On-chain Foreign Exchange and Cross-border Payments

Austin Adams, Mary-Catherine Lader, Gordon Liao, David Puth, Xin Wan*

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Abstract

This paper studies the use of distributed ledger technologies in the trading and settlement of foreign exchange (FX) on public blockchains as well as use cases in international payments. We compare the traditional trading and settlement of FX with blockchain-based implementations using payment stablecoins and automated market making protocols. Using public blockchain data, we quantify the liquidity, stability, and transaction costs of on-chain FX transactions in early adoption. We find consistency between on-chain FX exchange rate and those observed through traditional trading venues and stable on-chain liquidity throughout all times of the day and weekends. Our estimates suggest that on-chain FX can reduce the cost of remittance by as much as 80 percent. We also discuss potential opportunities for financial inclusion, applications in small and medium-sized enterprises and corporate contexts, as well as barriers to further adoption and relevant policy considerations.

Keywords: Foreign exchange, automated market maker, blockchain, distributed ledger technology, tokenized cash, financial stability

*Adams and Wan are Research Scientists at Uniswap Labs. Lader is the Chief Operating Officer of Uniswap Labs. Puth is a senior advisor to Circle Internet Financial. Liao is the Chief Economist at Circle Internet Financial and an advisor to Uniswap Labs.

1 Introduction

The foreign exchange (FX) market is one of the largest markets in the world with volume surpassing that of equities and the U.S Treasury market. By its global nature, the FX market has some elements of decentralization in that trading does not occur on a single exchange; rather, trades are handled by individual brokers and dealers often over-the-counter and settled through a complex network of bilateral arrangements and multilateral netting processes. Despite the lack of a single regulatory body with the authority and ability to oversee it, the FX market has been functioning remarkably effectively for institutions, facilitating over $7 trillion of currency exchange a day mostly without hiccups.

Yet, there are important shortcomings in this market dominated by institutional capital. The correspondent banking model of FX settlements introduces long intermediation chains that raise the costs and complexity of transactions for end-users. Settlement risk, in which one party to a currency trade fails to deliver the currency owned, remain sizable, and has been cited by the Bank of International Settlements (BIS) as a concern that "can result in significant losses and undermine financial stability".[1] The most recent BIS Triennial Survey in 2022 indicates that around one-third of deliverable FX turnover, around $2.2 trillion, is at risk on any given day, up from $1.9 trillion in 2019. Moreover, non-financial businesses, particularly smaller enterprises, as well as everyday consumers that rely on the currency market for global commerce, international payments, and remittances face a much higher total cost of transaction, long delays in settlements, and often non-transparent pricing.[2]

In recent years, distributed ledger technologies have spurred the growth of decentralized finance (DeFi), an alternative financial technology that is still in its early stages of development. By design, DeFi adheres to the principles of robustness, openness, and transparency that underlie the FX Global Code through its adherence to immutable computer

[1] Glowka and Nilsson (2022)

[2] For instance, the Consumer Finance Protection Bureau highlighted the issue of FX transparency among remittance providers. (https://www.reuters.com/markets/us/us-cfpb-will-look-improving-exchange-rate-transparency-among-remittance-2022-12-14/)

code deployed on blockchains. The use of payment stablecoins, particularly those pegged to the U.S. Dollar and other major fiat currencies, has allowed DeFi to find immediate real-world applications in the foreign exchange market and international payments. On-chain FX trading and settlement using DeFi technologies has the potential to address many of the challenges faced by the traditional FX market, such as slow settlement speeds, high costs, and settlement risks.

The recognition that DeFi can be a solution to FX settlement is shared by the regulators, as evidenced by the recent launch of Project Mariana, a joint effort from the BIS, central banks of France, Singapore, and Switzerland to explore cross-border Central Bank Digital Currency trading and settlements using DeFi protocols.[3] This important public sector effort is modeled after the innovations in DeFi protocols and payment stablecoins that are already being used in cross-border payments.

This paper examines early data from the exchange of major payment stablecoins, Euro Coin (EUROC) and USD Coin (USDC), through the Uniswap Protocol, the most widely used automated market making protocol. In the first six months since the launch of EUROC in July of 2022, on-chain exchange of the EUROC/USDC pair has surpassed $124 million dollars cumulatively with daily volume as high as $8.6 million exchanged on a 24-7 basis.[4] [5] We find that payment stablecoin trading has consistent liquidity throughout the week, including on weekends. Furthermore, on-chain exchange rates have traded within a few basis points of exchange rates observed in traditional markets, suggesting a reasonable level of price efficiency for this market still in its infancy.

The adoption of on-chain foreign exchange technology benefits not only institutions, but also enhances commerce and payments for individuals and small businesses. This innovation, coupled with more user-friendly interfaces and improved fiat-to-stablecoin conversion capabilities, can reduce intermediary steps and benefit billions of underserved individuals

[3]See "Project Mariana: CBDCs in automated market makers", BIS from the BIS Innovation Hub
[4]See https://dune.com/queries/1865638?d=1
[5]See https://dune.com/queries/1865661?d=1

worldwide through faster and cheaper transfers. The cost savings are particularly significant in the remittance use case. Our estimates based on on-chain data and existing on-ramps suggest that DeFi can reduce remittance costs by as much as 80 percent relative to banks and money transmitters relying on traditional payment systems. This cost is expected to fall further with expansion of on-ramp options and cheaper blockchain layers. With a global remittance flow of over $550 billion per year to low- and middle-income countries and typical remittance costs averaging around 6.3 percent of remittance sent, adoption of DeFi remittance channels could translate into a gain of around $30 billion per year going to households that are most in need.[6] Additionally, the implementation of blockchain analytics, safeguards at the point of on-ramping, and decentralized identity standards that verify the identity of user wallets without disclosing user data can both protect consumers and address concerns around illicit finance.

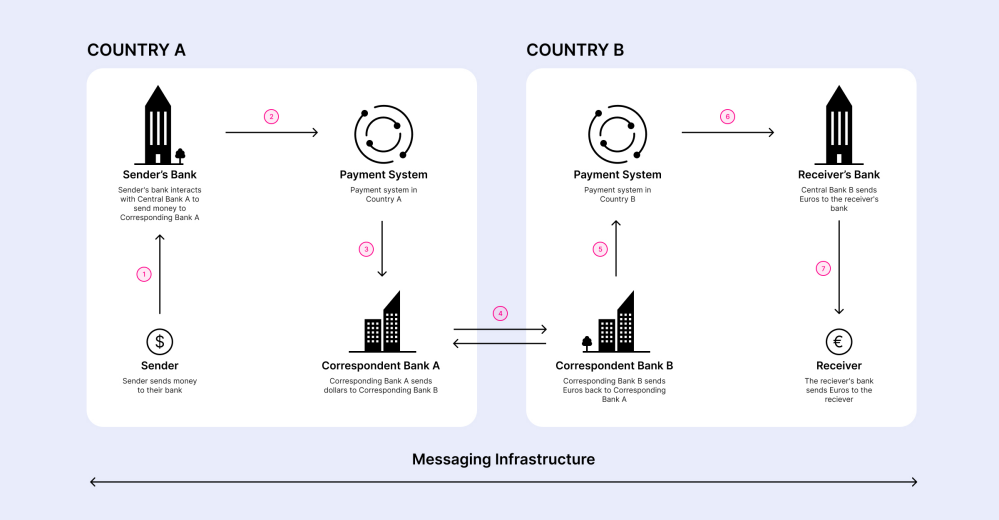
2 Market structure innovation

Innovations in distributed ledger technology and decentralized finance can address some of the key challenges facing traditional foreign exchange trading, clearing, and settlement. At its core, DeFi removes the need for multiple intermediaries and their balance sheets in order to exchange and transfer value across borders. This new model of value exchange offers a solution to the slow speeds and high costs of cross-border payments for businesses and consumers, as well as addresses the up-front liquidity needs of financial institutions. Figure 1 compares cross-border transactions under a simplified version of traditional banking with those using decentralized finance.

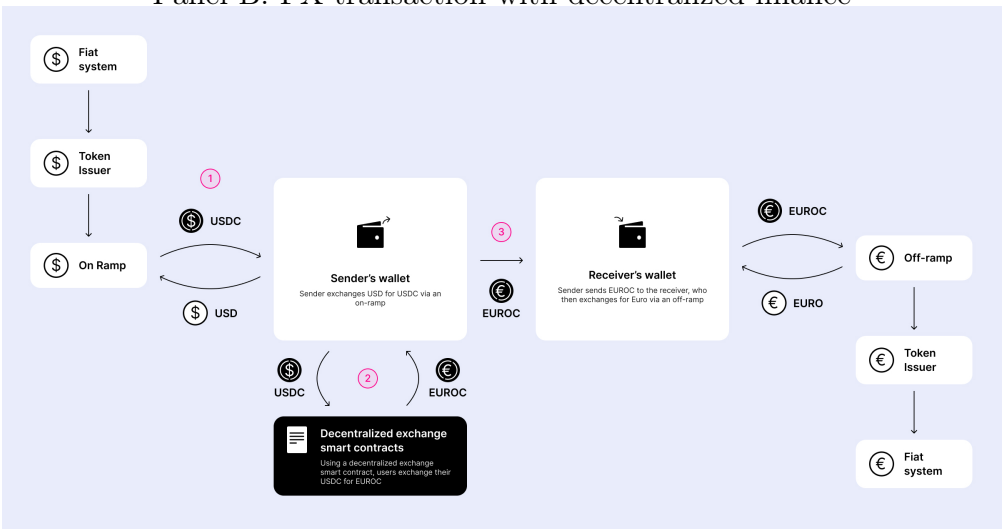
[6]Remittance flow data is from Global Knowledge Partnership on Migration and Development. Remittance costs are from Remittance Prices Worldwide published by the World Bank.

Figure 1: Comparison of correspondent banking model and DeFi model in FX transactions

Panel A: FX transaction with correspondent banking



Panel B: FX transaction with decentralized finance



In the correspondent banking framework of foreign exchange, intermediaries must have access to multiple domestic payment systems in different currency areas. This is because each payment system is tied to a specific currency and central bank, so correspondent banks handling foreign exchange transactions must have accounts with multiple central banks. The settlement of interbank transfers is done by crediting and debiting the correspondent banks' accounts at each central bank on separate systems and time frames. This model introduces cost, complexity, and risks, as access to local payment systems is restricted. Additionally,

the market making functions and messaging layer, such as SWIFT, are separate from the transaction process, leading to additional complexity and potential points of failure.

In contrast to the traditional foreign exchange model, decentralized finance relies minimally on intermediary balance sheets to facilitate cross-border payments. Instead, end-user wallets - whether self-custodied, or custodied with service providers - are at the center of all transactions. This new model of value exchange has the potential to offer a faster, cheaper, and more efficient alternative to traditional methods.

One key advantage of DeFi is that it uses blockchain technology to enable atomic, Payment versus Payment (PvP) transactions. This means that one leg of a trade cannot occur without the other, eliminating credit risk in the settlement process. Additionally, the messaging and settlement layers are combined, reducing the potential for errors. DeFi also allows for the encoding of market-making functions directly onto the blockchain through the use of smart contracts, such as the Uniswap Protocol. This further enhances the efficiency and transparency of the value-exchange process.

This alternative system of cross-border payment relies on two key service layers: tokenized cash ("payment stablecoin") issuers and decentralized exchange protocols. Tokenized cashissuers serve as an important bridge between fiat currencies and their tokenized forms. Trust, transparency, and appropriate regulatory guardrails are necessary for issuers to ensure the full backing of the cash tokens, provide redemption on demand, and prevent spillover risks. Backing cash tokens with high-quality assets is critical to facilitate on-demand liquidity for conversion into fiat.[7] Tokenized cash stablecoins such as USDC and EUROC are backed by full-reserves composed of high-quality and liquid assets, ensuring the ability for redemption into the fiat counterparts anytime.

The other key service layer is the decentralized exchange protocols that facilitate the price discovery, risk exchange, and settlement of tokenized cash in one currency versus another. These protocols are sets of smart contracts that operate autonomously on blockchains,

[7]Liao (2021)

requiring proper mechanism design and implementation to ensure transparency, safety, and efficiency. The Uniswap Protocol, for instance, allows users to swap tokens on blockchains without intermediaries, ensuring assets are held by users at all times. With smart contracts functioning as an Automated Market Maker (AMM), the Uniswap Protocol has processed over $1.2 trillion of trading volume since its inception in 2018, serving as an emerging alternative to centrally operated central limit order books.

The advantages of DeFi for foreign exchange transactions are numerous, including faster, cheaper, and more efficient value exchange and transfer. Table 1 summarizes a comparison of key market features in the traditional FX market and DeFi.

Table 1: Comparison of FX market features

Features	Traditional FX market	On-chain FX
Market hours	Nominal 24 hour market during weekdays; poor liquidity between NY close and Tokyo open; No trading and settlement on weekends	Always-on 24-7 trading liquidity through AMMs and near instantaneous settlement on blockchains
Settlement time	T+2 business days by convention and often greater than T+5 calendar days with holidays and weekends	Near instantaneous settlements in seconds; Occasional blockchain congestions that may result in high gas costs
Settlement risks (credit exposure and liquidity risk)	Around one-third of deliverable FX turnovers are subject to settlement risk exposure on any given day	Minimal settlement risks as on-chain transactions adhere to Payment vs Payment principles by design
Transparency and trade reporting	Limited trade reporting with non-harmonizing standards across jurisdictions; reporting predominantly on forwards and swaps	Privacy-preserving transactions recorded on public ledgers in real-time
Benchmark transparency	Key benchmark had issues of rigging with lack of transparency in the price discovery process	Transaction data visibility to the public allows for transparent benchmark construction and audits
Liquidity fragmentation	Increasing fragmentation in liquidity due to internalization of customer flows by banks	Composability of token standards enable direct liquidity aggregation from different AMM platforms
Liquidity providers	Principal trading firms supply liquidity on limit order books and dealers supply liquidity via bank platforms and voice	Any holders of tokenized cash in multiple currencies can supply liquidity via AMMs

2.1 Settlement risk exposure

Among the top reasons for why on-chain trading might gain wide adoption is the ability for blockchains to reduce risks to firms and the financial system. FX settlement risk, in which one party pays out a currency without receiving the other currency it bought, is also known as "Herstatt risk", named after the German bank, Bankhaus Herstatt, which froze the global payment system and undermined financial stability during its collapse in 1974. At

the time, Bankhaus Herstatt had received one-way FX payments in Deutsche marks without sending correspondent US dollar payments to its counterparties. Spillover to other financial institutions ensued and global payment froze over the following three days, driving a spike in short-term borrowing rates as the demand for liquidity intensified.

The need to create a system that enabled payments between bank counterparties led to the introduction of the Real Time Gross Settlement System or RTGS. The adoption of Payment vs Payment (PvP) protection, which ensures that one leg of the transaction cannot occur without the other, has greatly reduced settlement risks in FX transactions. The largest of such efforts has been the creation of the Continuous Linked Settlement (CLS) system in 2002 that performs netting of cross-border transactions among member banks. The BIS 2022 Triennial survey shows that around 36 percent of FX transactions have PvP protection through CLS, with another 33 percent of transactions protected from settlement risk through alternative methods such as pre-settlement netting and same-clearer âon-usâ loss protection. This leaves still around a third of all FX transactions or around $2.2 trillion of settlement risk outstanding on any given day.[8]

CLS is recognized for creating significant market efficiencies, including that ability to net the vast majority of intraday transactions that take place between major market counterparties. This netting impact dramatically reduces the amount of currency that needs to be settled on a daily basis. CLS today is focused on the settlement of 18 major currencies. The majority of the worldâs currencies settle outside of CLS. There is a significant opportunity today to provide more efficient settlement to over 100 freely traded currencies, notably those from developing economies.

One of the barriers to the wider adoption of PvP protection is the requirement for member banks to preposition funding, which DeFi can potentially overcome. Preposition of funding or liquidity limits the use of the CLS to major currencies and introduces capital inefficiencies as member banks have to post funding for the netting process. In comparison, on-chain FX also

[8]Glowka and Nilsson (2022)

requires prepositioning of funding in the sense that the users have to convert fiat currency into tokens to be used on blockchain. This preposition of funding, however, is performed by end users and thus unaffected by the balance-sheet constraints of intermediaries. Additionally, once on-ramped, the on-chain funding can be used for a variety of purposes including making end payments for goods and services without the need for off-ramping. As such, preposition of funding is akin to on-ramp in blockchain can be a one time activity for DeFi. The broad utility of token balances held on blockchains will in the future reduce the need for back and forth conversion between the fiat and the token representation of money.

Another barrier to the adoption of PvP is that only member banks, and their roughly 30,000 âthird partyâ clients, are able to use the CLS, which means that end users must rely on a chain of correspondent banks to intermediate their transactions. Today, few traditional corporate foreign exchange participants settle through CLS. In contrast, DeFi FX extends that network membership to the end users, reducing the intermediation chain required, and thus extending the PvP protection to the end users in addition to reducing the cost and speed of transactions.

PvP settlement protection in finance closely mirrors the concept of atomicity in computer science. Atomicity ensures that in a series of transactions on a database or ledger, either all of them occur, or none. This built-in feature of distributed ledgers is particularly useful for decentralized finance protocols, such as the Uniswap Protocol, which can settle trades with PvP protection in a matter of seconds or minutes, eliminating settlement risks.[9]

2.2 Transparency and market integrity

In addition to improving the settlement process, DeFi can improve price discovery. The use of blockchain technology in FX transactions allows for increased transparency, providing valuable insight into market behavior and ensuring fairness in trading and benchmarking.

[9]There are, however, important legal clarifications needed to define what constitutes settlement finality on proof-of-work blockchains that could be reorganized or forked. Proof-of-stake blockchains such as Ethereum 2.0 can guarantee settlement finality after a short period of time. See Wandhofer and Berndsen (2019)

Past instances of misconduct have resulted in significant fines and posed operational risks for some of the largest global banks. The adoption of the Global FX Code by largely sellside dealers have greatly ameliorated these market conduct issues, but buyside entities have lagged behind in the adoption and those that interact with consumers such as remittance providers have been flagged as offering opaque pricing as a consumer protection issue. [10]

The use of blockchain enhances market integrity in three notable ways. First, it provides a secure and transparent ledger for recording transactions, which makes it difficult for market participants to engage in fraudulent activities such as market manipulation or benchmark rigging. This increased transparency can help to build trust and confidence in the market, which can, in turn, enhance its integrity. The transaction-derived records are also superior to ex-post transaction reporting, such as the Swap Data Repository in the U.S. or the European Market Infrastructure Regulation reporting requirements that are prone to input errors.

Second, the use of self-executing smart contracts transforms the terms of the agreement between buyer and seller directly into lines of code. This can help to automate the enforcement of contracts and reduce the need for intermediaries, such as brokers or clearinghouses, which can reduce conflicts of interest and other forms of market manipulation.

Third, the decentralized nature of blockchain networks can help to prevent a single entity from gaining too much control over the market. The trend toward more internalization of trades, whereby dealers temporarily warehouse risks in an attempt to match clients rather than rely on the inter-dealer market, has been highlighted as a potential concern by the BIS. [11] A more decentralized network can help to ensure that the market remains open, fair, and competitive, which can further enhance its integrity.

Overall, the use of blockchain technology in the FX market has the potential to increase transparency, reduce the potential for fraud and manipulation, and promote fair and open competition, all of which can help to enhance market integrity.

[10] Logan and Nordstom (2022) or Lang (2022)
[11] Schrimpf and Sushko (2019)

2.3 Always-on liquidity

The foreign exchange market operates 24 hours a day, but the amount of liquidity available during the day can fluctuate significantly. This can sometimes lead to intraday flash crashes, particularly during the "witching hours" between the close of trading in New York and the opening of trading in Tokyo. These events have raised concerns about the issue of "liquidity mirage" and have attracted the attention of market regulators. [12] For example, on Oct 7, 2016, sterling experienced a 9% flash crash against the dollar during early Asian market hours. A subsequent BIS study pointed to "time of day" being a significant driver. The BIS report cited a Bank of England analysis that estimated the sensitivity of bid-offer spread to realized price volatility to be more than five times higher at night than during day time. [13] Additionally, there is no liquidity available on weekends, which makes it difficult or impossible to hedge against geopolitical and country-specific risks. Of course there is no guarantee that the introduction of decentralized finance will create liquidity in the market during those hours however we expect that more participants will enter the markets during those times than exists today.

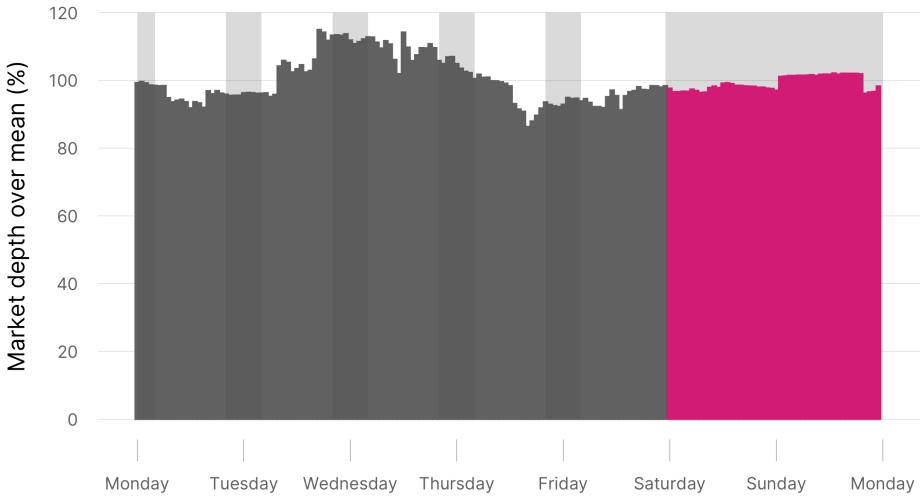
Decentralized finance has the potential to improve liquidity in the foreign exchange market. One way that DeFi does this is through the use of automated market makers, which are algorithms that automatically set the prices of assets traded on a decentralized exchange. An example of an AMM protocol is Uniswap, which uses a unique mechanism for providing liquidity. This involves rebalancing pools of capital that are provided by liquidity providers. The pools of capital are managed by smart contracts on the Ethereum blockchain, which automatically match buyers and sellers and execute trades on their behalf. This automatic nature of smart contracts supports liquidity provision 24-7 as long as liquidity pools are not depleted.

[12] See, for instance, Group (2017) , a report that discusses a 9 percent intraday flash crash in the sterling without notable market events. Similar flash crashes have often been observed in early Asia trading hours when liquidity is thin.

[13] Ibid.

Figure 2 below shows the relative liquidity (measured as market depth relative to the mean) at the 15-minute frequency throughout the week. As the chart shows, there is no clear relationship between the time of day, the day of the week and market liquidity. Although overall on-chain liquidity is still low, the lack of significant fluctuations in relative liquidity throughout the day and week is a positive sign for the ability of smart contracts on the blockchain to facilitate always-on price discovery.

Figure 2: Relative liquidity of dollar and euro on-chain exchange over the course of the week

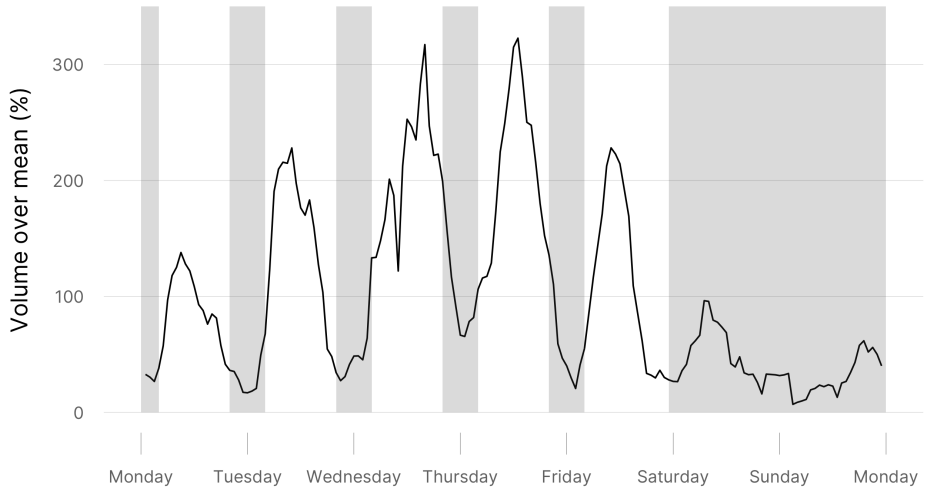


Note: This graph shows the relative market depth on the USD coin and Euro coin exchanged over the Uniswap Protocol averaged at the 15-minute frequency throughout the week from the period of September 1, 2022 to December 12, 2022. The largest and smallest values at each time were dropped from the sample. The shaded area indicates non-New York, non-London market hours.

The availability of always-on liquidity supports trading volume during non-conventional hours, as shown in Figure 3. The volume of on-chain foreign exchange trading follows a predictable pattern, with peaks during the early New York sessions around 8:30 am Eastern Standard Time (EST) when economic data are typically released. The volume troughs during the hours after the New York market closes and before the London market opens (shaded

area). Somewhat surprisingly, trading volume also has a minor peak on Saturday and, to a lesser extent, on Sunday. Although these weekend trading activities are lower, they still represent around 10% to 20% of the weekday average. If this weekend demand for on-chain FX transactions are realistic reflections of the broader FX market, DeFi can fill the gap to serve a meaningfully sizable demand that is currently unaccommodated.

Figure 3: Relative volume of the EUROC-USDC pair traded on Uniswap protocol over the course of the week



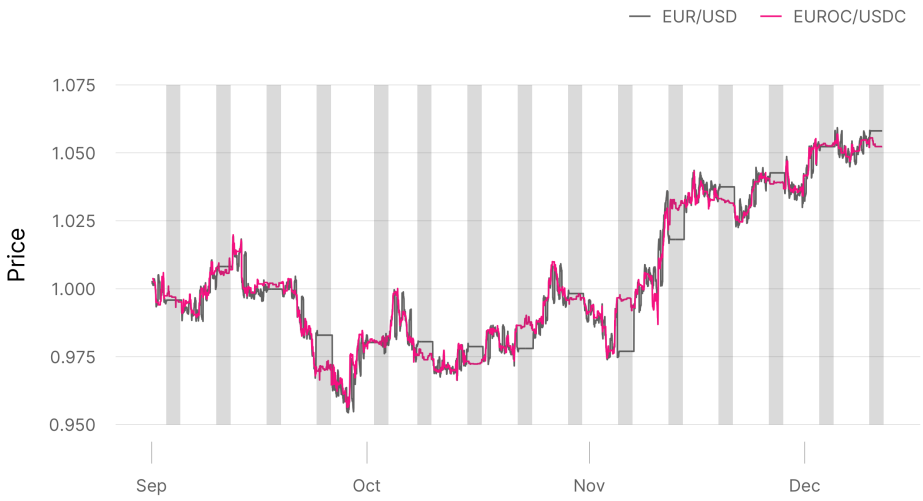
Note: This graph shows the 6 hour rolling trading volume for EUROC and USDC pair relative to the mean over the course of the week averaged across the time period from September 1, 2022 to December 12, 2022.

2.4 Pricing Transparency and Fairness

On-chain FX prices closely mirror those quoted through typical FX exchange venues. Figure 4 below shows the time series of price movements for EUR/USD and the on-chain equivalent EUROC/USDC pair. The average pricing difference during normal trading is around 5 basis points, roughly equivalent to the breakeven fee for arbitrageurs for the main on-chain liquidity pool.

Transaction fees paid to liquidity providers are typically in the range of 1-5 basis points. The transparency of blockchain transactions also allows market participants to see the latest transaction prices in real time, with minimum delays of blockchain confirmation times. This real-time reporting of transactions can improve price discovery efficiency and maintain market integrity. Additionally, market participants can use public transaction records to create relevant benchmarks in a transparent manner without relying on costly third-party benchmark providers.

Figure 4: Price comparison between on-chain and off-chain price



Note: This graph shows the exchange rate for EUROC/USDC pair relative to fiat EUR/USD exchange rate. The on-chain exchange rate is mid-market price from Uniswap Protocol EUROC/USDC pool and the fiat exchange rate is from Bloomberg BFIX. The sample period is from September 1, 2022 to December 12, 2022.

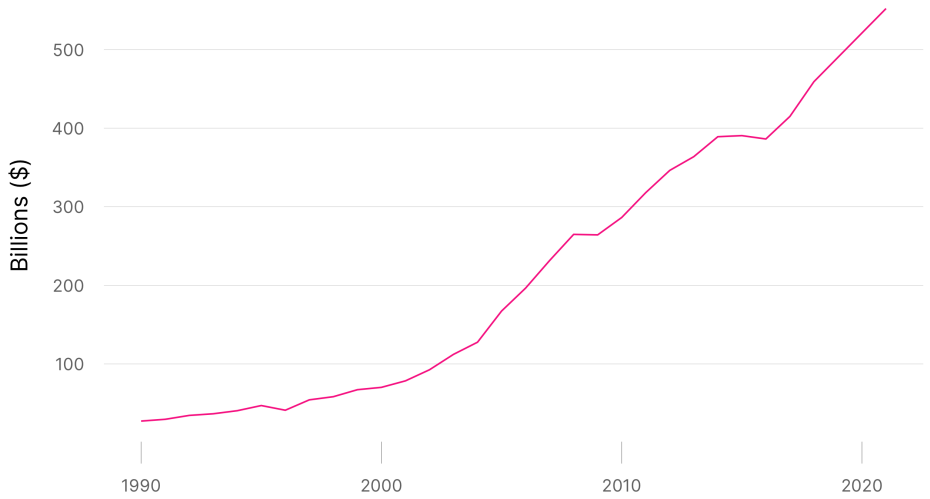
3 Remittance use case and financial inclusion

The implementation of on-chain foreign exchange technology can provide benefits not only to institutions, but also to enhance commerce and payments for individuals. One area in which the improved pricing of foreign exchange services through this technology can have

a significant impact is in the realm of remittances. By providing more efficient and cost-effective methods of transferring funds, on-chain FX technology has the potential to improve the financial stability and well-being of individuals who rely on remittances to meet their basic needs.

Cross-border remittances from family members living abroad are a major source of income for many families in developing countries. According to the World Bank, more than 200 million migrant workers sent home a total of $760 billion in 2019, with nearly 80% of that amount, or $554 billion, going to low and middle-income countries. On the receiving end, the United Nations estimates that over 800 million people rely on these remittances to cover expenses such as food, utilities, education, and other necessities. For many of these families, remittances are a vital source of income that helps to support their basic needs and improve their standard of living.

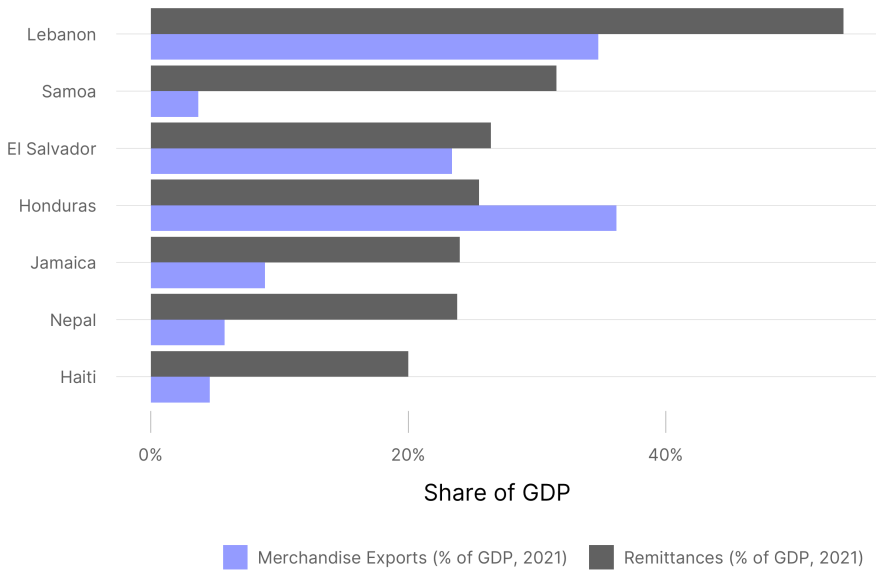
Figure 5: Remittance flow to low- and middle-income countries



Note: The graph shows aggregate remittances in current US dollars in low- and middle-income countries excluding China from 1990 to 2021. Low- and middle-income country definitions are from the World Bank. Remittance data is from Global Knowledge Partnership on Migration and Development.

The importance of remittances to certain countries can be seen by comparing their share of gross domestic product (GDP) to that of merchandise exports. In many countries, remittances represent a larger share of GDP than merchandise exports. This highlights the significant role that remittances play in the economies of these countries as shown in Figure 6. For example, in countries such as Lebanon, El Salvador, and Nepal, remittances make up more than 20% of GDP. In contrast, merchandise exports typically make up a much smaller share of GDP in these countries. The large share of GDP represented by remittances in some countries demonstrates the crucial role that these financial flows play in supporting economic activity and providing income for individuals and households.

Figure 6: Share of GDP from remittances and merchandise exports by country in 2021



The current methods of cross-border remittance extract a significant percentage of these funds, leaving families with less to support their livelihoods. Figure 7 below shows the cost of sending a $500 remittance based on data from on-chain transactions and estimates from the World Bank. Every year, billions of dollars are being taken from migrant workers and their families in low- and middle-income countries in the form of remittance fees. These high

fees, which can range from 5% to 20% or more of the total remittance amount, can have a significant impact on the ability of families to support themselves and can hinder economic development in the recipient countries.

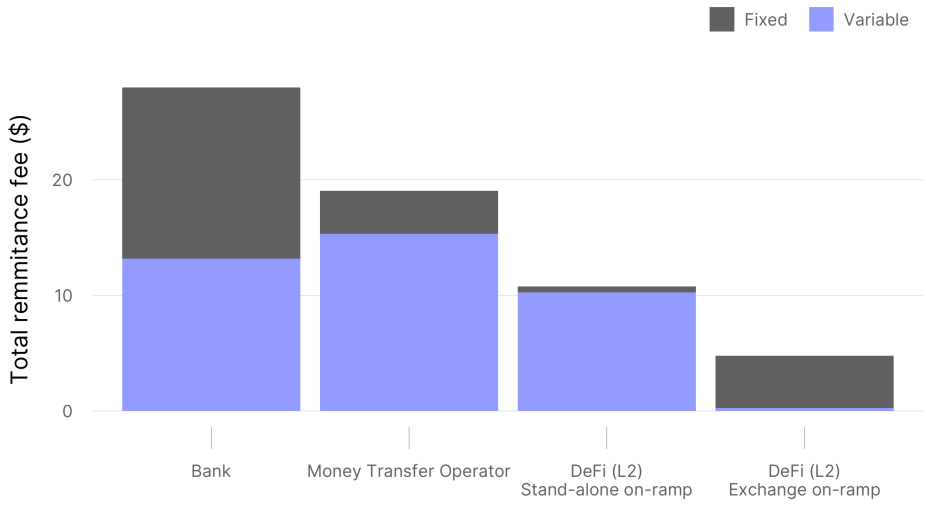
Adoption of blockchain technology removes multiple layers of intermediation in the remittance process, and it may be possible to reduce these fees by as much as 80 percent and improve the economic well-being of households relying on remittance around the world. Table 2 provides a breakdown of the cross-border remittance cost through stablecoins and DeFi.

Table 2: Cost of sending a cross-border remittance through stablecoins and DeFi

Realized fees and costs		Description of fees and costs	Range Estimates
+	On-ramp fees	Fees for converting fiat money to payment stablecoins by either centralized exchanges or dedicated standalone on-ramps that perform necessary user verifications and links to fiat payment systems. This process relies on local fiat payment rails such as ACH or SEPA.	0% - 1%; Centralized exchanges on-ramps are often free while stand alone on-ramps such as Moonpay have fees that are often 1%.*
+	Exchange fees	Fees paid to liquidity providers on the Uniswap protocol for converting stablecoins of one tokenized currency to another.	0.01% - 0.05%; Liquidity pool fees range from 1 and 5 bps.
+	Network transactio n fees	Fees paid to network validators (miners) associated with computation costs in automated market makers, exchanging payment stablecoins, and sending from wallet to wallet.	$0.35 - $5 Layer 2 network fees are typically less than $1; Ethereum mainnet fees average around $5 based on historical transactions.**
+	Off-ramp fee	Fees from converting payment stablecoins for fiat money for the recipient user. If the recipient continues to use payment stablecoins domestically for payment of goods and services, this off-ramp fee can be avoided.	0%-1% or fixed around $5 for certain off-ramp payment rails; Similar to on-ramp fees for stand alone on-ramps; centralized exchanges sometimes charge around $5 depending on the off-ramp payment rail.
=	Total cost of sending a remittance through stablecoins		From 0.01% + $0.35 to 2.05% + $5

Note: This table is modeled after WEF's Digital Currency Governance Consortium White Paper Series' paper on financial inclusion.[14] *On-ramp and off-ramp costs for USDC on centralized exchanges such as Coinbase are zero. On-ramp costs on centralized exchanges for EUROC range from €0 (Bitmart) to €6 (Bitpanda) and off-ramp costs are around €4 through these centralized exchanges. Costs through stand-alone on-/off-ramps such as MoonPay is typically 1% of the notional value as of December 2022.** Network fees are based on transaction fee averages on EUROC/USDC in the sample period from December 6th, 2022 to January 6th, 2023.

Figure 7: Remittance costs for $500 transfer



Note: This figure shows the remittance cost for $500. The cost estimates for banks and money transfer operators are from the World Bank Remittance Prices Worldwide database. The costs of on-chain FX are based on historical transactions on Uniswap v3 protocol in Layer 2s and different on-ramp options. The fixed portion of the cost invariant to transaction size for DeFi is composed of network gas fee and on/off-ramp costs in the case of centralized exchange on/off-ramps. The variable portion of the fee is the amount paid to liquidity providers, usually running from 1 to 5 basis points of the transaction notional and on/off-ramp costs through stand alone on-ramps.

Migrant workers often face high costs when sending money back to their home countries, which can incentivize them to wait and send larger lump sums less frequently. However, this approach can cause delays and expose them to greater exchange rate risk. Blockchain technology and decentralized finance (DeFi) can offer a solution to this problem. Scaling solutions such as Layer 2 networks can reduce the cost of sending transactions to a fraction of a dollar (or even a fraction of a penny), while providing global access, nearly instantaneous settlement, and the security of a public blockchain. This can make it more affordable and convenient for migrant workers to send remittances, while also reducing the risks associated with lumping multiple transactions together.

4 Corporate and institutional use cases

4.1 Use case for SMEs

Small and medium-sized enterprises (SMEs) can often face significant challenges and costs when it comes to managing their foreign exchange risk. Whether it is paying suppliers or employees in a different currency area or processing invoicing of goods and services denominated in a foreign currency, SMEs can face FX exposures similar in nature as larger firms. Traditional methods of hedging, such as using multi- or single-dealer platforms, can be expensive and may not be accessible to SMEs. This is because these platforms typically require a certain level of sophistication and infrastructure to use, and the costs associated with accessing them can be prohibitive for smaller businesses.

The use of blockchain technology and stablecoins can provide SMEs with a more cost-effective and accessible way to manage their FX risk. By enabling direct access to FX markets, blockchain-based solutions can help SMEs to avoid the costs and complexities associated with intermediaries. In addition, automated market makers, which are commonly used in the blockchain space, tend to favor smaller transactions, making them well-suited for the needs of SMEs.

Furthermore, the near instant settlement and 24/7 availability of on-chain foreign exchange can provide SMEs with significant cost savings and risk reductions. This is particularly relevant for businesses that have regular cash flows denominated in multiple currencies, as it allows them to manage their exposure to FX risk in a more efficient and timely manner. Overall, the use of blockchain technology and stablecoins offers SMEs a valuable tool for managing their FX risk and improving their access to financial services.

4.2 Use case in reducing operational costs and risks

The use of decentralized finance has the potential to reduce operational costs and risks in the foreign exchange market. A significant portion of the cost of liquidity in the FX market is

associated with middle-office and back-office operations. DeFi can help to eliminate a large part of this cost by simplifying the process of international cross-currency transactions.

Currently, banks are often unable to directly hold money extraterritorially with foreign central banks. As a result, international cross-currency transactions typically require communication and reconciliation among multiple parties, such as the banks of the sender and receiver, the SWIFT network, and the FedWire system. With DeFi, most of this process can be streamlined into a single transaction on the blockchain. If stablecoins or cryptocurrencies are widely adopted as a medium of exchange, even the need for a fiat on-ramp can be eliminated from the process.

This simplification of cross-currency transactions has the potential to reduce operational costs and risks for banks and other financial institutions. By using DeFi, these institutions can avoid the need for multiple intermediaries and reduce their exposure to potential errors or fraud. Additionally, the use of stablecoins or cryptocurrencies can provide greater stability and security, as well as faster and cheaper transactions. In this way, DeFi has the potential to greatly improve the efficiency and effectiveness of the FX market.

5 Missing pieces and market opportunities

Despite promises of DeFi in FX and cross-border transactions, barriers remain for the adoption of the technology by the mainstream. Below we discuss several developing trends in the industry that would enhance adoption of on-chain FX.

- *Regulatory clarity on the application of DeFi.* The regulatory environment for DeFi and on-chain FX is still uncertain, with many countries considering regulations that protect consumers while also supporting innovation. This lack of clarity can deter mainstream users from adopting on-chain FX. Constructive policy making that also harmonizes across jurisdictions likely remains the single largest barrier for the adoption of on-chain

FX. Specific legal standards such as defining the finality of settlement on blockchain still need to be established before institutional use could expand.

- *On-chain decentralized identity solutions.* The implementation of on-chain identity solutions that allow attribution of identity to wallet addresses while protecting user privacy can help to improve trust and market integrity in the expansion of on-chain foreign exchange beyond retail users. These solutions can also help to comply with existing anti-money laundering and know-your-customer regulations, thereby preventing illicit transactions from occurring.
- *User-friendly interfaces.* The adoption of on-chain FX is hindered by the lack of user-friendly interfaces on DeFi platforms, which often have a steep learning curve and can be difficult for non-technical users to navigate. As these platforms become more intuitive and user-friendly, they may attract a wider audience, including those at the bottom of the socioeconomic pyramid and migrant workers who lack access to traditional financial services. The development of user-friendly mobile wallets can particularly benefit this demographic.
- *Safe custody service providers.* The lack of safe custody services is a major obstacle to the adoption of on-chain FX, as it forces users of DeFi to rely on private wallets and provides no insurance or protection for their funds if the private key is lost. Mainstream users are accustomed to the safety and security of traditional financial institutions, and may be hesitant to use on-chain FX transfers without the protection of safe custody services. In order to attract mainstream users, DeFi platforms must integrate these services to protect user funds and assets, and create a sense of trust and security. Multiparty computation custody solutions, such as those offered by Cybavo and Fireblocks, could provide rule-based access control to funds for both individuals and institutions.
- *Forwards instruments.* The use of forward and swap instruments for foreign exchange transactions is prevalent, representing the majority of all FX transactions, and the success of these instruments relies on the parallel development of on-chain fixed income

instruments. Hedging against foreign exchange risks and aligning the settlement time of traditional assets such as bonds requires the trading and settlement of forwards. Although early developments in on-chain fixed income show potential, further progress is necessary before a market for FX forwards can be established.

- *Effective fiat on-ramps and payment ecosystem.* The adoption of on-chain FX by the mainstream is dependent on the availability of fiat on-ramps, which enable the seamless and efficient conversion of fiat currencies into their tokenized versions. Without cost-effective and user-friendly on-ramps, mainstream users may be deterred from using on-chain FX solutions. The further adoption of stablecoin as a means of payment could also reduce the need for on- and off-ramps, allowing funds to be kept in circulation on-chain.
- *Improved scalability and performance of blockchains.* As blockchain networks continue to evolve, they are likely to become more scalable and able to handle larger numbers of transactions. This could make on-chain FX and DeFi more practical and attractive for mainstream use. The implementation of Layer 2 solutions has already significantly reduced the cost of on-chain transactions, as discussed earlier.

6 Conclusion

The use of distributed ledger technologies and decentralized finance in the foreign exchange market has the potential to address many of the challenges facing traditional FX trading, liquidity provision, and settlement. Through the implementation of payment stablecoins and automated market making protocols, on-chain FX can offer faster and more affordable transaction processes, as well as greater liquidity and stability. Additionally, on-chain FX has the potential to promote financial inclusion and support remittance, small and medium-sized enterprises, and corporate use cases. While there are still barriers to adoption, including the lack of user-friendly interfaces, safe custody services, and regulatory clarity among other is-

sues, the continued development of DeFi solutions and the increasing scalability of blockchain networks may make on-chain FX more practical and attractive for mainstream use. Further research is needed to address these barriers and promote the wider adoption of on-chain FX by mainstream users.

References

Forum, W. E. (2021). What is the value proposition of stablecoins for financial inclusion?

Glowka, M., & Nilsson, T. (2022). Fx settlement risk: an unsettled issue.

Group, B. M. C. W. (2017). The sterling 'flash event of 7 october 2016'.

Lang, H. (2022). *U.s. cfpb will look at improving exchange rate transparency among remittance providers -chopra.* Reuters. Retrieved from `https://www.reuters.com/markets/us/us-cfpb-will-look-improving-exchange-rate-transparency-among-remittance-2022-12-14/`

Liao, G. (2021). Macroprudential considerations for tokenized cash. *Available at SSRN*.

Logan, L., & Nordstom, A. (2022). *Contributing to a fair and transparent fx market.* Retrieved from `https://tellerwindow.newyorkfed.org/2022/06/21/contributing-to-a-fair-and-transparent-fx-market/`

Schrimpf, A., & Sushko, V. (2019). Fx trade execution: complex and highly fragmented. *BIS Quarterly Review, December*.

Wandhofer, R., & Berndsen, R. (2019). Proof-of-work blockchains and settlement finality: A functional interpretation. *The Journal of Financial Market Infrastructures*, *7*(4), 71–104.