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On par: A Money View of stablecoins

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Abstract

This paper presents a money view analysis of the recent crypto innovation of stablecoins, which have seen a remarkable rise and more recently some spectacular collapses. By analogizing on-chain with offshore, and developing an extended analogy of stablecoins with Eurodollars, we reveal the primitive character of the existing on-chain liquidity mechanism which supports the promise of par settlement by existing on-chain stablecoin models. Liquidity, not solvency, is the issue confronted by par settlement.

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Introduction

Views on stablecoins are a kind of Rorschach ink blot test that reveals unconscious monetary priors, intuitive understandings of money that arise from prior experience. Depending on who you ask, stablecoins are like money market mutual funds, casino chips, wildcat banks, exchange-traded funds, currency boards, or fixed exchange rates.[1] Our own quite conscious monetary priors are those of the money view, and that leads us to analogize stablecoins with Eurodollars.[2] For us, *on-chain* is like *offshore*: each term identifies a particular institutional boundary. Payment on either side of that boundary is comparatively easy; moving funds across the boundary—back off-chain, or back onshore—is comparatively difficult.

The difficulty is par.

Eurodollars are offshore private dollar deposits; stablecoins are on-chain private dollar deposits.[3] By "deposit" we mean a form of credit, proximately a promise to pay dollars, onshore or off-chain dollars respectively, and ultimately a promise to pay liabilities of the Federal Reserve, in both cases. Not just to pay dollars, but in fact to pay dollars at a fixed price of one, a particular kind of price called *par*. The whole idea, for both Eurodollars and stablecoins, is to enable offshore and on-chain settlement without having to make use of onshore and off-chain dollars. Both Eurodollars and stablecoins are intended to function as a means of settlement in their own respective worlds, while economizing on the difficult transaction of crossing back onshore or off-chain.[4] Eurodollars have been around a lot longer, however, and the story of their development therefore provides a useful frame for thinking about stablecoins, which are yet very much in their infancy.

The rest of the paper is structured as follows. The second section reviews the architecture of the offshore dollar system, with a focus on the features that are relevant to the analogy we develop. The third section provides a frame to think about stablecoins from a money view perspective. A fourth section brings these perspectives together. In the fifth section we discuss the architecture of the on-chain dollar system. The paper then looks ahead to what developments may come in the sixth section, before concluding with broader implications.

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[1] For recent papers studying stablecoins from various angles, see Ahmed et al (2023), Bertsch (2023), d'Avernas et al (2023), Gorton et al (2022a,2022b), Li and Mayer (2021) and Ma et al (2023), among others.
[2] Readers unfamiliar with money view thinking can refer to Appendix I for a brief summary. Schenk (1998) provides a historical account of the origins of the offshore dollar (i.e. "Eurodollar") system. McCauley et al (2021) provide a more recent overview of the past and present of the market. Interestingly, they note its origins in financial innovation and regulatory arbitrage – much like stablecoins.
[3] Appendix II provides a succinct history of stablecoins.
[4] The focus on par settlement and the hierarchy of money distinguishes a money view of stablecoins from alternatives that focus on exchange, such as the "no-questions asked" principle (Holmström (2015)).

Architecture of the offshore dollar system

In the offshore world, *settlement* is the disciplining mechanism for the offshore dollar money and capital markets. Both markets have historical origins in the postwar reconstruction of financial markets after the exigencies of war finance, beginning in the United States and then extending to Europe (which achieved currency convertibility only in 1958). For a time, it looked like New York might serve both onshore and offshore markets, as London had in the pre-World War I sterling standard system. But domestic politics ruled that out, and after Nixon closed the gold window, the offshore system was built during the rest of the 1970s, and then integrated with the onshore system in the 1980s.

The details of that integration are instructive. From a money view perspective, the key point of integration is par settlement between offshore and onshore, and the key stabilization mechanism that ensures par settlement in the cash market is the rate of interest–specifically deviations between onshore and offshore rates. When these rates differ, there is an arbitrage opportunity: borrow at the lower rate and lend at the higher rate, or reduce lending at the low rate and decrease borrowing at the higher. In this way, interbank credit enables deficits and surpluses at settlement to be pushed off into the future, fluctuations in the quantity of credit operating as a relief valve taking pressure off the present spot price.[5]

Such borrowing does eventually come due, however, so the valve offers only temporary relief. In the course of ordinary banking practice, however, that is often enough, buying time to address the underlying source of imbalance. Sometimes however it is not enough. When the elasticity of credit reaches its limits, the promise of convertibility at par comes under threat, and lender of last resort actions by central banks come into play. In practice, over time, the US Federal Reserve (Fed) has evolved into an international lender of last resort, providing emergency liquidity through its liquidity swap lines with other major central banks, lending dollars which other central banks can on-lend to their own commercial banks (Mehrling (2022)). The swap lines allow central banks to create offshore dollars at scale.

The details of that lending are also instructive. Central banks other than the Fed issue their own currencies which, since the breakdown of Bretton Woods, are no longer strictly fixed to the dollar. The exchange rate between these currencies and the dollar thus operates as another relief valve to take the pressure off the exchange rate between the onshore and offshore dollar. In normal times, covered interest parity arbitrage keeps exchange rates and domestic interest rates from deviating too far, as interbank borrowing expands to harvest the profit from such deviations (Borio et al (2016)). In crisis times, central bank liquidity swap lines, priced as a spread (usually 50 bp)

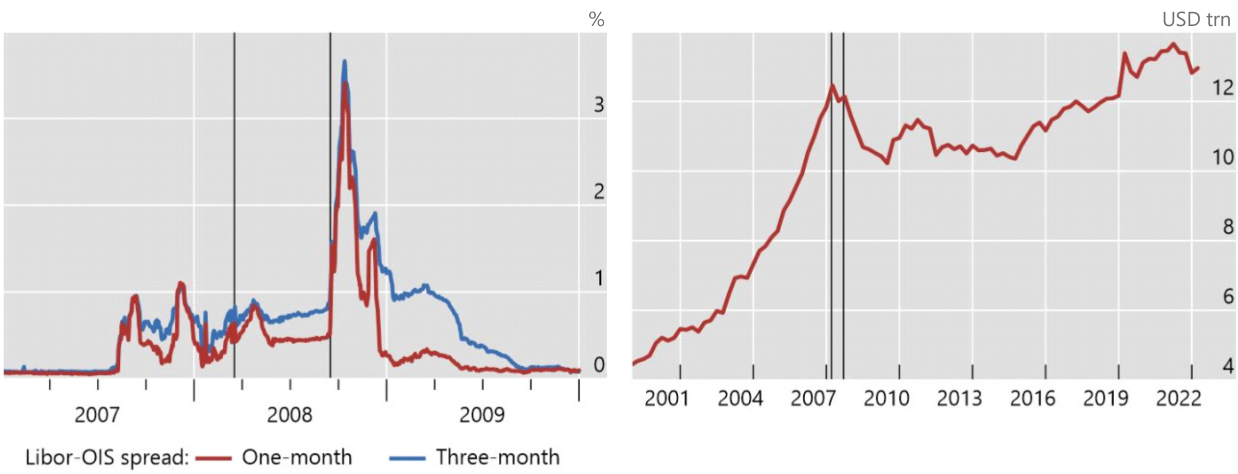
[5] There is a lot more that could be said here, building from the observation that the typical Eurodollar deposit is not a demand deposit but rather a time deposit, and the interbank forward market enables banks to line up anticipated cash inflows and outflows in advance. But these are details, perhaps distractions from the main point at this stage.

around covered interest parity, put bounds on that deviation. In both Eurodollar and FX markets, when private bank credit reaches the limits of its elasticity, central bank credit steps in, with the ultimate goal of protecting par in global dollar settlement.

This is exactly what happened during the great financial crisis, from mid-2007 until about the beginning of 2009. In the years prior, the offshore dollar system had expanded dramatically, from some $5 trillion in 2000 to over $12 trillion on the eve of the crisis. As anxiety grew, holders of Eurodollars increasingly sought to redeem their claims for onshore dollars, and demanded higher offshore interest rates as compensation for not doing so. The left panel of Graph 1 shows the spread of dollar LIBOR above onshore overnight index swaps (OIS) of the same maturity, whereas the right panel shows a rough measure of the quantity of offshore dollars.

The offshore dollar market: prices and quantities Graph 1

A. LIBOR-OIS spreads around the great financial crisis B. Global dollar offshore deposits



The vertical lines respectively refer to the failures of Bear Stearns and Lehman Brothers.

Source: Bloomberg; BIS Locational Banking Statistics by Residence; authors' calculations.

At the height of the crisis, it seemed that no financial institution was certain to be liquid. Despite the evident risks of US financial institutions, offshore banks were even riskier: they lacked access to the Fed and so had no backup source of dollars. Offshore dollar interest rates spiked to a spread of more than 300 basis points above onshore rates. It was at this moment that the Fed opened the liquidity swap lines to other central banks, creating some $600 billion in offshore dollars. This was sufficient to stem the demand for redemptions and to return the spread to zero (Grad, Mehrling and Neilson (2011)).

The system passed the test of 2008, as it has passed other tests, for example in March of 2020 (Avdjiev et al (2020)). A Eurodollar does in practice serve as a kind of dollar. In fact, an incipient breakdown of par clearing is more likely to show up as an institutional failure (e.g. as a default) rather than a fluctuating price. But par is indeed a price, much like a fixed exchange rate (Hicks

(1989)), and the non-trivial institutional apparatus that supports that rate is essentially a kind of FX dealer system.

In outline, that is how the offshore dollar market works today: it is a system that has been worked out over time, bit by bit, in response to multiple moments of crisis. The result has been an expansion of the global dollar system from Europe, to Asia, and in the last decade to the Global South quite generally (Aldasoro and Ehlers (2018)). By construction, it is a hierarchical system, with the Fed at the apex, major central banks at the next layer, and others farther down (Denbee et al (2016)). This hierarchy is the source of perennial discontent that regularly manifests in calls for international monetary reform, in search of a flatter system. But the lesson of history is that actual institutional change comes in response to actual crises, change that may be ratified or not once the crisis is over.

Which brings us to stablecoins

This brings us to stablecoins, and the run that is currently being experienced in the on-chain world. Just as Eurodollars are promises of offshore par settlement, so stablecoins are promises of on-chain par settlement. Following the analogy, we ask what is the stabilization mechanism that keeps stablecoins at par, and how does it compare to the Eurodollar stabilization mechanism?

The literature reports that there are three such mechanisms in play.[6] One idea is that the value of a stablecoin pegged to the dollar needs to be backed by an equivalent value of short-term safe dollar assets – short-term so that the value of the assets themselves does not fluctuate very much. Safe may mean government, or maybe high-quality commercial paper. Tether and USDC, the two most prominent stablecoins (Graph II in Appendix) are this kind of thing.

A second idea is that the value of a stablecoin can be supported by collateral with a dollar value greater than the stablecoin itself, perhaps even crypto collateral, with a margin of safety to take account of potential fluctuations in value. Dai is an example of this type.

A third idea is that a stablecoin's value can be supported by an algorithmic trading protocol that increases and decreases the quantity of a paired token in response to deviations of the stablecoin price from par, understanding these deviations as caused by fluctuating demand that can be absorbed by fluctuating supply. TerraUSD is (or rather was) this kind of thing (Box A).

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[6] See Anadu et al (2023).

Division by zero: lessons from TerraUSD's death spiral

Box A

In May 2022, algorithmic stablecoin TerraUSD collapsed in value, rapidly destroying some $20 billion of what, to that point, had appeared to be a money-like crypto token. Over the course of a few days, the algorithm's capacity to sustain par exchange between TerraUSD tokens and off-chain dollars was severely tested, and ultimately failed. Various autopsies have been performed on Terra's collapse (e.g. Liu et al (2023), BIS (2022, Box A, page 82)). The analogy between stablecoins and Eurodollars introduced in the present paper exposes the conceptual errors in the design of TerraUSD in a more fundamental way. In this box, we discuss the mechanics of the TerraUSD meltdown and the algorithm's key theoretical error, a deep assumption not at all unique to Terra.

Best laid plans. TerraUSD was designed to use an automatic market-making mechanism to try to keep its dollar price at one. The algorithm was meant to work by creating an arbitrage—deviations from par would automatically create a profit opportunity, attracting speculative capital that would drive the token's price back towards one. Participants in the algorithm's distributed computation mechanism, known as miners in crypto parlance, held TerraUSD tokens. In the T accounts below (Graph A1), we show these as a liability to the Terra protocol, because that is how they functioned in this system, though the legal status of such claims raises some doubts.

On May 9, 2022 TerraUSD started trading below par (90 cents on the dollar), a problem that the algorithm was supposed to solve (Graph A2). The TerraUSD algorithm allowed miners to redeem ("burn") TerraUSD tokens in exchange for a different token, Luna. Luna tokens represented a claim on the proceeds of mining, not unlike a bondholder's receiving interest, or a shareholder's receiving dividends. On the protocol's balance sheet, we therefore write them analogously to bonds or shares, as another liability. Redemption of TerraUSD tokens in exchange for Luna tokens was handled by unattended programmable contracts, with no discretionary intervention.

Division by zero: The Terra arbitrage mechanism for TerraUSD below par

Graph A1

The Terra mechanism: (1) Miners held TerraUSD tokens with a market price of 90 cents; (2) The Terra algorithm allowed automatic redemption of TerraUSD into Luna tokens with a market value of one dollar; (3) All the miner had to do was find someone who would pay that price in dollars for Luna tokens.

Source: authors' illustration.

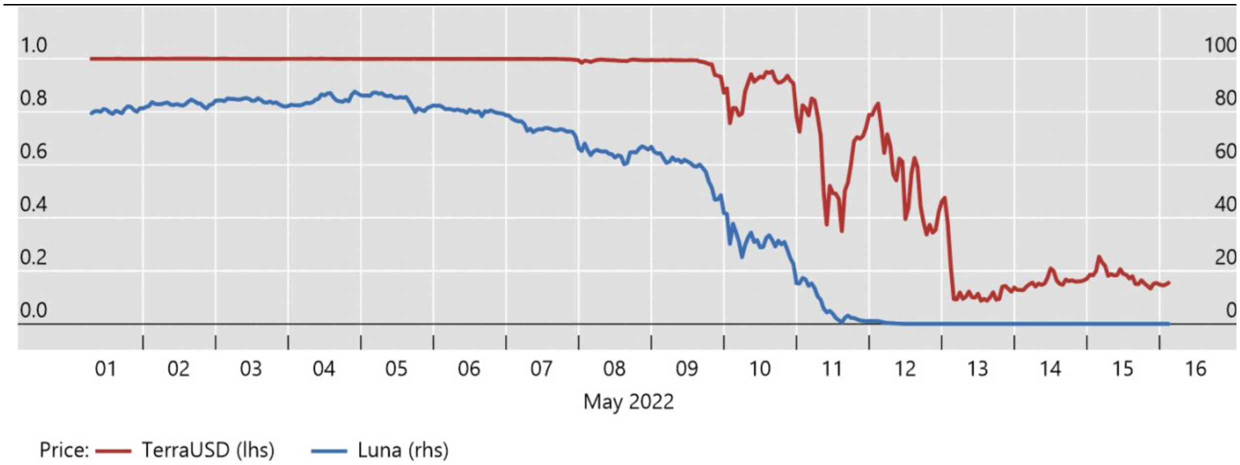
The heart of the algorithm was the redemption price between TerraUSD and Luna tokens. If a miner redeemed TerraUSD, trading at 90 cents but with a face value of one dollar, the algorithm would give them one dollar's worth of Luna, measured at Luna's spot price at the time of redemption. Algebraically, if the market price of Luna was p dollars, the miner received $1/p$ Luna tokens per TerraUSD token. So when Luna tokens were trading at $50, one token of

TerraUSD could be redeemed for 0.02 Luna tokens: 0.02 Luna tokens at $50 had a market value of one USD. In other words, the miner could convert a TerraUSD token with a market price of 90 cents into Luna tokens with a market price of one dollar, an arbitrage profit of ten cents. This arbitrage would cause the price to return to par. To achieve this, the algorithm gave out free money in the form of Luna tokens, and all a miner/speculator had to do was find someone who would exchange those Luna tokens for dollars at that price.

The algorithm did not work as its designers intended, as Graph A2 illustrates. The price of TerraUSD (red line) occasionally moved away from $1 (e.g. on May 7), but speculators took advantage of the Luna arbitrage and quickly brought the price of TerraUSD back into line. By May 9, however, TerraUSD fell significantly below par. Although the Terra algorithm began furiously issuing new Luna tokens, par was never restored, and TerraUSD's value collapsed.

Division by zero: TerraUSD's death spiral

In US dollars — Graph A2



Source: CryptoCompare.

A lesson: never take market liquidity for granted. The design of TerraUSD's algorithm failed to consider *market liquidity* for its tokens. Its designers made the incorrect assumption that there would always be a market-clearing price greater than zero for Luna tokens. The money view perspective taken in this paper, by contrast, starts instead from real markets, where liquidity is the central concern and never something that can be taken for granted. Centuries of experience in financial and other markets make plain that sometimes there are no buyers at any price. Liquidity has a tendency to disappear just when it is wanted the most.

In this case, the reason to hold Luna tokens was that they conferred a claim on the proceeds of mining TerraUSD. Doubts about the viability of the Terra protocol had made that proposition unconvincing, however, and the result was not just a falling price for Luna tokens, but, more fundamentally, the evaporation of any willingness to buy Luna at any price.

This design flaw was the critical failure for TerraUSD. Remember that the Terra algorithm issued $1/p$ Luna tokens for each burned TerraUSD token. As the dollar price of Luna tokens p fell to zero over the next three days, the number of Luna tokens outstanding exploded from hundreds of thousands to trillions over a few days. Trading was suspended and both tokens are now agreed to be worthless. Terra shares these structural features with other automated market-makers, but the issue of market liquidity tends to lurk as an assumption.

The logic of each of these three mechanisms is superficial, hiding deep assumptions that have come to the surface, or will come to the surface, when stablecoins' promises to pay come into question. Most important, the first two see the problem through a solvency lens not a liquidity lens, assuming that it is the value of the assets of the issuer that supports the value of the stablecoin. As for the third, algorithmic stablecoins simply assume the problem of liquidity away: Terra's algorithm, for example, assumed that price would always clear the market for Luna, a secondary token meant to absorb deviations from par of the primary token Terra. In the event, and contrary to this unstated assumption, there were no buyers for Luna at any positive price.

By contrast, observe that solvency played no role in our discussion of the mechanisms supporting par clearing of offshore dollars. To the extent that solvency entered the analysis at all, it was as a potential constraint on interbank credit lines, but with the proviso that the most important fluctuations in those lines have little to do with the assessed solvency of counterparties, and much more to do with macroeconomic fluctuations, fluctuating imbalances in the pattern of payments and hence strains on net settlement. In this regard, it is worth emphasizing that stablecoins emerged initially out of an ethos quite determined to eliminate financial intermediaries of all kinds. In the offshore system, as we have seen, credit is a feature and not a bug; in the on-chain system, it was thought to be a bug, not a feature.

Indeed the original cryptocurrency was Bitcoin, by design an asset that is no-one's liability.[7] In time, volatility in Bitcoin's price gave rise to demand for some kind of stable store of value inside the crypto ecosystem, where capital gains could be realized and held for future deployment. Here lay the origin of stablecoins; speculators could stay on-chain, shifting between Bitcoin and stablecoins, rather than between Bitcoin and off-chain fiat. The second phase of stablecoins was more ambitious: Facebook's attempt to create a means of payment that could be used within its platform. It was this phase that caught the attention of regulators, concerned about walled gardens and interoperability, but also seeing a challenge to the status of central bank liabilities as the ultimate means of payment.

The present paper is however prompted instead by more recent history: the remarkable expansion of stablecoins after Covid, and the equally remarkable contraction apparently triggered by tightening US monetary policy.[8] During Covid, central banks flooded the zone, and some of that flood spilled over into stablecoins. Once Covid was declared over, central banks proceeded to return to normal. Post-Covid supply chain bottlenecks produced local price spikes which aggregated into measured inflation, providing ample political cover for a rapid and large increase in overnight rates from near zero in February 2022 to over 5% today. Our central argument,

[7] This paragraph is a desperately brief summary of the longer natural history in Appendix II, to which the reader is referred.

[8] As discussed in Appendix II, the rise of stablecoins during this period was closely intertwined with the explosion of decentralized finance (DeFi) applications.

developed in detail below, is that the spread between on-chain and off-chain interest rates was the driver of both the stablecoin boom and its subsequent and continuing bust.

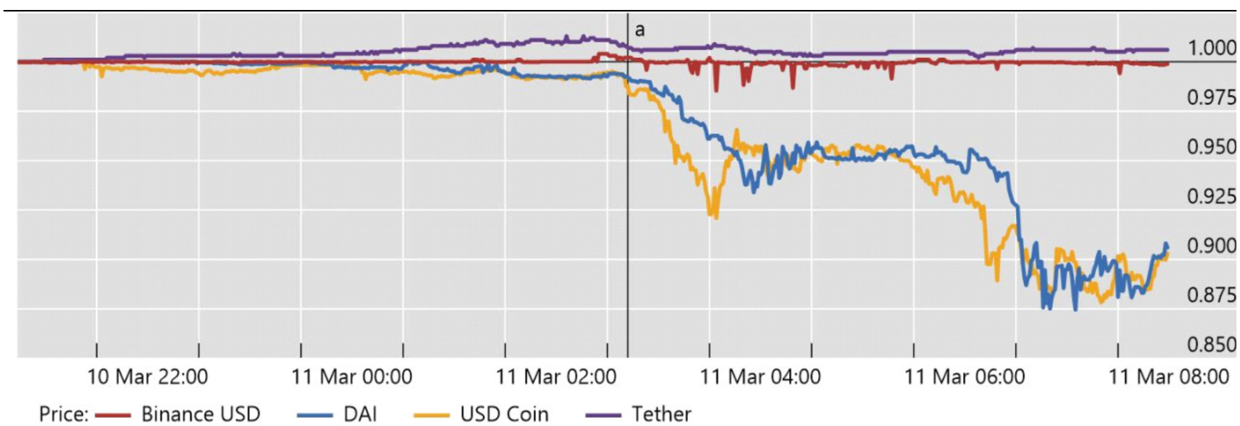
How to think about stablecoins

Analogy with the Eurodollar system naturally leads us to inquire about the operation of forward markets in stablecoins, where pressures on par that come from deficits at the settlement might temporarily be absorbed. And we wonder further about access to or exclusion from lender of last resort facilities, i.e. about where stablecoins fit in the hierarchy of international money.

Regulators have started from the latter question—central banks were probably surprised to find that lender of last resort support for Silicon Valley Bank in March 2023 was also in effect lender of last resort for USDC, a stablecoin that held substantial deposits at SVB as its purportedly liquid reserve (see Graph 2). But even before that, ever since the collapse of Terra in May 2022, there has been a scramble to find the right regulatory response to stablecoins more generally. The most recent iteration is the Financial Stability Board's "High-level Recommendations for the Regulation, Supervision and Oversight of Global Stablecoin Arrangements" (FSB (2023)). It is perhaps telling that this report explicitly limits itself to the first two varieties of stablecoins (safe-collateral stablecoins and haircut stablecoins), not considering Terra a stablecoin at all, because of its deficient stability mechanism.

Breaking par: Stablecoin pegs around the collapse of SVB

In US dollars Graph 2



[a] Disclosure by Circle that $3.3 billion of USDC's cash reserve was held by Silicon Valley Bank.

Source: CryptoCompare.

From a money view standpoint, however, the question of forward markets is the more important one, since it is there that normal pressures should be absorbed, and since any last-resort intervention should be contingent on the market's capacity to absorb those normal pressures. The offshore Eurodollar system holds its ultimate reserves as deposits in New York but, as emphasized above, the whole system was organized to economize on the use of those reserves, diverting pressure into forward markets instead. The on-chain system, it turns out, was holding its reserves at SVB (among other places), but the real question is: Where were the forward markets?[9]

There is plenty of borrowing and lending on-chain: DeFi protocols have at times offered returns in excess of 10%, a healthy spread above rates available off-chain.[10] Even in the worst days of the great financial crisis, the LIBOR-OIS spread only reached 300 basis points. But LIBOR was the output of a survey of major global banks, and hence an attempt to measure a general market rate, whereas DeFi protocols remain specialized and speculative instruments.[11] We might reasonably say that rather than infrastructural liquid forward markets in stablecoins, crypto to date has been built only on highly speculative and illiquid forward markets. Such markets are ill-equipped to absorb stablecoins' deviations from par.

Liquidity comes in three forms: monetary liquidity, funding liquidity, and market liquidity. Monetary liquidity is about holding of actual monetary reserves, which in the crypto world typically takes the form of deposits in an off-chain bank. (Note that this means stablecoins are typically lower in the monetary hierarchy than deposit accounts, which themselves are lower than central bank liabilities.) Funding liquidity is about the ability to borrow which, as we have seen, is very limited not only in practice but also in principle, because of the deep crypto commitment to developing a trustless system that eschews credit. And finally, market liquidity is about the ability to convert asset holdings into money, i.e. to sell them. The important point is that, for lack of funding liquidity, it is market liquidity on which current stablecoins depend. That is the reason for the unremitting emphasis on solvency.

The question however is not so much about the *value* of the assets relative to the liabilities. The question is whether, in the event of a run, the assets of the stablecoin issuer are adequate to *liquidate* its stablecoin liabilities. For any individual stablecoin issuer, perhaps it is okay to assume that reserve assets can always be sold into liquid markets, so that liquidation price is close to value. Par, however, is not about individual issuers, but rather the net settlement between on-chain and off-chain. The ability of the on-chain system to meet a deficit at the settlement depends on its ability to sell assets to the off-chain system. This is very different from the offshore system, which is organized around funding liquidity. By comparison on-chain is much less elastic, much more fragile.

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[9] As Graph 2 shows, a second layer in the stablecoin hierarchy is represented by Dai, which itself held USDC as collateral to defend its peg.

[10] See for example Figure 9 in He et al (2023) and Graph 3 below.

[11] FTX proposals for an on-chain forward commodity market might have produced such a thing. In the event, other problems at FTX meant that these proposals went nowhere. Documentation of the proposal can be found here.

The emergence of interest rates in the on-chain world is illustrative of these issues and allows us to tie the story together. Crypto speculation began with bitcoin and bitcoin arbitrage across different trading platforms. Typically, US based platforms had the lowest (dollar) price, and bitcoin traded at a (often quite substantial) premium elsewhere. There was therefore a potential profit from buying bitcoin in the US and selling it in Korea or Japan, for example.[12] An important source of this "inefficiency" came from the difficulty of repatriating profit that was realized in won or yen, which required not only conversion into dollars but also transferring those dollars back to the United States. Perhaps we might say that divergence from the law of one price for bitcoin in the on-chain world was a symptom of the international hierarchy of money in the off-chain world.

For our purposes, the important consequence of this inefficiency was that, while it persisted, there was a regular source of profit for those able to access it, and this profit was a regular incentive to shift funds from off-chain to on-chain. However, the difficulty of realizing profits provided a natural limitation to this incentive, allowing the inefficiency to persist. One early use case for stablecoins was to overcome this difficulty (Makarov and Schoar (2019, p 295)). Once such innovations removed the limits to arbitrage, however, the arbitrage itself removed the inefficiency, and hence also the incentive to shift funds from off-chain to on-chain.

The next opportunity came with the development of bitcoin (and other) crypto futures. Here the relevant arbitrage came from deviations from covered interest parity. The creation of crypto futures happened more or less simultaneously in the off-chain world at the Chicago Mercantile Exchange (CME) and in the on-chain world at exchanges such as Binance and (infamously) FTX. The CME futures were just a version of its existing cash-settled futures on traditional securities, with similar regulations, and hence did not get a lot of traction (Schmeling et al 2023). The real volume was in the so-called perpetual futures using on-chain funds[13] (He et al 2023). The weak correlation between prices in these two different worlds, but the strong correlation between prices within each, speak to the strong segmentation of these markets. The on-chain world, being unregulated, is much less transparent (though of course prices are visible), but one can get some sense of the dynamics from the more transparent off-chain world.

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[12] Makarov and Schoar (2019) and Bankman-Fried (2022) respectively discuss the Korean and Japanese cases.

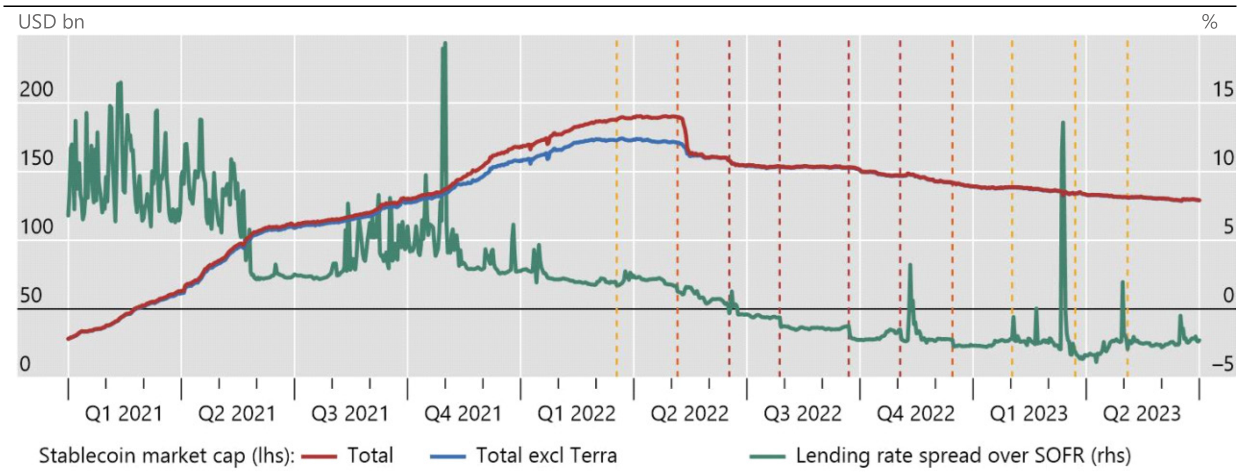
[13] Why perpetual futures? From a money view standpoint, it appears to be a way to economize on liquidity. We have noted above (fn 5) that the offshore dollar system works largely with time-dated deposits. which makes it possible to line up future cash inflows and outflows and so reduce reliance on reserves held onshore. Perpetual futures do something similar since there is never any date when the underlying is delivered. Instead, every 8 hours there is a small payment (called the "funding rate") from long futures to short futures assuming positive basis over the preceding 8 hours. There is no convergence of futures and spot at maturity because there is no maturity. Note that the most commonly traded perpetual futures contracts are funded using on-chain tokens, but are not themselves on-chain. Rather they exist on the servers of exchanges such as BitMEX. From our perspective, because one must enter a position in perpetual futures using on-chain assets, they are even more removed from the off-chain world than stablecoins. Not just on the other side of the fence, but across the yard and over the next fence, too.

Basically, the story seems to have been that long crypto futures attracted interest largely from retail customers because of the availability of cheap leverage. If one wanted to bet on bitcoin, one could get a lot more exposure for the money by using futures and a lot more on-chain than off-chain. But this was always essentially a momentum trade, which raises the question of who takes the opposite side. The answer was carry traders harvesting deviations from covered interest parity, typically professional traders including the exchange itself (Alameda, the hedge fund associated with FTX, was very active in this kind of business). In a nutshell, the retail pressure on the futures price opened up a profitable basis trade involving a long position in spot crypto and a short position in crypto futures. Schmeling at al. (2023) estimate that this trade yielded on average 10% from April 2019 to January 2022 in the regulated CME space, which is considerable, though they emphasize that the arbitrage is not really as riskless in practice as it seems in theory.

For our purposes, a key observation is that the availability of apparently regular arbitrage profits to professionals in the on-chain world gives rise to a rate of interest in the on-chain world. To fix ideas, consider Schmeling et al's account of the arbitrage (fn 11, page 10): "a trader could borrow the present value of one dollar (1/(1+r)), buy bitcoin at the spot rate (which results in 1/S BTC per dollar invested), lend out the BTC at gross rate (1+r*) and then sell the BTC forward at F".

There are two interest rates here. When the trade happens using on-chain instruments, the dollar interest rate is a stablecoin interest rate, which of course investors can easily compare to dollar interest rates off-chain. Zero interest rates off-chain meant a big incentive to shift dollars on-chain, which persisted throughout the pandemic and only ended when monetary policy rates began rising (Graph 3).

On-chain rates, stablecoins and off-chain monetary policy — Graph 3



The yellow, orange and red vertical dashed lines respectively indicate 25, 50 and 75 basis point increases in the policy rate by the U.S. Federal Reserve. Lending rate refers to the average of the lending rates of USDC, Tether and Dai in the DeFi protocol Aave.

Sources: Bloomberg; Coingecko; Dune Analytics; authors' calculations.

The important point to emphasize here is that the source of the difference between the on-chain and off-chain rate of interest, analogous to the difference between the off-shore and the on-shore rate of interest (Graph 1), was (1) speculative interest in the underlying crypto assets and (2) inefficiencies in the on-chain system that gave rise to substantial and regular profits from the carry trade. Perhaps it goes without saying that both of these features are fragile by their very nature, as they proved to be in practice.

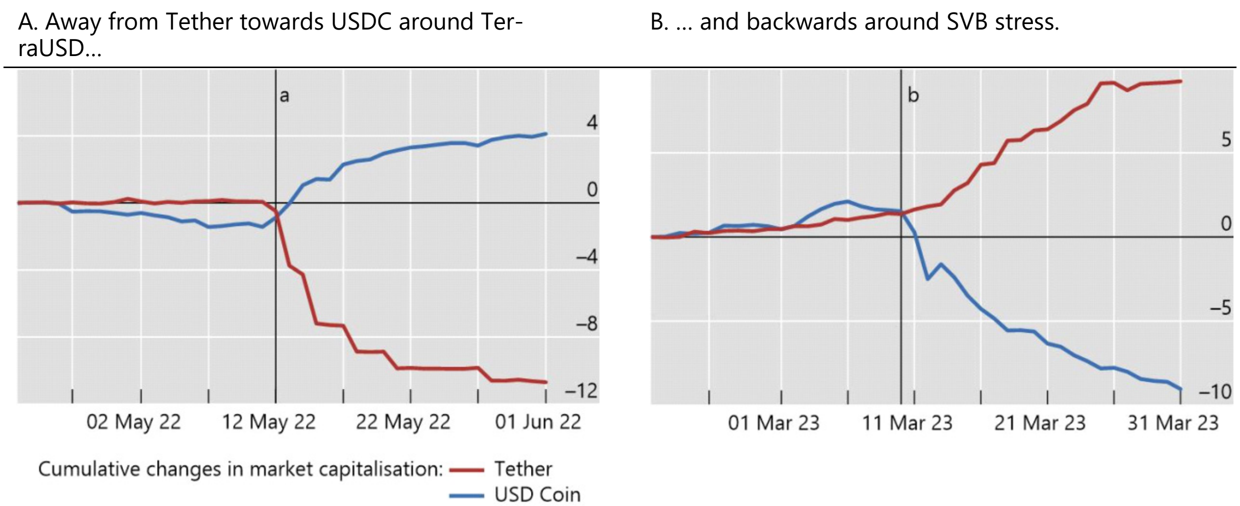
Architecture of the on-chain dollar system

The issue of par extends beyond ultimate par between off-chain and on-chain dollars. Multiple stablecoins co-exist, each with its own stabilization mechanism, on various blockchains and some on multiple blockchains. Within the on-chain dollar system therefore two derivative problems emerge: that of par between different stablecoins on-chain, and of par across blockchains.

Some sense of the challenge involved in the first problem comes from the experience of recent stablecoin stress episodes, namely the demise of TerraUSD and SVB. The TerraUSD collapse caused holders of other stablecoins to flee to (perceived) quality, away from Tether and into USDC (Graph 4.A). This led to a temporary breakdown of par for Tether. Stress at SVB, in turn, caused shifts in the exact opposite direction (Graph 4.B), as USDC broke par (Graph 2).

Flight to (shifting) safety?

In billions of US dollars — Graph 4

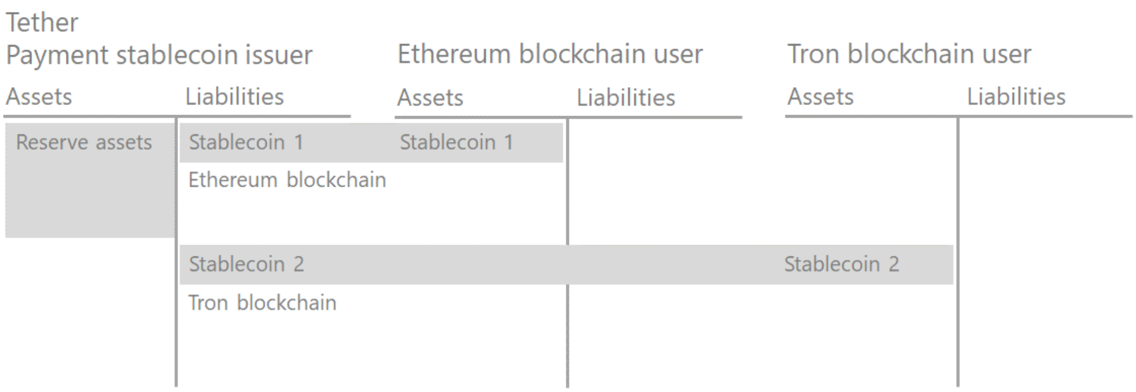


[a] Terra Blockchain was halted. [b] Silicon Valley Bank failure.

Sources: CoinGecko; authors' calculations.

There is also the problem of par between the same stablecoin issued on different blockchains. If a single issuer operates on multiple blockchains, as Tether does, it can use its own balance sheet to maintain par between its tokens, burning Tethers on Ethereum and minting on Tron (for example, see Graph 5). The transactions are analogous to intra-company cross-border transactions in the off-chain world.

Financial structure of payment stablecoins Graph 5



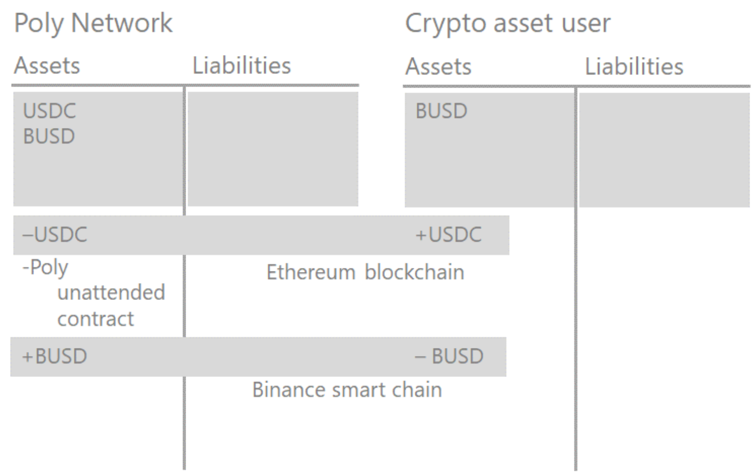
Source: authors' illustration.

An on-chain solution is provided by so-called bridge protocols. Generically, these are linked algorithms running on two different distributed ledgers. A user can instruct the bridge protocol to lock tokens on one ledger, releasing tokens of an equivalent value on the other ledger. From the user's perspective, the effect is similar to a foreign-exchange transaction, moving value from one payment area to another payment area. DeFi technology allows the protocol to execute without discretionary intervention. Behind the scenes, however, such protocols have mostly operated using (very) large token balances. This consumes a lot of capital, and is difficult to imagine operating smoothly at scale. One such protocol is Poly Network, which offers the facility to shift BUSD into USDC, among others, as depicted in Graph 6. It is important to note, however, that the facility works by holding large reserves of both. That is, liquidity rears its ugly head again.

Connecting transactions across blockchains with unattended contracts

A stylized example based on Poly network

Graph 6



Poly enables users to exchange between tokens on different blockchains. The protocol requires large token balances.

Source: authors' illustration.

From a money view perspective, bridge protocols are essentially foreign exchange dealers, but of a very primitive kind. In the off-chain world, exchange dealers expand and contract their balance sheets on both sides to absorb imbalances in order flow. They are essentially credit operations. But crypto is inclined to contract intermediaries' balance sheets (Mehrling (2017)), and, as a consequence, on-chain market-making requires actual holdings of the two tokens being exchanged. There is no elasticity of credit to absorb pressure on price, so defense of par on-chain requires what amounts to large on-chain monetary reserves.

Defense of par between on-chain and off-chain is similarly primitive. Monetary reserves in the off-chain world inevitably fall short, hence the ultimate reliance on selling assets to the off-chain system. Defending par within the crypto world is hard enough; defending par with the off-chain world is an order of magnitude harder.

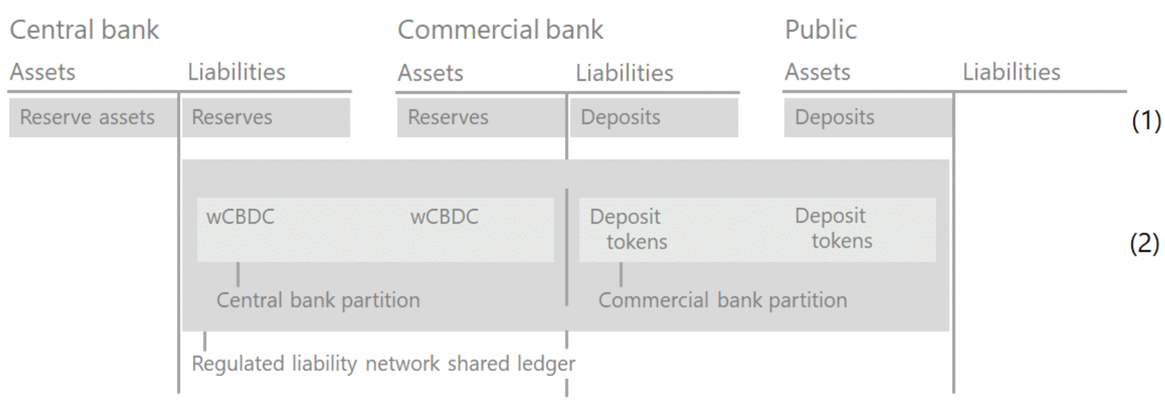
Looking ahead

Meanwhile, it does appear that the major global banks and central banks are on track to mount their own stablecoin system, in the form of tokenized deposits that are ultimately promises to pay

CBDC (Central Bank Digital Currency). This for example is the underlying concept of the Regulated Liability Network (Graph 7).[14] [15]

Efforts like this are an attempt to build a new system that would move the institutional novelty from crypto's brief history into the onshore world. A key feature of such projects is that they would be *inside* the regulatory perimeter. On-chain claims would be legally constituted as bank liabilities and regulated as such. The explicit and implicit guarantees of bank regulation would be in effect, and tokenized deposits would be at the same hierarchical level as non-tokenized deposits.

Partitions on the Regulated Liability Network | Graph 7



Source: authors' illustration.

How will such a system protect par? Designed to fall under the direct oversight of the Federal Reserve, par clearing would be not just the dubious promise of a private issuer, but the commitment of a fully-fledged banking system that would include the central bank and thus have a credibility that today's private crypto stablecoins lack.[16] But in technological terms, the key question would seem to be: How are funds moved between off-chain and on-chain?[17]

[14] A similar issue is studied in BIS (2023a), Chapter III.

[15] The recent launch of a stablecoin by PayPal suggests another possible path. Unlike the RLN, PYUSD appears as a retail phenomenon, making use of a public blockchain (Ethereum) while leaving the door open for a future shift to another set of payment rails. PayPal intends to collateralize PYUSD tokens with deposits at regulated banks, repos and treasury securities.

[16] In other words, such a system can confer payment finality through ultimate settlement in the central bank balance sheet. At the same time, however, the quest for atomicity in payments (which characterizes most efforts to onboard crypto innovations) is in effect a race to squeeze credit out of the system. This stands in opposition to all heretofore existing payment systems, which are essentially credit systems.

[17] Again, this is a problem of market-making and liquidity (Aldasoro and Neilson (2023)).

Conclusion

The run on stablecoins is revealing their hierarchy, as well as the inadequacy of their stabilization mechanisms. The underlying cause of the run is not at all a sudden and widespread appreciation of their underlying fragility. Instead, the key driver seems to be dollar monetary policy, specifically the end of the decade-long zero interest rate policy (ZIRP) that followed the great financial crisis. In retrospect, ZIRP created favorable conditions for on-chain experimentation: when interest rates are zero, forward dollars and cash dollars trade at par, and so the lack of a forward market for stablecoins was not such an impediment as it now apparently is. Perhaps we can analogize the ZIRP experience to the 1970s construction of the Eurodollar after Nixon closed the gold window in August 1971. And perhaps we can analogize the current determination to end ZIRP to Volcker's 1979 determination to stabilize the onshore dollar. Just as policies back then reestablished the hierarchy of the onshore dollar, current policies are reestablishing the hierarchy of the off-chain dollar. The result has been contraction of the on-chain stablecoin universe, as also credit more generally.

If the history of real-world (hierarchical) money systems teaches us anything, it is that during crises everyone wants money, no one wants credit, and promises to pay money are tested. Defense is provided by the level immediately higher in the system (and in the extreme, by the ultimate settlement asset - central bank reserves), for which credit represents what counts as money in the level below. But as noted earlier, there is no such thing for crypto. Attempts to artificially shoehorn stablecoins within the hierarchy of money should contend with this fact: the promise will be tested, and when it is, high-level money will be called upon to act as backstop.

Appendix I: A brief primer on the money view

A proper understanding of new forms of money-like claims such as stablecoins requires an adequate theory of money. To this end, and as background to the discussions in the main body of the paper, this appendix briefly reviews the key ideas behind the money view, closely following Mehrling (2012).

Two ideas stand at the core of the money view: banking as a *payments* system and banking as a *market-making* system. The first emphasizes the role of the settlement constraint: the requirement that debts be paid when due, sometimes referred to as the "survival constraint" (Minsky (1954)). The second underscores the critical role of dealers as suppliers of liquidity. Coming respectively from the fields of economics and finance, neither idea plays a central role in its field of origin. This is in no small part because both fields tend to abstract from money, which is seen as a veil: for economics the veil masks an underlying real world of commodity production and exchange, for finance a world of asset pricing grounded on the projection of future cash flows. In contrast, the money view treats the veil as the essential substance of a world of interlocking promises to pay, policed by the settlement constraint and with prices set by the dealer system.

The central role of settlement underpins a related key notion: the inherent hierarchy of money (see Graph I for a stylized illustration).[18] From a money view perspective, the defining quality of money is that it is a means of payment, that is, a means of settlement. This notion points to a key qualitative distinction between money and credit – between means of payment and promises to pay. Credit is a promise to pay money (or delay final settlement), and money is a way to cancel credit (i.e. to fulfil debt obligations). Settlement thus happens when money is used to repay a debt – in this sense, money is better than credit, especially during crises.

But what constitutes money and what constitutes credit depends on the level of the system at which one sits.[19] Standing at the top of Graph I, bank reserves at the central bank (and cash) are the ultimate means of payment, and bank deposits are a form of credit in that they are promises to pay cash or to confer payment finality through ultimate settlement in the central bank balance sheet. Diverse institutional mechanisms underpin the credibility of such a promise to pay, but it is still a promise to pay a higher form of money. Further down the pyramid, securities are a promise to pay deposits over some time horizon, further removed from the ultimate money. As in any layer of the hierarchy, instruments which function as money one step higher in the hierarchy can help sustain the credibility of the promise.[20]

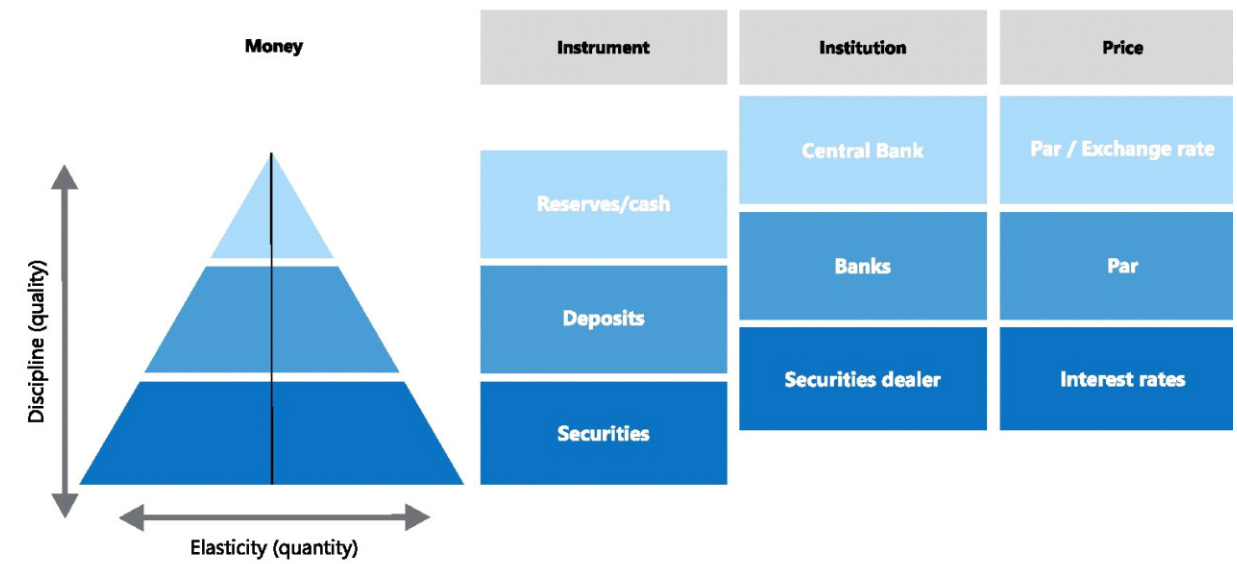
[18] Hierarchy is an emergent property of monetary systems (hence the use of "inherent"). Developments in the crypto space are testament to this.

[19] From a system's perspective, the liabilities of any agent are someone else's asset.

[20] Of course, this is a stylized representation of monetary hierarchy. As always, reality is considerably more complex and includes finer gradations even within the stylized categories we have included. For one, while we talk about reserves at the central banks and cash within the same group, these of course differ. Moreover, deposits can be split for example by their insurance coverage. There are also various deposit-like money

With the hierarchy of money-like instruments also come hierarchies of instruments' prices and of the market-making institutions policing those prices. Again, the mapping in Graph I is a simplified version of a more complex reality. As above, what is money and what is credit depends on the layer of the hierarchy, and this will involve different institutions. For example, bank reserves are the means of settlement for banks, but a liability of the central bank. Commercial bank deposits are in turn the means of settlement (i.e. money) for the public, but a liability of banks. Along the way, various institutions bridge the layers of the hierarchy with promises to convert credit into money and vice versa, at the relevant price. These prices could be exchange rates (the price of domestic in terms of foreign, i.e. hard, currency), par (the price of deposits in terms of currency/reserves), or interest rates (the price of securities in terms of deposits).

The hierarchy of money: a stylised illustration — Graph I



Source: Authors' elaboration, based on Mehrling (2012).

Thinking of money in hierarchical terms yields two important additional insights, coming respectively from the dynamic nature of the horizontal and vertical dimensions of the hierarchy. First, within each level of the hierarchy, agents can expand and contract the *quantity* of credit, which gives the system its *elasticity*. Expansions are periods where assets and liabilities grow and even risky borrowers are able to obtain credit – a flattening of the hierarchy, as it were. The opposite occurs during contractions, as weaker borrowers must settle their debts and only the stronger borrowers are able to refinance their positions.

claims such as money market fund shares, which themselves have various subcategories. Distinctions among securities can be even more granular (think for instance about maturities or ratings). For a more in-depth discussion of these distinctions, see Pozsar (2014).

Along the vertical dimension, differentiation in terms of the *quality* of credit is what matters. Here the moneyness of the various types of credit is either taken for granted or put into question. Through this lens, expansions are characterized by liabilities at any level of the system being treated as close substitutes for the liabilities one level above. Contractions are then periods when differentiation in the claims to moneyness of various instruments along the hierarchy reasserts itself. This is what provides *discipline* to the system.

The interplay between discipline and elasticity characterizes the monetary system both at any given point in time and over time. At any given level of the hierarchy, the availability of money from the level above serves as a constraint on expansion that imposes discipline, as agents cannot on their own increase the quantity of what constitutes money one level above.[21] Within any given level of the system, however, agents can increase the quantity of credit (and hence the quantity of money for lower levels). In other words, credit is elastic and can help to relax the constraints of discipline and scarcity at the margin - but not forever.

[21] In other words, "credit is payable in money, but money is scarce" (Mehrling (2012)).

Appendix II – A bird's eye view of the stablecoin market

Stablecoins are digital cryptocurrencies that promise to keep a stable value with respect to an external asset, typically the dollar. Like other cryptocurrencies, they are tokens representing ownership and are recorded on a decentralized and public ledger – typically a blockchain.

The history of the stablecoin market can be divided into four stages. Stablecoins trace their origin to the birth of Bitcoin in 2009 (Nakamoto (2008)), which introduced the radical idea of a decentralized and peer-to-peer means of transferring value on a public database. Despite the original ethos of decentralization and the goal of representing a new form of intermediary-free money, it soon became clear that crypto assets are highly volatile.[22] Users who wanted to speculate on the value of crypto assets saw the need for a representation of off-chain bank money that would be native to the ecosystem and settle crypto transactions quickly. Stablecoins arose, that is, in response to the demand for a money-like liability that would be recorded on the same database as crypto assets. Users could then realize capital gains from speculation and decide when to re-enter speculative positions in crypto assets, without ever moving funds off-chain.[23]

Stablecoins gained notoriety with the Libra (later Diem) proposal by Facebook (later Meta) in June 2019. The project did not prosper, and its intellectual property was eventually sold off to the now also defunct Silvergate bank. But the announcement put stablecoins at the centre of policy discussions, energizing proponents and unsettling the central banking community. Up until that point and for some time thereafter, however, the size of the stablecoin market remained small.

The history of stablecoins entered a third period with the arrival of Covid-19 and the return of zero interest rate policies (ZIRP). Stablecoin use took off in earnest beginning in early 2020, and accelerated sharply in 2021 (Graph 1.A). The development of new market structures like decentralized finance (DeFi), based on automated, programmable financial functions, further fuelled speculative activities. This created a strong demand for the key function provided by stablecoins, and so demand grew. Effectively, stablecoins operate as DeFi's settlement asset. The high demand for stablecoins is reflected in their considerably higher turnover relative to other cryptoassets (Graph 1.B).

We argue that the end of ZIRP marks the beginning of a fourth stage, still ongoing. Rising rates rebalance the system away from elasticity towards reasserting discipline, by making the rollover of promises to pay more expensive and making the survival constraint tighter at the margin. With positive (and rising) interest rates, settlement in money becomes more binding in the real world, and the opportunity cost of holding zero-yielding tokens for the purpose of speculating in crypto markets inches up. Accordingly, since the beginning of policy tightening in the United States (marked as a gray-shaded area in Graph 1.A), the stablecoin market has been on a continuous downward path, losing over $63 billion in market capitalization up to August 2023. Rising rates

[22] See BIS (2023b).

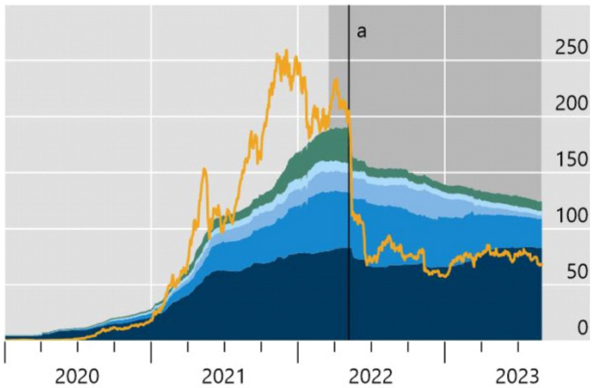
[23] The first stablecoins (BitUSD and NuBits) were issued in 2014. The best-known stablecoin (Tether, still the largest) entered the market in 2015.

represent a wider stress-test of the whole crypto apparatus, the credit that has been supporting asset prices in the space and the stablecoin par relations.

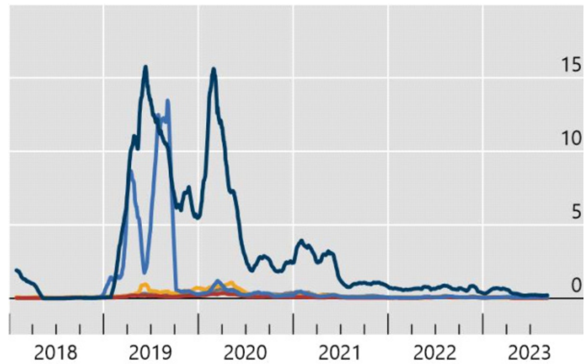
Stablecoins' remarkable growth, in tandem with DeFi, and high turnover

Graph II

A. Daily stablecoins market capitalisation and total value locked in DeFi[1]



B. Trading and settlement asset: stablecoins' turnover dwarfs that of other cryptoassets[2]



[a] TerraUSD and Luna collapse.

The grey shaded area in panel A denotes the period of rising interest rates.

[1] As of the 29 August 2023, it includes 65 other stablecoins. [2] Based on the top 20 cryptoassets by market capitalisation as of 29 Aug 2023 (three stablecoins, six DeFi coins and 11 other cryptoassets). Turnover is the volume-to-market capitalisation ratio.

Sources: CoinGecko; authors' calculations.

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