Base offer fees that are typically fractions of a cent. The level of gas fees relative to transaction size shapes the distribution of stablecoin activity across networks, with smaller-value payments gravitating toward lower-cost chains.

3 Data

Our primary dataset comprises all transactions for all wallets on the Ethereum blockchain between January 2020 and December 2025. The data are obtained directly from the Ethereum blockchain and enriched through publicly sourced address labels and wallet classification. For each transaction, we observe the participating wallet addresses, the transaction amount, the time of settlement, and the gas fee paid. We aggregate these data to a daily frequency. The geographic attribution exercise in Fact 2 and the structural cash-management estimation in Fact 3 are based on this Ethereum dataset. The aggregate market series in Fact 1 (circulation, transaction volume, and velocity) are instead constructed across all chains on which USDC and USDT circulate, using onchain data summed to a monthly frequency consistent with the methodology used by public aggregators such as DeFiLlama; Appendix A describes these aggregate series in detail. Fact 4 draws on protocol-level onchain credit

aggregates from public DeFi dashboards, and Fact 5 combines the blockchain transfer data with x402 protocol records from Dune Analytics; data construction for these series is described in Appendix A (Sections A.7, A.8, and A.10).

Although the pseudonymous nature of blockchain addresses does not allow us to identify end users directly, we can classify wallets into three broad types based on their onchain characteristics and publicly available address labels. *Externally owned accounts* (EOAs) are addresses controlled by a private cryptographic key, typically representing individuals or businesses. *Smart contract addresses* are identified from the Ethereum contract registry and include DeFi protocols, multisignature wallets, and other programmable addresses. *Exchange-affiliated addresses* are identified by combining curated address labels with exchange deposit address mappings that trace the flow of funds from individual deposit addresses to known exchange hot wallets.[4]

Our analysis focuses on holdings and transactions of the two dominant dollar stablecoins: USDC and USDT. Together, these two stablecoins account for approximately 85 percent of total dollar stablecoin circulation and over 99 percent of onchain stablecoin transaction volume as of December 2025. We observe transactions in other stablecoins, such as DAI, but exclude them from our primary analysis given their much smaller scale and different reserve structures.

For the wallet-level analyses, we restrict attention to a cohort of active stablecoin wallets. Cohort membership requires that a wallet maintain a peak stablecoin balance of at least $1,000, execute at least five stablecoin transactions during the year, and be active from the beginning of the calendar year. We further exclude transitory addresses (pass-through wallets that never hold an overnight balance) and ephemeral wallets (those whose outgoing transaction history spans fewer than three days). These filters isolate wallets engaged in sustained economic activity rather than mechanical

[4]Curated address labels are compiled from public blockchain analytics platforms, exchange disclosures, and community-maintained databases.

routing or one-off transactions. The cohort construction and all sample filters are described in detail in Appendix A.

4 Five Facts About Stablecoins

We now present five facts that characterize the stablecoin market. We begin by documenting the emergence of stablecoins as a transaction currency, then turn to their geographic distribution, and examine wallet-level usage patterns through the lens of a structural cash management model. The final two facts document the financial activities that stablecoins are beginning to support beyond person-to-person payments: a rapidly expanding onchain credit market, and a layer of programmable, machine-initiated transactions. The facts are connected rather than parallel: the transfer-cost declines documented descriptively in Fact 1 reappear as structural parameter movements in Fact 3; the geography estimated in Fact 2 disciplines the credit-creation analysis of Fact 4; and the lending protocols at the center of Fact 4 are the largest category of the machine-executed activity measured in Fact 5.

Fact 1: Stablecoins are Increasingly Used as a Transaction Currency

Although Bitcoin was originally conceived as "a purely peer-to-peer version of electronic cash" (Nakamoto 2008), it has largely evolved into a speculative store-of-value asset rather than a medium of exchange. To the extent that Bitcoin is used for transactions, it primarily serves as a vehicle currency, rather than as a final medium of payment (Graf von Luckner, Reinhart, and Rogoff 2023). Stablecoins, by contrast, are increasingly functioning as a direct transaction currency: a form of digital money that users hold, send, and receive as an end in itself.

In this section, we document this shift along four dimensions that characterize a transaction currency. First, we show that stablecoin transaction *volume* has grown rapidly and now exceeds that of Bitcoin, despite stablecoins' far smaller outstanding supply. Second, we show that stablecoins exhibit high and rising *velocity* while Bitcoin's velocity has remained low and flat, consistent with a store-of-value asset.[5] Third, we document a shift in the *transaction size distribution*: stablecoin transactions have become increasingly concentrated in small amounts since 2023, a pattern consistent with retail payment adoption that is absent for Bitcoin. Fourth, we show that the *composition of stablecoin wallets* has shifted toward payment-oriented users and away from exchange-affiliated and trading wallets. Together, these patterns suggest that stablecoins are emerging as the primary transaction currency of the digital asset ecosystem.

Circulation and Transaction Volume

The stablecoin market has experienced rapid growth in recent years. Figure 1 compares the end-of-month circulation of US dollar stablecoins (USDC and USDT combined, which together account for approximately 85 percent of all stablecoin circulation) to that of Bitcoin. Stablecoin circulation grew from $4.7 billion in January 2020 to $263.0 billion in December 2025, a 56-fold increase over six years; over the same period, Bitcoin's market capitalization grew approximately tenfold. Stablecoin circulation rose 45 percent in 2025 alone, adding $81 billion. As of December 2025, stablecoin circulation stood at roughly 15 percent of Bitcoin's market capitalization.

Transaction volume growth has been even more rapid, and Figure 2 shows it separately for USDC and USDT. Combined monthly stablecoin volume rose from approximately $24 billion in January 2020 to $6.2 trillion in December 2025, more than doubling over the course of 2025 alone,

[5] Velocity is defined as the ratio of transaction volume to circulation.

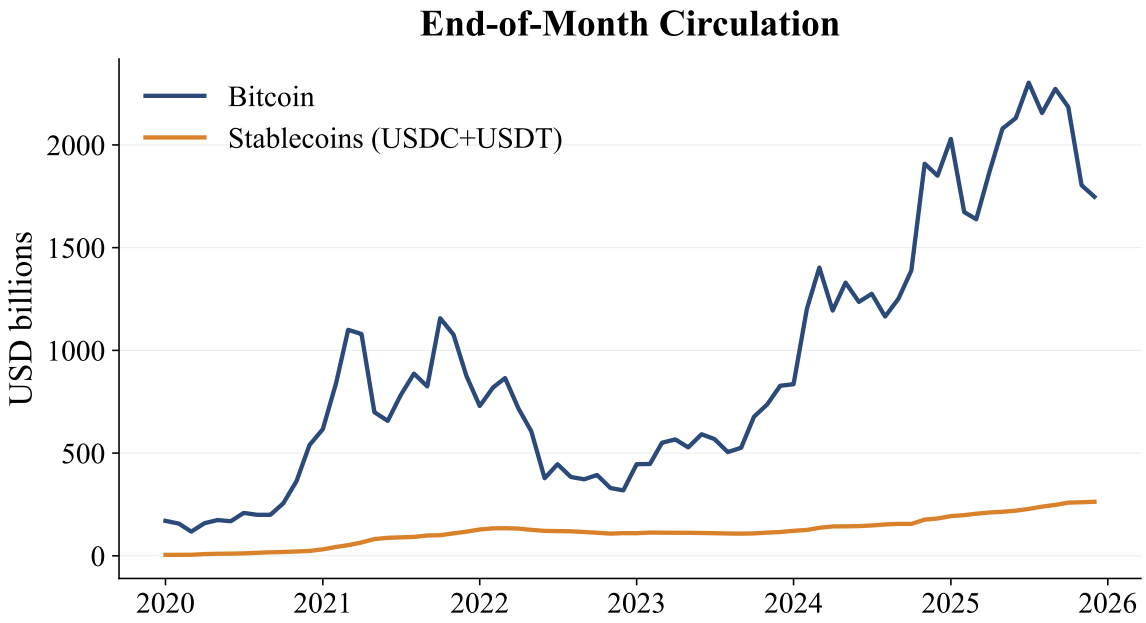


Figure 1: **End-of-Month Circulation.** The figure plots end-of-month circulation in USD billions for Bitcoin and for US-dollar stablecoins (USDC and USDT combined, aggregated across all chains on which they circulate). Stablecoin circulation is the onchain outstanding supply tracked from mint and burn events. Bitcoin circulation is the circulating coin supply multiplied by the month-end BTC/USD price.

and by December 2025 combined stablecoin volume was approximately four times Bitcoin's in the same month. The two stablecoins contribute unevenly: USDT led throughout the early years, but USDC monthly volume durably overtook USDT at the end of 2024 and by December 2025 was roughly three times larger ($4.6 trillion versus $1.6 trillion).[6] The acceleration in stablecoin volume during the second half of 2025 coincided with the passage of the GENIUS Act in July 2025, which established a federal regulatory framework for payment stablecoins.

[6] A substantial share of USDC's 2024 to 2025 volume growth is concentrated on the Base network and reflects automated market-making activity on decentralized exchanges rather than end-user payments. We report total onchain transfer volume and do not net out such activity, because this is the convention stablecoin issuers use in their own disclosures. Therefore, the level of aggregate volume should be read as gross onchain throughput rather than as a direct measure of payment activity.

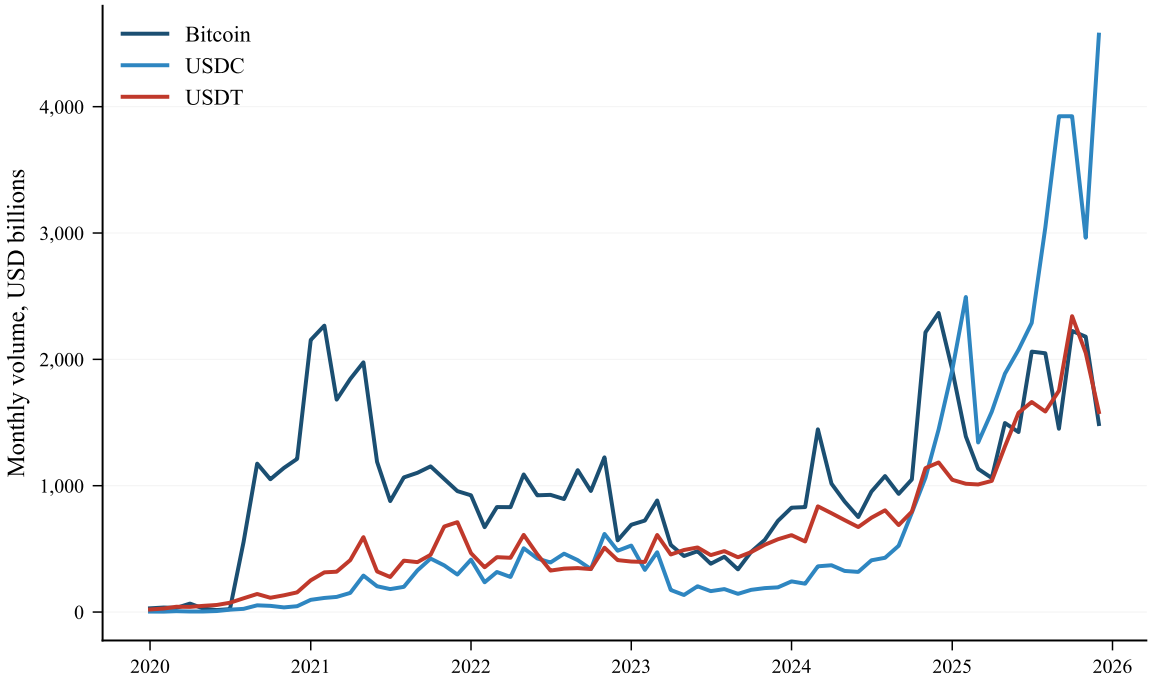


Figure 2: **Monthly On-Chain Transaction Volume.** The figure plots monthly onchain transaction volume in USD billions for Bitcoin and for the two largest US-dollar stablecoins, USDC and USDT, shown separately. Each stablecoin series aggregates all send transactions across the chains on which it circulates, excluding Solana.

Velocity

The combination of modest circulation and large transaction volume implies that stablecoins turn over at rates far exceeding those of other digital assets. Figure 3 plots monthly velocity for Bitcoin, USDC, and USDT separately. Bitcoin velocity has remained low and flat throughout the sample, fluctuating around one and ending 2025 at approximately 0.85, consistent with its primary function as a store of value. Both stablecoins turn over far faster. USDT velocity has been relatively stable in the mid-single digits, averaging roughly 7 in 2020 and ending 2025 near 8. USDC velocity is both higher and rising, climbing from around 12 in 2020 to roughly 60 by December 2025.[7]

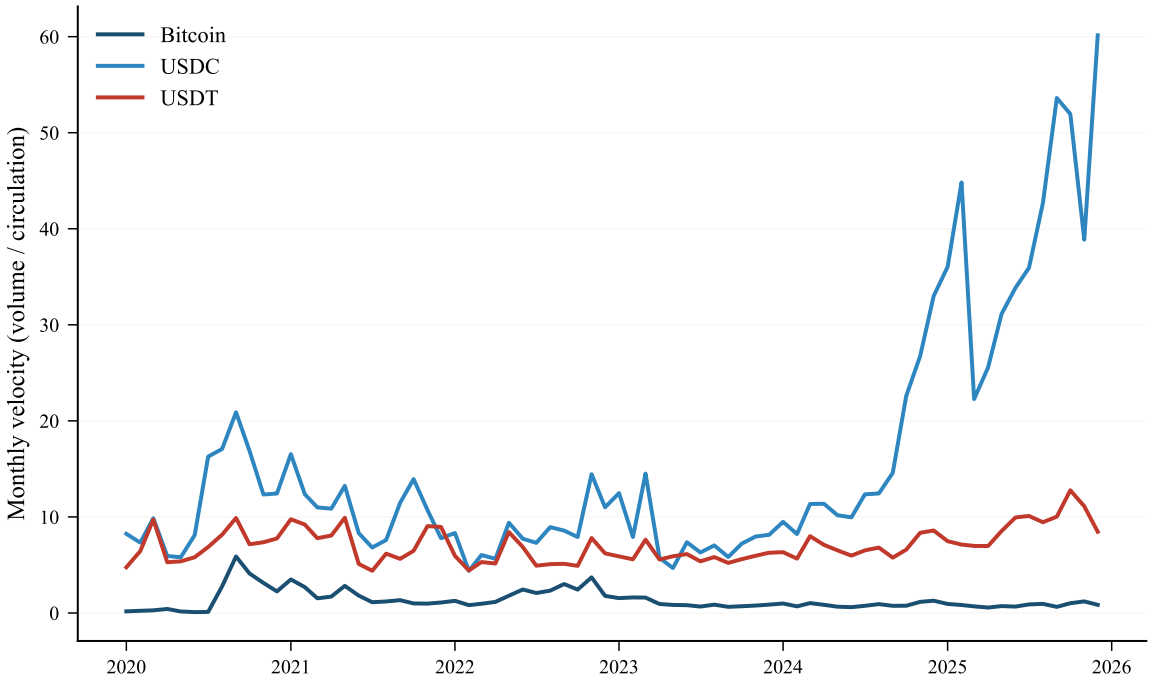


Figure 3: **Monthly Velocity.** The figure plots monthly velocity, defined as the ratio of monthly onchain transaction volume to end-of-month circulation, for Bitcoin and for USDC and USDT shown separately.

[7]The steep rise in USDC velocity partly reflects the concentrated decentralized-exchange market-making activity that also inflates its volume series, rather than payment turnover alone. In addition, because the volume numerator excludes Solana while the circulation denominator is measured across all chains, reported velocities understate true same-network turnover, most notably for USDC, which carries a sizable Solana float.

Transaction Size Distribution

A defining feature of a payment currency is frequent use in small-denomination transactions. Figure 4 compares the distribution of annual transactions by amount bucket for Bitcoin and stablecoins (USDC and USDT combined, across all chains excluding Solana) in 2022 and 2025. In 2022, the two distributions were broadly similar, with activity in both assets concentrated in the $10–$1,000 range and only modest mass in the smallest buckets. By 2025, the distributions had diverged sharply at the bottom of the size scale: the share of stablecoin transactions below one dollar alone reached 36 percent and the combined share of stablecoin transactions below $10 reached 46 percent.[8] Stablecoin activity in the larger $10–$100 and $100–$1,000 buckets, by contrast, fell well below Bitcoin's, consistent with a shift in the marginal stablecoin transaction toward retail-scale and even micropayment-scale transfers.

Appendix B reports the same comparison restricted to USDC and USDT transactions on Ethereum, together with a full-population breakdown by individual stablecoin, and shows that the shift toward small-denomination stablecoin transactions is robust across these cuts.

This divergence is consistent with stablecoins being adopted for everyday payments and micropayments, which are use cases that Bitcoin has not captured. We next examine the role of declining transaction costs in driving this shift.

[8]These shares are measured as fractions of annual *transaction counts*, not volume. The stablecoin series pools USDC and USDT send transactions across all chains on which they circulate, excluding Solana, and restricts senders to externally owned accounts (excluding contract, exchange-deposit, and exchange-omnibus addresses). The Bitcoin series excludes block-reward (coinbase) transactions—newly minted coins paid to miners—and heuristic change-like outputs. Bitcoin's own below-one-dollar share (24.7 percent in 2025) is itself inflated by Ordinals, BRC-20, and Runes inscription outputs posted at the 546-satoshi dust limit rather than economic payments (Appendix B, Section B.1); excluding these non-payment outputs would widen the gap relative to stablecoins further. Construction details are in Appendix A (Section A.9); robustness to an Ethereum-only restriction and to a full-population measure are in Appendix B (Section B.1).

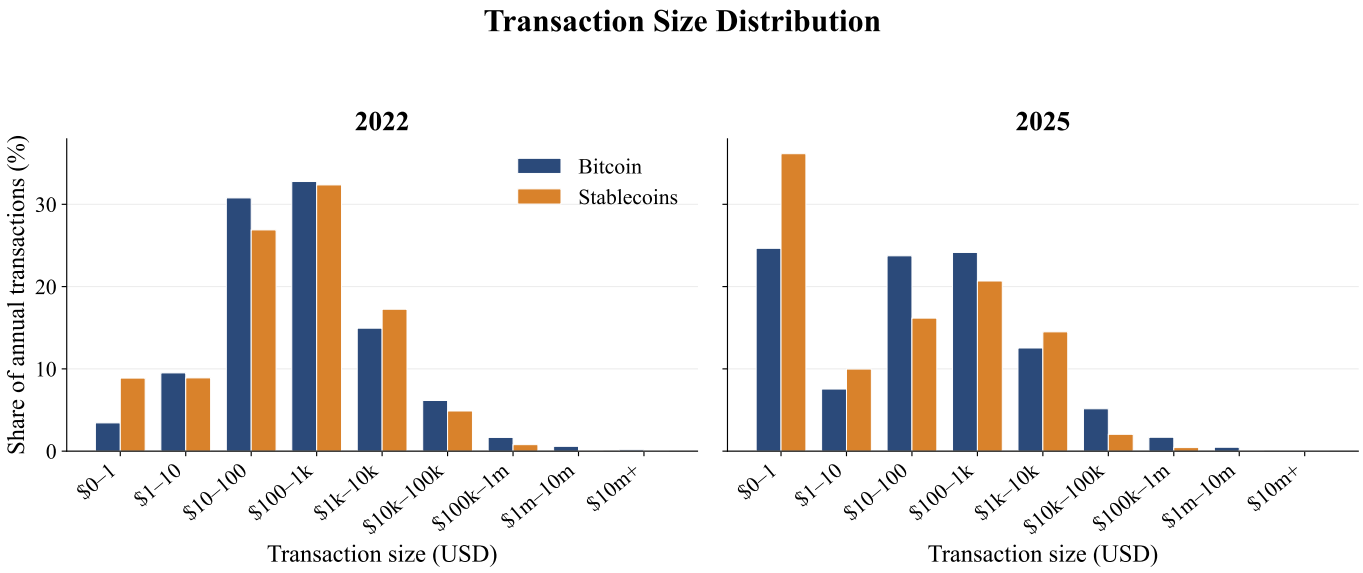


Figure 4: **Transaction Size Distribution: Bitcoin vs. Stablecoins, 2022 and 2025.** Each panel plots the share of annual transaction *counts* falling in each USD amount bucket for Bitcoin (navy) and for US-dollar stablecoins (USDC and USDT combined, aggregated across all chains excluding Solana, orange). Stablecoin transfers are restricted to sends initiated by externally owned accounts. Transaction values are converted to USD at the daily price.

Transaction Costs

A natural question is what has driven the recent shift in stablecoin transactions toward very small amounts. One possibility is that the marginal cost of sending a stablecoin transfer has fallen far enough to make small-value payments economically viable in a way that they were not in earlier years. Figure 5 documents this directly. Panel (a) plots the average dollar cost of an ERC-20 token transfer on Ethereum layer-1 (mainnet), computed as the average gas used by an ERC-20 transfer multiplied by the average gas price (in gwei) and the prevailing ETH price in USD. We emphasize that this series reflects Ethereum L1 alone, which represents an upper bound on the cost of transacting in the stablecoin ecosystem: cheaper layer-2 networks and alternative layer-1 chains carry transfer costs that are typically an order of magnitude smaller still, so the broader cost of moving stablecoins has fallen by even more than Panel (a) implies. The average transfer cost

on Ethereum L1 rose from $1.43 in 2020 to $18.37 in 2021 at the height of Ethereum congestion, then declined steadily through 2024, before collapsing to $0.68 in 2025 following the activation of EIP-4844 "proto-danksharding" and the maturation of layer-2 scaling solutions.[9]

Panel (b) shows that the count of Ethereum stablecoin transactions in the smallest two buckets moved sharply in the opposite direction. Annual transactions in the $0–$1 bucket grew from 0.3 million in 2020 to 26.9 million in 2025, an increase of nearly two orders of magnitude, with virtually all of the growth concentrated in the period after 2024 when the transfer cost fell below $1. Across the six years in our sample, the elasticity of $0–$1 transactions with respect to the transfer cost is approximately −1.3, with a Pearson correlation in logs of −0.77.[10] Although these are aggregate-time-series associations and should not be interpreted causally, the magnitude and timing of the comovement are consistent with the view that micropayment use cases for stablecoins were latent until transaction costs fell below the level at which they became economical. Fact 3 provides an independent, structural check on this cost decline: the per-deposit cost recovered from wallet-level replenishment behavior falls over the same post-2023 window, and costless replenishment opportunities become more frequent.

One potential use case enabled by the cost collapse documented above is *machine-initiated payments*—transfers executed programmatically by software, including transactions initiated autonomously by AI agents. Conventional payment rails, with per-transaction costs of tens of cents or more, cannot accommodate sub-cent transfers; stablecoin infrastructure, by contrast, can. We document the role of programmable and machine-initiated payments, including activity on the x402 machine-to-machine payment protocol, in Fact 5.

[9] We compute average transfer cost on Ethereum mainnet, where USDC and USDT first launched and where most early stablecoin activity took place. Multichain stablecoin transfers on lower-cost layer-2 networks and alternative chains carry transfer costs that are typically an order of magnitude smaller still.

[10] The elasticity is computed as the slope of a regression of log transaction counts on log fees.

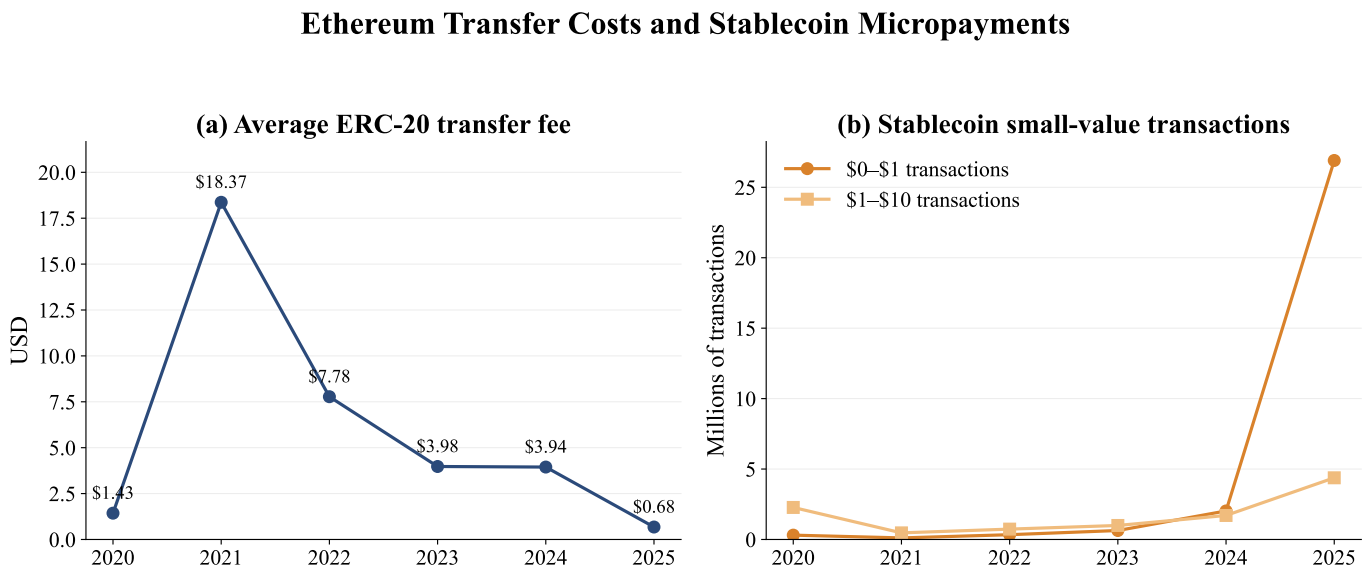


Figure 5: **Ethereum Transfer Costs and Stablecoin Micropayments.** Panel (a) plots the annual average dollar cost of an ERC-20 token transfer on Ethereum mainnet, computed as the average gas used per ERC-20 transfer multiplied by the average gas price (in gwei) and by the prevailing ETH/USD price. Panel (b) plots the annual count, in millions, of Ethereum USDC and USDT send transactions in the $0–$1 and $1–$10 amount buckets.

Wallet Composition

A final dimension concerns who is using stablecoins and for what purpose. If stablecoins are increasingly functioning as a transaction currency, we would expect to see a growing share of wallets dedicated to holding and transacting in stablecoins rather than using them as a peripheral instrument in cryptocurrency trading.

Figure 6 shows that the number of stablecoin-dominant wallets has risen steadily, growing more than threefold between 2020 and 2025, while the number of wallets that also transact in non-stablecoin tokens has been flat or declining since 2022. Stablecoin-dominant wallets primarily hold stablecoins and have minimal balances of other digital assets. This pattern is consistent with a growing population of users who hold stablecoins as tokenized cash rather than in support of speculative activity.

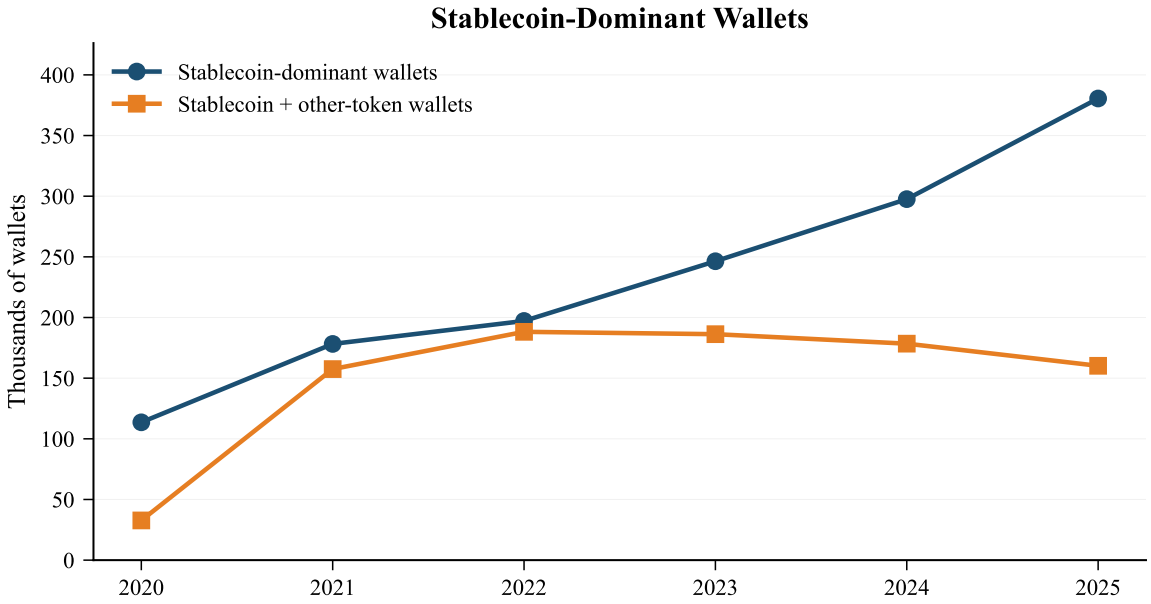


Figure 6: **Stablecoin-Dominant Wallets.** The figure plots the year-end number of active Ethereum wallets in two categories. Stablecoin-dominant wallets (navy) are wallets whose activity is concentrated in stablecoins with negligible non-stablecoin token activity, while stablecoin + other-token wallets (orange) are wallets that also transact in non-stablecoin tokens. Cohort eligibility and classification rules are described in Appendix A.

Figure 7 classifies active stablecoin wallets (excluding temporary wallets with a total transaction lifespan of three days or fewer) into three categories based on their non-stablecoin activity: *exchange wallets* affiliated with known cryptocurrency exchanges, *payment wallets* that hold stablecoins with minimal non-stablecoin activity (non-stablecoin transaction turnover ratio of 5 percent or less), and *trading wallets* with substantial non-stablecoin transactions. The share of payment-oriented wallets has grown steadily from 2021 to 2025, while the share of exchange-affiliated wallets has declined. This compositional shift reinforces the conclusion that stablecoins are increasingly used for payments and settlement rather than speculation. We note, however, that the trading category here refers specifically to onchain non-stablecoin trading while exchange-affiliated wallets also reflect trading and speculative use, so the trading share alone understates the total extent of trading- and speculation-related activity. The segmentation covers externally owned (non-contract) wallets

only; smart contracts, which carry a large share of stablecoin value but are not user-held wallets, are characterized separately in Fact 5. The pattern holds for USDC and USDT separately, though the two arrive by different routes; Appendix B reports the segmentation by stablecoin.

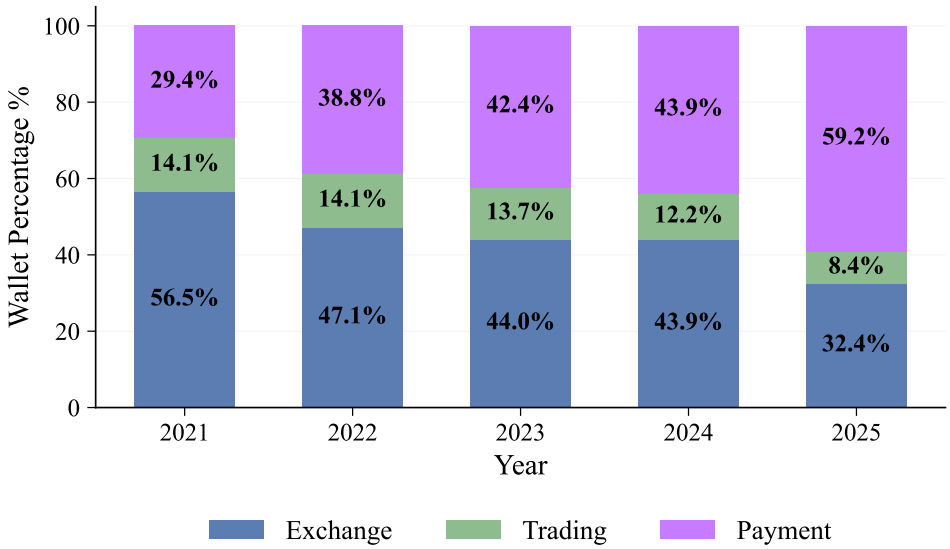


Figure 7: **Wallet Segmentation.** The figure plots the share of active stablecoin wallets classified as exchange, payment, or trading wallets, excluding ephemeral wallets. A wallet is classified as trading if its average daily non-stablecoin transfer volume exceeds 5 percent of its average stablecoin balance (a turnover ratio) and as payment otherwise. The segmentation covers externally owned (non-contract) wallets; smart-contract participation in stablecoin transfers is documented separately in Fact 5. Cohort eligibility and segmentation rules are described in Appendix A.

Having established that stablecoins are increasingly functioning as a transaction currency across multiple dimensions, we next examine where this activity is taking place.

Fact 2: Geographic Distribution of Stablecoin Activity

Geolocating cryptocurrency wallets is inherently difficult. In jurisdictions such as the United States and Europe, cryptocurrency exchanges must comply with know-your-customer (KYC) and anti-money laundering (AML) regulations, which require exchanges to verify the identities of their clients. However, this information is not publicly available. Moreover, many wallets operate outside

well-regulated jurisdictions and are not attached to any identifying information.

Industry-Standard Approach

The standard methodology for estimating the geographic distribution of cryptocurrency activity allocates onchain transaction volume proportionally based on the geographic distribution of web traffic to identified counterparty services.[11] For each wallet-to-wallet stablecoin transfer, we trace the flow of funds through a chain of up to ten intermediate transactions to identify a counterparty with known geographic characteristics, typically a cryptocurrency exchange or payment processor. The transfer volume is then allocated across regions in proportion to that counterparty's IP traffic distribution.

As an example, consider a 100 USDC transfer from a wallet traced to an exchange whose web traffic originates 60 percent from the Americas and 40 percent from Europe. The standard approach attributes 60 USDC to the Americas and 40 USDC to Europe.

This standard approach infers geography from aggregate service-level traffic distributions. A wallet traced to a global exchange with users in 100+ countries has its volume fractionally attributed across all those countries, even though the wallet owner transacts from a single location. As a result, the standard approach systematically overstates the cross-regional share of flows. In our sample, the standard methodology attributes approximately 63 percent of wallet-to-wallet volume as cross-regional across all years (Figure 10).

[11] For example, this method is used by Chainalysis in their annual Geography of Cryptocurrency Report (Chainalysis 2024) and widely adopted in the industry.

Bayesian Refinement Using Transaction Timing

We extend the standard approach by incorporating a Bayesian update from transaction timing. The key insight is that each wallet's transactions occur at specific UTC hours, and the distribution of transaction activity across hours differs systematically by region due to circadian patterns. Wallets in the Americas transact disproportionately during American business hours, and similarly for EMEA and APAC.

Let $\rho \in \{\text{Americas}, \text{EMEA}, \text{APAC}\}$ denote a region, and let $h \in \{0, 1, \ldots, 23\}$ denote the UTC hour at which a transaction occurs. For each region ρ, we construct an empirical hourly likelihood $P(h \mid \rho)$ defined as the probability of observing a transaction at hour h given that the wallet is located in region ρ from exchange-level transaction data, calibrated separately for each year to account for shifts in the global activity distribution. Each wallet's visitor-share allocation from the industry-standard approach serves as the prior $P(\rho)$, representing the probability that the wallet belongs to region ρ before observing any transaction timing. For a wallet with n observed transactions occurring at hours $h_1, \ldots, h_n$, we combine the prior with the product of hourly likelihoods via Bayes' rule to obtain the posterior probability that the wallet is in region ρ:

$$P(\rho \mid h_1, \ldots, h_n) \propto P(\rho) \times \prod_{i=1}^{n} P(h_i \mid \rho).$$

Both the sender and receiver of each transfer are attributed independently via separate posteriors. We label this methodology "Model A". As an alternative specification, we calibrate the hourly likelihood distributions using BIS Triennial Survey data on foreign exchange turnover by time zone, which provides an independent anchor for the circadian activity pattern. We label this methodology "Model B".

Exchange-operated wallets are excluded from the Bayesian analysis because their transaction timing reflects operational batch schedules rather than user geography. These wallets constitute only 1.5 percent of wallet-to-wallet addresses but carry 57–65 percent of wallet-to-wallet volume; their extreme transaction counts (100,000+ per month) produce degenerate posteriors that can introduce spurious regime shifts in the regional time series. Excluding exchange infrastructure while retaining user-initiated deposits to exchanges preserves the geographic signal while removing a source of noise. Full methodological details are in Appendix A (Section A.6).

Results

Figure 8 presents the regional distribution of wallet-to-wallet stablecoin volume under the Bayesian attribution.[12] The Americas account for 36–44 percent of sender volume, EMEA for 27–34 percent, and APAC for 29–35 percent over the 2022–2025 sample period. A notable feature of the data is that the Americas share is robust across model specifications: both Model A and Model B assign approximately 38–39 percent of flows to the Americas on average, with a cross-model monthly correlation of 0.59. The key axis of model uncertainty is the EMEA–APAC split. Model A attributes roughly 30 percent to each, while Model B attributes approximately 41 percent to EMEA and 21 percent to APAC. This divergence arises because the FX-calibrated likelihood concentrates more probability mass in European trading hours, while the empirical likelihood that is calibrated from observed crypto exchange activity picks up more APAC-hours activity than traditional foreign exchange markets would predict.

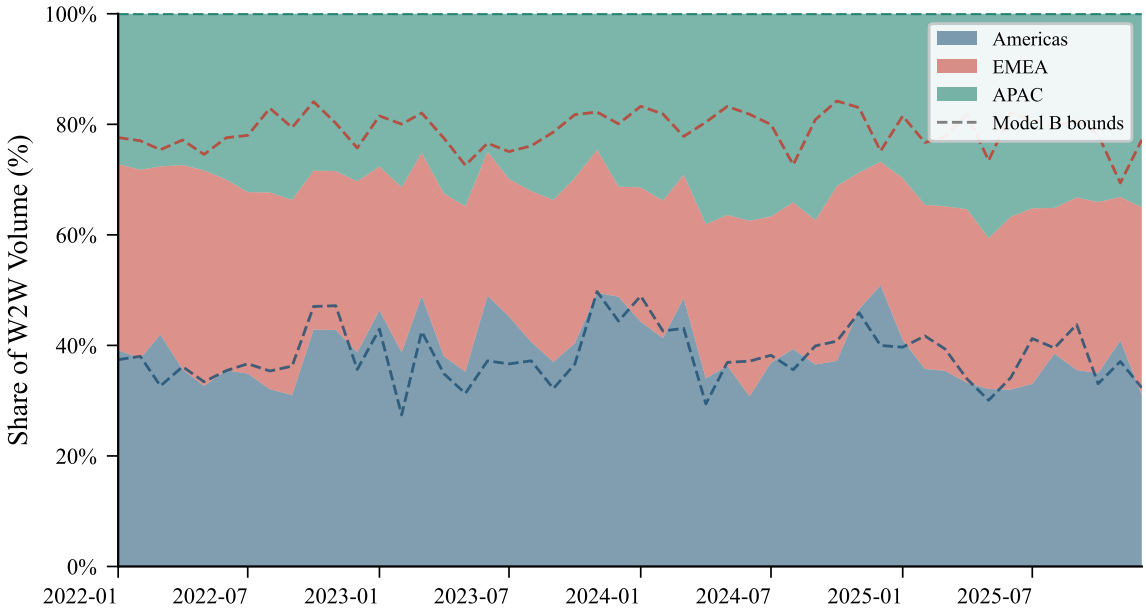
The pooled series in Figure 8(a) masks a pronounced compositional difference between the two

[12]The geographic analysis is conducted on Ethereum. Ethereum and Tron together account for roughly 84 percent of outstanding USDC and USDT balances and about 57 percent of monthly onchain transfer volume as of late 2025, with the remainder spread across Solana, BNB Chain, Base, and other networks. Appendix C re-estimates the attribution on Tron USDT and finds that the regional pattern is robust across the two chains.

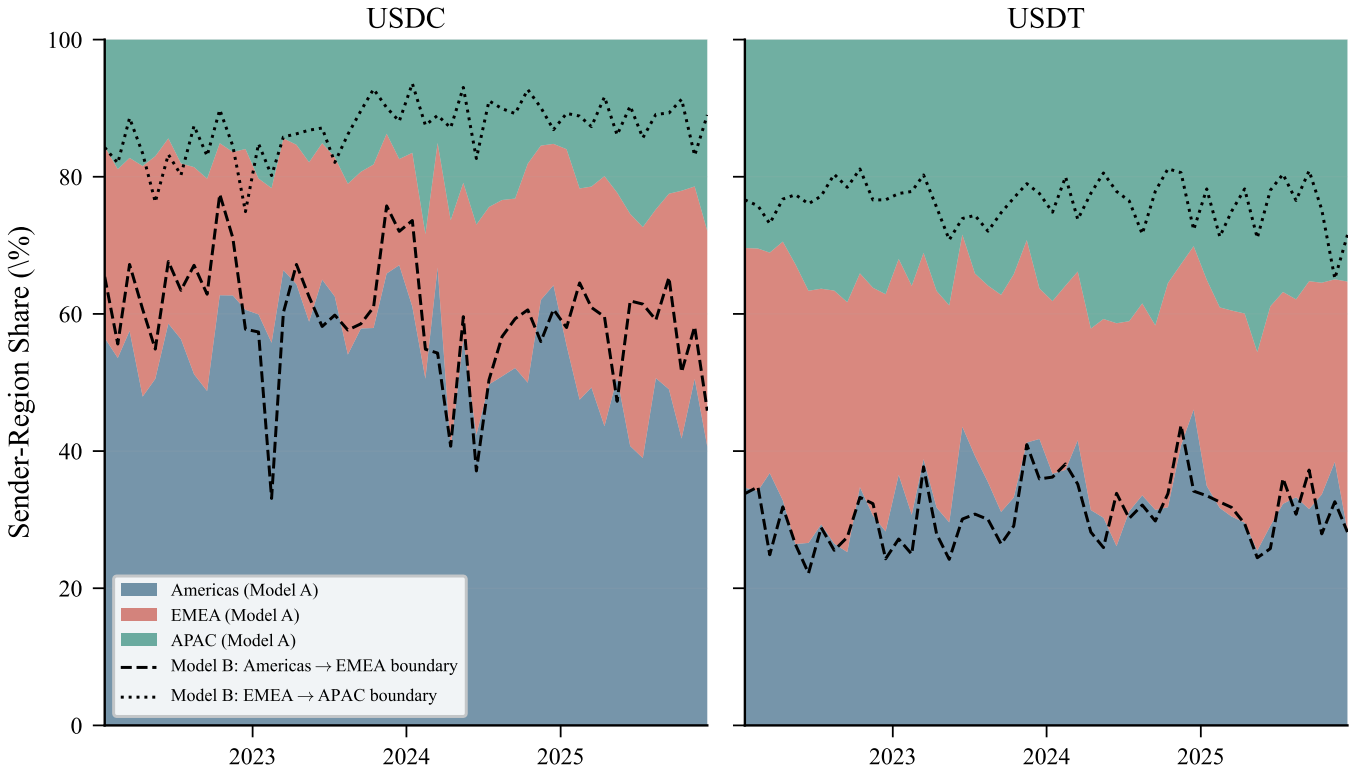
largest stablecoins, which Figure 8(b) isolates by re-estimating the model separately for USDC and USDT. USDC sender volume is concentrated in the Americas, which account for just over half of the total under both specifications (52 percent under Model A and 58 percent under Model B), consistent with a user and exchange base centered on U.S.-regulated venues. USDT is considerably more globally distributed: the Americas constitute its smallest or near-smallest region (31–34 percent), with EMEA and APAC each accounting for a comparable or larger share. The robustness of the Americas share across model specifications that we noted for the pooled series is therefore a property of USDC in particular; for USDT the Americas share is lower and the EMEA–APAC split remains the principal axis of model uncertainty, with Model A placing more weight on APAC (36 percent) and Model B on EMEA (44 percent).

The same token decomposition applied to the geography of stablecoin *balances* reveals an even sharper contrast (Figure 9). USDC balances remain anchored in the Americas throughout the sample: the Americas hold 58 percent of end-of-month USDC balances on average, and the APAC share never exceeds roughly one-fifth. USDT balances, by contrast, migrate steadily toward APAC, whose share of USDT balances rises from 27 percent at the end of 2022 to 56 percent at the end of 2025, while the Americas share falls from 44 to 25 percent over the same period. The pronounced migration of aggregate stablecoin balances toward APAC that we document below is thus driven by USDT rather than USDC, whose balance geography is comparatively stable.

Figure 10 compares the cross-regional share of volume under the prior-only allocation and the two Bayesian specifications. The prior-only approach attributes a stable 63 percent of volume as cross-regional throughout the sample. The exchange-calibrated Bayesian model (Model A) reduces this number significantly to 48 percent in 2022 and 42 percent in 2025. The FX-calibrated model (Model B) produces an even lower bound of 8–13 percent for cross-regional flows, reflecting the



(a) Pooled (USDC and USDT combined)



(b) Disaggregated by token: USDC (left) and USDT (right)

Figure 8: **Regional Distribution of Stablecoin Volume (Bayesian Attribution).** Monthly sender-region shares of wallet-to-wallet stablecoin volume on Ethereum, 2022–2025. Solid areas show the exchange-calibrated Bayesian model (Model A); dashed and dotted lines trace the cumulative Americas→EMEA and EMEA→APAC boundaries under the FX-calibrated alternative (Model B). Panel (a) pools USDC and USDT; panel (b) re-estimates the model separately for each token. USDC sender volume is concentrated in the Americas—just over half under both models—whereas USDT is distributed more evenly across the Americas, EMEA, and APAC.

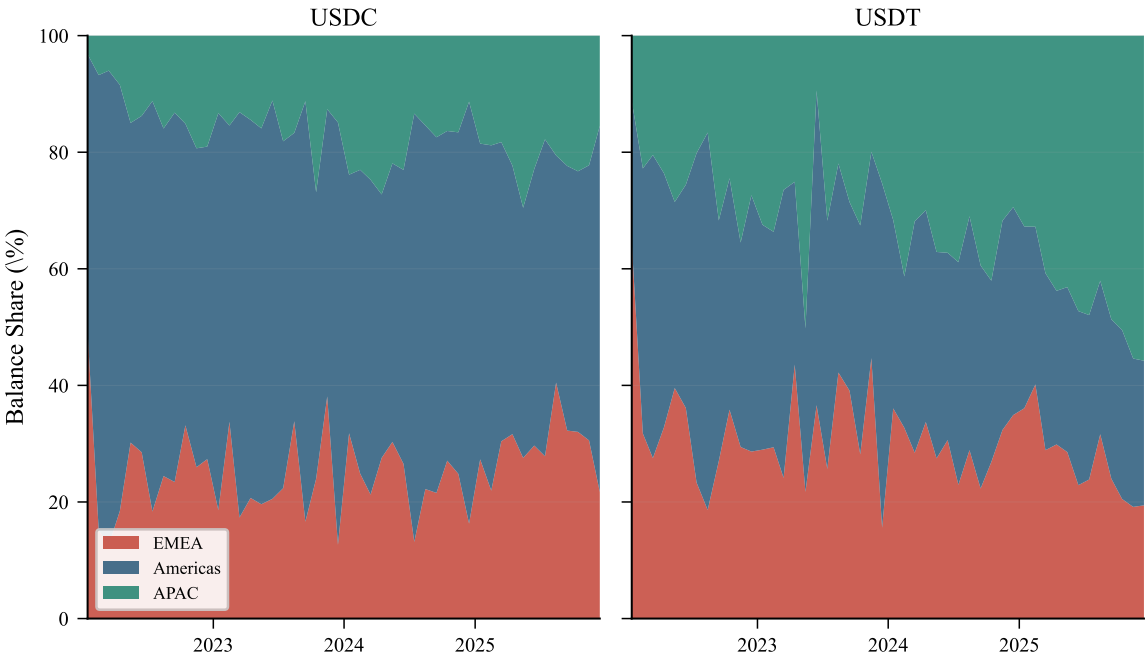


Figure 9: **End-of-Month Balance Share by Region and Token (Bayesian Attribution).** End-of-month stablecoin balances on Ethereum attributed to each region using the exchange-calibrated model (Model A), shown as monthly regional shares for USDC (left) and USDT (right). USDC balances remain concentrated in the Americas throughout the sample, whereas USDT balances migrate toward APAC, which holds a majority of USDT balances by the end of 2025. The aggregate balance migration toward APAC discussed in the text is therefore a USDT phenomenon.

stronger concentration of posteriors when the likelihood is anchored to foreign exchange market timing. We interpret the Model A and Model B estimates as plausible bounds on the true cross-regional share.

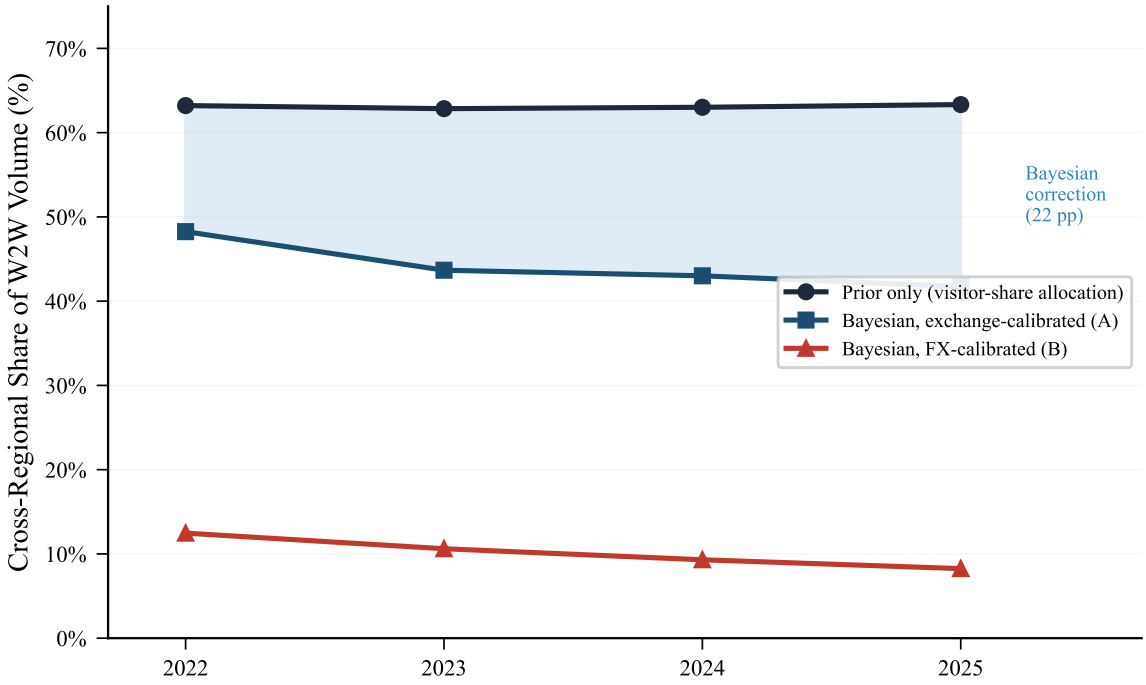


Figure 10: **Cross-Regional Share: Prior-Only vs. Bayesian Attribution.** The prior-only visitor-share approach (gray) attributes roughly 63% of wallet-to-wallet volume as cross-regional. Bayesian updating with circadian timing evidence reduces this to 42–48% (exchange-calibrated, Model A) or 8–13% (FX-calibrated, Model B). The shaded area highlights the correction from the exchange-calibrated Bayesian model.

Net Bilateral Flows and Balance Geography

The corridor-level data reveal a persistent directional pattern in net bilateral flows. Over the full 48-month sample, the Americas is a net sender of stablecoins to both EMEA and APAC under both model specifications. Under Model A, cumulative net outflows from the Americas total $31.7 billion to EMEA and $29.6 billion to APAC; the Americas to EMEA corridor is directionally robust under Model B as well ($27.9 billion). EMEA, in turn, is a net sender to APAC ($11.0 billion under Model A).

This hub-and-spoke pattern in which stablecoins flow outward from the Americas is consistent with minting activity concentrated among U.S.-connected issuers and subsequent redistribution through onchain intermediation. Net outflows from the Americas to EMEA accelerated during 2024, with monthly flows rising from a typical $100–300 million range in 2022–2023 to peaks exceeding $3 billion in late 2024.

The geographic distribution of stablecoin *balances* exhibits an even more pronounced shift than the flow data. Under Model A, APAC's share of end-of-month stablecoin balances rose from 15.5 percent in 2022 to 41.7 percent in 2025, while the Americas' share declined from 57.6 percent to 31.4 percent over the same period. Model B produces a directionally consistent pattern: APAC balances rose from 11.2 to 30.4 percent, while Americas balances fell from 67.5 to 27.5 percent. The fact that balance shares shift more rapidly than flow shares implies that APAC-attributed wallets have lower stablecoin turnover than Americas-attributed wallets. In other words, they receive stablecoins and hold them longer, rather than passing them through quickly.

Event-Driven Geographic Reallocation

The 48-month panel spans several major market events, and the geographic attribution data reveal systematic patterns of event-driven reallocation. Events with a clear U.S. nexus such as the FTX collapse (November 2022), the SVB-induced USDC secondary market dislocation (March 2023), and the U.S. presidential election (November 2024) are each associated with a 6–10 percentage point spike in the Americas' sender share, consistent with U.S.-domiciled wallets reacting to domestic catalysts more rapidly and intensely than wallets in other regions. By contrast, the Luna/UST collapse (May 2022)—a global event originating in Asia—produced a 6 percentage point *decline* in the Americas' share, as activity surged simultaneously across all regions. In each case, the Americas share reverts

toward its pre-event level within two to three months, suggesting that these event responses reflect temporary liquidity and positioning adjustments rather than permanent geographic shifts.

Discussion

The broad geographic distribution of stablecoin volume with substantial activity across all three major regions is consistent with broad international demand for dollar-denominated digital payment instruments, a pattern studied in a model by Murakami and Viswanath-Natraj 2025. At the same time, the Bayesian correction indicates that the majority of wallet-to-wallet volume flows within regions rather than across them, which is consistent with stablecoins serving domestic payments and savings use cases alongside cross-border transfers.

The net bilateral flow pattern and the balance migration toward APAC together suggest a dynamic in which dollar stablecoins are minted primarily through Americas-based infrastructure and subsequently accumulate in wallets attributed to other regions. This pattern is structurally analogous to the distribution mechanics observed in international dollar funding markets, where dollar-denominated instruments are originated domestically and subsequently intermediated to meet demand abroad. The event-window results further demonstrate that onchain stablecoin flow data contain extractable geographic signals: regional shares respond systematically to macrofinancial events in a manner consistent with wallet owners' proximity to the event's epicenter. The geographic estimates also do quantitative work later in the paper: in Fact 4 they bound the share of stablecoin demand that could be displacing domestic U.S. deposits and anchor the cash-substitution weight at the center of the credit-creation analysis. The pattern they describe, with dollars originated through U.S.-connected infrastructure and held heavily offshore, mirrors the geography of traditional dollar instruments: roughly half of U.S. banknotes circulate abroad, and eurodollar

balances serve the same offshore demand that stablecoins now reach.

The third fact takes a deeper look at the wallet-level behavior of stablecoin users, examining whether stablecoin usage patterns resemble traditional cash management.

Fact 3: Stablecoin Wallet Usage Resembles Traditional Cash Management

The compositional shift toward stablecoin-dominant wallets documented in Fact 1 suggests that stablecoins are increasingly functioning as tokenized money: a digital form of money used for payments and liquidity management. We pursue this interpretation quantitatively by estimating a structural cash-management model on wallet-level transaction data. We estimate a cash inventory model built upon Alvarez and Lippi 2009 using the stablecoin transactions data, which allows us to recover two parameters that govern access to the stablecoin ecosystem: a free-adjustment intensity that measures how often wallet owners can replenish balances at zero cost, and a fixed cost paid on non-free deposits. Comparing the recovered parameters to corresponding estimates for cash wallets from Alvarez and Lippi 2009 allows us to compare the ease with which individuals access and transact using their stablecoin wallets.

Throughout this section, we focus on externally owned account (EOA) wallets, which best capture the behavior of individual and business users rather than centralized exchanges or smart contracts. Table 1 provides an overview of wallet-level summary statistics by balance size. We classify wallets into three groups based on their average stablecoin balance: small (below $1,000), medium ($1,000 to $10,000), and large (above $10,000). Larger wallets transact more frequently and move substantially larger amounts, but even the median small wallet maintains a balance of around $150 and sends roughly $35 per day. Deposit frequency (the fraction of days on which a wallet receives an inflow) is low across all groups, consistent with the periodic-replenishment behavior

predicted by inventory-theoretic models of money demand.

Table 1: Summary Statistics by Wallet Size

		<$1K	$1K–$10K	>$10K	All
Wallets		42,551	20,979	14,638	78,168
Balance ($)	p50	156.71	2,801	34,500	732.65
	p75	399.92	5,023	93,905	5,226
	p90	685.31	7,516	289,018	31,191
Daily Outflow ($)	p50	39.06	137.07	703.30	84.97
	p75	117.23	485.97	3,006	370.82
	p90	352.76	1,706	12,597	1,783
Txn Frequency	p50	0.022	0.033	0.038	0.027
	p75	0.041	0.066	0.085	0.055
	p90	0.074	0.126	0.189	0.107
Deposit Frequency	p50	0.014	0.016	0.016	0.016
	p75	0.030	0.038	0.046	0.033
	p90	0.055	0.079	0.118	0.070

Notes: This table reports the cross-sectional distribution of wallet-level summary statistics by average balance bucket, pooled across 2020–2025. The sample includes externally owned accounts (EOAs) on Ethereum (1/16 random sample). Balance is the time-series mean of daily total stablecoin balance. Daily outflow is average daily stablecoin sent. Transaction frequency is the fraction of observed days with any send or receive activity. Deposit frequency is the fraction of observed days with a positive stablecoin inflow. Rows report the 50th, 75th, and 90th percentiles within each bucket.

Theoretical Framework

Since we provide very little theoretical innovations to the model in Alvarez and Lippi 2009, we keep our description of the model brief. We refer readers to the appendix for a full setup and derivation of the model. In this section, we simply seek to provide intuition about the key parameters of the model and the data moments used to identify each parameter.

There exists a wallet owner who manages a stablecoin wallet that holds stablecoins. The stablecoin wallet is used to meet a constant liquidity demand c, and is financed from a separate interest-bearing account (such as a high-yield savings account) earning a nominal rate r. The owner's stablecoin balance $m \geq 0$ is drawn down continuously at rate c ($dm/dt = -c$) and is replen-

ished by deposits from the interest-bearing account. Each deposit incurs a fixed cost b, except when it coincides with a free adjustment opportunity, which is a costless chance to top up that arrives as a Poisson process with intensity p. The owner chooses when to deposit, and how much, to minimize the expected present value of fixed costs plus the interest foregone by holding balances in stablecoins rather than the interest-bearing account, subject to $m(t) \geq 0$. The two economic primitives we recover are the free-adjustment intensity p and the normalized transaction cost $\alpha \equiv b/c$, the fixed deposit cost scaled by liquidity demand. The key feature of the model is that the precautionary motive for holding stablecoins weakens as access to costless replenishment (higher p) or cheaper deposits (lower α) improves, so that the estimated parameters let us track improvements in stablecoin access over time. Appendix D states the owner's problem formally and derives the results summarized below.

The solution takes the form of a two-sided (s, S) rule: the owner lets balances fall to a lower trigger level $\underline{m}$, at which point a deposit restores them to an upper target $\overline{m}$, and additionally resets balances to $\overline{m}$ whenever a free adjustment opportunity arrives. Both $\underline{m}$ and $\overline{m}$ have closed-form expressions in (α, p, r) (Appendix D). When $p = 0$ the trigger $\underline{m}$ is zero and the model collapses to the classic Baumol-Tobin case, in which balances are run down to zero before each costly replenishment; when $p > 0$ the trigger is strictly positive, capturing the precautionary buffer the owner holds because a costless top-up may arrive before balances are exhausted.

The optimal policy implies closed-form expressions, derived in Appendix D, for three moments that we observe in the data and use to identify the parameters:

1. **Average holdings over liquidity demand (M/c),** the average stablecoin balance scaled by the rate of liquidity demand (equation (7)).

2. **Number of deposits (n),** the expected number of replenishments per unit of time (equation (8)).

3. **Level of precautionary savings ($\underline{m}/M$),** the trigger balance relative to average holdings (equation (9)).

Empirical Moments in the Data

We compute the three model-implied moments for each wallet in our sample and examine how they evolve over 2020–2025. Rather than aggregating to calendar years, we use a quarterly rolling-window construction: for each end-of-quarter date, we compute the per-wallet moments from the trailing two quarters (six months) of daily data and then take the cross-sectional mean within each wallet-size segment. The 6-month window provides a quarterly time series of moment estimates while still containing enough deposit events per wallet to identify the structural parameters.[13] To assess heterogeneity across the size distribution of stablecoin wallets, we report each moment separately for three balance-based segments—small (< \$1,000), medium (\$1,000–\$10,000), and large (> \$10,000)—alongside the full-sample series. Figure 11 plots the resulting time series; corresponding year-end estimates for each segment are tabulated in Tables 4, 5, and 6 in Appendix D.

The three moments display a coherent set of patterns over 2020–2025. The balance-to-consumption ratio (M/c, Panel a) rose substantially over our sample period. In the full sample, M/c climbed from approximately 1.8 days of outflow at the 2020-Q2 window to around 4.7 days by the end of 2025. The increase is broad-based across segments: the medium segment (\$1,000–\$10,000) tracks the full sample closely, and the smallest wallets (< \$1,000) remain below one day of outflow throughout.

[13] The estimation is conducted on a persistent 1/16 random sample of all wallet addresses drawn once from the union of all addresses observed in the raw data over 2020–2025. Our sample keeps wallet identities stable across calendar years, which matters for rolling windows. For the precautionary-savings moment $\underline{m}/M$, we identify the balance just before each (s, S)-style replenishment decision: consecutive deposit days within five days of each other are consolidated into a single replenishment event (provided the balance does not decline between them), and the trigger balance is the balance immediately before the first deposit in the run. Segment assignment within each rolling window uses the wallet's average stablecoin balance over that window. The annualized interpretation of each moment is preserved by the moment definitions themselves: the balance-to-consumption ratio is a stock-to-flow that does not depend on window length, and the deposit-frequency moment is normalized by the actual time span of the window.

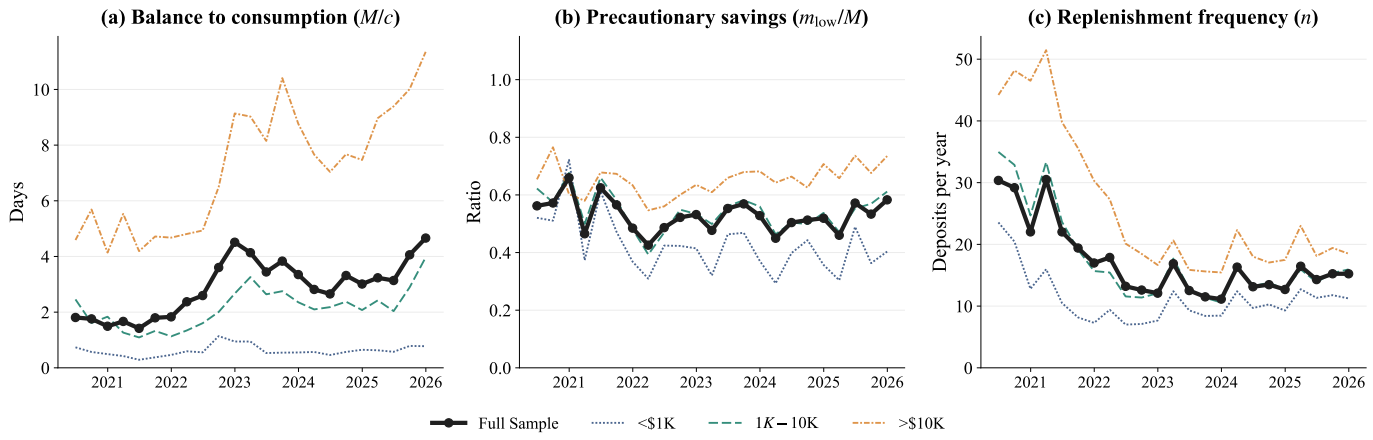


Figure 11: **Empirical Moments of Stablecoin Wallet Behavior, 2020-Q2 through 2025-Q4.** Each panel plots a rolling 2-quarter (6-month) cross-sectional mean computed from the trailing 183 days of daily wallet data and reported at the end of each quarter. The full-sample series is shown as a thick solid line; the three wallet-size segments are shown as lighter dashed lines. Panel (a) plots the balance-to-consumption ratio (M/c): average daily stablecoin balance divided by average daily outflow. Panel (b) plots precautionary holdings ($\underline{m}/M$, denoted m_{low}/M in the figure): the ratio of the trigger balance (minimum balance observed before a deposit) to average balance. Panel (c) plots the annualized number of replenishment events per year (n). Corresponding calendar-year estimates are tabulated in Tables 4–6 of Appendix D.

The largest wallets (> \$10,000) exhibit a much sharper upward trajectory, climbing from roughly 4–5 days of outflow in 2020–2021 into a 7–11 day range from 2023 onward, which brings them into the 10–19 day cash-balance range that Alvarez and Lippi 2009 report for Italian households. For the full sample, however, M/c remains below the Italian benchmark, indicating that the typical stablecoin wallet owner turns over balances more frequently than households held cash in the early 2000s. The rise in M/c also has a geographic counterpart: Fact 2 documents balances migrating toward APAC-attributed wallets with slower turnover, so part of the aggregate increase reflects a growing store-of-value clientele alongside transactional use.

Precautionary holdings ($\underline{m}/M$, Panel b) display modest variation around a roughly stable level throughout the sample. The full sample stays in a 0.43–0.66 range from 2020 onward, averaging close to 0.51 in the post-2022 portion of the sample, with a visible year-end seasonal pattern in which windows ending in Q1 typically show lower trigger-to-average ratios than windows ending in Q3

or Q4. Cross-sectional heterogeneity is pronounced: small wallets exhibit the lowest precautionary buffers (a 0.29–0.49 range from 2022 onward), the medium segment tracks the full sample, and the largest wallets hold the highest precautionary buffers (a 0.55–0.74 range over the same period). The full-sample level sits slightly above the 0.30–0.47 range reported by Alvarez and Lippi 2009 for traditional cash—suggesting that accessing stablecoins remains costly enough in expectation that wallet owners maintain meaningful buffers, with the median stablecoin wallet holding a somewhat larger trigger balance relative to average balance than the typical Italian household did in the early 2000s.

Replenishment frequency (n, Panel c) shows the sharpest non-monotonic trajectory of the three moments. The full sample peaks at approximately 30 deposit days per year at the 2020-Q2 window, declines through 2022, and settles within an 11–18 deposit-day-per-year range from 2022 onward. Large wallets transact noticeably more frequently than the full sample (15–27 deposit days per year in the post-2022 steady state), and small wallets less frequently (7–13 deposit days per year). For comparison, Alvarez and Lippi 2009 report 16–23 annual cash withdrawals for households far from ATMs and 50–64 for households near ATMs; the post-2022 stablecoin replenishment rate for the typical wallet thus falls within the range of cash withdrawal rates for households without ready ATM access. The series also exhibits residual within-year variation that reflects calendar-month seasonality in raw deposit activity, which the 6-month window does not fully average over.

Parameter Estimation

We estimate the structural parameters p and α in two stages, exploiting the fact that each wallet's deposit frequency n_i is directly observable. Since equation (8) defines n as a function of α, p, and r, we can substitute out α and express the remaining theoretical moments as functions of p and n

alone. This reparameterization reduces the first-stage estimation to a single parameter, p.

In the first stage, we estimate p by matching the balance-to-consumption ratio M/c and the precautionary savings ratio $\underline{m}/M$ to their theoretical counterparts evaluated at the sample mean deposit frequency $\bar{n}$. We minimize the criterion function:

$$Q_N(p) = \bar{g}_N(p)' \, W_N \, \bar{g}_N(p), \tag{1}$$

where $\bar{g}_N(p)$ is the vector of deviations between the cross-wallet sample means of M/c and $\underline{m}/M$ and their model-implied values, and W_N is a diagonal weighting matrix. We implement an iterative procedure: in the initial step, W_N is the identity matrix; in subsequent iterations, we update the diagonal of W_N using the inverse of the estimated cross-wallet variance of each moment's residuals and re-estimate p. We iterate until convergence.

In the second stage, given the estimated $\hat{p}$ and each wallet's observed deposit frequency n_i, we recover the wallet-specific normalized transaction cost α_i analytically. Using the structural relationship implied by equation (8), we compute the implied target balance $\overline{m}_i/c$ for each wallet and then solve for α_i from the target-level equation. We calibrate the interest rate r to the average three-month US Treasury yield for each year. To limit the influence of outliers, we report the median value of α across wallets.

The two parameters are identified from different features of the data. The free-adjustment intensity p is identified primarily by the precautionary-savings ratio $\underline{m}/M$ together with the deposit frequency n: the model implies the simple relationship $\underline{m}/M = p/n$ at the trigger, so once n is observed, p is essentially pinned down by the level of $\underline{m}/M$. Intuitively, $\underline{m}/M$ measures how close to depletion wallet owners are willing to let their balances run, which directly reflects how

confidently they can expect a costless replenishment opportunity. Given $\hat{p}$, the transaction cost α is then identified by deposit frequency n: holding p fixed, a wallet that deposits more often than the free-adjustment intensity alone would justify must be paying a lower fixed cost to do so, and conversely. The role of M/c disciplines the joint fit but does not necessarily pin down either parameter on its own.

Parameter Estimates and Discussion

Figure 12 plots the resulting structural parameter estimates at quarterly frequency, again using the rolling 2-quarter window construction. Corresponding year-end estimates are tabulated in Table 7 of Appendix D.

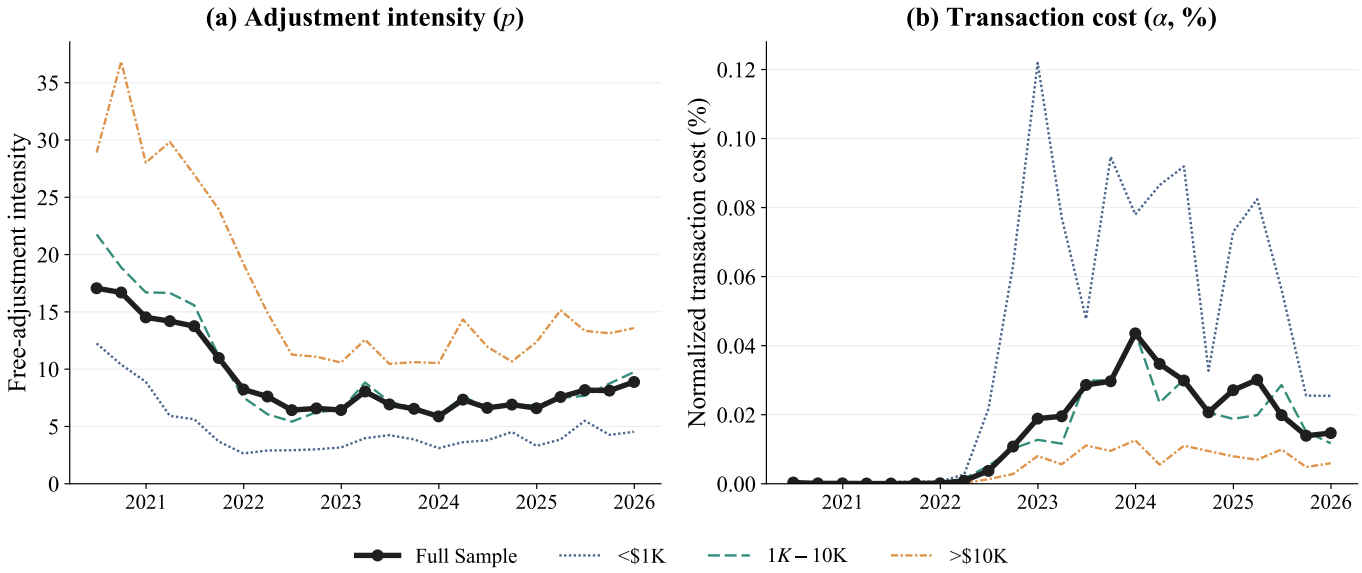


Figure 12: **Alvarez-Lippi Parameter Estimates, 2020-Q2 through 2025-Q4.** Each panel plots quarterly estimates computed from a rolling 2-quarter (6-month) window of daily wallet data. The full-sample series is shown as a thick solid line; the three wallet-size segments are shown as lighter dashed lines. Panel (a) plots the estimated free-adjustment intensity p, interpreted as the average number of costless deposit opportunities per year. Panel (b) plots the median normalized transaction cost $\alpha = b/c$ (in percent), the per-deposit fixed cost relative to annual liquidity demand. Corresponding calendar-year estimates are tabulated in Table 7 of Appendix D.

The estimated free-adjustment intensity p (Panel a) traces out a distinct two-phase trajectory.

The full-sample series peaks at approximately 17 costless deposit opportunities per year in the 2020-Q2 window, then declines steadily through a trough near 5.9 by 2023-Q4. From 2024 onward the series reverses direction and rises steadily, reaching approximately 8.9 by the end of 2025. The same pattern is apparent in both the medium-wallet segment (peak near 22 in 2020-Q2, trough of 5.4 in 2022-Q2, rising back to 9.8 by 2025-Q4) and the large-wallet segment, which falls from above 28 in 2020–2021 to a trough near 10.5 in 2022–2023 and then climbs back to 13.6 by the end of 2025. A natural interpretation of the early-sample peak is that the COVID-19 period generated unusually frequent costless replenishment opportunities for stablecoin wallet owners, plausibly because wallets were funded heavily during a window of broad-based crypto inflows and stay-at-home retail engagement. The 2020–2023 decline then reflects normalization as that initial surge subsided. The renewed rise from 2024 onward is more economically novel: it indicates that the underlying deposit technology has been improving over the past two years, with wallet owners now accessing the onchain rails at gradually rising frequencies.

The normalized transaction cost α (Panel b) was effectively zero through 2021 and then rose for all segments over 2022–2023, reflecting an environment in which the typical wallet's revealed deposit frequency was low enough to imply a meaningful per-deposit fixed cost. For the full sample, α peaks at approximately 0.044 percent of annual liquidity demand in 2023-Q4. Since 2024, the series has trended downward across nearly every segment: the full-sample α declines from its 2023-Q4 peak to about 0.015 percent by 2025-Q4, the medium-wallet segment falls from 0.044 to 0.012 percent over the same span, and the large-wallet segment drops from 0.013 to roughly 0.006 percent. The small-wallet segment remains the noisiest and the highest-cost group, with median α values in a 0.02–0.12 percent range from 2022 onward, but the broad post-2024 movement is downward there as well. The decline since 2024 indicates that the implied per-deposit cost of moving stablecoins on

chain has been falling: for the median wallet, it has become measurably cheaper to transact.

Taken together, the two parameter trajectories tell a coherent story about how onchain access has evolved for the median stablecoin wallet. From 2023 onward, the free-adjustment intensity has been steadily rising while the transaction cost has been steadily falling. Both parameter estimates suggest that stablecoin owners are gaining more frequent and cheaper access to the onchain rails. This pattern provides a structural counterpart to the descriptive evidence in Fact 1: the same forces that have driven the post-2023 fall in Ethereum transfer costs and the divergent micropayment-scale shift in the stablecoin transaction size distribution show up here, within the cash-management model, as improvements in the two parameters that govern wallet replenishment behavior. By 2025, the typical stablecoin wallet faces a deposit technology that is broadly comparable to that of the early-2000s Italian households studied by Alvarez and Lippi 2009, but is trending toward an environment in which costless replenishment is even more readily available.[14] Two qualifications attach to this aggregate picture. First, the smallest wallets face a meaningfully higher implied transaction cost than medium and large wallets do, and this gap emerged in 2022–2023 and has only partially closed since. Second, the large-wallet segment exhibits sustained increases in the balance-to-consumption ratio that bring its M/c into and beyond the range observed for traditional cash.

In short, our ability to characterize stablecoin wallet behavior using a traditional cash management model highlights the money-like aspects of stablecoins. The final two facts turn from how stablecoins are held and spent to the financial activities they make possible: an expanding onchain credit market (Fact 4) and programmable, machine-initiated payments (Fact 5).

[14]The level comparison between our α estimates and those reported by Alvarez and Lippi 2009 is more difficult to interpret than the comparison for p, because $\alpha = b/c$ scales the per-deposit fixed cost by daily liquidity demand. Differences in c across populations therefore confound direct comparisons of α.

Fact 4: Onchain Credit Markets Are Expanding

Stablecoins serve not only as a medium of exchange but also as the unit of account and settlement currency for a growing onchain credit market. Decentralized finance protocols have enabled the development of both secured and unsecured lending entirely onchain, with stablecoins as the primary currency for borrowing and lending. The expansion of these markets represents a deepening of stablecoin use beyond payments into broader financial intermediation. It also bears directly on a central question in the policy debate over stablecoins: whether the migration of money onto blockchain rails diminishes the economy's capacity to create credit. We first document the growth of onchain credit and then discuss how tokenized credit provision differs structurally from bank-led intermediation.

Secured credit protocols, such as Aave, allow users to borrow stablecoins against crypto-collateral deposited onchain. Figure 13 shows that total outstanding loans on secured DeFi protocols have expanded from $10.0 billion to $41.4 billion over the past two years, representing a fourfold increase.

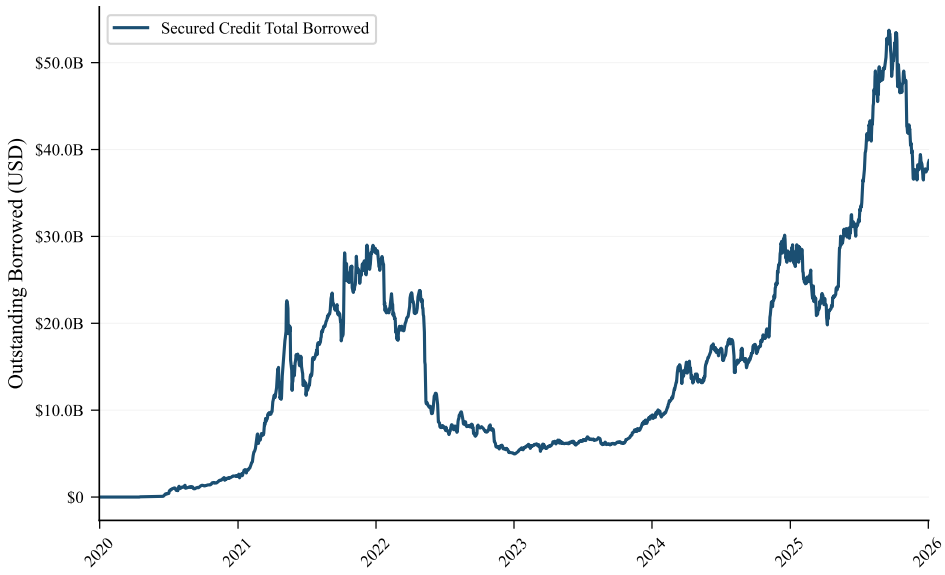


Figure 13: **Secured Credit Outstanding Loans.** This figure presents the total value of outstanding loans on secured credit DeFi protocols (e.g., Aave) over time.

Unsecured credit protocols, such as Maple Finance, facilitate lending without requiring onchain collateral, instead relying on off-chain credit assessments and institutional borrowers. Although smaller in scale, this market has grown even faster: Figure 14 shows that outstanding unsecured loans have expanded 459% since April 2025, rising from $0.38 billion to $2.15 billion.

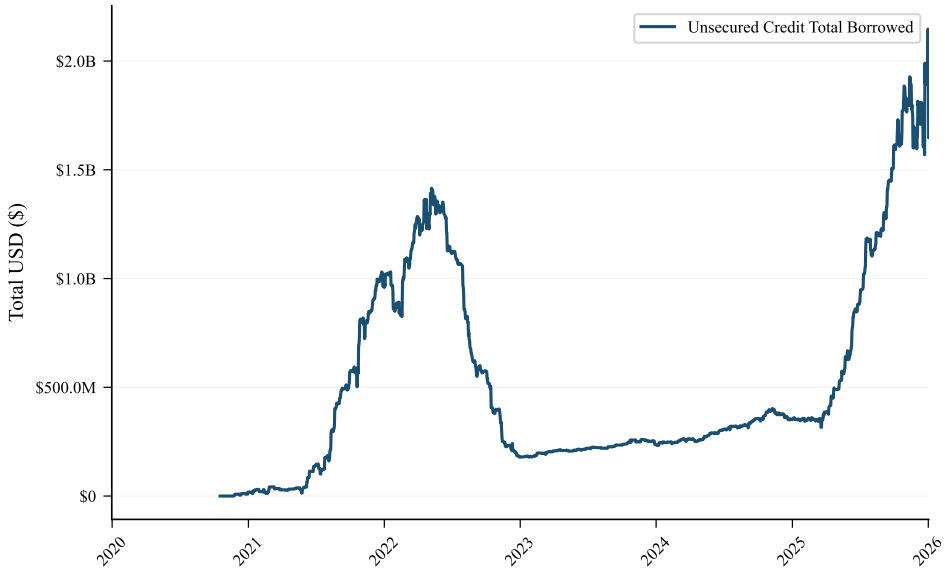


Figure 14: **Unsecured Credit Outstanding Loans.** This figure presents the total value of outstanding loans on unsecured credit DeFi protocols (e.g., Maple) over time.

Tokenization as a Source of Credit

The credit documented above is created through two channels that parallel the mechanics of traditional bank intermediation and partially substitute for them. First, tokenization converts otherwise illiquid assets into standardized, transferable, and programmable collateral. Lending against imperfectly liquid collateral is the core business of banking: banks extend credit against houses, inventories, receivables, and other assets that are costly to value and to seize. Onchain, the same economics operate through overcollateralized lending protocols, in which tokenized assets are pledged as collateral for stablecoin loans. The eligible collateral set today consists predominantly of

liquid crypto-assets, but it is broadening as tokenized money market funds, Treasury securities, private credit, and other real-world assets migrate onchain. Each newly tokenized asset class becomes, in principle, pledgeable collateral for stablecoin-denominated credit.

Second, onchain credit provision is market-based rather than intermediary-based. Interest rates on lending protocols adjust algorithmically with pool utilization; collateral haircuts and loan-to-value limits are posted publicly; undercollateralized positions are liquidated by competitive arbitrageurs the moment they breach their thresholds. Credit risk is thereby continuously priced, collateralized, and marked to market. In bank-led intermediation, by contrast, much of the underlying risk is not directly priced at the exposure level: it is warehoused on opaque balance sheets, funded by deposits whose holders have little ability or incentive to monitor it, and managed primarily through regulation in the form of capital requirements, supervisory examination, and deposit insurance (Allen and Gale 2000). The onchain model shifts the burden of risk management from regulatory oversight of intermediaries toward market forces operating on transparent positions. Viewed from the programmability side, these lending protocols are also the largest single category of the smart-contract activity documented in Fact 5, accounting for a third of contract-involved transfer volume in 2025: the credit market described here is the principal workload of the machine-executed payment layer.

Rule-Based Intermediation and Moral Hazard

A further structural difference concerns discretion. Traditional credit intermediation delegates substantial discretionary authority to the intermediary in screening borrowers, monitoring exposures, choosing risk, and timing the recognition of losses. The agency frictions created by that delegation are a classic source of moral hazard in banking (Diamond 1984; Holmström and Tirole

1997), particularly when the intermediary's liabilities are insured or implicitly guaranteed. Onchain lending protocols are designed to keep discretionary choices to a minimum: collateral eligibility, loan-to-value limits, interest-rate schedules, and liquidation triggers are encoded in publicly auditable smart contracts and applied uniformly to every participant, with no scope for forbearance, selective disclosure, or discretionary risk-shifting once the rules are deployed. Provided the protocol's rules are set appropriately, this rule-based structure removes important margins along which a discretionary intermediary could otherwise transfer risk to its creditors or to a public backstop.

The qualification matters. Rule-based intermediation does not eliminate risk so much as relocate it, shifting exposure from the intermediary's discretion to the design of the rules themselves: to the governance processes that set protocol parameters, the oracles that supply prices, and the mechanical behavior of liquidation engines under stress. Poorly calibrated rules fail without discretion to cushion them. And the rapid growth of unsecured protocols, which reintroduce off-chain credit assessment of institutional borrowers, shows that discretionary credit evaluation has not disappeared from the onchain credit stack so much as moved to a different layer of it.

Stablecoins and Aggregate Credit Creation

These observations speak to a concern frequently raised about stablecoins: that by drawing funds out of bank deposits, they shrink the deposit base that funds bank lending and thereby "destroy credit." The force of this argument turns on three margins: which monetary instruments stablecoins actually displace, how banks respond when deposits do migrate, and what the funds backing stablecoins finance instead. On each margin, the economics are more favorable to credit provision than the headline concern suggests. A one-dollar balance-sheet exercise makes the mechanics concrete before we take the margins in turn.

Consider the worst case for the concern: a household converts one dollar of domestic bank deposits into one dollar of stablecoins, and the fully reserved issuer places the dollar in reserve assets, that is, in bank deposits, Treasury bills, or Treasury repurchase agreements. Table 2 traces every placement. If the issuer holds the dollar as a custodial bank deposit (chain a), aggregate deposits are unchanged: a retail deposit has become a custodial deposit at the same or another bank. If the issuer buys a bill from a nonbank investor such as a money market fund or dealer (chain b), the seller redeposits the proceeds and aggregate deposits are again unchanged; the bill has changed owner. Only when the bill is sold, net, out of a bank's own securities portfolio (chain c) does the banking system shrink, and it shrinks on the liquid margin: securities fall by one dollar against deposits, while loans appear in no chain. Writing η for the share of reserve backing acquired through chain (c) and ΔC for the dollar amount of stablecoin issuance,

$$\Delta\text{Deposits} \;=\; -\eta\,\Delta C, \qquad \Delta\text{Loans}\big|_{\text{mechanical}} \;=\; 0. \tag{2}$$

Deposits are relabeled rather than drained, except for the chain-(c) share, and no payment chain reaches the loan book: a payment instruction transfers ownership of existing claims and cannot extinguish a loan contract. Total credit outstanding, government plus private, is identical in every chain; what changes is who holds it (Tobin 1963; Brunnermeier and Niepelt 2019).

Equation (2) compresses two observations. The first is that the deposit consequences of issuance are governed by a single share: when the reserve dollar remains a bank deposit (chain a), or buys a bill from a nonbank seller who redeposits the proceeds (chain b), bank funding is rearranged among depositors and across banks but not reduced, so only the chain-(c) share η registers in the aggregate. The parameter is observable from reserve disclosures and the identity of marginal bill sellers, and

under current reserve practice (Section 2) the relabeling chains dominate. The second observation is structural: no sequence of payments can turn a household's adoption of stablecoins into a reduction of any bank's loan book, because no loan is traded in any leg of any chain. The mechanical exercise therefore locates the entire credit question in banks' subsequent portfolio response, an elasticity to be measured rather than an identity, to which the response margin below returns.

Table 2: **Where the Deposit Goes: Payment Chains for One Dollar of Stablecoin Issuance.** The table traces one dollar converted from a domestic bank deposit into stablecoins through each admissible reserve placement; entries are balance-sheet changes. h denotes the household; S the stablecoin issuer; M a nonbank investor (money market fund or dealer) that sells a Treasury bill to the issuer; "coins" denote stablecoins; η is the share of reserve backing acquired through chain (c).

Chain (a): reserves held as a custodial bank deposit $\Delta D^{agg} = 0$

Household		Issuer			Banking system	
deposits	−1	deposit at bank	+1	coins +1	(unchanged)	deposits, h −1
coins	+1					deposits, S +1

Chain (b): bill bought from a nonbank investor, proceeds redeposited $\Delta D^{agg} = 0$

Household		Issuer			Nonbank investor M		Banking system	
deposits	−1	T-bill	+1	coins +1	T-bill	−1	(unchanged)	deposits, h −1
coins	+1				deposits	+1		deposits, M +1

Chain (c): bill bought, net, from a bank's securities portfolio $\Delta D^{agg} = -1$

Household		Issuer			Banking system	
deposits	−1	T-bill	+1	coins +1	securities	−1 deposits, h −1
coins	+1				**loans**	**0**

The substitution margin. Payment stablecoins are, in essence, tokenized outside money: fully reserved claims on safe assets that perform no maturity or liquidity transformation (Lagos 2006). Their closest traditional analogues are physical currency and offshore dollar balances, not the domestic transaction deposits that fund bank loans. The wallet-level evidence of Fact 3 points the same way: owners manage stablecoin balances as a transactional float that is run down and replenished from a separate interest-bearing account, the behavior of a cash substitute rather than of a savings-deposit substitute. The geographic evidence in Fact 2 indicates that the marginal stablecoin holder is disproportionately located outside the United States, holding stablecoins for cross-border

settlement and dollar-denominated savings. These are dollar services historically provided by U.S. banknotes, roughly half of which circulate abroad, and by eurodollar deposits used to settle cross-border trade. To the extent that stablecoins substitute for foreign-held physical cash and offshore eurodollar balances rather than for domestic deposits, the funding base for domestic bank credit is largely bypassed. The balance-sheet exercise extends across these origins. Conversions from offshore dollar balances relabel existing onshore clearing balances; conversions from foreign-held banknotes *create* a deposit when the notes are banked; only the issuance leg itself subtracts, through the chain-(c) share. Per dollar of issuance,

$$\Delta\text{Deposits} \;=\; (\mu_n - \eta)\,\Delta C, \tag{3}$$

where μ_n is the share of stablecoin demand displacing physical currency. The two terms of (3) separate the two legs of the transaction. Every issued dollar carries the reserve-placement leg, which subtracts η regardless of where the buyer came from; a dollar that displaces foreign-held banknotes also adds a deposit when the notes are banked; and conversions out of domestic deposits or offshore dollar balances add nothing further, since they only relabel ownership. Deposit erosion thus requires the chain-(c) share to exceed the cash-substitution share, $\eta > \mu_n$. The geographic evidence suggests the opposite ordering is at least as plausible, in which case substitution out of physical currency crowds deposits *into*, not out of, the banking system.

Both parameters can be disciplined by data; Appendix E records the bounds. On the issuance leg, reserve composition anchors η: the bank-deposit share of reserves is chain (a) by construction, banks hold only a few percent of Treasury bills outstanding, and Treasury repo placed with dealers recycles within nonbank money markets, placing η plausibly below 0.1. On the buyer leg, Fact 2

places roughly two thirds of activity outside the Americas, and cash fractions of the offshore portfolio mix consistent with the size of the foreign-held banknote pool place μ_n between roughly 0.1 and 0.3. Currency data provide an independent check, summarized in Table 3.[15] Since 2021, all net growth in U.S. currency has come from $100 notes, the denomination held predominantly abroad as a store of value (Judson 2017), while transactional denominations have been shrinking with payment digitization. Growth of the $100 stock has slowed from 7.4 percent per year before the pandemic to under 3 percent, and it did not re-accelerate when policy rates eased over 2024–2026 even as stablecoin issuance ran near $90 billion per year. A substitution weight of $\mu_n = 0.2$ would account for about one fifth of the currency shortfall relative to its pre-pandemic trend, leaving the remainder to interest rates and payment digitization. These ranges discipline magnitude and sign separately. On magnitude, the effect $(\mu_n - \eta)\,\Delta C$ per $100 billion issued runs from about −$10 billion at the adverse corner (high η, low μ_n) to about +$25 billion at the favorable corner (low η, high μ_n); even the largest corner is under 0.15 percent of the roughly $18 trillion U.S. deposit base, so the effect is economically small in either direction. On sign, that plausible band straddles zero—it is the difference of two comparably sized shares—so over the full parameter box the sign is genuinely ambiguous. At the central readings, however, $\mu_n \approx 0.2$ exceeds $\eta \approx 0.05$–0.10, so the central estimate is a small increase in deposits rather than a contraction. The full grid is recorded in Appendix E (Table 8).

The response margin. Even where stablecoins compete directly with domestic deposits, the quantitative literature on digital currency and bank intermediation does not support mechanical credit destruction. When banks exercise market power in deposit markets and pay deposit rates

[15] The stablecoin column of Table 3 uses total dollar-stablecoin circulation across all issuers—the aggregate dollar-stablecoin circulating supply reported by DeFiLlama, summed across all chains—rather than the narrower USDC-plus-USDT onchain supply series plotted in Figure 1. The two differ by the roughly 85 percent USDC-plus-USDT share: the all-issuer total stood at $308 billion in January 2026, against $263 billion for USDC and USDT in December 2025. The per-period figures are December-to-December annual changes, with the final period extended to mid-2026.

Table 3: **Currency in Circulation and Stablecoins: Growth by Period and Denomination.** Total currency is currency in circulation (Federal Reserve notes plus coin; FRED series CURRCIR), measured December to December, with the final period extended to the weekly reading of $2,467 billion on June 10, 2026; relative to its 2012–2019 trend, the June 2026 stock is about $305 billion (11 percent) below trend. Denomination growth rates are computed from the Board of Governors "Currency in Circulation: Value" tables (December 31 values, available through 2025; notes only). The stablecoin column reports the annualized year-end change in total outstanding dollar-stablecoin circulation across all issuers, of which the USDC and USDT series of Figure 1 account for roughly 85 percent; the all-issuer total stood at $308 billion in January 2026.

Period	Total currency (%/yr)	$100 notes (%/yr)	$1–$20 notes (%/yr)	Stablecoins (Δ, $bn/yr)
2012–2019	6.7	7.4	3.5	≈ 0
2019–2021 (pandemic)	11.3	11.4	10.3	+80
2021–2023 (policy tightening)	2.4	3.3	−2.0	−16
2023–June 2026 (policy easing)	2.3	2.6	−0.2	+86

below competitive levels, an attractive digital outside option forces deposit rates up, drawing *more* funding into banks and expanding lending while compressing net interest margins (Chiu et al. 2023); Figure 15 illustrates the mechanism. Structural estimates that allow banks to re-optimize their funding mix reach a complementary conclusion: even when digital currency displaces deposits nearly one for one at the margin, bank lending falls by only about a quarter of the deposit outflow, because banks substitute toward wholesale funding (Whited, Wu, and Xiao 2023). Analyses specific to stablecoins similarly find that effects on credit supply depend on the design of the arrangement, with two-tiered reserve structures preserving intermediation capacity and deposit-erosion effects hinging on frictions such as deposit-rate stickiness rather than operating mechanically (Liao and Caramichael 2022; Cong 2025). Appendix F organizes these results, and the mechanism drawn in Figure 15, within a single stylized model of bank funding. In the model, a bank with access to wholesale markets runs its lending business and its deposit franchise separately: stablecoin competition raises deposit rates and compresses franchise margins while leaving the marginal lending condition unchanged. Shutting the wholesale margin recovers the deposit-market-power

configuration of Chiu et al. 2023, which is exactly the configuration drawn in the figure, and reopening it at rising cost yields a pass-through bound on lending that contains the structural estimate of Whited, Wu, and Xiao 2023. The model introduces no new claim; it shows why the cited results take the form they do.

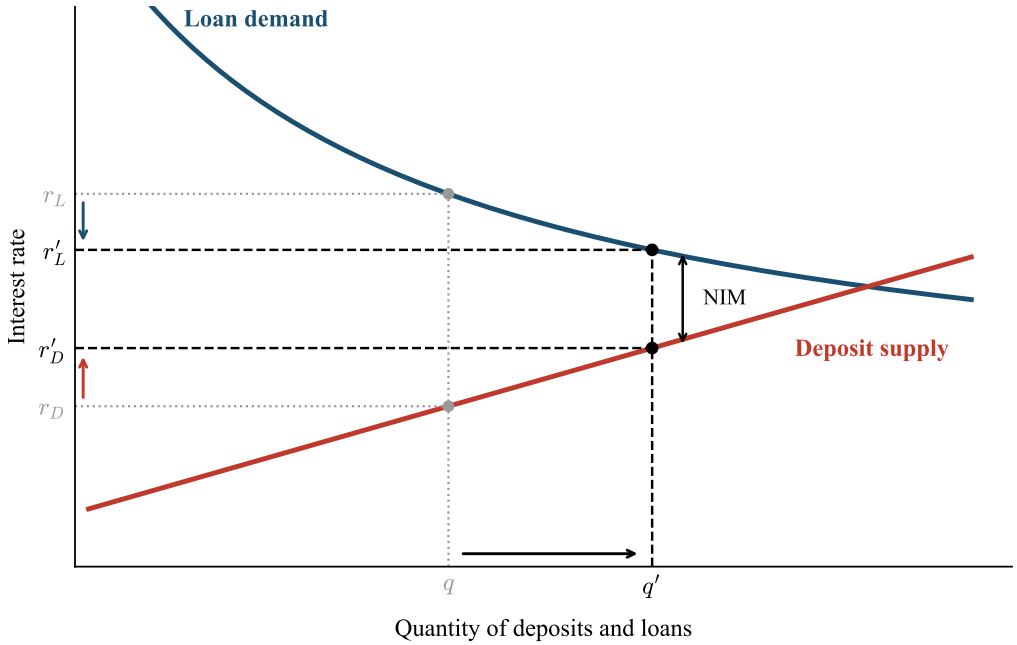


Figure 15: **Deposit Market Power and Competition from Digital Currency.** The figure illustrates the mechanism analyzed by Chiu et al. 2023 and quantified by Whited, Wu, and Xiao 2023. A bank with market power in the deposit market pays a deposit rate r_D below the competitive level, restricting the quantity of deposits, and hence loans, to q and lending at rate r_L. A digital-currency outside option, such as a payment stablecoin or a central bank digital currency, raises the rate the bank must pay to retain deposits to r'_D. Deposits and lending expand from q to q', the loan rate falls to r'_L, and the bank's net interest margin (NIM) compresses: under deposit market power, competition from digital money can increase bank lending.

The asset side. Reserve-backed stablecoins recycle their funding into the short-term claims they hold as reserves, primarily Treasury bills and Treasury repurchase agreements, so the funds backing stablecoins remain within the financial system's funding markets (chains a and b of Table 2). Moreover, what matters for the economy is total credit provision across banks, nonbank intermediaries, and now onchain protocols, rather than bank credit alone; in most advanced economies the

nonbank share of credit intermediation has been rising for decades, and onchain credit continues that migration. As this section documents, stablecoins are not merely a sink for deposit funding: they directly fund a growing volume of credit onchain. The stock of onchain credit remains small relative to bank balance sheets, but its growth indicates that tokenized money is reproducing, in rule-based and market-priced form, the credit-creation function usually cited as the casualty of stablecoin adoption. The evidence is thus more consistent with a changing composition of credit provision than with its destruction.

While onchain credit extends stablecoins deeper into financial intermediation, our final fact documents a capability of tokenized money that has no close analogue in traditional finance: payments initiated by machines.

Fact 5: Stablecoins Enable Programmable, Machine-Initiated Payments

The first four facts concern uses of stablecoins with recognizable analogues in traditional finance: payments, savings, cash management, and credit. The final fact concerns a structural capability of tokenized money that has no such analogue: programmability. Because stablecoins settle on programmable ledgers, value can be held and transferred by software. A stablecoin payment can be initiated by a person signing a transaction, but it can equally be executed by a smart contract carrying out pre-specified logic, or initiated by an autonomous software agent transacting on behalf of a principal. Traditional payment systems, by contrast, are organized around account relationships anchored to identified human or corporate account holders; a piece of software cannot hold a bank account in its own right. On public blockchains, contract accounts are first-class holders of money.

This section documents the machine-initiated layer of stablecoin activity in two steps. We first measure the footprint of smart contracts in stablecoin transfers and categorize the activities they

perform; these programmable payments already constitute a substantial share of all stablecoin activity. We then examine the newest extension of machine-initiated payments: agentic commerce, in which AI agents transact autonomously over open payment protocols such as x402.

Smart-Contract Activity in Stablecoin Transfers

We measure the footprint of machine-executed payments directly, using the complete history of USDC and USDT transfer events on Ethereum from January 2020 through May 2026. Each address is classified as a smart contract or an externally owned account based on observed onchain deployment or event emission, a registry-based classification validated against live chain state for the largest stablecoin holders (Appendix A, Section A.10). We then measure, for each month, the share of stablecoin transfer transactions in which a smart contract appears on at least one side of a transfer, and the share in which a transfer is itself executed by contract logic, meaning that the token-level sender is a contract disbursing funds according to its code.

Figure 16 shows that machine-executed transfers are not a niche activity: they carry the majority of stablecoin value movement. In 2025, 35 percent of stablecoin transfer transactions on Ethereum involved a smart contract, and these transactions carried 69 percent of transfer volume (the dollar value of stablecoins moved); 28 percent of transactions included a contract-executed transfer, and such transfers accounted for 60 percent of volume. The transaction-count share has exceeded one quarter in every year since 2021, and the volume share has trended upward, reaching roughly 80 percent in the final months of the sample. Programmability, in other words, is not a prospective feature of stablecoins: most of the dollar value that moves onchain already moves through code.

Figure 17 decomposes contract-involved volume by the economic function of the contract, mapped from curated address labels. The composition has shifted markedly over the sample. In



Figure 16: **Smart-Contract Involvement in Stablecoin Transfers, 2020–2026.** Monthly shares of USDC and USDT transfer activity on Ethereum involving smart contracts. Solid lines plot the share of transfer transactions (navy) and of transfer volume, the dollar value of stablecoins moved (crimson), with a smart contract on at least one side of a stablecoin transfer; dashed lines plot the stricter measure requiring the transfer to be executed by a contract (the token-level sender is a contract). The dashed series are a subset of the solid ones and therefore always lie below them. Addresses are classified as contracts from observed onchain deployment or event emission (Appendix A, Section A.10); mint and burn events are excluded. Data for 2026 run through May.

2020–2021, decentralized exchanges and yield protocols dominated. By 2025, the largest category is lending protocols at 33 percent of contract-involved volume (the credit infrastructure documented in Fact 4), followed by professional market-making and OTC settlement (25 percent) and exchange-operated custody contracts (22 percent), with decentralized exchanges at 8 percent. By transaction count, decentralized exchanges (32 percent) and exchange custody infrastructure (31 percent) lead. These categories describe automated financial operations that code executes at machine speed and scale: collateral management, liquidity provision, settlement, and custody. Notably, contracts labeled as payments and commerce processors account for only 0.1 percent of contract-involved volume: the programmable layer of stablecoins has so far automated *finance*, leaving machine-native *commerce* largely unoccupied—the gap that agentic payment protocols, discussed below, are beginning to fill.

The participation data underscore both how concentrated and how widely used this programmable layer is (Figure 18). Roughly 779,000 distinct contract addresses, each a programmable counterparty with no analogue in traditional payment systems, transacted in USDC or USDT during 2025. Yet contracts constitute only 3 percent of the 24.6 million active stablecoin addresses. This compact layer of machine intermediaries serves most of the user base: the share of active EOA wallets that transacted with at least one smart contract during the year rose from 8 percent in 2020 to 50 percent in 2025. Transacting with code, rather than only with other people, is now the experience of the typical stablecoin user.

A stock measure completes the picture. Figure 19 plots the share of Ethereum USDC and USDT supply held inside smart contracts at month-end: 16 percent at the end of 2020, peaking at 31 percent during the 2021–2022 DeFi expansion, and 18 percent (roughly $27 billion) as of May 2026. The contrast between the flow and stock measures is informative: contracts execute roughly 70 percent

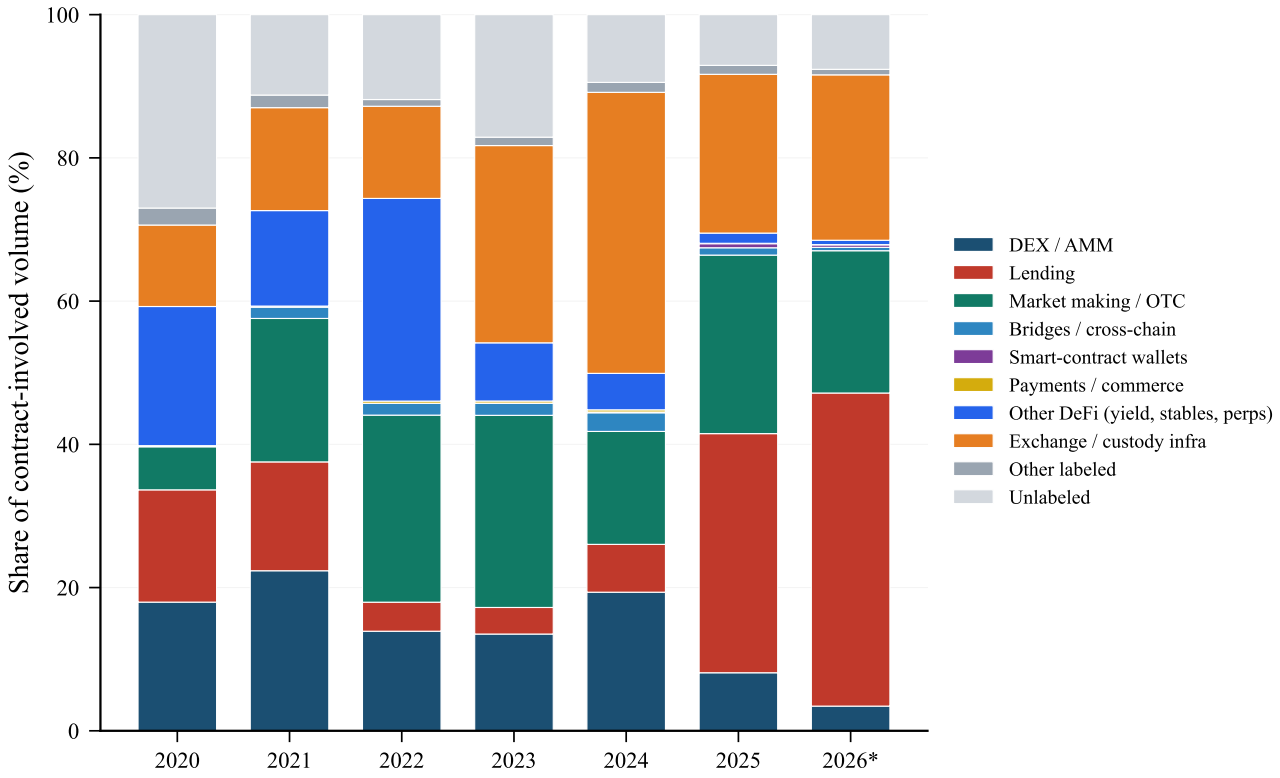


Figure 17: **Composition of Contract-Involved Stablecoin Volume by Contract Function.** Annual shares of contract-involved USDC and USDT transfer volume on Ethereum, attributed to the function of the contract counterparty (the sending contract where both sides are contracts), mapped from curated address labels, smart-account standards, and inferred contract classifications. Exchange-operated smart-custody accounts are assigned to exchange/custody infrastructure rather than to smart-contract wallets. In 2025, 93 percent of contract-involved volume maps to a labeled category. The 2026 bar covers January through May.

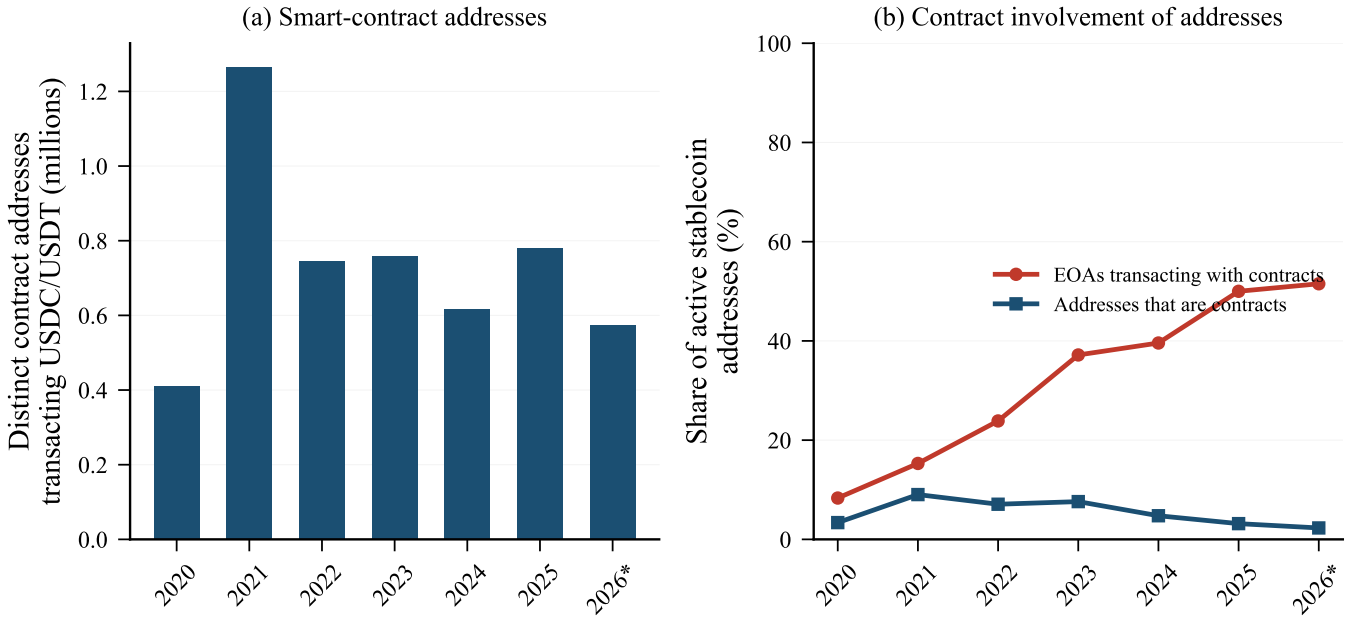


Figure 18: **Smart-Contract Addresses in the Stablecoin Ecosystem.** Panel (a) plots the number of distinct smart-contract addresses that sent or received USDC or USDT on Ethereum each year. Panel (b) plots contracts as a share of all active stablecoin addresses (navy squares) and the share of active EOA wallets that transacted with at least one smart contract during the year (crimson circles). Active addresses include every address with at least one transfer during the year, with no balance or activity thresholds. The 2026 figures cover January through May.

of stablecoin volume while holding under 20 percent of supply, indicating that the contract layer functions primarily as flow infrastructure that routes, settles, and transforms value, rather than as a store of balances. The composition of contract-held balances also points to the growing role of programmable custody: as of May 2026, roughly $9.6 billion sits in exchange-operated smart-custody accounts built on account-abstraction standards, with a further $3.9 billion in end-user multisignature smart wallets.

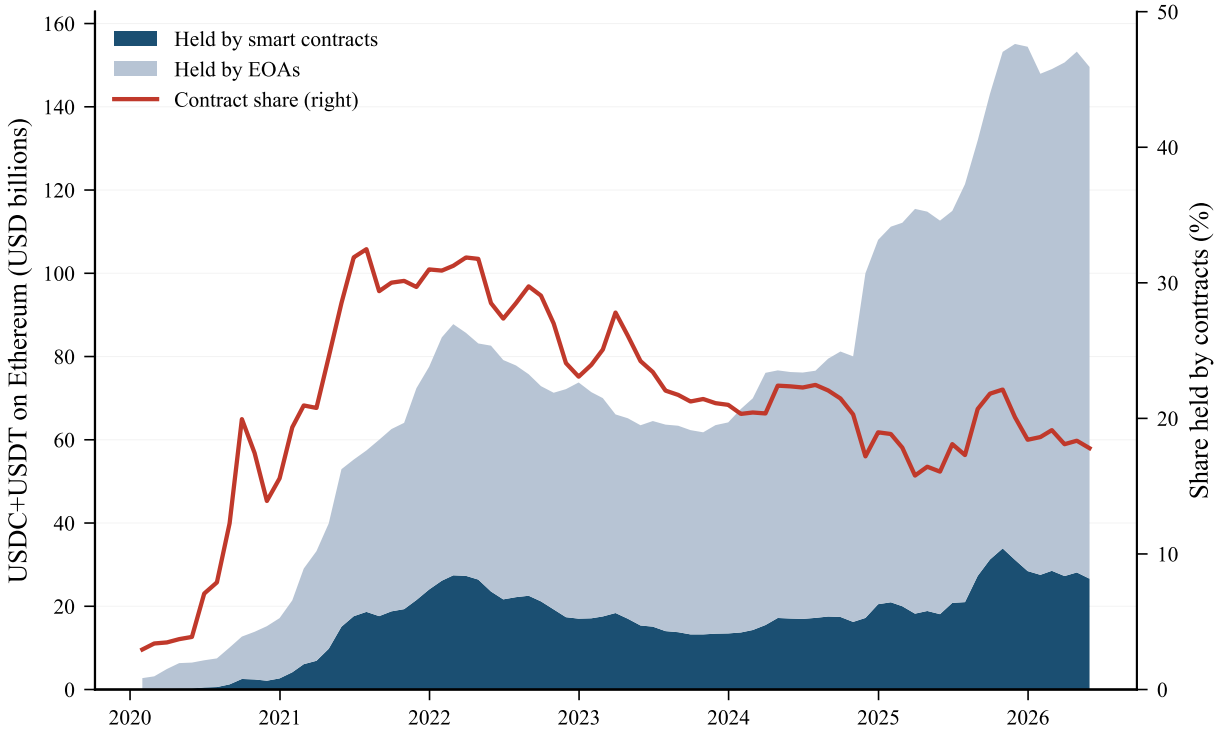


Figure 19: **Stablecoin Supply Held by Smart Contracts.** Month-end USDC and USDT balances on Ethereum held by smart contracts versus externally owned accounts (stacked areas, left axis), and the share held by contracts (line, right axis), January 2020 through May 2026.

Two qualifications frame the interpretation of these measures. First, a transfer executed by a contract is machine-*executed* but not necessarily machine-*originated*: at the top of most call chains is a human-signed transaction, with the contract carrying out disbursement logic that the human invoked. Second, as the category decomposition makes clear, today's programmable activity is overwhelmingly financial automation rather than the purchase of goods and services. Both qualifi-

cations point to the same frontier: payment flows in which software is not merely the executor but the initiating economic agent.

Agentic Commerce and the x402 Protocol

Smart-contract activity documents machines *executing* payments according to rules set by humans. A newer development is machines *initiating* payments: autonomous AI agents that procure services and settle for them in stablecoins. The most visible early infrastructure for such payments is the x402 protocol, an open internet payment standard named after the previously unused HTTP status code *402 (Payment Required)*, which attaches stablecoin payments to standard HTTP request flows. When a client, whether human or machine, requests a paid resource, the server responds with payment terms; the client signs a stablecoin payment authorization; and a *facilitator* service verifies the authorization and settles it onchain, allowing the request to proceed. Payment verification and settlement complete within a single request-response cycle, without accounts, subscriptions, or card credentials.

The protocol supports three broad use cases. First, x402 enables API monetization, paywalls, and pay-as-you-go services, allowing content and service providers to charge for access in real time. Second, it supports micropayments as small as fractions of a cent, which make long-tail and usage-based business models economically viable by allowing users to pay only for exactly the services they consume. Third, because payments can be made programmatically and without identity-linked accounts, x402 enables agentic payments, in which AI agents transact autonomously across the internet without human intervention.

Because x402 is an application-layer protocol with no unique smart contract or token standard, transactions cannot be identified directly from onchain metadata; we instead identify x402 activity

by cross-referencing transactions against the set of known facilitator services that handle payment verification on behalf of the protocol (Appendix A, Section A.8). All currently identified facilitators are EVM-native, so our sample is restricted to EVM-compatible blockchains. USDC accounts for 99.9 percent of x402 transactions and 98.6 percent of x402 volume in the sample.

Figure 20 plots monthly x402 transactions and volume since the protocol's launch in May 2025. Activity rose explosively through late 2025, from 725 transactions in the launch month to a peak of 42 million transactions in November, before contracting sharply as the initial wave of experimentation, incentive-driven usage, and protocol trials subsided.

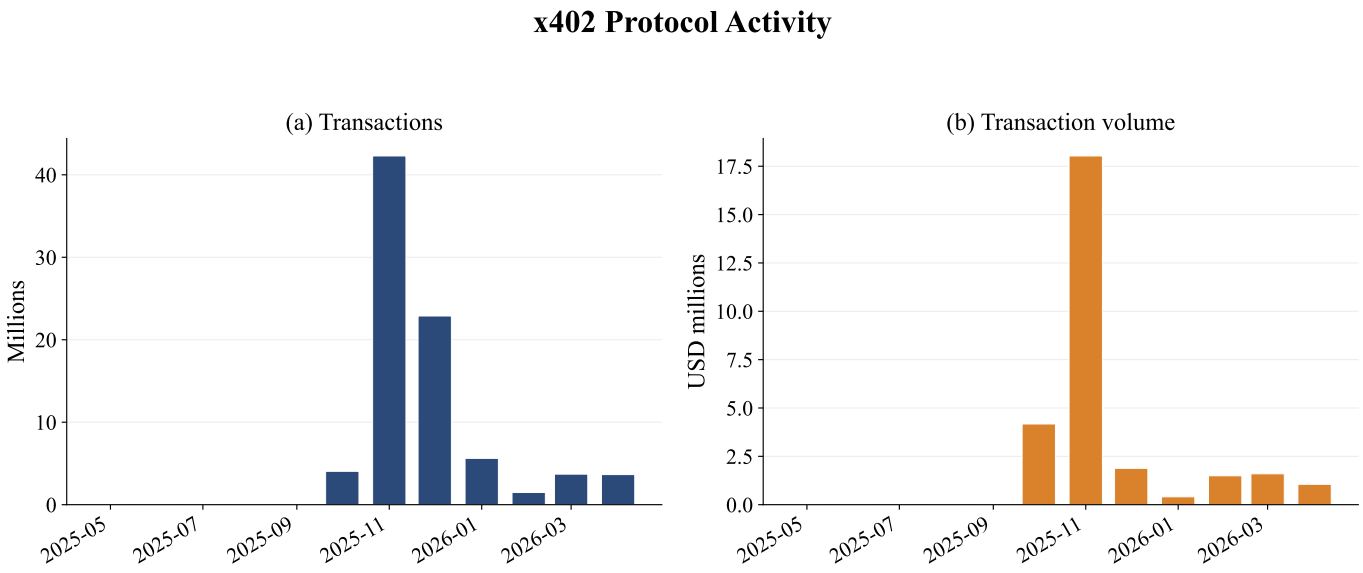


Figure 20: **x402 Protocol Activity, May 2025–April 2026.** Panel (a) plots the monthly count of x402 transactions, in millions. Panel (b) plots monthly x402 transaction volume, in USD millions. x402 transactions are identified by cross-referencing sender addresses against the set of known x402 facilitator services across all EVM-compatible chains; USDC accounts for 99.9 percent of transactions and 98.6 percent of volume in the sample. Data are sourced from Dune Analytics.

The contraction was not, however, the end of the protocol. Figure 21 extends the series through May 2026 using a broader, continuously maintained facilitator registry that includes facilitators added after the Dune sample was constructed, most notably on Solana; under this broader coverage,

activity peaked at 68 million transactions in December 2025.[16] After bottoming at 4.8 million transactions in February 2026, monthly transaction counts have risen for three consecutive months: 5.9 million in March, 6.4 million in April, and 7.6 million in May. The first ten days of June imply a monthly pace of roughly 11 million. Participation has broadened alongside: the number of distinct selling services rose from about 9,100 in February to 10,800 in May, and monthly active buyer wallets, which averaged roughly 30,000 in early 2026, spiked to 87,000 in May (Figure 22).[17] Notably, the recovery is concentrated in transaction counts rather than dollar volume, which declined from $2.2 million in February to $1.1 million in May: the average x402 transaction has fallen to roughly $0.14, and the sub-cent micropayment share has more than doubled since February, to 26 percent in May. This combination of many small machine-scale payments, a growing seller base, and falling dollar volume is consistent with payment-service providers and API vendors building and exercising acceptance capability ahead of sustained end demand.

Figure 23 decomposes x402 activity into micropayments, defined as transfers of less than one cent. Micropayments dominated in the protocol's early months and declined as a share of transactions over the late-2025 burst, reflecting an increase in higher-value pay-per-use API transactions; in the post-February 2026 recovery, the micropayment share has risen again, consistent with renewed machine-scale usage. The median x402 micropayment in the high-activity period was approximately $0.0001, four orders of magnitude below the minimum economical transaction size on conventional card rails.

[16] The two series agree within roughly 2 percent through October 2025 and diverge thereafter as Solana-based facilitators, which at times carried up to 40 percent of transactions, came online. The broader registry covers 184 facilitator addresses across 17 EVM-compatible chains and Solana (Appendix A, Section A.8). Because the registry was last expanded in April 2026, facilitators launched since then are not captured, so the most recent months are, if anything, understated.

[17] Part of the post-February growth in transaction counts is concentrated: on Polygon, several million monthly transactions originate from fewer than 500 buyer addresses. Activity on Base, the protocol's largest venue, shows the same rising pattern, with 2.1 million transactions in April, 2.5 million in May, and a June pace near 6 million, alongside much broader buyer participation.



Shaded region marks the zoom window.

Figure 21: **x402 Protocol Activity Under Extended Coverage, May 2025–May 2026.** The top panels plot monthly x402 transactions (millions) and volume (USD millions) over the full sample; the bottom panels zoom in on the February–May 2026 recovery, with month-over-month growth rates labeled. A transfer is classified as an x402 settlement if the transaction is signed by a known x402 facilitator address (registry of 184 addresses), settling via EIP-3009 `transferWithAuthorization`, Permit2, multicall, or the Solana equivalent; coverage spans 17 EVM-compatible chains and Solana, predominantly USDC on Base.

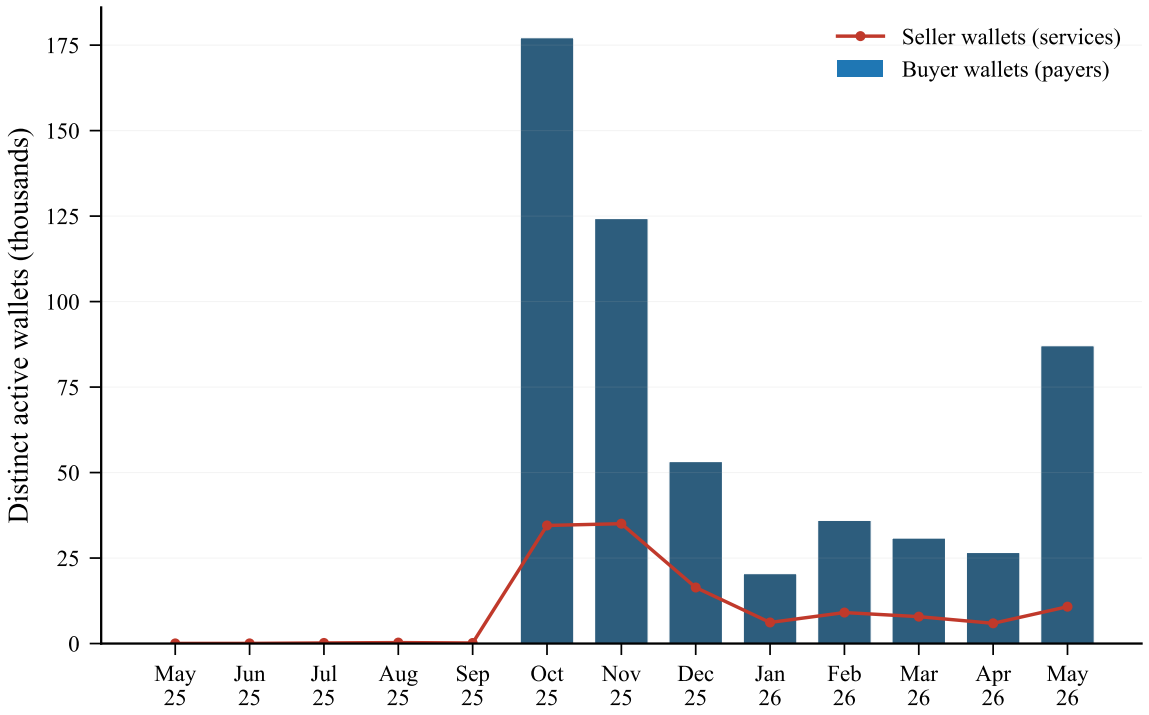


Figure 22: **x402 Buyer and Seller Wallets, May 2025–May 2026.** Bars plot monthly distinct buyer wallets; the line plots monthly distinct seller services receiving x402 payments. Sample construction follows Figure 21.

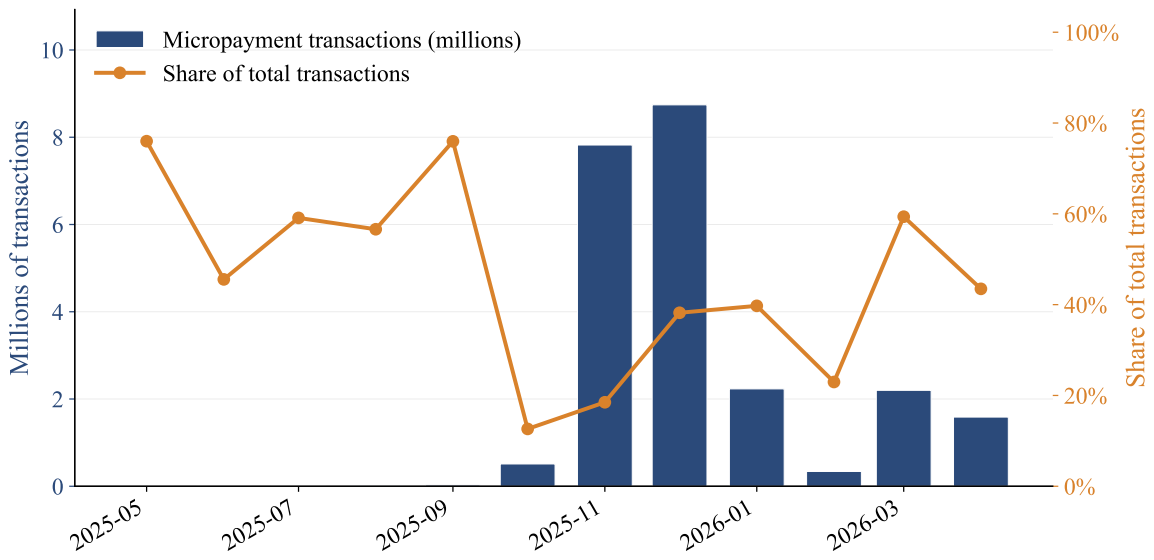


Figure 23: **x402 Micropayments, May 2025–April 2026.** Bars (left axis) plot the monthly count of x402 micropayment transactions, defined as transfers of less than $0.01, in millions. The line (right axis) plots the share of total monthly x402 transactions that qualify as micropayments. Sample construction follows Figure 20.

Discussion

The x402 trajectory of explosive growth, sharp retrenchment, and gradual rebuilding from a lower base is characteristic of new protocol infrastructure, in which speculative experimentation precedes durable demand. We accordingly read the x402 evidence not as proof of sustained agentic commerce at scale, but as a demonstration of technical and economic feasibility: machine-to-machine payments at sub-cent denominations clear at internet scale on stablecoin rails, something no conventional payment system can do. Meanwhile, merchants and payment service providers have continued to build x402 acceptance capability through the retrenchment, positioning the infrastructure ahead of demand.

The relevance of this capability is likely to grow. AI systems are increasingly deployed in *agentic* workflows, in which software agents plan and execute multi-step tasks with limited human su-

pervision, and the capability frontier of these systems continues to advance. As agents take on a growing share of economically valuable work over the coming years, they will increasingly need to procure inputs such as data, computation, API calls, content, and services from other agents, and therefore to exchange value at machine speed and machine granularity. Conventional payment rails are poorly suited to this demand: their per-transaction costs are orders of magnitude above sub-cent price points, and their account, authentication, and fraud frameworks presuppose human counterparties. Stablecoin rails offer the combination that machine-native commerce requires: transaction costs measured in fractions of a cent (Fact 1), programmability that lets payment conditions be expressed in code, continuous settlement, and the ability for software to hold and disburse value directly.

Together, the substantial smart-contract share of stablecoin activity today and the nascent agentic-payment infrastructure being built on top of it indicate that tokenized money is becoming the settlement layer not only for human commerce conducted through machines, but for commerce conducted *by* machines.

5 Discussion

The five facts documented above characterize stablecoins as a rapidly maturing form of tokenized money: usage patterns increasingly resembling those of a transaction currency, a distinct geographic footprint, wallet-level behavior consistent with classical cash-management theory, a growing rule-based credit market settled in stablecoins, and a layer of programmable, machine-initiated payments with no traditional counterpart. We close the paper by situating these findings in two broader contexts: the implications of stablecoin growth for traditional financial markets, and the design of

regulatory frameworks that have begun to govern stablecoin issuance and circulation.

5.1 Implications for Traditional Financial Markets

The growth of stablecoins also has implications for traditional financial markets, most directly through the reserve assets that stablecoin issuers hold to maintain their pegs. Both Tether and Circle hold the bulk of their reserves in short-dated U.S. Treasuries and Treasury repurchase agreements, which means that stablecoin issuance translates almost mechanically into demand for short-end Treasury securities. This channel makes stablecoin issuers a structurally novel class of marginal buyers in the U.S. Treasury market, with reserve flows driven by stablecoin issuance and redemption dynamics rather than by the conventional demand drivers operating in money market funds and bank balance sheets. The flows are no longer negligible: issuance added roughly $86 billion per year to reserve-asset demand over 2024–2026 (Table 3), tied to adoption rather than to yield, and therefore a demand source whose elasticity differs from that of money funds and bank portfolios.

The banking system is the second point of contact. A standing concern is that stablecoin growth drains the deposit funding behind bank credit; the accounting and evidence of Fact 4 bound this concern tightly. Issuance relabels deposits across holders and banks except for the share of reserves that is, at the margin, sold out of bank securities portfolios, and no payment chain reaches a loan book mechanically. The substitution evidence indicates that the marginal stablecoin dollar displaces physical currency and offshore dollar balances more than domestic deposits, so that even at the adverse edge of the parameter ranges, a year of issuance at the 2024–2026 pace would reduce U.S. deposits by less than one twentieth of one percent, and the central readings are positive rather than negative. Where stablecoins do compete with deposits, the pressure falls on deposit pricing and franchise margins rather than on lending volumes, echoing earlier episodes of deposit

competition from money market funds, and the reserve dollars themselves recycle to money funds and dealers, the marginal suppliers of bank wholesale funding. The aggregate relevant for credit provision, across banks, nonbank intermediaries, and now onchain protocols, is reallocated rather than reduced.

Our analysis also has implications for the structure of the international monetary system. Despite the stated desire of other countries to diversify away from the dollar for both payments and foreign exchange reserves, the rising demand for dollar-backed stablecoins for both within and cross-region transactions could reinforce the dollar's dominance, especially in its role as a payment currency (see Liao, Prasad, and Zhang, forthcoming). By lowering the cost and friction of cross-border payments, stablecoins can expand access to dollar-denominated savings and payment rails in emerging market and developing economies, while also raising questions for policymakers about how existing frameworks for capital flows and exchange rate management adapt to faster, more open payment systems. The denomination evidence in Fact 4 suggests the substitution is already under way: growth of the foreign-held $100-note pool, the traditional vehicle of offshore dollar savings, has fallen well below its historical rate and did not recover as policy eased, even as stablecoin issuance accelerated.

5.2 Implications for Regulatory Frameworks

The empirical patterns we document have direct implications for the design of stablecoin regulation. The passage of the GENIUS Act in July 2025 established the first federal regulatory framework for payment stablecoins in the United States, requiring full reserve backing in cash and short-dated Treasury equivalents, regular audits, and consumer disclosures. Our evidence that stablecoins are increasingly used as tokenized cash—with transaction volume, velocity, transaction-size distribu-

tion, and wallet-level behavior all consistent with a transaction currency rather than a speculative asset—is consistent with the broad design choice embedded in the GENIUS Act of treating payment stablecoins as a payment instrument rather than as a security or as a deposit-substitute requiring intermediation. The accounting in Fact 4 speaks to the deposit-erosion concern most often raised against that choice: the parameters governing deposit displacement are observable and small under current reserve practice; the concern is, on present evidence, bounded rather than open-ended.

In the European Union, the Markets in Crypto-Assets Regulation (MiCA) places greater emphasis on where reserves are held: issuers of e-money tokens must hold a substantial portion of reserves—on the order of 30 to 60 percent, depending on the issuer's classification—as deposits at EU credit institutions. This requirement serves legitimate regulatory objectives, including supervisory oversight of reserve assets, counterparty diversification, and the integration of stablecoin reserves within the EU banking perimeter. It also raises an open question for dollar-denominated tokens: because European banks' capacity to source and deliver dollars depends in part on cross-border wholesale funding markets, how localized reserve-deposit requirements interact with the global structure of dollar liquidity—particularly during periods of market stress—is a question that merits further study as the market grows.

Taken together, these regulatory developments and our empirical findings highlight the central design tension in stablecoin regulation: balancing the legitimate sovereign interest in supervisory reach and monetary autonomy against the structural features of the international dollar system that shape how multi-jurisdictional reserve arrangements perform under stress. As stablecoins grow into a more central piece of the global payments architecture, the design of these frameworks will materially shape both the stability of stablecoin issuance and the broader pass-through of stablecoin growth into traditional financial markets. A further design margin is opened by Fact 5:

as a growing share of payments is initiated by contracts and autonomous agents rather than by identified account holders, frameworks built around issuer reserves and redemption will confront questions of authorization and attribution for machine-initiated transactions that current statutes leave open.

6 Conclusion

This paper has documented five facts that characterize the rapidly evolving stablecoin market. First, stablecoins are functioning as a transaction currency: their onchain transaction volume now exceeds Bitcoin's despite a much smaller outstanding supply, their velocity has risen sharply, their transaction-size distribution has shifted toward small-value and micropayment-scale transfers as onchain transfer costs have fallen, and their wallet composition has shifted toward payment-oriented users and away from exchange-affiliated and trading wallets. Second, stablecoin activity has a global geographic footprint, with transaction volume distributed roughly evenly across the Americas, Europe, and Asia; correcting the industry-standard attribution with transaction-timing evidence shows that the majority of volume flows within regions rather than across them, and that balances are migrating toward Asia-Pacific, which holds over forty percent of attributed balances by 2025. Third, at the wallet level, stablecoin usage closely resembles traditional cash management: the rising free-adjustment intensity and falling transaction cost estimated from the structural model indicate that stablecoin owners are gaining more frequent and cheaper access to the onchain rails. Fourth, stablecoins have become the settlement currency for a rapidly expanding onchain credit market in which collateral requirements, interest rates, and liquidations are enforced by rule-based smart contracts rather than by intermediary discretion, a structure that prices credit risk through

market forces and narrows the scope for moral hazard in intermediation while relocating risk to protocol design. Balance-sheet accounting disciplined by reserve disclosures and by currency-in-circulation data indicates that this growth proceeds by reallocation rather than destruction of credit, with deposit effects bounded near zero and positive at central readings. Fifth, stablecoins support programmable, machine-initiated payments: more than two thirds of stablecoin transfer volume already involves smart-contract logic, concentrated in financial automation such as lending protocols while machine-native commerce remains largely unoccupied, and early agentic-payment protocols such as x402 have demonstrated that machine-to-machine commerce at sub-cent denominations is feasible on stablecoin rails, a capability whose relevance will grow as agentic AI systems take on a larger role in economic activity.

Together, these facts suggest that stablecoins are emerging as a form of tokenized money. As we discuss above, this maturation has consequences that extend well beyond the stablecoin market itself: stablecoins generate structurally novel demand for short-dated U.S. Treasury securities, leave bank deposit funding largely undisturbed on current evidence, and pose new design questions for regulators in both the United States and the European Union. We expect that the patterns documented here will continue to evolve as the regulatory landscape matures, as the underlying blockchain infrastructure continues to scale, and as machine-initiated economic activity grows.

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Appendices for

Stablecoins as Tokenized Money

Lin William Cong Gordon Liao Eswar Prasad Tony Zhang

Appendix A: Data Construction

This appendix describes the construction of the datasets used throughout the paper. Our analysis draws on three primary data sources: (i) Ethereum blockchain records accessed via Google BigQuery's public and indexed blockchain datasets, (ii) aggregated market data from DeFiLlama and similar public dashboards, and (iii) Dune Analytics for x402 protocol transactions. We describe each in turn.

A.1 Blockchain transaction data. Our core dataset consists of the complete history of ERC-20 token transfers on the Ethereum blockchain from January 2020 through December 2025. These data are extracted from indexed blockchain tables that parse the raw Ethereum transaction logs into structured records of token transfers. For each transfer, we observe the sender address, recipient address, token identifier, transfer amount, block timestamp, and associated gas fee. We focus on transfers of USDC and USDT, the two dominant dollar-denominated stablecoins, which together account for approximately 85 percent of total stablecoin circulation and over 99 percent of onchain stablecoin transaction volume as of December 2025.

We complement the transfer-level data with a daily balance panel that records, for each wallet–token–day triple, the end-of-day stablecoin balance, the number of transactions, and the volume of sends and receives. This panel is constructed from the cumulative transfer history and enables us to track wallet-level holdings dynamics at a daily frequency without requiring real-time node queries.

A.2 Wallet classification. We classify all Ethereum addresses into three mutually exclusive categories based on their onchain characteristics.

Externally owned accounts (EOAs) are addresses controlled by a private cryptographic key, typically representing an individual, a business, or an institutional user. EOAs are the residual category after excluding contract and exchange addresses.

Smart contract addresses are identified from the Ethereum contract registry, which records all addresses that contain deployed bytecode. These include DeFi protocol contracts, multisignature wallets, and other programmable addresses. We exclude smart contracts from the wallet-level analyses, as their transaction patterns reflect automated protocol logic rather than individual or business cash management behavior.

Exchange-affiliated addresses are identified by combining two complementary sources. The first is a set of curated address labels that tag addresses belonging to known cryptocurrency exchanges (e.g., Coinbase, Binance, Kraken). These labels cover exchange hot wallets, cold storage addresses, and operational wallets, and are compiled from publicly available blockchain analytics, exchange disclosures, and community-maintained databases.[18] The second source is a table of exchange deposit addresses, which maps individual user deposit addresses to their parent exchange omnibus wallets by tracing the flow of funds from deposit addresses to known exchange hot wallets. The union of these two sources provides comprehensive coverage of exchange-affiliated activity.

A.3 Active wallet cohort. For the wallet-level analyses, we restrict attention to a cohort of active stablecoin wallets. Cohort membership requires meeting three criteria within a given calendar year: (i) a maximum combined stablecoin balance (across USDC, USDT, and DAI) of at least $1,000 at any point during the year; (ii) at least five stablecoin transactions during the year; and (iii) the wallet must be active from the beginning of the year (i.e., it appears in the balance panel on January 1).

We further exclude two categories of wallets that are unlikely to represent sustained economic

[18] Public sources of exchange address labels include Etherscan labels, Dune Analytics community tables, and exchange self-disclosures in proof-of-reserves reports.

activity. *Transitory wallets* are those for which total sends approximately equal total receives and for which the overnight balance never exceeds zero—these are pass-through addresses that briefly hold stablecoins in transit. *Ephemeral wallets* are those whose outgoing transaction history spans fewer than three calendar days, indicating short-lived activity inconsistent with ongoing payment or savings behavior.

These filters are designed to isolate wallets engaged in meaningful, sustained stablecoin usage. The balance threshold excludes dust accounts and abandoned wallets; the transaction threshold excludes wallets with negligible activity; and the ephemeral and transitory filters remove addresses that serve a purely mechanical routing function.

A.4 Stablecoin-dominant wallet classification. To measure the prevalence of wallets that use stablecoins primarily for payment rather than in support of cryptocurrency trading, we classify each wallet in the active cohort based on its non-stablecoin token transfer activity. Specifically, we query the full ERC-20 token transfer history for each cohort wallet and flag wallets that sent at least one non-stablecoin token during the year. Wallets with no outgoing non-stablecoin transfers are classified as *stablecoin-dominant*: their onchain activity consists entirely of stablecoin sends, consistent with using stablecoins as a standalone payment instrument rather than as a complement to broader cryptocurrency trading.

This classification is intentionally conservative in that it examines only outgoing transfers. A wallet that passively receives non-stablecoin tokens (e.g., airdrops) but never actively sends them is still classified as stablecoin-dominant, as its revealed behavior is exclusively oriented toward stablecoin transactions.

A.5 Wallet segmentation. In addition to the stablecoin-dominant classification, we implement a finer-grained segmentation of active stablecoin wallets that categorizes each wallet into one of four segments based on its onchain behavior during a calendar year. This segmentation is applied

to all non-contract wallets that have received at least one USDC or USDT transfer during the year and maintain a positive holding-day average stablecoin balance above $10 (where the holding-day average is computed over days on which the balance is strictly positive).

The segmentation algorithm proceeds hierarchically:

1. *Exchange wallets.* An address is classified as an exchange wallet if it appears in either the curated exchange address label set or the exchange deposit address table. This category captures hot wallets, cold wallets, and deposit addresses operated by centralized cryptocurrency exchanges.

2. *Ephemeral wallets.* Among the remaining (non-exchange) addresses, those whose entire transaction history within the year spans three calendar days or fewer are classified as ephemeral. These wallets are typically used for a single transaction sequence and then abandoned.

3. *Trading wallets.* Among non-exchange, non-ephemeral wallets, we compute a turnover ratio defined as the average daily non-stablecoin transaction volume divided by the average daily stablecoin balance (both averaged over the same annual window). Wallets with a turnover ratio exceeding 5 percent are classified as trading wallets, indicating substantial engagement with non-stablecoin digital assets relative to their stablecoin holdings.

4. *Payment wallets.* The residual category consists of wallets with a turnover ratio of 5 percent or below. These wallets hold stablecoins with minimal non-stablecoin trading activity, consistent with using stablecoins primarily for payments, savings, or settlement.

The non-stablecoin volume used in the turnover ratio is computed from the full ERC-20 token transfer history (excluding USDC and USDT), with each token transfer valued at its daily spot price from decentralized exchange (DEX) price feeds. The stablecoin balance denominator uses the holding-day average rather than the calendar-day average, which avoids diluting the ratio for wallets that are intermittently active.

For reporting purposes, we present two variants: the full four-way segmentation (including ephemeral wallets) and an ex-ephemeral segmentation that redistributes attention to the three economically substantive categories. Balances are reported using a year-end snapshot (December 31) rather than an annual average, as the snapshot more closely corresponds to reported aggregate circulation figures.

A.6 Geographic attribution. The geographic distribution of stablecoin activity presented in Fact 2 is estimated using wallet-to-wallet transfer volumes on Ethereum, with geographic attribution proceeding in two stages: a prior based on counterparty visitor shares and a Bayesian update based on transaction timing.

Prior construction. For each stablecoin transfer, we trace the flow of funds through a chain of up to ten intermediate transactions to identify a counterparty wallet or service with known geographic characteristics—predominantly cryptocurrency exchanges, payment processors, and regulated on-ramp/offramp services with measurable web traffic patterns. Once a counterparty is identified, we allocate the transaction volume proportionally across regions based on the counterparty's observed IP traffic distribution. This visitor-share allocation serves as the prior $P(\rho \mid \text{wallet})$ over three broad regions: the Americas, Europe–Middle East–Africa (EMEA), and Asia–Pacific (APAC). Transfers that cannot be linked to a service with known geographic traffic within ten hops are excluded.

Bayesian updating. We refine the prior using the timing of each wallet's transactions. Because circadian activity patterns differ across regions, the distribution of transaction hours (in UTC) carries geographic information. We construct empirical hourly likelihood distributions $P(h \mid \rho)$ from exchange-level transaction data, using exchanges with known regional concentration to identify region-specific timing patterns. The likelihoods are calibrated separately for each calendar year to account for shifts in global activity distributions. For a wallet with n observed transactions at UTC

hours $h_1, \ldots, h_n$, the posterior region probability is

$$P(\rho \mid h_1, \ldots, h_n) \propto P(\rho) \times \prod_{i=1}^{n} P(h_i \mid \rho).$$

Both the sender and receiver of each transfer are attributed independently via separate Bayesian posteriors. This dual-sided attribution means that a transfer's sender and receiver may be assigned to different regions with different confidence levels.

Exchange wallet exclusion. Exchange-operated wallets (hot wallets and cold storage addresses, identified via address-label databases) are excluded from the Bayesian attribution. These wallets constitute approximately 1.5 percent of wallet-to-wallet addresses but carry 57–65 percent of wallet-to-wallet volume. Their extreme transaction frequencies (100,000+ transactions per month) cause the posterior to converge to whatever region has slightly higher likelihood density, producing degenerate attributions that can introduce spurious regime breaks in the time series. The exclusion filter operates on the transaction signer (the externally owned account that signed the Ethereum transaction), which preserves user-initiated deposits to exchanges while excluding exchange-initiated withdrawals and rebalancing flows.

Robustness. As an alternative specification (Model B), we calibrate the hourly likelihood using data from the BIS Triennial Central Bank Survey of foreign exchange turnover by time zone, which provides an independent anchor for regional activity patterns. The exchange-calibrated model (Model A) and FX-calibrated model (Model B) produce bounds on the cross-regional share of flows: 42–48 percent (Model A) and 8–13 percent (Model B), compared with 63 percent under the prior-only allocation.

Limitations. The prior-based step assumes that transaction sizes are distributed similarly across regions for a given counterparty and may be distorted by VPN usage. The Bayesian update assumes that circadian timing patterns are stable within each calendar year and that the exchange-level training sample is representative of the broader wallet population. Transactions that do not pass

through identifiable services are excluded, which may introduce selection bias.

A.7 Onchain credit data. Data on secured and unsecured onchain credit (Fact 4, Section 4) are sourced from public DeFi protocol dashboards and data aggregators. Secured credit outstanding is measured as the total value of stablecoin loans on overcollateralized lending protocols (principally Aave, Compound, and MakerDAO), where borrowers post cryptocurrency collateral that exceeds the loan value. Unsecured credit outstanding is measured from institutional lending protocols (principally Maple Finance and Clearpool) that extend stablecoin loans based on off-chain credit assessments rather than onchain collateral. Both series are reported at monthly frequency.

A.8 x402 protocol data. Transaction data for the x402 protocol (Fact 5, Section 4) are sourced from Dune Analytics. Because x402 is an application-layer protocol rather than a distinct smart contract standard, x402 transactions cannot be identified directly from onchain metadata such as contract addresses or event logs. Instead, we identify x402 activity by cross-referencing the sender address of each token transfer against a curated table of x402 *facilitators*—intermediary services that handle payment verification and blockchain settlement on behalf of the protocol. This facilitator table is maintained as a community-curated Dune Analytics query and is updated as new facilitators join the protocol.

For each identified x402 transfer, we observe the block date, token symbol, transfer amount in USD, and the project affiliation of the facilitating intermediary. We classify transactions into economic use cases based on the facilitator's project affiliation: *API* (pay-per-use API access), *Agentic* (autonomous AI agent transactions), *Developer* (developer tools and SDKs), *Content* (digital content and media), *Exchanges* (exchange-integrated payments), and *Other*. Transfers with a USD value below $0.01 are classified as micropayments.

Because all facilitators identified in the Dune sample operate on EVM-compatible blockchains, that sample is restricted to these networks (principally Base, Polygon, and Ethereum) and covers

the period from the protocol's launch in May 2025 through April 2026. The extended series in Figures 21 and 22 supplements the Dune sample with x402 settlement records identified by the same facilitator-signer rule under a broader, continuously maintained registry of 184 facilitator addresses spanning 17 EVM-compatible chains and Solana, covering settlements executed via EIP-3009 `transferWithAuthorization`, Permit2, multicall, and the Solana equivalent. The two sources agree within approximately 2 percent through October 2025 and diverge thereafter as Solana-based facilitators came online. For each settlement, the extended records identify the buyer (payer) wallet, the seller (recipient) wallet, the facilitating service, and the settlement amount, which permits the wallet-participation counts reported in Fact 5.

A.9 Aggregate market data. Aggregate stablecoin circulation (Fact 1) is constructed from on-chain mint and burn events for USDC and USDT across all chains on which they circulate, summed to a monthly outstanding supply. Monthly onchain transaction volume for USDC and USDT is computed as the monthly sum of stablecoin transfer value across all chains, excluding Solana, with senders restricted to externally owned accounts. Bitcoin circulation is the circulating coin supply multiplied by the month-end BTC/USD price; Bitcoin onchain transaction volume is the monthly sum of native BTC transfer value. Velocity is the ratio of monthly onchain transaction volume to end-of-month circulation. The transaction-size distribution underlying Figures 4 and 24 is constructed by bucketing each stablecoin send initiated by an externally owned account by its USD value at transaction time; recipient address class is not filtered. The Ethereum transfer-cost series in Figure 5 is computed on Ethereum mainnet as the average annual gas price (in gwei) multiplied by 65,000 (the standard gas usage of an ERC-20 `transfer()` call) and the prevailing ETH/USD price.

A.10 Smart-contract activity in stablecoin transfers. The smart-contract activity series in Fact 5 (Figures 16–19) are constructed from the complete history of natively issued USDC and USDT transfer events on Ethereum mainnet from January 2020 through May 2026, observed at transfer-

event grain with transaction-hash, counterparty, and transaction-origin fields. Mint and burn events (transfers with the zero address on either side) and zero-amount events are excluded.

Contract identification. An address is classified as a smart contract if its deployment was observed onchain or if it has emitted event logs, which only deployed code can do. We deliberately do not use heuristic "called-as-contract" inference, which misclassifies several high-balance exchange-operated EOAs as contracts. The resulting classification was validated against live chain state (`eth_getCode`) for the 150 largest USDC and USDT holders, with 100 percent agreement. Addresses created counterfactually (funded before deployment) count as EOAs until deployed; EOAs with delegated code under EIP-7702 count as contracts. Both groups are negligible at the scale of the reported series.

Measures. A *transaction* is a distinct transaction hash containing at least one stablecoin transfer; it is contract-involved if any of its stablecoin transfers has a contract as the token-level sender or receiver, and machine-executed if the token-level sender of a transfer is a contract. Category attribution assigns each contract-involved transfer to the contract side (the sender where both sides are contracts), mapped from curated address labels (vertical and subvertical), smart-account standards (ERC-4337, Safe, and related), and inferred contract classifications, with exchange-operated smart-custody accounts assigned to exchange/custody infrastructure rather than to end-user smart-contract wallets. In 2025, 92.9 percent of contract-involved volume (80.7 percent of transfer events) maps to a labeled category; the unlabeled residual is largest in 2020. Active-address counts include every address with at least one transfer as sender or receiver during the year, with no balance or activity thresholds (in contrast to the wallet-cohort analyses of Facts 1 and 3). The supply-share series uses daily address-level end-of-month balances; month-end totals reconcile with public circulation figures applied to Ethereum's chain share.

Scope. The Ethereum-only restriction avoids known gross-volume artifacts on other chains, including automated market-maker rebalancing on Base, derivatives-clearing loops on Injective, and bot-generated dust transfers on Celo. As a cross-check, Ethereum USDC and USDT transfer

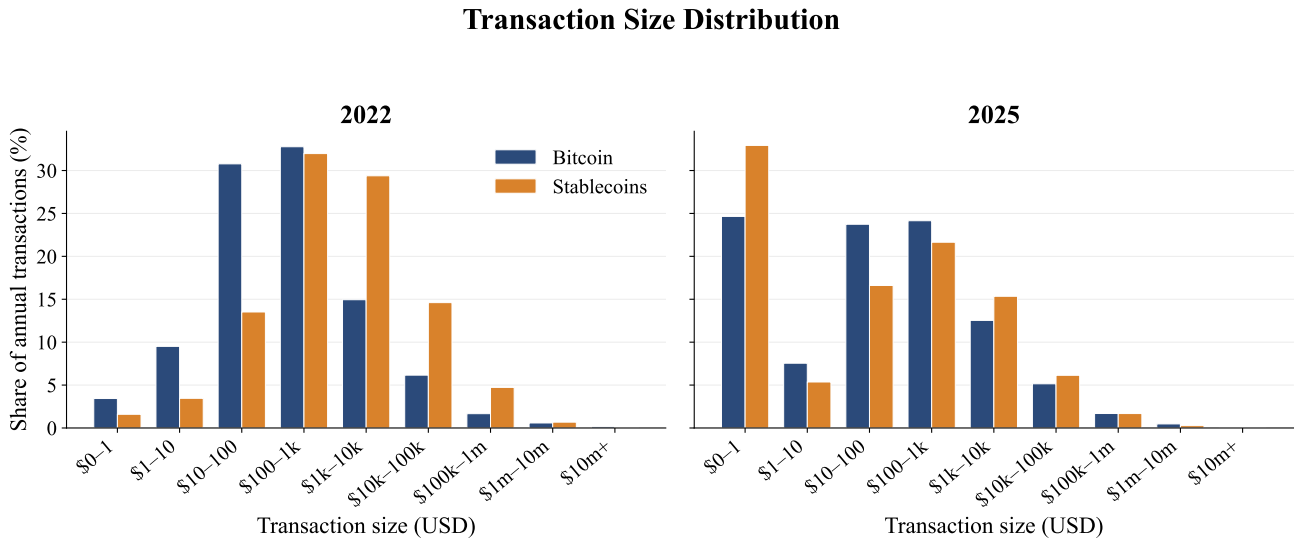
volume in December 2025 ($2.1 trillion) is consistent with Ethereum's share of the all-chain volume series reported in Fact 1.

A.11 Currency in circulation data. The currency series in Table 3 (Fact 4) are constructed from public Federal Reserve sources. Total currency in circulation (Federal Reserve notes plus coin) is FRED series CURRCIR at monthly frequency, extended with the weekly H.4.1 release for the most recent observations. Growth by denomination is computed from the Board of Governors "Currency in Circulation: Value" tables, which report December 31 values by denomination through 2025; the $1–$20 aggregate sums the five transactional denominations. Period growth rates are December-to-December compound annual rates, with the final period extended to the June 10, 2026 weekly observation. The pre-pandemic trend referenced in the text and table is a log-linear fit on January 2012 through December 2019. The stablecoin column is the annualized year-end change in total dollar-stablecoin circulation across all issuers, taken from DeFiLlama's stablecoin circulating-supply data summed across all issuers and chains; this all-issuer aggregate is broader than the USDC-plus-USDT onchain supply series of Section A.9 used in Fact 1, of which USDC and USDT comprise roughly 85 percent.

Appendix B: Additional Results for Fact 1

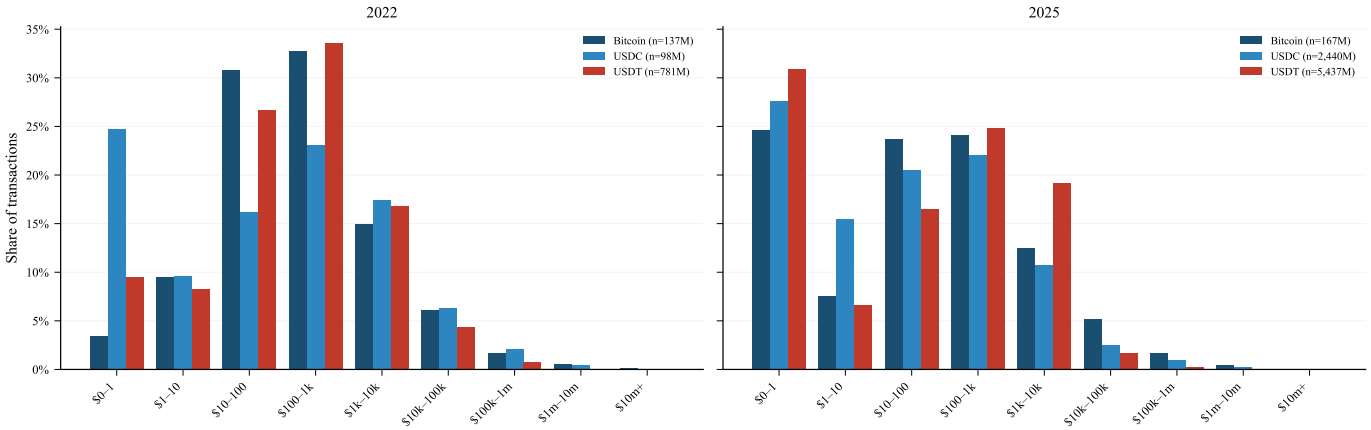
This appendix collects supplementary results referenced in Fact 1. Section B.1 reports two additional cuts of the Bitcoin-versus-stablecoin transaction size distribution—a comparison restricted to Ethereum mainnet, and a full-population breakdown by individual stablecoin. Section B.2 disaggregates the wallet segmentation of Figure 7 by stablecoin.

B.1 Transaction size distribution: additional cuts. The transaction-size comparison in Figure 4 pools stablecoin activity across all chains on which USDC and USDT circulate, excluding Solana. Figure 24 below repeats the exercise restricted to USDC and USDT transfers on Ethereum mainnet. The pattern documented in the main text—similar distributions in 2022, with sharp divergence at the bottom of the size scale by 2025—is robust to this restriction.



Appendix Figure 24: **Transaction Size Distribution: Bitcoin vs. Stablecoins (Ethereum only), 2022 and 2025.** Each panel plots the share of annual transaction *counts* falling in each USD amount bucket for Bitcoin (navy) and for US-dollar stablecoins (USDC and USDT combined, restricted to Ethereum mainnet, orange). Stablecoin transfers are restricted to sends initiated by externally owned accounts.

Full-population breakdown by stablecoin. The main-text comparison pools USDC and USDT and follows the EOA-initiated-send construction described in Section A.9. Figure 25 instead plots the distribution separately for USDC and USDT under a full-population measure that includes all send transactions regardless of address class (excluding Solana). The concentration of stablecoin activity in small denominations holds for each stablecoin individually: in 2025, 27.6 percent of USDC and 30.9 percent of USDT transactions were below one dollar. Bitcoin's below-one-dollar share also rises under this measure, to 24.7 percent in 2025, but—unlike the stablecoin activity—it reflects Ordinals, BRC-20, and Runes inscription outputs posted at the 546-satoshi dust limit rather than economic payments.[19]



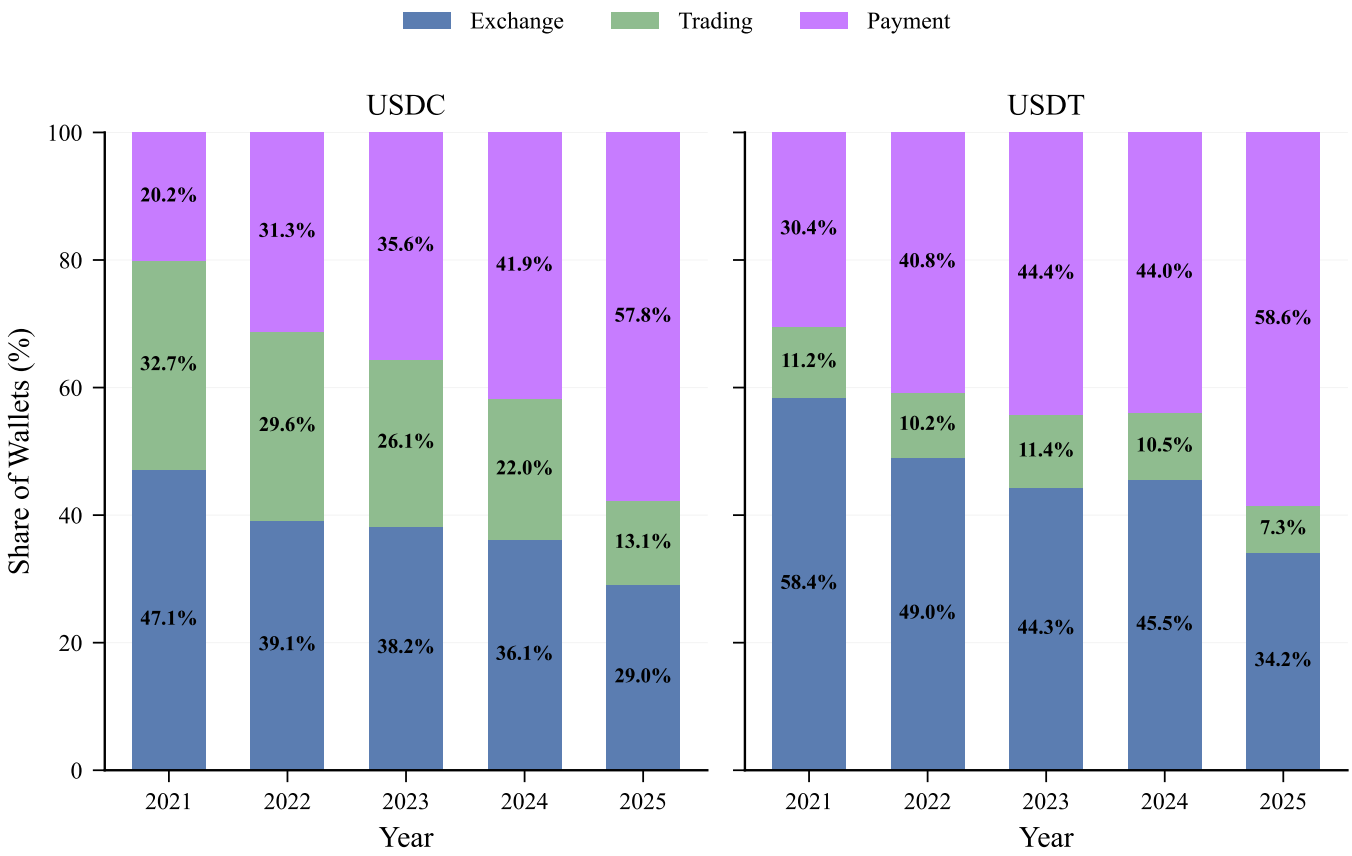
Appendix Figure 25: **Transaction Size Distribution by Stablecoin: Bitcoin, USDC, and USDT, 2022 and 2025 (full population).** Each panel plots the share of annual transactions falling in each USD amount bucket for Bitcoin, USDC, and USDT shown separately. Stablecoin series include all send transactions across the chains on which each circulates, excluding Solana, with no address-class filter; Bitcoin amounts are converted to USD at the daily price. Bitcoin's large below-one-dollar share in 2025 reflects Ordinals/BRC-20/Runes inscription outputs at the 546-satoshi dust limit rather than economic payments.

B.2 Wallet segmentation by stablecoin. The wallet segmentation in Figure 7 pools USDC and USDT. Figure 26 disaggregates the same ex-ephemeral segmentation by stablecoin. A wallet enters the USDC panel if it received at least one USDC transfer during the year, and the USDT panel if it

[19] Outputs of exactly 546 satoshis—the standard dust-limit carrier for these inscription protocols—were negligible before 2023 and rose to tens of millions per year in 2023–2024, coincident with the protocols' launch.

received at least one USDT transfer; its segment label is assigned from combined stablecoin behavior exactly as in Section A.5, so a wallet active in both tokens appears in both panels under the same label. Within each panel the three segments are renormalized to sum to 100 percent, and pooling the two tokens (counting each wallet once) reproduces Figure 7 exactly.

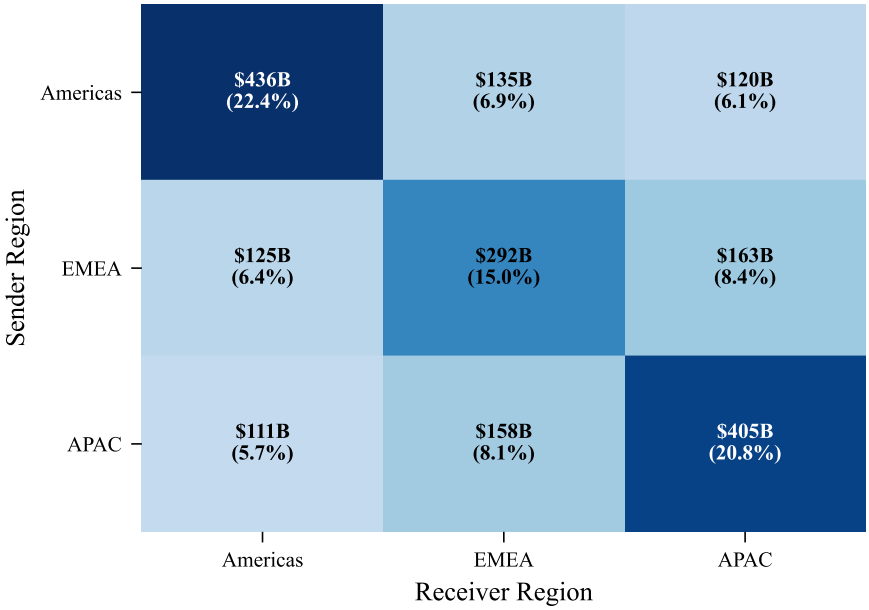
The payment migration documented in the main text holds within each stablecoin, but the two arrive by different routes. USDC wallets begin trading-oriented—32.7 percent are classified as trading wallets in 2021—and shed that share over time, to 13.1 percent by 2025, as the payment share rises from 20.2 to 57.8 percent. USDT wallets begin exchange-oriented—58.4 percent are exchange-affiliated in 2021—and shed that share, to 34.2 percent by 2025, as the payment share rises from 30.4 to 58.6 percent. By 2025 both stablecoins converge to a nearly identical payment-wallet share of approximately 58 percent, consistent with a common shift toward payment and settlement use that is not specific to either issuer.



Appendix Figure 26: **Wallet Segmentation by Stablecoin: USDC vs. USDT, 2021–2025.** The figure plots the share of active stablecoin wallets classified as exchange, trading, or payment wallets (excluding ephemeral wallets) separately for USDC (left) and USDT (right). A wallet enters a panel if it received at least one transfer of the corresponding token during the year; segment labels are assigned from combined stablecoin behavior as in Figure 7 and described in Appendix A (Section A.5). Shares are renormalized to 100 percent within each token-year, and pooling the two tokens reproduces Figure 7.

Appendix C: Additional Results for Fact 2

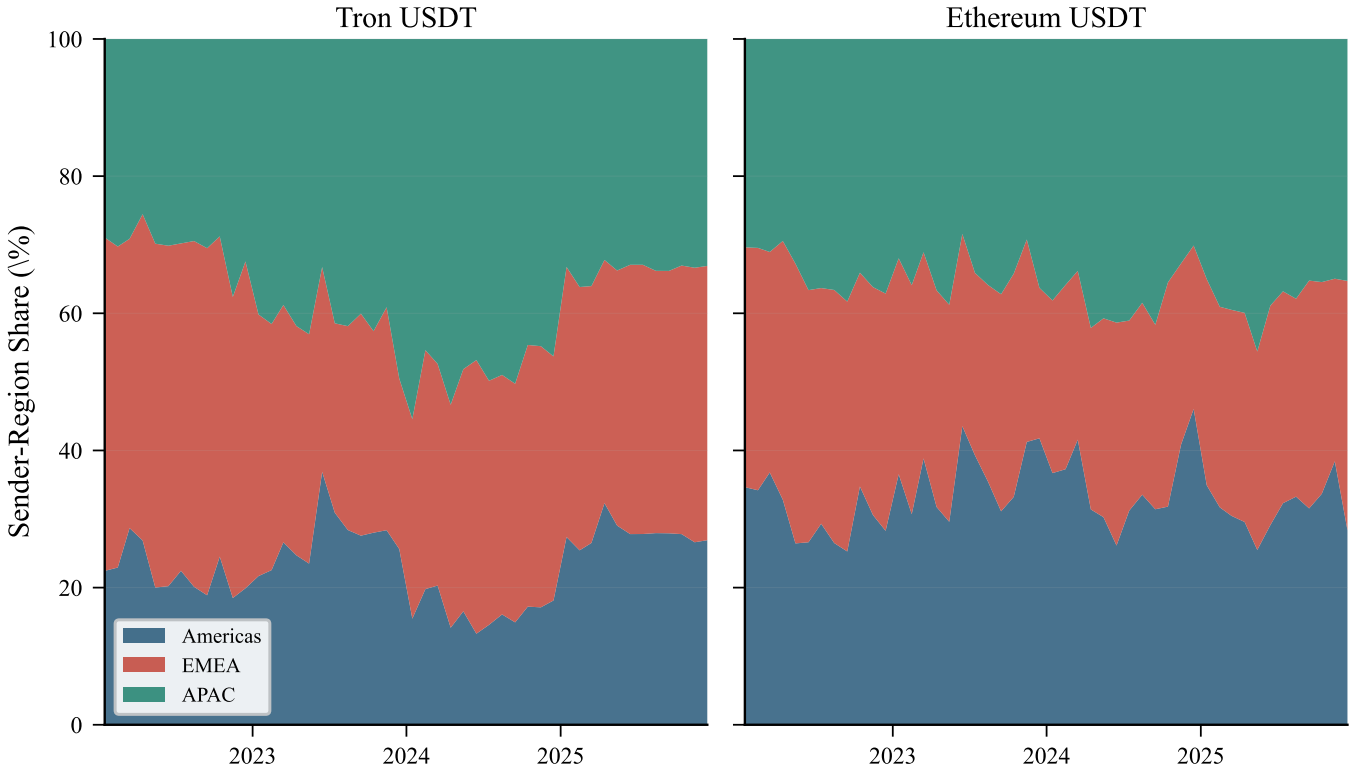
This appendix collects supplementary results referenced in Fact 2. Figure 27 reports the bilateral cross-regional corridor flows underlying the regional shares plotted in the main text.



Appendix Figure 27: **Stablecoin Corridor Flows, 2025 (Bayesian Attribution).** Each cell reports the gross volume (in billions of USD) and percentage of total wallet-to-wallet volume flowing from the sender region (row) to the receiver region (column). Estimates are based on the exchange-calibrated Bayesian model (Model A) applied to Ethereum USDC and USDT transfers.

Robustness to chain coverage. The main-text estimates are computed on Ethereum, which together with Tron accounts for the large majority of stablecoin activity. As of late 2025, the two chains hold roughly 84 percent of combined USDC and USDT balances (Ethereum 56 percent, Tron 28 percent) and account for about 57 percent of monthly onchain transfer volume, with the remainder spread across Solana, BNB Chain, Base, and other networks. To assess whether the regional attribution is sensitive to the choice of chain, we re-estimate the model on Tron USDT transfers using the same dual-sided Bayesian procedure with a Tron-specific empirical likelihood. Tron is effectively a USDT-only network—USDC activity on Tron is negligible—so the natural comparison

is to Ethereum USDT. Figure 28 plots the two side by side. The non-Americas orientation of USDT documented in the main text is robust across chains and is, if anything, more pronounced on Tron: the Americas account for 24 percent of Tron USDT sender volume on average (versus 34 percent on Ethereum), with EMEA (37 percent) and APAC (39 percent) making up the balance. We treat the Tron estimates as indicative rather than definitive, because Tron's exchange ecosystem is dominated by a small number of globally distributed venues, which flattens the region-specific circadian likelihood and causes the attribution to rely more heavily on the visitor-share prior than in the Ethereum sample.



Appendix Figure 28: **Sender-Region Share by Chain: Tron vs. Ethereum USDT (Model A).** Monthly sender-region shares of wallet-to-wallet USDT volume under the exchange-calibrated Bayesian model (Model A), for Tron (left) and Ethereum (right), 2022–2025. The non-Americas orientation of USDT is robust across both chains and is more pronounced on Tron, where the Americas average 24 percent of sender volume against 34 percent on Ethereum. Tron estimates are indicative: its concentrated exchange base weakens the circadian-timing signal relative to Ethereum.

Appendix D: Cash-Management Model for Fact 3 (Alvarez-Lippi)

This appendix provides additional detail on the structural cash management model used in Fact 3. The model follows Alvarez and Lippi 2009, which extends the classical inventory-theoretic framework of Baumol 1952 and Tobin 1956 by introducing stochastic free adjustment opportunities.

Environment. Time is continuous. A representative wallet owner faces a constant liquidity demand $c > 0$ that must be financed using stablecoins, so that stablecoin balances $m(t)$ evolve according to $dm/dt = -c$. The owner can replenish balances at any time by transferring funds from an interest-bearing account (earning nominal rate $r > 0$), but each such transfer incurs a fixed cost $b > 0$. In addition, free adjustment opportunities—moments at which the owner can deposit without incurring the fixed cost—arrive according to a Poisson process with intensity $p \geq 0$.

The owner chooses stopping times $\{\tau_j\}$ at which to deposit and the post-deposit balances $\{m(\tau_j^+)\}$ to minimize the expected present value of transaction costs plus the foregone interest on stablecoin balances, subject to $dm/dt = -c$ and $m(t) \geq 0$:

$$G(m) = \min_{m(t),\tau_j} \mathbb{E}\left\{\sum_{j=0}^{\infty} e^{-r\tau_j}\left[I_{\tau_j} b + \left(m(\tau_j^+) - m(\tau_j^-)\right)\right]\right\}, \tag{4}$$

where the indicator I_{τ_j} equals zero when the deposit coincides with a free adjustment opportunity and one otherwise, so that the fixed cost b is incurred only on non-free deposits. The key economic trade-off is between the opportunity cost of holding non-interest-bearing stablecoins (which increases with r) and the fixed cost of replenishing them (which increases with b). The free adjustment parameter p captures the ease of accessing the stablecoin ecosystem: a higher p implies more frequent costless adjustment opportunities, reducing the need for precautionary balances.

Optimal policy. The solution takes the form of a two-sided (s, S) rule. Define the normalized transaction cost $\alpha \equiv b/c$. The owner maintains balances within the interval $[\underline{m}, \overline{m}]$, where:

$$\frac{\overline{m}}{c} = \left(\frac{2\alpha}{r}\left(1 + \frac{p}{r}\right)\right)^{1/2}, \tag{5}$$

$$\frac{\underline{m}}{c} = \left(\frac{2\alpha}{r} \cdot \frac{p}{r}\right)^{1/2}. \tag{6}$$

When balances reach the lower trigger $\underline{m}$, the owner deposits enough stablecoins to restore the balance to the upper target $\overline{m}$. Additionally, whenever a free adjustment opportunity arrives, the owner resets balances to $\overline{m}$ regardless of the current level.

The model nests several classical cases. When $p = 0$ (no free adjustment opportunities), the trigger level $\underline{m}$ equals zero and the model reduces to the standard Baumol-Tobin framework, in which the owner depletes balances entirely before incurring the fixed cost to replenish. When $p > 0$, the trigger level is strictly positive, reflecting a precautionary motive: the owner maintains a buffer stock of stablecoins because free adjustment opportunities may arrive before balances are fully depleted.

Closed-form moments. The optimal policy yields closed-form expressions for three observable moments as functions of the two structural parameters (α, p) and the interest rate r. The average balance relative to liquidity demand is

$$\frac{M}{c} = \frac{1}{p}\left(\frac{p\left(\frac{2\alpha}{r}\left(1 + \frac{p}{r}\right)\right)^{1/2}}{1 - \exp\left(-p\left(\frac{2\alpha}{r}\left(1 + \frac{p}{r}\right)\right)^{1/2}\right)} - 1\right), \tag{7}$$

the expected number of deposits per unit of time is

$$n = \frac{p}{1 - \exp\left(-p\left(\frac{2\alpha}{r}\left(1 + \frac{p}{r}\right)\right)^{1/2}\right)}, \tag{8}$$

and the ratio of the trigger balance to average holdings, which measures precautionary savings, is

$$\frac{\underline{m}}{M} = \frac{2\sqrt{p/r}}{\sqrt{1+p/r}+\sqrt{p/r}-\frac{1-e^{-p\sqrt{2\alpha/r}(\sqrt{1+p/r}-\sqrt{p/r})}}{p\sqrt{2\alpha/r}(\sqrt{1+p/r}-\sqrt{p/r})}(\sqrt{1+p/r}-\sqrt{p/r})}. \tag{9}$$

Mapping to the data. We compute the empirical counterparts of these moments for each wallet in our sample:

- M/c: Average daily stablecoin balance divided by average daily outflows (liquidity demand).
- n: Number of deposit events per year, where a deposit is defined as a net inflow that increases the wallet balance.
- $\underline{m}/M$: Minimum balance observed prior to each deposit event, divided by average holdings.

Identification and estimation. Because the deposit frequency n_i is directly observed for each wallet, we can express the remaining model moments as functions of p and n alone, reducing the first-stage estimation to a single parameter. We estimate p by iterative minimum distance using two moments—M/c and $\underline{m}/M$—with the diagonal weighting matrix updated at each iteration using the inverse of the cross-wallet residual variance for each moment until convergence. Given $\hat{p}$, we recover wallet-specific values of α_i analytically from the structural equations, using the three-month US Treasury yield as the interest rate r. All wallet-level moments are winsorized at the 2.5th and 97.5th percentiles prior to estimation to limit the influence of extreme observations.

Interpretation. The estimated parameter $\alpha = b/c$ represents the transaction cost of depositing stablecoins, normalized by liquidity demand. A declining α over time indicates that the cost of accessing stablecoins is falling relative to usage, consistent with improvements in onramp infrastructure, lower gas fees on Layer 2 networks, and broader exchange integration. The parameter p governs the frequency of free adjustment opportunities. A rising p implies that wallet own-

ers face more frequent opportunities to costlessly adjust their stablecoin holdings—for example, through incidental transfers, yield harvesting, or automated portfolio rebalancing—reducing the precautionary motive for holding large stablecoin buffers.

Tabulated empirical moments and parameter estimates. The following four tables report year-end snapshots of the empirical moments and structural parameter estimates plotted at quarterly frequency in Figures 11 and 12 of Fact 3. Each column reports the rolling 2-quarter (6-month) window ending December 31 of the indicated year, so the tabulated values correspond exactly to the year-end observations of the quarterly series shown in the figures. Tables 4–6 report the three empirical moments by year and wallet-size segment, and Table 7 reports the estimated free-adjustment intensity p and median normalized transaction cost α.

Appendix Table 4: **Average Wallet Holdings Relative to Consumption (M/c).** The table reports the cross-sectional mean of average daily stablecoin balance divided by average daily outflow, by year and wallet-size segment.

	2020	2021	2022	2023	2024	2025
Full Sample	1.49	1.83	4.51	3.35	3.01	4.66
<1K Wallets	0.49	0.46	0.95	0.55	0.65	0.78
1K-10K Wallets	1.84	1.13	2.67	2.35	2.07	3.97
>10K Wallets	4.14	4.68	9.14	8.76	7.47	11.35

Appendix Table 5: **Balance at Time of Replenishment Normalized by Average Balance ($\underline{m}/M$).** The table reports the cross-sectional mean of the trigger-to-average balance ratio (the minimum balance observed before each deposit, normalized by average balance), by year and wallet-size segment.

	2020	2021	2022	2023	2024	2025
Full Sample	0.66	0.48	0.53	0.53	0.52	0.58
<1K Wallets	0.72	0.37	0.41	0.37	0.36	0.40
1K-10K Wallets	0.68	0.48	0.53	0.56	0.54	0.61
>10K Wallets	0.60	0.63	0.64	0.68	0.71	0.73

Appendix Table 6: **Number of Annual Replenishments (n).** The table reports the cross-sectional mean of annual deposit events, by year and wallet-size segment. Consecutive deposits within five days of each other are consolidated into a single deposit event when the wallet balance does not decline between them.

	2020	2021	2022	2023	2024	2025
Full Sample	22.02	16.98	12.10	11.13	12.69	15.24
<1K Wallets	12.80	7.29	7.66	8.46	9.28	11.24
1K-10K Wallets	24.69	15.68	12.07	10.58	12.73	15.95
>10K Wallets	46.51	30.31	16.66	15.45	17.49	18.49

Appendix Table 7: **Alvarez-Lippi Model Parameter Estimates.** The table reports estimates of the free-adjustment intensity p and the median normalized transaction cost α (in percent), by year and wallet-size segment.

Segment	2020	2021	2022	2023	2024	2025
Parameter: p						
Full	14.52	8.23	6.43	5.88	6.59	8.88
<1K	8.89	2.65	3.17	3.11	3.31	4.53
1K-10K	16.70	7.54	6.44	5.92	6.84	9.75
>10K	28.02	19.21	10.58	10.53	12.37	13.59
Parameter: α (%, median)						
Full	0.000	0.000	0.019	0.044	0.027	0.015
<1K	0.000	0.001	0.122	0.078	0.073	0.025
1K-10K	0.000	0.000	0.013	0.044	0.019	0.012
>10K	0.000	0.000	0.008	0.013	0.008	0.006

Appendix E: Bounding the Substitution and Leakage Parameters (Fact 4)

This appendix records the evidence behind the parameter ranges used in the credit-creation discussion of Fact 4 (Section 4). Two shares govern the deposit arithmetic of equations (2) and (3): the leakage η, the fraction of each reserve dollar whose ultimate seller is a bank parting with a security out of its own portfolio (chain c of Table 2), and the substitution weight μ_n, the fraction of stablecoin demand that displaces physical currency.

Bounding η. Three nested bounds apply. First, the mechanical ceiling is the non-deposit share of reserves: the 10 to 20 percent of USDC reserves held as bank deposits (Section 2) is chain (a) by construction and cannot leak. Second, the bill leg tightens the ceiling considerably: banks hold only a few percent of Treasury bills outstanding, which sit mainly with money market funds, foreign investors, and households through funds (Financial Accounts of the United States, table L.209), so if marginal sellers are roughly proportional to holders, issuer bill purchases land overwhelmingly on chain (b). Third, Treasury repurchase agreements placed with dealers finance dealer inventory and recycle within the nonbank money market rather than extinguishing a commercial-bank deposit. Together these place η on the order of 0.05 to 0.1 in normal conditions, with 0.2 a stressed value for episodes in which banks are active net sellers of securities, as during quantitative tightening. Each ingredient is observable: the reserve mix monthly from issuer disclosures, the bill ownership distribution quarterly from the Financial Accounts.

Bounding μ_n. The geographic attribution of Fact 2 does not observe the displaced asset, but it observes where holders are, which yields two steps. First, the share of demand displacing domestic deposits cannot exceed the Americas share of activity, roughly one third, and is lower still because the Americas include Latin America, where cash and local-currency margins dominate, and because U.S. institutional purchases are funded out of bills and fund shares rather than transaction deposits.

Second, with roughly two thirds of activity outside the Americas, μ_n equals the offshore share times the cash fraction of the offshore counterfactual mix, whose candidates are foreign-held U.S. banknotes (a roughly $1 trillion pool, about half of currency outstanding), eurodollar deposits (larger, but wholesale and corporate), and local-currency deposits. The retail, small-transaction profile of offshore activity documented in Facts 1 and 2 skews the relevant margin toward the cash pool; cash fractions between one sixth and one half give μ_n between roughly 0.1 and 0.3. As a feasibility check, at $\mu_n = 0.2$ the entire early-2026 stablecoin stock would have displaced about $60 billion of banknotes, around 5 percent of the foreign-held pool (Judson 2017).

The currency evidence. Table 3 in the main text organizes currency growth by period and denomination, and three observations discipline its reading. First, the aggregate shortfall relative to the pre-pandemic trend, about $305 billion by June 2026, is overdetermined: payment digitization, the 2022–2025 interest-rate cycle, and normalization of the pandemic cash bulge all push the same way, so the aggregate alone delivers only a weak ceiling on μ_n. Second, the denomination decomposition concentrates the information: $100 notes are 83 percent of currency value and account for more than all net growth since 2021, while the $1 to $20 stock has been shrinking outright, a domestic digitization phenomenon irrelevant to μ_n; roughly 85 percent of the missing currency flow is missing $100 notes, precisely the foreign-held store-of-value pool in which stablecoins compete. Third, timing separates the confounders in both directions. The sharp 2021–2023 deceleration of the $100 stock occurred while the stablecoin stock was shrinking after the 2022 crypto-market collapses, so that leg belongs to the rate shock and caps the share of the level gap attributable to substitution. Conversely, the failure of the $100 stock to re-accelerate as policy eased over 2023–2026, while issuance ran near $90 billion per year, is the substitution-consistent component. Attributing to stablecoins only the incremental deceleration after rates began easing implies $\mu_n \approx 0.15$; attributing the entire missing-hundreds flow would imply values near one, which is implausible because the level effects of rates and the bulge normalization do not vanish. The currency data thus independently corroborate the

range built from Fact 2.

Summary. Table 8 collects the parameters, ranges, and sources. Combining the ranges, the implied deposit effect per $100 billion of issuance, $\Delta\text{Deposits} = (\mu_n - \eta)\,\Delta C$, lies between −$10 billion and +$25 billion, within 0.15 percent of the roughly $18 trillion U.S. deposit base, with the central readings positive. Even at the adverse corner of the parameter box, the lending response is bounded further by the pass-through analysis of Appendix F: $|\Delta L| \le \kappa \max(\eta - \mu_n, 0)\,\Delta C \approx$ $2.5 billion at $\kappa = 0.25$, about 0.02 percent of bank loans.

Appendix Table 8: **Parameter Bounds and Their Sources.** Central readings and ranges for the two shares governing the deposit arithmetic of Fact 4, with the evidence anchoring each bound.

Parameter	Central	Range	Anchors and sources
η: reserve-placement leakage (chain c)	0.05–0.10	0–0.2	Bank-deposit share of reserves is chain (a) by construction (issuer disclosures); banks hold a few percent of bills outstanding (Financial Accounts L.209); dealer repo recycles within nonbank money markets.
μ_n: cash-substitution weight	0.2	0.1–0.3	Offshore activity share (Fact 2) times cash fraction of the offshore mix; $1 trillion foreign-held banknote pool; $100-note growth timing (FRED CURRCIR; Board of Governors denomination tables; Judson 2017).

Appendix F: A Stylized Model of the Response Margin (Fact 4)

This appendix formalizes the response margin discussed in Fact 4 (Section 4). The model is deliberately minimal. Its purpose is to show, in one set of first-order conditions, why the two results cited in the text take the form they do: the finding of Chiu et al. 2023 that a digital outside option can *raise* deposit rates and lending when banks hold deposit-market power, which is the mechanism illustrated in Figure 15, and the finding of Whited, Wu, and Xiao 2023 that lending falls by only a fraction of any deposit outflow once banks re-optimize their funding mix. Both emerge from the

same balance-sheet logic, with the wholesale funding margin closed in the first case and open in the second.

Setup. There is one period, and Treasury bills yield r. A bank with fixed equity E chooses loans L, a deposit rate r_D, and wholesale funding F, subject to the balance-sheet identity $L = D + F + E$. Loan demand $L^d(r_L)$ is downward sloping. Households supply deposits along $D(r_D; \theta)$, increasing in the deposit rate and decreasing in θ, an index of the attractiveness of the stablecoin outside option; θ is the only channel through which stablecoins enter the problem, since the coins themselves are fully reserved (Table 2). Wholesale funds cost $r + \psi$, and deposits and loans carry operating costs c_D and c_L per dollar, so profits are $\pi = (r_L - c_L)L - (r_D + c_D)D - (r + \psi)F$. Using the balance-sheet identity to eliminate F,

$$\pi \;=\; \underbrace{\big[r_L - c_L - (r+\psi)\big]L}_{\text{lending business}} \;+\; \underbrace{\big[(r+\psi) - r_D - c_D\big]\, D(r_D;\theta)}_{\text{deposit franchise}} \;+ (r+\psi)E. \tag{10}$$

Equation (10) is additively separable: the lending business and the deposit franchise are each priced against the wholesale rate $r + \psi$, and they interact only through it. Three results follow.

Result 1 (neutrality of lending). The lending term of (10) involves neither D nor θ. The marginal profit of a loan is $r_L - c_L - (r + \psi)$, so loan supply is perfectly elastic at $r_L^* = r + \psi + c_L$ and equilibrium lending is $L^* = L^d(r_L^*)$. Stablecoin competition does not appear in this condition: when the marginal dollar of funding is wholesale, deposits are infra-marginal to the loan decision, and a deposit outflow is met one for one by wholesale issuance with no change in the loan rate.

Result 2 (incidence, and the market-power case of Figure 15). The deposit franchise solves $\max_{r_D} \big[(r + \psi) - c_D - r_D\big]\, D(r_D; \theta)$. The first-order condition $-D + \big[(r + \psi) - c_D - r_D\big]\, \partial D/\partial r_D = 0$

gives the monopsony markdown

$$(r+\psi) - c_D - r_D^* \;=\; \frac{D}{\partial D/\partial r_D} \;\equiv\; \frac{1}{\varepsilon(\theta)}, \tag{11}$$

where ε is the semi-elasticity of deposit supply. A rise in θ has two effects. By the envelope theorem, profits fall through the franchise term alone, $d\pi/d\theta = \left[(r+\psi) - c_D - r_D^*\right] \partial D/\partial\theta < 0$; and insofar as the outside option makes deposit supply more elastic, the markdown $1/\varepsilon$ narrows and r_D^* rises. Borrowers face an unchanged r_L^* throughout: the burden of stablecoin competition falls on deposit-franchise rents, the benefit accrues to depositors, and the pattern matches the deposits-channel evidence of Drechsler, Savov, and Schnabl 2017. Figure 15 is the special case in which the wholesale margin is shut. With $F \equiv 0$, the balance sheet forces $L = D + E$, the lending and deposit decisions re-couple, and the narrowing markdown raises deposits and loans together while the loan rate falls; that is the configuration analyzed by Chiu et al. 2023 and drawn in the figure. The diagram and this appendix are the same model with the wholesale margin closed and open, respectively. In both configurations the outside option disciplines deposit pricing, and in neither does lending fall.

Result 3 (a bound on pass-through, and the Whited, Wu, and Xiao estimate). Between the two polar cases lies an upward-sloping wholesale supply schedule $r + \psi(F)$ with $\psi' \geq 0$: the bank can replace lost deposits, but at rising cost. Equilibrium is characterized by three conditions: loan-market clearing $L = L^d(r_L)$, the lending margin $r_L = r + \psi(F) + c_L$, and the balance sheet $F = L - D - E$. Totally differentiating each with respect to a deposit displacement $dD < 0$,

$$dL = L^{d\prime}\, dr_L, \qquad dr_L = \psi'\, dF, \qquad dF = dL - dD,$$

and solving the three linear equations for dL,

$$dL \;=\; \kappa\, dD, \qquad \kappa \;=\; \frac{\left|L^{d\prime}\right|\psi'}{1+\left|L^{d\prime}\right|\psi'} \;\in\; [0,1). \tag{12}$$

Lending falls by at most the fraction κ of the deposit outflow. The two limits recover the two polar cases: $\kappa \to 0$ as wholesale supply flattens ($\psi' \to 0$, Result 1), and $\kappa \to 1$ as the schedule steepens without bound, the textbook loanable-funds case in which every deposit dollar is a loan dollar. The structural exercise of Whited, Wu, and Xiao 2023 estimates exactly this object: their banks re-optimize the funding mix after a digital-currency-induced outflow, and lending falls by roughly one quarter of the outflow, an interior point $\kappa \approx 0.25$. Two observations discipline the likely value of κ for stablecoins. First, by the flow of funds in Table 2, the dollars that leave deposits reappear as wholesale supply: the issuer's reserve purchases place funds with money market funds and dealers, the marginal buyers of bank wholesale liabilities, so the system-wide schedule $\psi(\cdot)$ is anchored by the spread between retail and wholesale funding rather than stretched by the outflow itself. Second, the binding caveat is cross-sectional rather than aggregate: smaller banks with limited wholesale access face locally steeper schedules (Kashyap and Stein 2000), so a moderate aggregate κ can coexist with a tighter margin for some lenders, a distributional question distinct from aggregate credit destruction.

What the model is and is not. The model is a benchmark for organizing the cited results, not a forecast. It abstracts from run risk, capital requirements, and relationship lending; in particular, a stablecoin-induced deposit outflow consumes no bank capital, unlike outflows that coincide with losses on securities portfolios. Its three parameters are observable in principle, ε from the pass-through of market rates to deposit rates, ψ' from the slope of wholesale funding spreads, and $L^{d\prime}$ from loan-demand elasticities, so the bound in (12) is an estimable quantity rather than a free assertion.

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