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Some Simple Economics of Stablecoins

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Abstract

Stablecoins have the potential to drastically increase competition and innovation in financial services by reducing our reliance on traditional intermediaries. But they also introduce new challenges, as regulators rely on intermediaries to ensure financial stability, market integrity, and consumer protection. Because they operate at the interface between traditional banking and cryptocurrencies, stablecoins also represent an ideal setting for understanding the key trade-offs cryptocurrencies involve, and insights from robust stablecoin design and regulation are highly relevant for related innovations in decentralized finance (DeFi), nonfungible tokens, and Web3 protocols. In this review, we describe the following: key stablecoin design choices, from reserve composition to stability mechanism; legal claim against the issuer; noninterference with macroeconomic stability; and interoperability with public sector payment rails and central bank digital currencies. Last, we cover the key benefits of stablecoins in the context of real-time, low-cost programmable payments, financial inclusion, and DeFi.

1. INTRODUCTION

Blockchain technology has the potential to support payments and financial services without assigning the same degree of market power and control to traditional intermediaries (Catalini & Gans 2020). This poses a challenge for regulators, as they rely on their ability to regulate and monitor intermediaries to uphold financial stability, market integrity, compliance, consumer protection, and more. The cryptocurrency market has been riddled with these challenges since the release of the Bitcoin white paper in 2008 (Nakamoto 2008), each stage witnessing a push-pull between the perceived benefits of increased disintermediation and worries about losing centralized counterparties as safekeepers. Proponents of disintermediation cite the ability of open markets, greater transparency, and interoperability to unbundle existing services and promote innovation and competition in financial markets. But disintermediation also makes it difficult to enforce compliance standards, ensure the stability of the financial system, and protect consumers from fraud and financial risk. In a world with increased disintermediation, how can the public sector achieve its goals and preserve society's values and principles within these new markets? And how should it evolve regulatory frameworks to account for the constraints and possibilities that the technology enables?

This article studies the trade-off between disintermediation and centralization in the context of stablecoins. At their core, stablecoins are cryptocurrencies designed to trade at par with a reference asset (typically the US dollar). Stablecoins are an ideal starting point for analyzing this tension because of their proximity to traditional payment systems and banking services. From a regulatory perspective, they are a "canary in a coal mine," and it is likely that more recent waves of innovation within cryptocurrency, such as decentralized finance (DeFi) and Web3, will face similar challenges as they become more mainstream. Stablecoins are also interesting to study because their designs encompass the whole spectrum—from completely centralized to fully decentralized solutions.

At one extreme, centralized designs rely on intermediaries to play the role of the issuer and manage the reserve of assets backing the coins in circulation. To perform well in stressed market conditions, these designs should be backed 1:1 with high-quality, liquid assets [for a more detailed discussion, see Catalini & Shah (2021) and Catalini & de Gortari (2021)]. A special case of this approach is a central bank digital currency (CBDC), where a central bank issues coins directly on blockchain-based infrastructure and guarantees convertibility with fiat. At the other extreme, fully decentralized models—often referred to as purely algorithmic stablecoins—rely exclusively on code to issue coins and implement the economic operations needed to keep the price close to par.[1]

Stablecoins provide a useful lens for studying the broader cryptocurrency industry, since their ultimate evolution will quite likely incorporate elements from both centralized and decentralized models. They are intrinsically important to understand, as they have the potential to drastically improve traditional payments and financial services. Because of their cost structure, stablecoins can make inroads on financial inclusion and help remove last mile frictions for segments of the population that are currently excluded. Within the cryptocurrency market, stablecoins also act as a necessary base layer for DeFi protocols, as they bring a stable asset to an otherwise volatile ecosystem.

For regulators, stablecoins offer a useful laboratory for understanding how oversight can evolve in a situation where intermediaries play a different role than in the past. The lessons therefore apply more broadly than stablecoins and extend to DeFi, nonfungible tokens (NFTs), and Web3 applications. In general, if cryptocurrencies are to be successful within mainstream applications,

[1] It is important to recognize that, to date, no fully decentralized model has been able to produce a stablecoin that trades at or close to par for extended periods of time.

the public sector will have to play the fundamental role of developing frameworks that enhance their strengths while addressing their weaknesses. While the technology brings new opportunities around the privacy, auditability, and safety of digital transactions—from payments to financial contracts and digital content—the lack of traditional structures means that it also carries new risks. Addressing these risks while preserving the long-term potential of the technology to reshape market structure and increase competition is the key challenge regulators, entrepreneurs, and software developers face in this space.

The article proceeds with a description of the origin of stablecoins in Section 2. Section 3 discusses the core stablecoin design choices. Section 4 covers the main benefits to the financial system that robust economic design can provide in this context, and Section 5 concludes.

2. FROM VOLATILE CRYPTOCURRENCIES TO STABLECOINS

Cryptocurrencies first received public attention following the release of the Bitcoin white paper and subsequent growth of the Bitcoin network (see Nakamoto 2008, Narayanan et al. 2016). Bitcoin was originally described as "an electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party" (Nakamoto 2008, p. 1). Before Bitcoin, intermediaries were necessary to solve the double-spending problem that affects all traditional forms of digital cash. While Bitcoin's value has surged, the main driver behind its diffusion has not been its use as a medium of exchange.[2] Various reasons account for this—long settlement time, lack of merchant acceptance, and complex tax treatment—but the main reason is price volatility. Since Bitcoin's supply increases slowly and predictably in the short run, and is capped in the long run, shifts in demand for Bitcoin directly translate into sharp fluctuations in its price.[3] Of course, current levels of volatility could be the result of Bitcoin being on a transition path toward equilibrium and not yet in that steady state. Therefore, volatility could be the result of the high uncertainty Bitcoin faces from a regulatory, technological, and market-fit perspective. As expectations across these dimensions evolve, the price may stabilize. The potential use of Bitcoin as a store of value often leads it to being characterized as "digital gold," a new type of reserve currency, or a hedge against inflation.[4] While some of the theoretical arguments are compelling, the empirical evidence so far suggests otherwise.[5] It is also possible that Bitcoin belongs to a completely new asset class with its own novel properties.

The technology behind Bitcoin not only changes the role of intermediaries but also fundamentally affects two key economic costs (see Catalini & Gans 2020). First, it lowers the cost

[2]Bitcoin's market cap has peaked four times—at $205 million in June 2011, $13.5 billion in November 2013, $325 billion in December 2017, and $1.3 trillion in November 2021.

[3]The amount of Bitcoin in circulation is fixed in the long run at 21 million coins and highly inelastic in the short run. Currently, approximately 90% of all Bitcoins have already been minted, and 6.25 new Bitcoins are issued with each block (roughly every 10 minutes).

[4]Various factors contribute to Bitcoin's potential role as a store of value: It is easily transferable by anyone with an internet connection, it offers a high degree of censorship resistance, and it is easy to store since it is fully digital.

[5]In line with the view of Bitcoin being in a transition phase, adoption is still far from gold (Bitcoin's current market cap is approximately only one-tenth that of gold's, currently approximately $10 trillion). This factor may explain Bitcoin's much higher price volatility relative to gold and is consistent with how market participants reacted during the flight to safety of early 2020: During the COVID-19 (coronavirus disease 2019) crisis, the peak-to-trough decline in the S&P 500 Index was approximately 35%, while gold's price fell only by approximately 12%. Bitcoin's price, however, fell by 64%—far outpacing the decline in equities and weakening the argument that it is an effective hedge against economic turmoil.

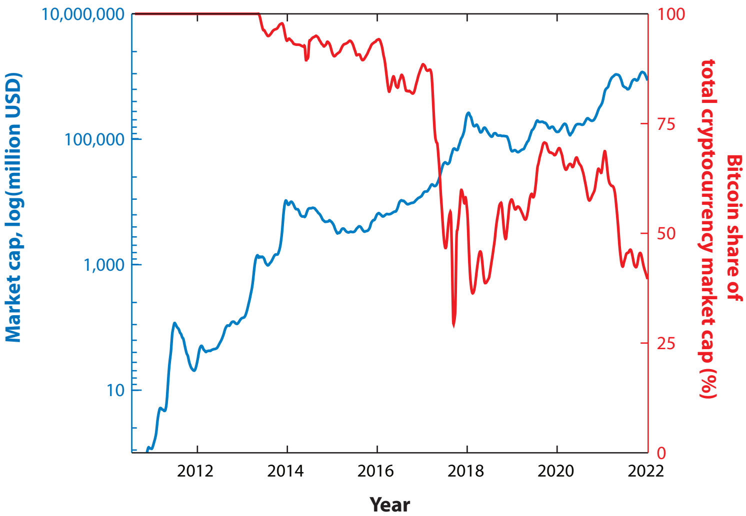

Figure 1

Bitcoin market cap over the years in log(million USD) and Bitcoin's share of the overall cryptocurrency market (%). Data from **https://coinmarketcap.com**.

of verifying information on a digital ledger—such as information about past transactions and current ownership in a digital asset. Second, through novel forms of distributed governance, it allows participants to bootstrap and operate a digital platform without assigning control to the platform creator. This replaces traditional forms of governance with decentralized consensus-based mechanisms.[6] Taken together, these properties replace some of the functions of traditional intermediaries with a combination of cryptography and incentives. The technology can thus blend some of the advantages of traditional digital platforms [e.g., the ability of participants to rely on shared infrastructure and application programming interfaces (APIs), benefit from interoperability and network effects, etc.] without assigning market power to the platform creator.

The evolution of the cryptocurrency space and the role of intermediaries within it over the last decade can roughly be split into four phases. In the first phase, between 2009 and mid-2012, most of the effort was focused on Bitcoin (**Figure 1**).[7] This phase saw a first push toward disintermediation, with some users custodying their coins directly rather than through a third party. However, the phase also witnessed several events that, at the time, put into question Bitcoin's survival, such as protocol bugs, hacks and fraud at cryptocurrency custodians, and the emergence of illegal marketplaces.[8]

[6]For a detailed primer of exactly how Bitcoin avoids the double-spend problem and perpetuates a shared ledger using cryptography and consensus, see Narayanan et al. (2016) and John, O'Hara & Saleh (2022).

[7]As of December 2021, Bitcoin remains the largest project as measured by market capitalization and represents 40% of the cryptocurrency's $2.3 trillion market cap. All of the numbers in this section come from **https://coinmarketcap.com/**, **https://www.blockchain.com/**, and **https://defipulse.com/**, accessed on December 9, 2021.

[8]Among other things, these early years witnessed the identification and subsequent fix of a bug in the protocol code enabling the creation of an infinite amount of coins, the collapse of the Mount Gox cryptocurrency exchange, and the emergence and later shutdown of the Silk Road darknet marketplace.

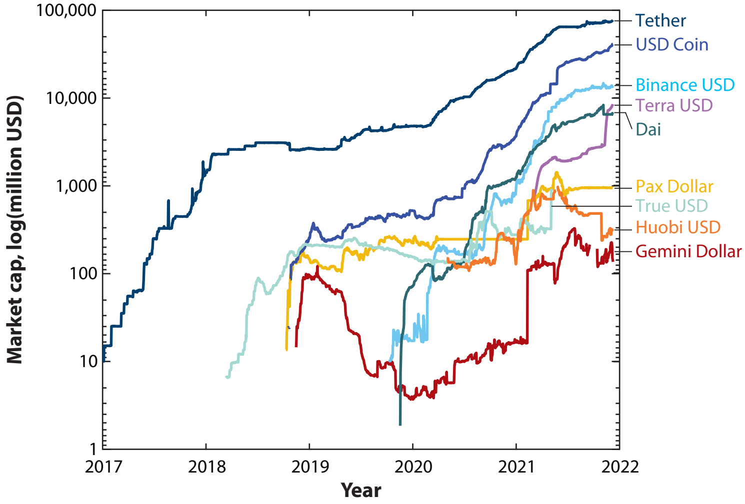

Figure 2

Market cap in log(million USD) for the leading USD-linked stablecoins. Data from **https://coinmarketcap.com**.

The second phase, from mid-2012 to mid-2015, saw the entry of altcoins: alternative cryptocurrencies that imitated key features of Bitcoin. The altcoin market cap peaked at approximately $2 billion and was marked by a number of hard forks of Bitcoin and other cryptocurrencies. This period also brought the first initial coin offerings (ICOs), by which start-ups raised funds through the issuance of cryptocurrency tokens (see Catalini & Gans 2019).[9] It is also when the first stablecoin, Tether, came online.

Stablecoins are cryptocurrencies whose prices are linked to reference assets. They were developed with the goal of creating a cryptocurrency-native medium of exchange that could be easily moved across cryptocurrency exchanges to arbitrage price differences. In other words, stablecoins delivered the ability to move stable-value, dollar-pegged coins in a way that was faster than moving actual dollars on legacy rails.[10] Because of their ability to support real-time payments and broader forms of interoperability and programmability, stablecoins also offer a natural path for upgrading traditional payment systems (see Catalini & Lilley 2021).[11] Tether—linked to the US dollar—was issued in 2014 and remained the only stablecoin until 2018. As **Figure 2** shows, several other USD stablecoins have been issued since then, with Tether maintaining a disproportionate share of the market.[12] In contrast to Bitcoin, stablecoins tend to operate with centralized protocols in which

[9]Two notable ICOs include Mastercoin, which launched the first ICO in 2013, and the highly successful ICO-funded launch of Ethereum in 2014 (today's largest blockchain after Bitcoin, current market cap of $490 billion).

[10]Note that price volatility is also a burden for financial services: For example, a Bitcoin-denominated loan used to fund a business with fiat revenues entails similar risk to taking a loan issued in a foreign currency with a highly volatile exchange rate.

[11]Interoperability is important for encouraging a more competitive and innovative payments ecosystem, while programmability reduces or eliminates the need to rely on intermediaries for offering financial services.

[12]Tether coins run on several blockchains, among which the most important are the Bitcoin (OMNI), Ethereum (ETH), and Tron (TRX) integrations. See **https://tether.to/faqs/**.

new coins are issued at the discretion of a single entity and not based on a set of rules enforced by a decentralized group of actors.[13] The main exception is Dai, which uses a decentralized protocol.[14]

The third phase—taking place between mid-2015 and late 2019—saw the development of additional projects with large-scale ambitions.[15] Yet, this boom would prove brief, and the whole market's value would drop to approximately $100 billion at the beginning of 2019 from a peak of $830 billion. Last, the fourth and current phase began in early 2020 and has led to a new boom cycle driven by broader retail and institutional adoption.[16] Driven at least partly by the liquidity influx from expansionary fiscal policy, the cryptocurrency's market cap has increased to approximately $2.3 trillion as of December 2021, following an earlier peak of $2.9 trillion in November 2021. Bitcoin currently accounts for approximately 40% of the market, and other cryptocurrencies have firmly established themselves in specific verticals, such as the Ethereum blockchain within DeFi applications and NFTs.

Stablecoins, being the connective tissue across all cryptocurrency applications, have become extremely important to the cryptocurrency economy. Their accelerated growth trajectory has also attracted increased regulatory scrutiny,[17] with concerns focused on the design of their reserves, consumer protection challenges, financial crime, and financial stability. We now turn to the key stablecoin design trade-offs next.

3. KEY STABLECOIN DESIGN CHOICES

In 2020–2022 the stablecoin landscape rapidly expanded, with six coins hitting more than $1 billion in market cap as of December 2021. But this explosion also brought wide heterogeneity in designs across dimensions such as backing assets, stabilization mechanism, consumer protection, and market structure. Broadly, these decision choices fall along the continuum between fully centralized and fully decentralized solutions. While centralized approaches typically involve setting up a corporate entity as the licensed issuer of coins, building linkages with banks for holding the reserve assets, and varying degrees of regulatory engagement, decentralized solutions usually place fewer restrictions on governance and licensing and may not involve any regulatory engagement at all.

In this section, we discuss the key stablecoin design choices between centralization and decentralization as well as their economic, legal, and policy implications. In some cases, an additional

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[13]Stablecoins have played a key role in making cryptocurrency markets more efficient and enabling new functionality such as DeFi. Yet, stablecoins also introduce an important tension when it comes to decentralization. On the one hand, the most important stablecoins, as measured by coins in circulation, are all based on centralized designs and back their coins with off-chain assets. On the other hand, it is an open question whether the cryptocurrency industry would have been able to grow and mature to its current size without centralized stablecoins.

[14]It is important to note, however, that in practice Dai's price stability relies heavily on the stability of USD Coin (USDC), which is a centralized stablecoin. Consequently, Dai's stack does rely deeply on a layer of centralization, even if its protocol appears to be fully decentralized in theory.

[15]Bitcoin's share of the overall cryptocurrency market cap had fallen to approximately 65% by late 2019, following an all-time low of 30%, and this cemented the idea that there was demand and product-market fit for the other coins. Ethereum, in particular, established itself as the second major blockchain, with Ether—its native asset—inheriting Bitcoin's extreme volatility and witnessing a peak-to-trough decline from approximately $1,300 to $100 per coin.

[16]Retail users saw an increased offering of cryptocurrency on-ramps, including Robinhood, CashApp, PayPal, and Venmo, while some institutional investors such as corporate treasuries—MicroStrategy, Square, and Tesla—and hedge funds increased their exposure to cryptocurrency. In addition, various crypto funds, such as those offered by Greyscale and Fidelity, saw increased inflows during this period.

[17]For more information, readers are referred to G7 Work. Group Stablecoins (2019), Financ. Stab. Board (2020), Pres. Work. Group Financ. Markets (2020), and Pres. Work. Group Financ. Markets (2021).

constraint in terms of what a stablecoin issuer can or cannot do depends on its ability to also shape the blockchain network on which its coins move, opening a wider set of levers and choices.[18]

3.1. Reserve Design and Financial Stability

The core purpose of a stablecoin is to offer stability against a reference asset. Stablecoin issuers have two key levers to protect stability: (*a*) the choice of reserve assets and (*b*) the design of the stabilization mechanism used to keep the coin price pegged to the reference asset. When demand rises, the stabilization mechanism typically increases the supply of coins (minting). Vice versa, when demand decreases, the stabilization mechanism reduces the supply of coins (burning) through the sale of reserve assets.[19]

Three approaches to these basic operations have emerged, spanning the centralization–decentralization spectrum: (*a*) stablecoins backed by fiat rely on financial intermediaries to custody reserve assets and to mint and burn coins with market participants; (*b*) stablecoins backed by cryptocurrencies automate reserve operations and interface with different blockchains supporting reserve assets through smart contracts; and (*c*) stablecoins backed partially or fully by their own investment token only rely on their own algorithms and smart contracts.

Consider first stablecoins backed by fiat. Most stablecoins with a large market cap are in this category and match each coin liability issued with fiat-based assets on their balance sheet. Tether, USDC, the Paxos Coins [Paxos Standard, Binance USD, Huobi Coin (HUSD)], and Gemini Dollar are fully backed by dollar-denominated assets, including cash, US treasuries, commercial paper, and more. Most of these issuers directly issue new coins and redeem existing coins directly to the market at par. This creates arbitrage opportunities whenever the price deviates from the peg and keeps the price of the stablecoin relatively stable.[20]

Robust reserve design for fiat-backed coins is inspired by narrow banking (Catalini & Massari 2021) and aims to minimize mismatches in market risk and liquidity needs (Catalini & Shah 2021). However, most of the USD-pegged coins issued today do not follow this model, as stablecoin issuers invest in fairly risky assets. This can cause problems in two ways. First, the value of the backing assets can change, tipping a fully backed coin into a partially backed coin. Second, concerns around the solvency of an issuer can be self-fulfilling: If coin holders fear insolvency and try to redeem their coins, even a solvent stablecoin issuer may be forced to liquidate its assets at discounted fire-sale prices and thus become insolvent in the process. These concerns of solvency and liquidity are well-known in the banking industry, but currently no common regulatory standards exist for stablecoin issuers. Gorton & Zhang (2021) argue that uniform standards should be imposed, e.g., reserve assets at FDIC-insured banks, in US Treasury bonds, or potentially held at the Federal Reserve itself. While some stablecoin issuers have provided increasingly transparent information about their backing, including monthly audited reports, this is unlikely to be sufficient.[21] For a detailed discussion of ideal reserve design, see Catalini & Shah (2021).

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[18]Most existing stablecoins (e.g., Tether and USDC) run on multiple external networks, and so the design choices are largely oriented around the coin itself. However, a few projects, such as Terra and Diem, also design and govern the network on which the stablecoin runs.

[19]Since stablecoins are traded on secondary markets, both within cryptocurrency exchanges and over the counter, arbitrage across these markets is also important for maintaining parity beyond the basic reserve operations of minting and burning coins. Agents make profits by arbitraging price differences across exchanges and, ideally, this practice keeps stablecoins' prices confined to tight spreads in all marketplaces.

[20]For evidence that this mechanism works as intended for Tether, in the sense of keeping spreads small, see Lyons & Viswanath-Natraj (2020).

[21]For example, while several issuers claim to hold reserves in FDIC-insured bank accounts, it is unclear what structure is used to ensure that FDIC insurance limited to $250,000 applies to their large reserve sizes. One

Next, consider stablecoins backed with cryptocurrencies. While fiat-backed stablecoins are issued by entities that need to hold licenses and rely on financial institutions to custody assets, cryptocurrency-backed coins can be constructed and managed in a decentralized way. For instance, Dai, an ERC-20 token issued on the Ethereum blockchain and designed by MakerDAO, is a decentralized USD-linked stablecoin that can be minted by anyone with sufficient collateral in other cryptocurrencies.[22] While overcollateralization requirements guard against losses, this approach is riskier than the fiat-backed one. Some of the backing cryptocurrencies, such as Bitcoin or Ether, often exhibit large price fluctuations. As a result, it is possible that a fast and abrupt change in the price of the cryptocurrency collateral, coupled with fading liquidity in markets, could lead to undercollateralized smart contracts. In this case, the stablecoin would no longer be fully backed, would enter an unbacked and more unstable phase, and could be at risk of a death spiral.

Last, consider algorithmic stablecoins. These stablecoins are not backed by external assets and rely on their own equity to deliver some degree of stability. In particular, they typically regulate coin supply through two sets of coins: the stablecoin and an investment coin (also called "seigniorage" or "dual" coin) targeted at absorbing market volatility. At a high level, their stabilization mechanism inflates the outstanding supply of stablecoins in exchange for investment coins when prices are above par and deflates it when they are below par. When the price is below par, the protocol issues more investment coins and uses the proceeds to repurchase stablecoins and remove them from circulation, raising the price. Thus, the investment coins function as equity, bearing the risk of dilution when coins trade below par, but enjoying additional returns in periods of growth. To ensure investment coins have some intrinsic value, they are often imbued with additional functionality; e.g., they are required for paying transaction fees.

Algorithmic stablecoins, by virtue of their use of smart contracts and their lack of external links to external assets (fiat or cryptocurrency), do not require an intermediary and can be truly decentralized. While this may look safe in normal times, it forces investment coin holders to bear all the market risk in the same way that equity holders do for corporations (see Sams 2015). Such arrangements are prone to self-fulfilling crises in which nervous market participants running on the reserve can trigger a death spiral. In such situations, the algorithm has no choice but to further dilute investment coins to the point that they are unable to support the peg. Catalini & de Gortari (2021) note that, unlike stablecoins backed by fiat assets or cryptocurrencies, the true solvency of an algorithmic coin is linked to the public's confidence in the coin, allowing death spirals to materialize even in unstressed conditions. While these stablecoins often add mechanisms to prevent a death spiral from occurring, in practice, they are unlikely to be effective. For example, in stressed times, protocols may levy stability or redemption fees on coin holders to recapitalize the reserve. However, these mechanisms only accelerate the run, as investment coin holders may realize that fees will rise as the run deepens and thus preemptively run. Overall, these risks impede this form

likely solution involves seeking pass-through FDIC insurance, but it is unclear if this design would hold up in an insolvency.

[22] Minting Dai requires a consumer posting a specified amount of another cryptocurrency as collateral, where the overcollateralization ratios are proportional to the risk of the collateral (e.g., at least 101% with USDC, 150% with Ether, etc.) and where the collateral is liquidated if it falls too far in price. Dai's stabilization mechanism relies on two forces: the issuing and redemption of new Dai at par to prevent prices on the secondary market from deviating, and a mechanism known as the Dai Savings Rate that pays users that lock Dai into a smart contract and can be adjusted to affect Dai's price (e.g., the Savings Rate falls when Dai's price is above par).

of stablecoin design from being viable at scale for any application that needs to guarantee stability over the long run.[23]

Empirically, decentralized designs have higher price volatility, while most fiat-backed stablecoins have been successful at maintaining price stability. Lyons & Viswanath-Natraj (2020) note that the average deviations for large fiat-backed coins have been under 10 basis points and further find that maximum spreads were within 10 basis points, with a few notable deviations (e.g., up to 300 basis points during the volatility of March 2020). The authors also show that cryptocurrency-collateralized coins trade with larger spreads (e.g., between $1.01 and 1.03 during May–November 2020) and have an average trading deviation of 40 basis points.[24] Meanwhile, Kuo, Iles & Rincon-Cruz (2019) note that some algorithmic coins have seen extremely large volatility, trading between $0.50 and $1.50. Catalini & de Gortari (2021) and Catalini & Shah (2021) highlight that high-quality liquid assets can better retain value during stressed conditions than cryptocurrencies and that, in turn, both are more stable than the investment coins that back algorithmic coins.

While the quality of the reserve backing and its correlation with the reference asset are critical, one added challenge must be considered by stablecoin issuers: liquidity. Stablecoins trade globally and at all hours. But limitations of traditional banking rails make this difficult, as fiat movement is limited to operating hours. To address the potential liquidity mismatch, additional layers of intermediation have emerged. The main solution is to use on-network liquidity providers that can intermediate overnight transactions, although this works well only for established coins that can support enough activity. Another solution is to rely on 24/7 banks that have the technology to let their customers transact at all hours.

3.2. Consumer Protection

Consumer protection goes beyond the design and financial stability of the reserve. In particular, stablecoin issuers must consider the legal claim that a coin represents and must develop rules regarding the types of entities that can hold their coins (e.g., only regulated intermediaries versus anyone). Such protections vary depending on whether the underlying stablecoin has chosen a more centralized or decentralized design.

First, consider the nature of the claim that a stablecoin's holders have. Centralized projects must decide whether consumers have a direct claim against the issuer, direct claim on the underlying assets held with a custodian, or no direct claim at all.[25] Decentralized projects must make similar choices, although in many cases those choices manifest in the design of a smart contract rather than a legal agreement.[26] Second, stablecoin projects may implement restrictions on how their coins are distributed and used. These restrictions are easier to enforce if the stablecoin issuer operates its own blockchain and may impact the types of entities that are allowed to hold consumer coins. Stablecoin projects focused on consumer protection, compliance, and market

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[23]It could be argued that such coordinated run dynamics seem implausible, but the history of fixed exchange rate regimes shows that it is quite possible for even country-level monetary systems to collapse entirely and abruptly.

[24]For example, issuing Dai with USDC as collateral requires a 101% collateralization ratio. Hence, arbitraging Dai price differences away through this process is profitable only when Dai's price trades above $1.01.

[25]As one example, Barnett & Dowling (2020) explain that Tether has picked the first of these: Tether holders have direct claims on the issuing corporation but not on the assets custodied with Tether's banking partners.

[26]Dai, for instance, chooses to prioritize those who have locked up collateral to create Dai over those who transact Dai on secondary markets in its emergency shutdown procedures. In an emergency, the protocol will first release excess collateral to the former group and then use any remaining funds to redeem Dai from the second group, possibly at a value below par.

integrity may perform due diligence on the intermediaries that can buy and sell their coins [known as virtual asset service providers (VASPs)] and may insist on the intermediaries disclosing key risks to consumers, offering protections against their own insolvency, and using a transparent fee structure for redemptions. Indeed, these dimensions have attracted regulatory attention, with the Pres. Work. Group Financ. Markets (2020) explicitly calling out transparent fees, bankruptcy-remote protections, risk disclosures, and direct claims as issues stablecoin projects need to address.

Historically, additional consumer protections required coordination between stablecoin issuers and intermediaries. However, cryptocurrency-native solutions are also being developed. One leading example is proof of solvency, a scheme by which consumers can verify the integrity of their funds held by VASPs without relying on a trusted third party such as an auditor. Chalkias et al. (2020) illustrate an approach in which consumers can directly check whether their balances are represented in the overall assets of an intermediary through a mapping known as a Merkle tree. This mechanism effectively serves as a decentralized audit, decreasing the degree of trust consumers have to place in a digital custodian.

3.3. Interoperability

Stablecoin-based payment rails are different from traditional ones because they can support not only programmability but also deeper forms of interoperability between network participants.[27] By design, traditional digital wallets and card networks do not invest in interoperability to reinforce network effects within their walled garden and lock in consumers and/or merchants. In China, for example, even though WeChat Pay and Alipay jointly account for more than 90% of mobile payments, they do not let users transfer funds between the two providers, and transferring money requires cashing out to a bank account and then cashing in to the other, which is costly since withdrawal fees are pretty much the only fees charged by these services. These challenges are even more severe in countries where payments systems are more fragmented.

Interoperability incentivizes competition and disproportionately helps smaller players, as the benefits from compatibility are asymmetric and enable smaller service providers to offer payments to and from the larger installed base of the incumbents. When interoperability is implemented at the network level (e.g., as in the Unified Payments Interface in India), the resulting competition drives down prices, lowers barriers to entry, and reduces the market power of incumbents and within-provider network effects. While stablecoins running on permissionless networks inherit some degree of interoperability from the openness of the infrastructure they rely on, for competition to truly thrive, interoperability across networks and protocols will also be important.

3.4. Macroeconomic Stability

At scale, stablecoins raise a key additional area of concern based on how they interact with the broader international financial system. Regulators, including the G7 Work. Group Stablecoins (2019) and Bank of England (2020), have identified several risks to the broader economy if stablecoin adoption becomes widespread and a stablecoin emerges as a parallel monetary system. These macroeconomic concerns—namely, stablecoins facilitating destabilizing capital flows, replacing

[27]In the words of Duffie (2020), "two different ledgers are interoperable if there is always at least one intermediary holding accounts on each of the two ledgers that automatically meets legal requests to transfer funds from any account on one of the ledgers to any account on the other. . .at negligible or nearly negligible latency and user cost" (p. 2). This definition rules out most existing payment services, where users can transfer funds from one to another but at a significant cost in time or money, whereas VASPs on a shared blockchain can indeed transfer funds at very low cost.

a country's local currency, and enabling an alternate financial system—are critical for stablecoin issuers to address.

First, consider the ability of stablecoins to facilitate rapid capital flows, as pointed out by G7 Work. Group Stablecoins (2019) and Grenville (2019), among others. Following the currency crises of the late 1990s, in which inbound and outbound flows of hot money led to asset bubbles and systematic distress, respectively, the International Monetary Fund and most central banks recommended capital controls and other macroprudential policies. However, digital currencies pose new challenges to the enforcement of such regimes. Chainalysis (2020) detected large flows of cryptocurrency from East Asia to other regions (some \$50 billion in 2020) and ascribes at least some of it to the evasion of capital controls that prevent Chinese citizens from sending more than \$50,000 per year overseas. Baydakova (2019) further finds reports of stablecoins being used to avoid capital controls between Russia and China, and von Luckner, Reinhart & Rogoff (2021) document broader evidence of capital flows being facilitated by traditional cryptocurrencies (namely, Bitcoin). While these incidents are not yet widespread, it is possible that a widely adopted stablecoin could enable disruptive flows in the future.

Second, a related risk around stablecoins is one in which they substitute for the local currency of a country (dollarization), as G7 Work. Group Stablecoins (2019), Benigno, Schilling & Uhlig (2019), Cecchetti & Schienholtz (2019), and others discuss. Several countries have already suffered currency substitution in the fiat realm. For instance, the US dollar has already replaced the local currency of countries as diverse as Cambodia, Ecuador, and Zimbabwe, and in doing so, it has removed those countries' ability to conduct monetary policy. Stablecoins may prove to be another path to currency substitution and in unique ways. For instance, acquiring and storing fiat dollars are cumbersome, giving the local currency an innate advantage in most countries; however, for digital currencies, these disadvantages are muted. Stablecoins are potentially easier to acquire and far easier to store, and thus they introduce new risks.

Finally, stablecoins may give rise to a parallel financial system (shadow banking), as G7 Work. Group Stablecoins (2019) and Brunnermeier, James & Landau (2019), among others, have noted. DeFi already represents a manifestation of this, in which a parallel network that facilitates lending, trading, derivatives, and other financial contracts is being built on top of cryptocurrency tokens. A broader parallel digital financial system poses two risks. First, distress on such a system could spill over into distress on the stablecoins that support it. For instance, a market crash could scare users into redeeming their stablecoins for fiat, overwhelming the issuer's redemption capabilities. Second, from a macroeconomic perspective, any such financial system would not benefit from the modern safeguards, ranging from oversight to last resort lending, that onshore financial systems have developed. Currently, such parallel financial systems are small, but stablecoins could enhance their appeal and scope.

Any solution to these issues entails trade-offs. For instance, the public sector and stablecoin issuers could tightly regulate the perimeter of stablecoin ecosystems (e.g., on- and off-ramps between stablecoins and fiat) and only allow regulated VASPs on their networks. This approach would mitigate the macroeconomic risks but could also make stablecoins less interoperable with other systems and less effective at facilitating cross-border transfers, expanding on financial inclusion, etc.

3.5. Evolution Toward Central Bank Digital Currencies

Thus far, we have focused on privately issued stablecoins. Private stablecoins face key decisions on how to back their coins, stabilize their reserve, protect consumers, design their networks to ensure integrity and compliance, and integrate with the existing financial system. But in the long run, there is an alternative that can address some of these questions more naturally: central bank digital currencies (CBDCs).

Discussion on CBDCs has accelerated over the last few years.[28] In particular, retail-facing CBDCs, in which central banks issue digital tokens to consumers, would represent an innovation on two fronts. Unlike cash, CBDCs would be electronic money, and unlike central bank reserves, CBDCs would represent direct claims on the central bank that are accessible to consumers. According to a set of Bank of International Settlement surveys (see Barontini & Holden 2019; Boar, Holden & Wadsworth 2020), 70% of central banks conducted conceptual CBDC research in 2018, half of those ran experiments and proof-of-concept tests, and five had progressed to running pilot projects. In order of importance, the main motivations for issuing a CBDC were payment safety and efficiency, financial stability and inclusion, monetary policy implementation, and cross-border payments. That said, 85% of central banks thought it would be unlikely that they would issue CBDCs in the short- or medium-term (3–6 years). This likelihood had fallen to 70% by the end of 2019 yet remains high.[29]

While at first glance it may appear that stablecoins compete with CBDCs, they can coexist harmoniously. In particular, CBDCs can be embedded within a public–private partnership that leverages each sector's comparative advantage, with central banks providing the base layer of money and the private sector innovating on top (see Catalini et al. 2021). Indeed, some central banks are already espousing this view. According to the Bank of England (2020): "An approach to CBDC where Bank of England does everything, with no private sector involvement, is unlikely to meet most of our design principles. . . . A safe payment system is only useful if people use it, which means CBDC would also need to enable fast, efficient, user-friendly and inclusive services. This in turn requires that a CBDC payment system would be open to innovation and competition, and built around the comparative advantage (relative strengths) of the Bank and the private sector" (p. 20). In fact, as Goldstein (2020) chronicles, money in virtually every era has been grounded in a public–private partnership, whether tenth-century Chinese merchants exchanging coins for paper, seventeenth-century English goldsmiths issuing IOUs, or the modern monetary system's interplay between central and commercial banks. CBDCs can be the next step of this evolution.

Assuming that CBDCs develop as a public–private partnership, the central bank could provide reserve custody, payment settlement, and interoperability across private sector rails and digital assets. Private sector participants could then be in charge of the products, consumer interfaces, and customer due diligence processes (know your customer, etc.). This approach could represent a blend of public governance at the bottom of the stack and distributed or even decentralized private innovation at the top. Operationally, this partnership could manifest in a few different forms. One model is for the central bank to provide a backstop for private stablecoins, i.e., let stablecoin operators custody funds with the central bank but otherwise issue coins and operate independently. This model corresponds to the synthetic or hybrid CBDC design introduced by Adrian & Mancini-Griffoli (2019), in which private players become narrow banks with liabilities held in central bank reserves, thus removing market and liquidity risk. Another potential model involves users interfacing through private products but holding accounts directly at the central

[28]For an overview of CBDC features and proposals, see Bordo & Levin (2017); Bank of Israel (2018); Comm. Paym. Market Infrastruct. (2018); Off. Monet. Financ. Inst. Forum (2019); Auer, Cornelli & Frost (2020); Bank of England (2020); Banque de France (2020); Prasad (2021).

[29]The notable exception is, of course, China, which appears to be fairly advanced in the piloting process of its digital currency electronic payment (DC/EP) project. Faced with a uniquely advanced digital payments ecosystem, largely developed by Alipay and WeChat, China will likely be able to rely on its population's familiarity with digital currencies to drive adoption of its CBDC.

bank as a true CBDC. As Bank of England (2020) discusses, distribution in an alternative model could be done through a two-tiered system in which users access CBDC tokens through a middle layer of payment interface providers. Finally, the central bank could offer wholesale liquidity to banks, financial institutions, and payment system providers (i.e., a wholesale CBDC, as in the status quo), and these entities could in turn develop their own form of retail digital tokens that are interoperable through the wholesale CBDC. Any given structure entails answering additional questions, such as whether CBDCs should pay interest, how commercial banks should fit in the system, if central banks should uphold the privacy features of cash, and how compliance provisions should be enforced.

It is important to stress that central banks do not have to participate in stablecoin arrangements from the outset. Central banks in both developed and emerging markets have different priorities, have varying tastes in the speed and degree at which they shift policy stances, and face distinct monetary and payments ecosystems.[30] As such, they can preserve optionality by letting private approaches evolve independently in a tech-neutral manner (same risk, same regulation) and connect with these new types of networks when appropriate.[31]

In the meantime, stablecoin issuers face important design choices ranging from reserve design to financial stability, consumer protection, interoperability, and macroeconomic ramifications. While issuers have developed a wide array of solutions, as stablecoins evolve and mature, standardization will be necessary. As such, regulators should build high-quality and consistent regulatory standards. For instance, regulators should provide a framework for the appropriate capital and liquidity requirements governing stablecoins. Furthermore, regulators should harmonize these rules with their foreign counterparts. Currently, many topics—such as the legal classification of stablecoins, the legal certainty of settlement finality, and the rules around privacy—are fragmented. Different jurisdictions treat the same instrument differently (some as tokens, some as e-money, etc.), handle the concepts of settlement finality and payment instruction irrevocability differently, and set different standards about data-sharing across entities and across borders. There are some encouraging cases: The efforts of the Financial Action Task Force to set baseline standards for financial entities have culminated in proposed rules to counter money laundering, and the Bank of International Settlements is developing global standards for CBDCs, so as to allow them to interact directly through a shared mBridge platform. But broader coordination is essential if stablecoins are to deliver on their broader promises to society.

4. POTENTIAL BENEFITS OF STABLECOINS

In the short run, stablecoins can enable low-cost digital payments and make payments programmable. Over time, they can also improve financial inclusion for the unbanked and support novel types of DeFi applications.

4.1. Low-Cost, Real-Time Digital Payments

Existing payment systems are slow and expensive (see Catalini & Lilley 2021). For instance, the largest US banks charge between \$10 and \$35 for a same-day domestic wire transaction between

[30]To name one example, the Bank of England (2020) noted the declining use of cash as a motivation for investigating CBDCs to retain its ability to deliver public (risk-free) money to its citizens. The Bank of Israel (2018), in contrast, has been more cautious, given that the Israeli economy has not significantly seen a decline in the use of cash.

[31]For example, central banks could let stablecoins and other digital assets launch, grow, and compete against each other and then promote the most successful ones to synthetic CBDCs by taking custody of the private backing reserves.

consumers, and even slower transfers incur hefty fees. Small businesses pay between 1% and 3% to accept card transactions, with an additional 1% for online payments, faster settlement, etc. Moreover, many countries lack a cheap, real-time gross settlement network that can transfer value across a broad set of participants quickly and cheaply. In the United States, for example, Fedwire is only available to a small set of institutions transacting large volumes, and attempts to expand on availability [like The Clearing House (TCH)] have not gained meaningful scale. Through their widespread distribution and streamlined cost structure, stablecoins can offer a solution. They trade on networks that are cheaper to access for businesses, consumers, and intermediaries alike and therefore can deliver real-time gross settlement solutions for small transactions that are uneconomical to perform today.

4.2. Programmable Money

Stablecoins have one other advantage: programmability. Programmable money allows participants to customize payments and related financial agreements, creating new types of exchanges. Programmability can also play an important role for the public sector (see Catalini et al. 2021). For example, conditional cash transfer programs—whereby fund recipients need to perform an action before receiving funds such as attending school—are popular in emerging markets and effective for achieving policy goals (see Parker & Todd 2017). These programs could be implemented by transferring funds to recipients but also requiring them to fulfill a requirement (e.g., attending a health clinic for a vaccination) in order to unlock the funds. This approach could increase transparency and accountability and reduce corruption and errors. In the United States, for example, even the basic disbursement of stimulus funds faced severe delays and challenges in reaching unbanked beneficiaries (see Long & Singletary 2020).

4.3. Financial Inclusion

Consider first cross-border transfers. The remittances market—typically defined as cross-country person-to-person transfers (often to friends or family members)—is large and expensive. In 2019, remittances to low- and middle-income countries reached $554 billion—higher than all foreign direct investment flows to these countries.[32] Yet, the average remittance involves fees and commissions of approximately 6.8% globally and a staggering 8.9% when sending to sub-Saharan Africa. Even smart remitters who use digital solutions paid 4.2% on average. Stablecoins can reduce these costs by addressing last-mile distribution challenges in the same way that companies such as M-PESA have done with their mobile money initiatives. In Kenya, M-PESA not only contributed to financial inclusion but also helped decrease poverty and increased consumption, risk-sharing, productivity, women empowerment, and gender equality (see Jack & Suri 2011; Jack, Ray & Suri 2013; Suri & Jack 2016; Suri 2017).[33] At the same time, M-PESA's success was hard to replicate elsewhere—with various explanations posited by Fengler (2012), such as the absence of a strong national regulator, a dominant telecom company, and large investments in merchant networks—and Banerjee et al. (2015) find that utilization rates for new financial technology products are relatively low in the developing world. Similarly, blockchain technology could be used

[32]The overall remittance market is estimated at $714 billion. All remittance numbers discussed in this paragraph are from the World Bank Group (2020).

[33]Digital innovation in payments has been found to have positive impacts on productivity before. Scott, Van Reenen & Zachariadis (2017) documented that the adoption of SWIFT—a technology for worldwide interbank telecommunication—increased bank profitability and exhibited important network effects on performance.

to enhance peer group savings programs that have been successful at overcoming commitment issues and increasing savings in emerging markets (see Kast, Meier & Pomeranz 2018).[34]

4.4. Decentralized Finance

In the long run, stablecoins may end up having their largest impact through DeFi applications. DeFi applications are smart contract–powered financial contracts. To date, most DeFi activity takes place on the Ethereum blockchain.[35] DeFi grew from having approximately $1 billion of locked value at the end of 2019 to $16 billion at the end of 2020 and $100 billion by late 2021.[36] Relative to traditional financial services, DeFi applications are more transparent, are easy to access, and deliver more control to end users since they run on permissionless blockchains and do not involve an intermediary. They can also benefit from composability, i.e., the ability to combine multiple applications with each other to build more complex financial services. Combined with interoperability, this can encourage competition and innovation. Yet, relative to traditional financial services, DeFi applications also incorporate new risks. Some of these risks arise because the early stage nature of DeFi implies that the regulatory, compliance, and oversight guardrails from the traditional system have not been implemented yet—notably, protections against financial risk, systemic risk, and financial crime. Other risks, however, such as those stemming from errors in the codebase, are completely new. We discuss risks in more detail below.

At a high level, DeFi protocols rely on two main features. First, they depend on users locking value in order to use that liquidity to power some type of service. For example, a DeFi lending platform can offer credit if depositors have locked in value that can be lent, or a decentralized exchange can only process a large volume of trades if the protocol has sufficient liquidity to prevent slippage in exchange rates. In the specific case of Ethereum DeFi protocols, users can lock in both Ether, Ethereum's native asset, and any ERC-20 tokens running on the same blockchain.[37] Second, DeFi protocols typically have a mechanism for rewarding providers of liquidity, often in the form of the protocol's governance token. This mechanism adapts to market conditions in order to guarantee liquidity provision (e.g., increasing rewards when provision is low).

DeFi both extends the functionality existing in traditional finance and creates new services where no centralized intermediary has control over the underlying assets. There are currently dozens, if not hundreds, of DeFi protocols, but the market structure is fairly concentrated and value is locked in a very small number of top protocols (at the time of writing, the top five DeFi projects account for 70% of the locked value, and the top ten for more than 90%).

DeFi protocols can be grouped into four broad categories. First, decentralized exchanges (e.g., Uniswap, Sushiswap, Curve Finance, Balancer) let users exchange cryptocurrencies without relying on an intermediary. Instead of relying on order books—as centralized exchanges do—decentralized exchanges typically rely on liquidity pools for each pair of coins, where the relative proportion of each coin in the pool determines the relative prices between the pair. Users can thus exchange one coin for another according to the proportion in these pools, plus a small fee that is used to reward the users who provide liquidity to the protocol.[38]

[34] Indeed, M-PESA is already implementing a similar proposal through its Chama accounts.

[35] While DeFi applications exist on other blockchains, the majority currently run on Ethereum.

[36] All numbers in this section are from **https://defipulse.com**, accessed on December 9, 2021.

[37] Newer protocols are also able to leverage other types of on-chain assets such as NFTs.

[38] Typically, automated market makers define the precise function determining the exchange rate for each trade. For example, under the constant product market maker design, the decentralized exchange between two assets available in x and y quantities ensures that if a user wants to buy Δ_y coins, then the user has to

Second, collateralized lending platforms let users deposit one token in exchange for interest and borrow another token using the original one as collateral. For example, MakerDAO lets users lock up value in order to issue the Dai stablecoin. In other lending platforms, token deposits are important not only to incentivize borrowers to pay back their loans but also because they provide liquidity that other users can borrow. For example, on Compound and Aave, two separate users can deposit Ether and USDC, and then the Ether depositor can borrow USDC while the USDC depositor can borrow Ether—with the lending platform imposing overcollateralization ratios depending on the quality and volatility of the collateral.

Third, DeFi asset management platforms (e.g., Yearn.Finance) let users optimize portfolios by automating holdings to maximize returns across different DeFi protocols. These platforms create investment strategies in which user-provided liquidity is shifted across decentralized exchanges, DeFi lending platforms, and other protocols providing the highest returns. These strategies often involve several layers by which the protocol borrows assets against the ones it deposits in other protocols, or it uses the claims on the assets it has locked to further invest in other protocols.

Last, decentralized derivatives applications deliver functionality such as insurance, futures, or options contracts, relying on price movements that are external to the protocol and brought in through oracles. For example, Synthetix lets users go long or short on other cryptocurrencies such as Bitcoin or Ether. Other protocols, such as Nexus Mutual, provide insurance against smart contract risk.

DeFi protocols build additional functionality on top of cryptocurrencies, which partly explains why their use has increased so rapidly. Decentralized exchanges let users move value across assets at lower fees than centralized exchanges, reduce custody risk, and allow for trades between assets that are otherwise not listed on centralized exchanges. Collateralized lending lets users obtain short-term liquidity from long-term asset holdings, increase leverage and asset exposure, and short assets.[39] Finally, asset management and derivative platforms could, in theory, improve price discovery and the efficiency with which capital is allocated across different cryptocurrency platforms.

As mentioned above, DeFi protocols also introduce new risks. First, smart contracts execute automatically, meaning that bad actors can exploit code vulnerabilities in nefarious ways (e.g., stealing assets) and without obvious consequences. Second, various elements of these protocols adjust algorithmically (e.g., interest rates)—often with little transparency—implying that users do not always know how things change when the market shifts. Third, the DeFi ecosystem as a whole is potentially at risk, given that the different protocols are often intertwined with one another. This creates systemic risk, in that a vulnerability in one protocol can easily transmit across the whole ecosystem, potentially triggering a run out of DeFi. Critically, systemic risk arises not only from the financial risk of any given DeFi protocol failing due to poor economic design but also from the governance risk arising from a protocol being mismanaged by the governance token holders.

Stablecoins are needed for DeFi because they provide a nonvolatile asset that can be used to manage liquidity and move funds across protocols. With the exception of Ether, they represent the

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deposit Δ_x coins such that $(x + \Delta_x)(y - \Delta_y) = k$, with the pool's original assets determining k as $xy = k$. It is straightforward to see that, for a small trade, $\Delta_x = (x/y)\Delta_y$; i.e., the exchange rate is given by the relative size of the two pools.

[39]Short-term liquidity is particularly useful for long-term investors (i.e., HODLers) who would rather pay a fee to obtain liquidity than forgo the potential appreciation of their asset holdings. Meanwhile, increasing leverage is useful for bullish investors, and the ability to short assets is useful for bearish investors. For example, long Bitcoin holders can use their Bitcoin as collateral to borrow funds and increase their exposure to Bitcoin. Likewise, Ether short sellers can use their funds as collateral to borrow Ether and then sell it, with the hope that they will be able to repurchase it in the future at a lower price.

most important asset deposited in decentralized exchanges and lending platforms. Yet, the reliance on stablecoins as a base layer for stability creates its own risks for DeFi. A stablecoin that breaks its peg may undermine a protocol whose design assumes the price will always track the reference asset. Moreover, stablecoins themselves are a source of systemic risk, in that their widespread use within DeFi implies that the collapse of a major stablecoin would immediately transmit to the broader ecosystem. For these reasons, it is critical that stablecoin issuers adopt the safest designs and are able to protect the peg under stressed market conditions.

5. CONCLUSION

Stablecoins are the preeminent example of cryptocurrencies expanding beyond cryptocurrency use cases and into the traditional financial system. Well-designed stablecoins can enable fast, low-cost, and programmable payments, broader participation in the financial system, novel exchange and lending products, etc. But their long-term success is not guaranteed, and involvement from the public sector is important. Regulators must design novel frameworks that attain the broad goals of consumer protection, financial stability, compliance, low barriers to entry, transparency, accountability, and more—and they must do so using different tools than in the past. Stablecoin issuers and regulators must thus partner to find the right balance between centralized and decentralized solutions. If this partnership is successful, stablecoins have the potential to radically reshape the financial system for the better.

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Errata

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