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Cryptodollars and the Hierarchy of Money

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Abstract

US Dollar stablecoins are onchain financial instruments representing a dollar equivalent. This paper focuses on a subset of stablecoins, cryptodollars, which we define as redeemable for 'higher-level' money in the hierarchy of money. By analyzing primary market issuance and redemptions, we demonstrate that these stablecoins have provided reliable value ('maintained par') in the currently available market infrastructure. With sensible management/regulation and further maturation of market infrastructure, cryptodollars have the potential to i) lower secondary market volatility, ii) broader onchain financial impact, as well as deeper integration between on-and offchain ecosystems.

1 Introduction

Stablecoins, liabilities issued as tokens on a blockchain, have become the 'killer' use-case for crypto, with a market capitalization exceeding $150 billion at the time of writing. They are a financial instrument

[0]**Acknowledgment:** The author would like to thank Marcel Bluhm for feedback and input.

that promises to maintain its value relative to a referenced asset. The referenced asset can be a currency (e.g., USD, EUR), a commodity (e.g., gold), or a basket of products (e.g., the Facebook Libra project). Cryptodollars are stablecoins, which are redeemable against the reference asset, defined as 'higher-level money' in the hierarchy of money.

Examples of stablecoins include USDC (Circle), DAI (MakerDAO), and LUSD (Liquity), which reference the USD. According to our definition and further discussed below, both USDC and DAI are cryptodollars because they can be redeemed against USD and USDC, respectively. However, LUSD, while pegged to the USD, is not redeemable into USD (or a higher-level cryptodollar) by the issuing protocol and is thus not a cryptodollar. This distinction between redemption and market exchange is crucial; while USDC, DAI, and LUSD can all be exchanged on the market for USD, only the former two are directly redeemable by the issuer against USD (or a higher level cryptodollar).

The rapid rise of stablecoins, with a peak close to $190B market capitalization,[1] created considerable attention beyond the crypto ecosystem, in particular among researchers and financial institutions. Authors have explored different avenues to analyze their rise. One school of thought compares stablecoins with free banking [9, 13, 14] or early central banks [11]. The reasoning is that stablecoin issuers are issuing redeemable notes (called tokens) in a lightly regulated environment, conditions that are similar to those in free banking. Another view is that stablecoins are akin to money market funds (MMF) [3, 18]. This is relevant, as a significant number of stablecoins actually feature an asset structure similar to MMF in terms of reduced credit risk and duration. A last analytical framework is to recognize similarities with the eurodollar system [6, 2, 8]. Just like the eurodollar market [10] grew in the 1950s organically and offshore, remote from US regulation, the stablecoin market is largely emerging organically, mainly outside

[1] Peak of $188,629M achieved on March 4, 2022. Source DeFiLlama `https://defillama.com/stablecoins`

of US regulation and one step remote from the Fed, the pristine US dollar issuer.

While this paper may refer to cryptodollars' similarities to free banking and MMFs at some instances, the eurodollar system as well as the hierarchy of money are our main frames for analysis and reference.

First, consider the eurodollar system. Eurodollars are dollar-denominated deposits held in an institution that is not subject to US banking regulation, for example, a European bank that issues a US dollar deposit account. While it may hold some US dollars at a US bank, it could also have higher duration/risk US-denominated assets to generate an interest rate margin. The growth of Eurodollars was largely driven by regulatory arbitrage (in particular, the ability to provide a higher interest rate than allowed under Regulation Q), which to some extent is also the case for cryptodollars. However, an additional benefit for the latter comes from its permissionless nature. Most cryptodollars can be freely transferred between people without much restrictions.[2] Since cryptodollars are bearer assets and public blockchains are largely pseudonymous, holders can remain unknown to the issuer. Given these advantages in addition to providing access to the global reserve asset, cryptodollars quickly found their way into jurisdictions that don't provide easy USD access to their citizens. [3]

Second, we use the hierarchy of money [17] as our frame for analysis. It postulates that all monetary systems are hierarchical, and organized akin to a pyramid, ranging from the top with high-powered money (currency and reserves) to the bottom with credit-like instruments (securities). Each subsequent layer can extend the quantity of money but ultimately depends on the above layer to maintain its peg to higher level money. In other words, the hierarchy of money provides elasticity to a scarce supply of the higher level money. For example,

[2]Although blacklisting is possible, for example, if OFAC sanctions require centralized issuers to do so.

[3]See the 2023 Geography of Cryptocurrency Report `https://www.chainalysis.com/blog/2023-global-crypto-adoption-index/`.

banks can create money via issuing loans. The value of their deposits maintains par as long as customers trust it is solvent (and there is no bank run) or, as long as the lender of last resort (the central bank in the level above) provides it with reserves (higher-level money) to meet redemption demands from its customers. In a situation without lender of last resort (providing theoretically unlimited amounts of higher level money)[4] a bank would normally not be able to redeem all issued deposits with reserves or cash but would have to liquidate a large proportion of its loans to meet demand. Such a bank-run scenario may easily drive a bank from a situation of illiquidity to insolvency.

Note that the moneyness/quality (i.e., acceptability by market participants as money under all circumstances) decreases from the top to the bottom of the pyramid. Crucially, the acceptance of assets as money on any layer (except the top layer) depends on convertibility into higher level money, that is, its ability to maintain par. Each layer (except the first one) faces the risk of adverse clearing when a promise to pay higher level money is exercised. This creates discipline: To alleviate liquidity risk, each participant in the hierarchy holds some higher level money reserves.

As displayed in Figure 1, the hierarchy of the dollar system starts with Fed reserves (wholesale) and currency (retail). Below, we find US banks, which issue 'private' money but are actually money-like only to the extent that they promise to pay higher-level dollars (e.g., currency or reserves) on demand. Instruments on those levels are commonly referred to as dollars and are separated from the instruments on lower levels because, contrary to the latter, they have some governmental support (FDIC insurance, for instance) and access to the lender of last resort, the FED.

Eurodollars are one level further below as they are a promise from offshore (non-US-regulated) banks to pay US bank deposits. Fiat-

[4]Alternatives like deposit insurance are usually limited in coverage.

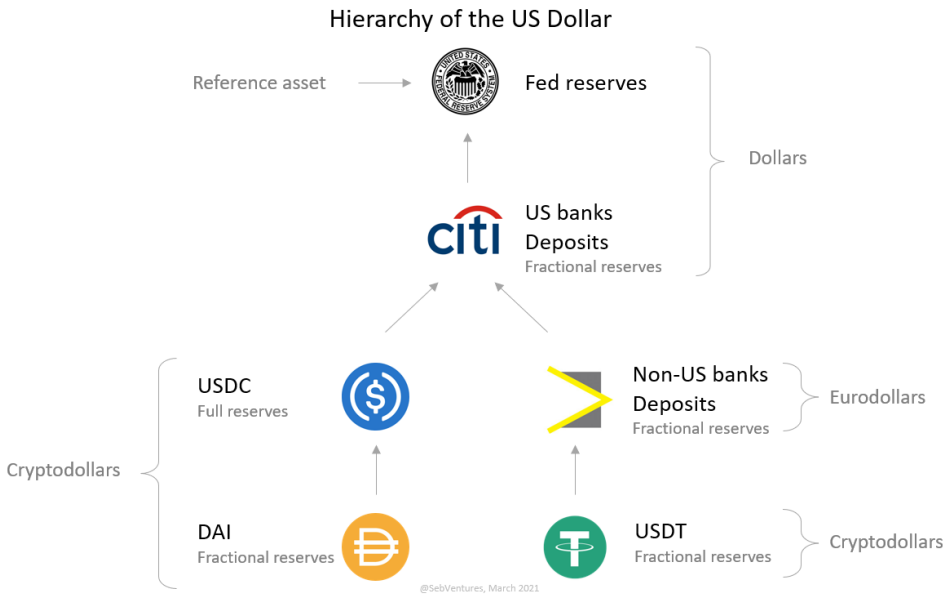

Figure 1: Hierarchy of Money With Cryptodollars

backed cryptodollars are one additional level below in this hierarchy, as they are a promise to pay bank money. Depending on their bank relationship, their reserves are either held as USD instruments held at US regulated banks (for instance USDC, USDP, and GUSD) or as eurodollar instruments if held at offshore banks (like USDT). Note that we oversimplify here for the sake of clarity. As will become clear later on, similar to banks, cryptodollar issuers do not only use banks to hold US dollars but also custodians to hold highly liquid instruments like eg reverse repos that can be used to quickly satisfy redemption demand.

Finally, there are onchain cryptodollars (like DAI) that don't have a direct link with banks (US-regulated or offshore). Their anchor in the hierarchy of money is another cryptodollar, in this case, USDC into which they are redeemable by the protocol.

Significant concerns have been raised regarding the susceptibility of stablecoins to bank runs and the perceived resulting instability [1, 2, 5].

Not least for that reason, some consider rapid adoption of stablecoins "socially undesirable" [5], and the G7 has stated that "no global stablecoin project should begin operation until it adequately addresses relevant legal, regulatory, and oversight requirements through appropriate design and by adhering to applicable standards". [5] In light of these concerns, we observe that despite missing legal, regulatory and oversight frameworks leading cryptodollars have so far demonstrated surprising resilience to bank runs and instability.

In this paper, we contribute to the discussion by providing i) an up-to-date taxonomy for cryptodollars, that takes into account whether they are fully reserved and hold their reserves onchain, and ii) evidence that key cryptodollars have been maintaining par on primary markets.

To carry out our analysis, we focus on how cryptodollars are anchored in the hierarchy of money, that is, maintain their fungibility (par) with higher-level money. This analysis is important as their increasing use around the world has been accompanied by concerns about the singleness of money [12]. We show that key cryptodollars investigated in this paper have so far fulfilled their role in the hierarchy of money without (significantly) breaking par. In our analyses, 'significantly' means the issuer stands ready to redeem at par within the time window required by NYDFS guidance[6] (2 business days).

Cryptodollars are not without (secondary market) volatility, especially when evaluated against traditional finance standards. However, this volatility is expected given current market infrastructure and the lack of deep integration with traditional financial systems. Sensible regulation, such as that from the NYDFS or MiCA[7], ensures that, when looking at primary market issuance and redemptions, stablecoins effectively fulfill their role in the hierarchy of money.

The structure of the paper is as follows. In Section 2, a taxonomy of

[5] https://home.treasury.gov/news/press-releases/sm1152

[6] https://www.dfs.ny.gov/industry_guidance/industry_letters/il20220608_issuance_stablecoins

[7] https://eur-lex.europa.eu/eli/reg/2023/1114/oj

cryptodollars is proposed. In Section 3, we describe how cryptodollars maintain par and then analyze in Section 4 how they fulfilled their role under various market conditions. Finally, we conclude and provide an outlook in section 5.

2 Defining Cryptodollars

As outlined in the previous section, stablecoins are onchain issued liabilities that promise to maintain value relative to a reference asset. In this section, we introduce a taxonomy of a subset of stablecoins, cryptodollars, which we have defined as stablecoins that are redeemable against 'higher-level money' in the reference asset's hierarchy of money.

The literature usually categorizes stablecoins, and by extension the subset of cryptodollars, into three types: fiat-backed, crypto-backed, and algorithmic [3, 7]:

- **Fiat-backed stablecoins** are issued centralized issuers, which hold their reserves in mainly liquid and safe assets, usually bank deposits, T-bills, T-bill collateralized overnight repos, and MMFs. In addition, while no longer significant, commercial paper and certificates of deposit were also used. Issuance and redemption are processed with fiat.

- **Crypto-backed stablecoins** have cryptocurrencies (e.g., ETH or WBTC) as collateral, usually to provide stablecoins in the form of an overcollateralized loan. MakerDAO[8] is the biggest issuer following this approach. Users can permissionlessly mint stablecoins by depositing enough collateral, which is automatically

[8]MakerDAO announced a rebranding to Sky on August 27, 2024, introducing a new stablecoin called USDS and a governance token called SKY. Stakeholders are currently discussing whether to (partially) revert the rebranding. Both, DAI and USDS feature the same underlying mechanics outlined in this paper. Since the discussion around rebranding is still ongoing and has no bearing on the protocol mechanics for stablecoins (at this point), we only refer to MakerDAO and DAI here.

liquidated if the collateralization falls below a certain threshold (usually well in excess of the stablecoin loan). For instance, the now-bankrupt Celsius was a significant borrower at MakerDAO (up to 10% of total assets), but no loss was recorded due to the secured nature of the lending. Collateral liquidation, especially in volume, remains a challenge and a risk.

- **Algorithmic stablecoins** use a native token issuance as backing to meet redemption demand. Luna/UST was in this category, where the issuance and redemption of UST were done in the LUNA token and not in higher-level money form. This framework features high risk of so-called 'death-spirals', where reflexivity between stablecoin and collateral prices may lead to spectacular bank run dynamics.

While this taxonomy was useful in the past, it no longer reflects the current landscape. First, fiat-backed stablecoins aren't entirely backed by fiat instruments. USDT, usually put as a leader in this category, holds its reserves partly in gold and bitcoin. Second, DAI, the main crypto-backed stablecoin, holds more than $2B of T-bills with traditional custodians. Third, the algorithmic stablecoin category appears obsolete as there seems to be consensus that this approach is not a sustainable basis for money-like instruments (i.e. an insolvent issuer shouldn't issue on-demand liabilities). Fourth, new categories blurring the boundary to stablecoins also emerge, such as Ethena's USDe - a so-called synthetic dollar.

In the following, we categorize cryptodollars with a two-by-two matrix (Table 1). One dimension is the extent to which cryptodollars are fully or fractionally reserved. The second dimension is how much of their balance sheet is onchain. Cryptodollar issuers, by definition, have cryptodollar liabilities onchain, but the asset side can be either onchain (like, to some extent, DAI) or offchain (most others).

Table 2 presents an overview of key cryptodollars.

	Fully Reserved	Fractionally Reserved
Offchain Reserves	PYUSD	USDT
Onchain Reserves	—	DAI

Table 1: Two-by-Two Matrix of Cryptodollars

The majority of stablecoins in Table 2 are fully reserved (e.g., PYUSD). This means that they hold only bank deposits, Money Market Funds (MMF), T-bills, and/or overnight repurchase agreements collateralized with government-issued debt. As detailed in [4], stablecoin issuers have evolved their asset strategy over time. For example, USDC was in the fractional reserve category but adjusted its strategy on August 8, 2021. Two factors drove this decision. First, there started to be concerns about the safety and lack of transparency of commercial paper products. Second, the yield on risk-free short-term instruments started to increase after years close to 0%. Figure 2 provides a stylized balance sheet outline for selected stablecoin issuers.

Below, we discuss the two introduced dimensions of cryptodollar reserves: first, the extent to which issuers are fully or fractionally reserved, and second, whether they hold assets on- or offchain.

2.1 Fractionally vs Fully Reserved Cryptodollars

At its core, the difference between fractionally and fully reserved cryptodollars centers on the degree of risk each carries. Fractionally reserved cryptodollars are only partially backed by higher-level money and can include cryptocurrencies (for example in the case of DAI), commodities (for example in the case of Tether), and non-monetary assets like commercial paper. This partial backing introduces financial vulnerabilities, notably interest rate risk, liquidity risk, and market

[9]Currently the T-Bills are held via an offchain structure. That is, DAI is currently more hybrid than fully onchain

Symbol	Circulation (in M$)	Reserves	Onchain	Provide Par
USDT	120,170	Fractional	No	Yes, bank deposits
USDC	34,693	Full	No	Yes, bank deposits
DAI	5,573	Fractional	Yes[9]	Yes, stablecoins
PYUSD	617	Full	No	Yes, bank deposits
USDM	48	Full	No	Yes, bank deposits or stablecoins

Table 2: Selected Examples of Cryptodollars (circulation on October, 26 2024

USDC

Repo	USDC
T-Bills	Equity
Cash	

MakerDAO

Crypto-Repo	DAI
T-Bills	Equity
Stable-coins	

Tether

T-Bills	USDT
Cash	Equity
Gold	
Bitcoin	

Figure 2: Simplified Balance Sheets of Current Cryptodollar Issuers

risk. Interest rate risk refers to the potential for losses due to changes in the interest rate environment, while liquidity risk is the risk of being unable to convert an asset into a reference asset (in our case higher level money) for a limited cost in a limited time. Market risk is the risk of losses in financial instruments due to adverse price movements in the market, including risks from market fluctuations, volatility, and events that impact the value of assets.

In contrast, fully reserved cryptodollars operate similarly to what is known in traditional finance as "narrow banking." These cryptodollars are backed entirely by money, such as currency or highly liquid cash equivalents. This full backing substantially mitigates risks associated with asset volatility, interest rate risk, and liquidity constraints, making fully reserved cryptodollars inherently less risky compared to their fractionally reserved counterparts.

2.2 Onchain vs Offchain Cryptodollars

These two deployment mechanisms for cryptodollars impact how reserve assets backing the stablecoins can be managed. The term 'onchain' can be understood at varying levels of engagement with blockchain: from being merely tokenized and visible on the blockchain, up to being tokenized, tradable, and highly liquid onchain.

The extent to which cryptodollars are integrated with the blockchain —whether in terms of visibility, tradability, or liquidity— significantly affects several operational aspects. Firstly, onchain reserve management enhances the mechanisms for redemptions; it facilitates onchain trading and can accelerate liquidations, potentially even enabling automatic liquidations due to smart contract functionalities. This integration allows for more efficient market responses and easier access to funds for holders, if the cryptodollar operates with both legs (issuer's assets and liabilities) onchain.

Secondly, having cryptodollars and their reserves managed onchain improves real-time data availability and verifiability. This transparency is crucial for trust and auditing purposes, enabling users and regulators to verify the existence and sufficiency of reserves instantaneously without relying on external audits or delayed reports.

In summary, our taxonomy distinguishes cryptodollars based on their reserve backing and the onchain or offchain status of their assets. This nuanced classification allows for a better understanding of the varying degrees of risk and operational complexity associated with different cryptodollars. In the following section, we will explore how cryptodollars maintain their peg to the reference asset, focusing on their mechanisms for ensuring stability and liquidity.

3 Maintaining Par

Having defined cryptodollars and introduced our taxonomy, let's address how cryptodollars maintain par. We define par, following NYDFS guidelines, which require that timely redemptions take 'not more than two full business days ("T+2")' [15] under all market conditions. Note that our focus here is on issuers' liquidity. Generally speaking, by definition, a cryptodollar issuer that is insolvent will not be able to maintain par. Insolvency can be triggered by different events, including fraud, default of a custodian, or illiquidity. While the former two (fraud or default of a custodian) are not in scope of our analyses, an issuer's liquidity is. To maintain par, Aldasoro et al [2] distinguish three forms of liquidity, monetary liquidity, market liquidity and funding liquidity:

- **Monetary liquidity** is the availability of higher-level money, such as a cryptodollar issuer holding reserves as bank deposits.
- **Funding liquidity** is the ability to borrow higher-level money, like a bank accessing a lender of last resort's marginal lending facility. Cryptodollar issuers currently have limited or no access to this liquidity.
- **Market liquidity** is the ability to convert assets into higher-level money without significantly impacting price. For instance, selling cryptocurrency reserves for higher-level money on the market or selling T-bills for USD, the latter involving an offchain element.

3.1 Primary Versus Secondary Prices

The literature on stablecoins often focuses on analyses of stablecoins breaking their peg [16, 2], typically using observable prices on central-

Exchange	Type	Pair	Price ($)
Coinbase	CeFi	PYUSD/USD	$0.9993
Kraken	CeFi	PYUSD/USD	$0.9987
Kraken	CeFi	ETH/PYUSD	$0.9977
Kucoin	CeFi	PYUSD/USDT	$0.9971
Curve	DeFi	PYUSD/FRAX	$0.9968
Curve	DeFi	PYUSD/USDC	$0.9959

Table 3: PYUSD Prices on different exchanges as reported on Coingecko on March 2^{nd}, 2023.

ized and decentralized exchanges, which are usually secondary markets. An exception is Coinbase, which provides both primary access to USDC as well as secondary market trading. We refer to the price at the issuer as the primary price (price on the primary market) and the price on secondary markets (such as exchanges unrelated to the issuer) as the secondary price. Many factors can impact the secondary price.

Let's investigate the difference between primary and secondary prices, considering the heterogeneity of secondary prices. Table 3 shows the price reported for PYUSD on March 2^{nd} 2024 for different venues as reported on Coingecko. The headline price reported was $0.9975. Meanwhile, the competitor CoinMarketCap was reporting $0.9991. As we can see, different exchanges report different prices, in our example with a 30bps spread, which is significant for a pegged asset. Depending on the underlying price source and aggregation methodology, different data providers provide different aggregated market prices. Even within an exchange, such as Kraken, we can see different prices. There is a 10bps spread between the PYUSD price compared to USD relative to the price implied by the ETH to PYUSD exchange rate. The same phenomenon exists for PYUSD on the decentralized exchange Curve (despite those pools having ample liquidity).

While secondary (implied) prices are heterogeneous, there is no reason to doubt that the price of PYUSD at Paxos (the issuer) wasn't exactly $1 at all times. PYUSD is NYDFS supervised and therefore has an obligation to provide par. The user interface at Paxos doesn't even make a difference between a dollar and PYUSD. The NYDFS has established a regulatory framework for stablecoins that is considered by many as the regulatory gold standard in the industry. This regime has proven to be sensible and is battle-tested, offering a robust blueprint for stablecoin regulation.

One of the key strengths of the NYDFS framework is its ability to effectively mitigate solvency issues for stablecoin issuers –barring scenarios like fraud, a U.S. sovereign default, or a custodian default. As mentioned before and crucial for our analysis, the NYDFS requires issuers to redeem stablecoins at par within two business days. This requirement is particularly pertinent given the non-stop nature of cryptocurrency operations, acknowledging the need for interaction with traditional banking systems, which do not operate over weekends and holidays.

For our empirical analysis, we adopt this two-day redemption requirement as a benchmark to assess cryptodollar issuers' ability to maintain par. By this standard, a failure to redeem a cryptodollar at a 1:1 value within the stipulated two business days constitutes a break of par. This operational definition will be used to evaluate various stablecoin issuers in the subsequent analyses detailed in Section 4. But why is there secondary market price heterogeneity if market participants trust the NYDFS' regulatory regime?

First, people tend to use primary venues mainly for on- and off-ramping. When they want to exchange their stablecoin into another cryptocurrency (or vice versa), they find better liquidity on exchanges. For example, USDT, being the largest stablecoin by market capitalization, is the most liquid stablecoin in most exchange pairs. If a GUSD owner (also regulated by the NYDFS) wants to exchange her GUSD

into BTC, transaction costs (spread and fee) may exceed i) wiring the GUSD to a CEX/DEX, ii) exchanging them into USDT, and then iii) swapping into BTC (three steps instead of one). Furthermore, some tokens, such as GNO, are not available on the primary venue.

Second, users often find convenience using their habitual exchange venue and might not seek the best price on all exchanges. Opening a new account at a centralized exchange takes time and administrative work (KYC/AML), while using a new decentralized exchange involves understanding risks. For example, Uniswap Labs, the creator of Uniswap Protocol, added 25bps fees on some transactions made from their website. Users could easily avoid these fees by using another front-end or an aggregator, such as Cow Swap. Yet, many continue using Uniswap Labs' front-end for convenience.[10]

Third, normally, price differences between exchanges and primary issuers should be arbitraged away by market makers. However, particularly with decentralized exchanges like Curve, high transaction costs during periods of volatility lead to market inefficiencies, resulting in temporary price discrepancies that are not arbitraged away. For example, if an arbitrage opportunity of $500 by buying GUSD for USDT 0.99 on Curve and then selling it for USD 1 on Gemini arises, it only makes sense to carry this out (probably in an automated fashion) if $500 exceeds transaction costs and spreads of the following steps: i) exchanging USDT into GUSD on Curve, ii) wiring GUSD to Gemini (and waiting until Gemini accepts the transaction as final), iii) exchanging GUSD to USD, iv) wiring USD via the banking system to Tether, and v) tokenizing USD back into USDT. Note that the trade is carried out sequentially and therefore is not entirely risk-free. However, given existing inefficiencies, such as the fiat leg (wiring USD to Tether for tokenizing back into USDT), this is unavoidable and may add an additional risk premium.

[10] See `https://dune.com/mylesoneil/uniswap-labs-metrics`.

While the above examples explain why there may be persistent price discrepancies on secondary venues, it is also clear that if a user actually wants to offramp, which is the very definition of maintaining par (exchanging the cryptodollar into fiat, higher-level money), they can do so with extremely high certainty within two business days (for cryptodollar issuers under NYDFS oversight). In this paper, we argue that this should be the yardstick for investigating whether or not cryptodollar issuers reliably provide par. However, with few exceptions [19], the distinction between primary and secondary markets is not made in the literature and discussions.

In addition to discussing centralized cryptodollar issuers, we examine the largest decentralized issuer, MakerDAO. Although not supervised by NYDFS, MakerDAO is battle-tested and employs a specific mechanism to maintain par. The following case study details how the Peg Stability Module (PSM) helps maintain DAI's peg to the USD. Figure 3 shows the DAI/USDC trading price from January 2020 to October 2021. The price generally fluctuates around the 1.000 mark, which is the intended peg for the DAI stablecoin. The graph also includes the 80% swap bands. There are notable periods of volatility, particularly during April 2020 where the price spiked above 1.060. A significant event marked on the graph is the "PSM introduction" (Peg Stability Module) in January 2021, after which the price shows noticeably reduced volatility and stays closer to the 1.000 peg.

Case Study: MakerDAO's Peg Stability Module (PSM)
The MakerDAO protocol includes a crucial mechanism known as the Peg Stability Module (PSM) to maintain DAI's peg to the USD. The PSM allows users to exchange DAI directly for other stablecoins like USDC at a 1:1 ratio, stabilizing DAI's price by managing its supply and demand.
When DAI's price rises above $1, users mint more DAI and exchange it through the PSM for USDC, increasing DAI's supply and bringing its price back to the peg. Conversely, when DAI's price falls below $1, users buy DAI cheaply on the market and then use the PSM to exchange it for USDC, reducing DAI's supply and helping to restore the peg.
The effectiveness of the PSM hinges on its reserves of stablecoins. These reserves act as high-quality liquid assets (HQLA), ensuring sufficient liquidity to handle large-scale exchanges and maintain price stability. The module's ability to maintain the peg during periods of market stress underscores its importance.
During the collapse of Silicon Valley Bank (SVB) in March 2023, the broader stablecoin market experienced significant volatility (USDC par was unclear). During the whole episode, it was possible to get GUSD from DAI at par meaning DAI kept it's anchor in the hierarchy of money.
Continuous monitoring and adjustment of the PSM's parameters by MakerDAO's governance ensure its effectiveness. These adjustments are based on real-time data, allowing the protocol to respond swiftly to changing market conditions.
In conclusion, MakerDAO's Peg Stability Module is a critical tool for maintaining DAI's stability. Its design and functionality allow the protocol to actively manage DAI's supply and demand, ensuring that the stablecoin remains pegged to the USD, even during periods of significant market stress.

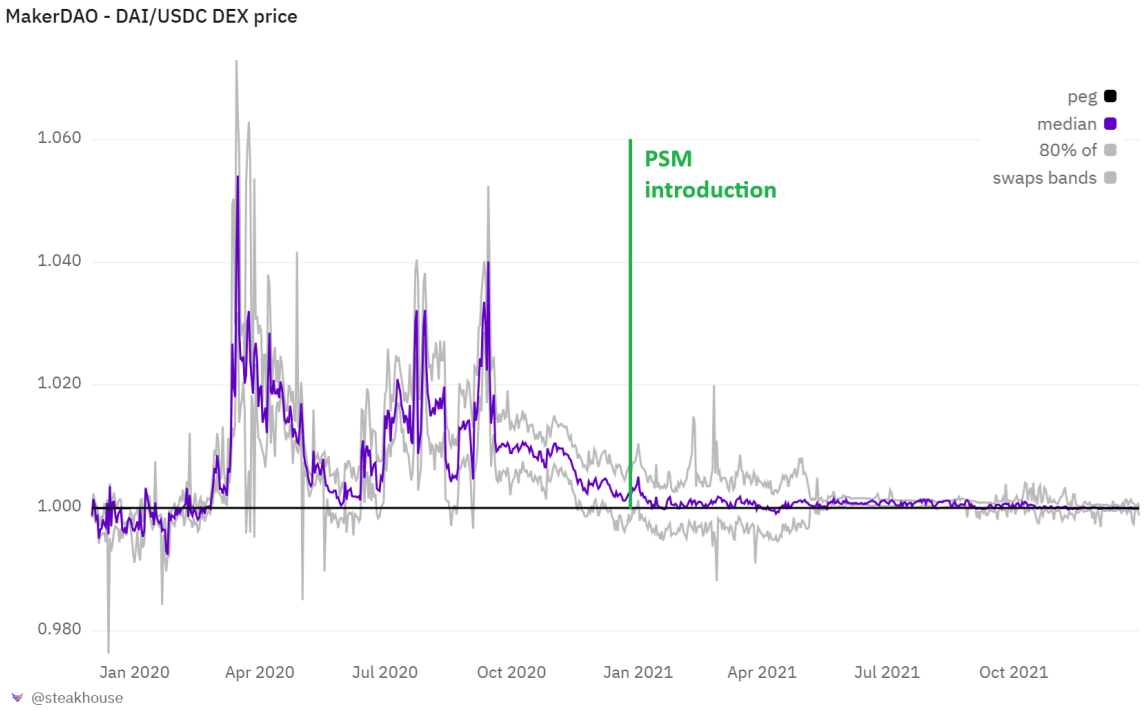

Figure 3: Price History of DAI versus USDC (used as USD reference) and PSM introduction. Notice, prototypes of the PSM started to be introduced in October.

4 Empirical results

To analyze conversion at par, we define two metrics: gross and net outflow. Gross outflow is the amount of cryptodollars issued that are converted into higher-level money. For example, every time someone redeems USDC to fiat at Circle or Coinbase, it is counted. Similarly, when someone uses the Maker PSM to redeem DAI for USDC / GUSD / USDP (which in terms of the hierarchy of money are the higher-level monies for MakerDAO's DAI), it is counted as gross outflow. Note that by this definition, a user repaying a DAI debt at Maker does not count as a gross outflow because in that case DAI is not exchanged against

higher-level money. However, very often the minting and burning of DAI done through borrowing, involves the PSM, which then picks up these transactions in our metric. For example, consider a user who borrows DAI, then exchanges the DAI via the PSM into USDC (and then offramp or speculate on cryptocurrencies). This transaction would show up in our metric as a gross outflow at par. Net outflow is defined as gross outflow minus new cryptodollars minted (for a given issuer).

In the following, we observe the 30-day rolling window of gross- and netted outflows for two key cryptodollar issuers, Circle (USDC) and MakerDAO (DAI)[11] to assess:

1. Their ability to absorb redemption demand by looking at the gross outflows, and

2. Their balance sheet elasticity by looking at the net outflows,

both under normal and stressed conditions.

4.1 Gross- and Net-Outflow Metrics for DAI

Figure 4 illustrates the net and gross outflows for DAI from January 2020 to April 2024, with the blue line representing gross outflows and the red line representing net outflows. Gross outflows, defined as the total amount of DAI converted to higher-level money, remain low until mid-2021 (keep in mind that the PSM was introduced only late 2020, no outflows was possible before that), after which significant spikes occur, indicating periods of high conversion activity. The most notable spikes coincide with major market events, such as regulatory changes and market turmoil.

[11] We do not cover Tether in our analysis because its redemption policy limits redemptions to at least 100000 USD, charging a redemption fee, which is the larger of 1000USD or 0.1%. For this reason, and lack of ability for any holder to redeem, the author don't consider USDT a cryptodollar.

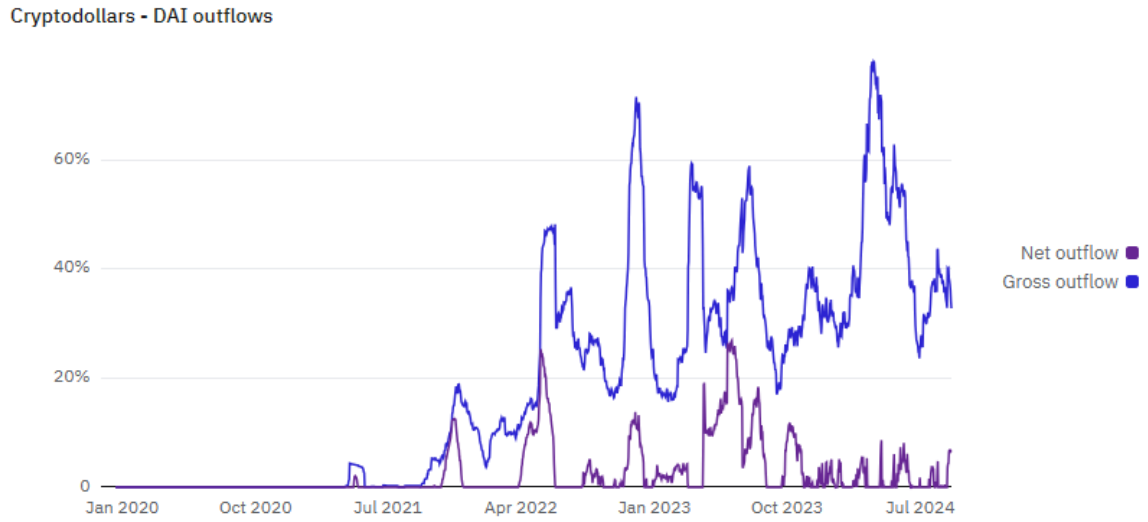

Figure 4: Gross and Net Outflows of DAI

Net outflows, calculated as gross outflows minus newly minted DAI (via the PSM), also stay relatively low until mid-2021, with notable peaks observed in late 2022 and early 2023. These peaks indicate periods where redemptions exceeded new issuances. The significant outflows in late 2022 and early 2023 can be linked to broader market uncertainty. Interestingly during the collapse of Silicon Valley Bank (SVB), which questioned the solvency of USDC, DAI got net inflows from USDC holder looking for a safer alternative[12]. While the USDP PSM was drained quite quickly, the GUSD PSM continued to allow people to exit DAI with a stablecoin that wasn't affected the SVB bankrun.

Despite these episodes of market stress, the DAI exhibited a high degree of elasticity, capable of handling substantial outflows without significantly breaking par, thanks to mechanisms like the PSM. Overall, DAI's outflow metrics reflect a robust system capable of maintain-

[12]During this period, USDC was still accepted at par to create DAI. Newer system like Angle Transmuter have safeties in place to avoid that.

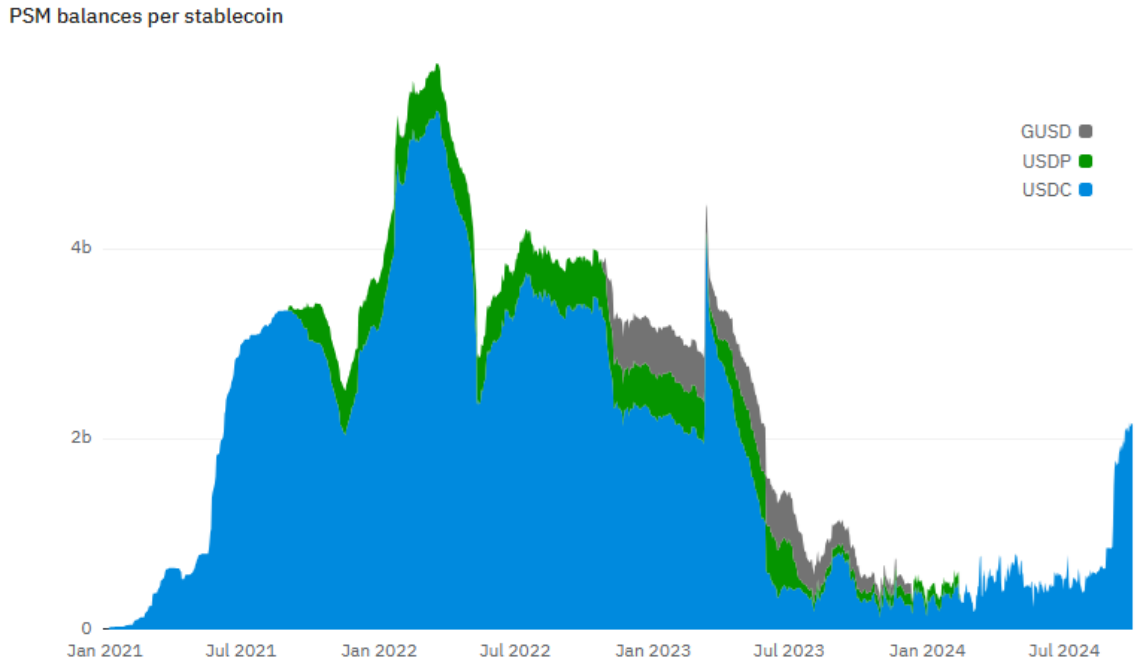

Figure 5: Balance of MakerDAO Price Stability Modules

ing stability and fulfilling its role in the hierarchy of money.

In addition, Figure 5 displays the daily available balance in the PSM. Since inception, the balance never went to zero, despite considerable market stress, which shows, that our par criterion –redemption within two business days against higher level money– was always maintained over the observed horizon.

Next, consider Circle's USDC.

4.2 Gross- and Net-Outflow Metrics for USDC

Figure 6 tracks USDC redemptions by our metrics over time. The blue line displays gross outflows. Over the period of observation, redemptions over a 30-day window hover around 20% of total reserves, indicating a continuous churn. A maximum is reached with 60% at

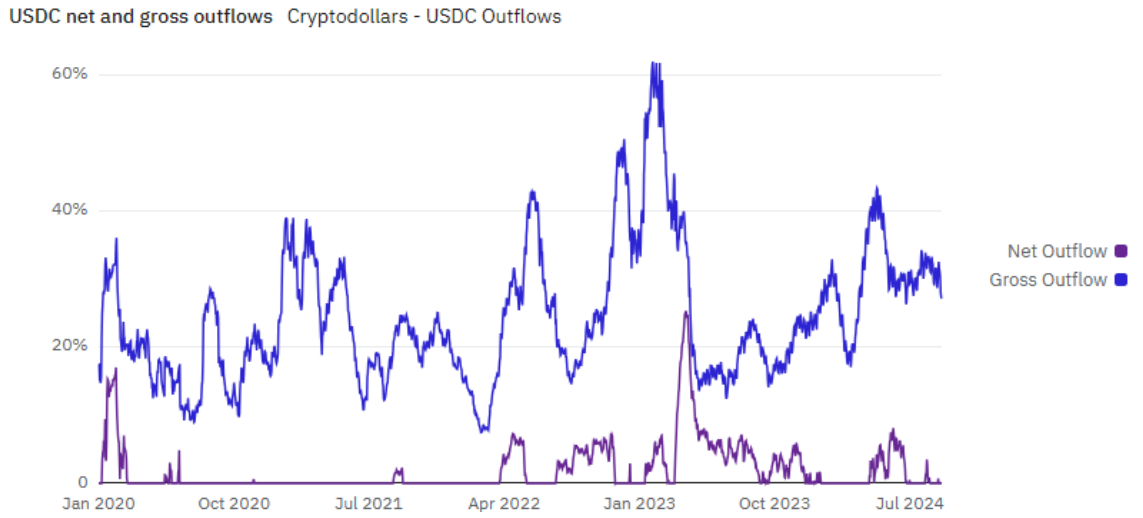

Figure 6: Gross and Net Outflows of USDC

the beginning of 2023. This peak is also reflected in the net outflows (purple line) at that time.

The significant outflows of USDC in early 2023 were driven by a combination of regulatory actions, banking sector turmoil, and de-pegging issues. A major factor for this peak was the collapse of Silicon Valley Bank (SVB) in March 2023, which locked $3.3 billion of Circle's cash reserves and caused USDC to temporarily lose its 1:1 peg to the dollar on secondary markets (but not on primary markets). This event led to massive redemptions as investors lost confidence in the stability of USDC. The situation was exacerbated by increasing regulatory scrutiny on stablecoins and the broader cryptocurrency market, which added to the uncertainty and prompted investors to seek safer alternatives.

The temporary de-pegging of USDC on secondary markets also triggered a negative feedback loop in the DeFi ecosystem, causing significant volatility and liquidity issues on platforms like Curve and Maker, which heavily rely on USDC for collateralization. These combined fac-

tors led to substantial USDC outflows, surpassing $10 billion, and a notable shift in stablecoin market dynamics.

Overall, the figure shows a constant churn of in-and-outflows (periods when gross outflows are positive to the tune of 20%, while net outflows are zero), effectively providing par. The figure also shows that Circle was able to absorb considerable stress to its balance sheet during the SVB bankruptcy event - it provided par for net outflows making up 20% of its balance sheet.

It is important to keep in mind that the data presented for USDC may reflect (equilibrium) market outcomes rather than guaranteed par for all users at all times. Of course, in case of a bank-run, issuers might ration redemptions, limiting the amount of cryptodollars that can be converted at any given time. It may just be the case that so far, the system was not hit by a large enough shock to derail it. Had people not been able to redeem their cryptodollars at par with the issuer, this would have led to a public outcry though.

Overall, our findings indicate that both stablecoins observed, USDC and DAI maintained par. Stress episodes show the system's elasticity under various market conditions but shares the same limitation regarding potential rationing. For example, during the collapse of Silicon Valley Bank (SVB) in March 2023, significant market volatility tested the robustness of stablecoins like USDC and DAI. Despite these stress events, both maintained par, demonstrating their resilience and the effectiveness of mechanisms like MakerDAO's PSM.

5 Conclusion

This paper argues that despite the inherent volatility of the crypto industry, prominent cryptodollars largely maintain the singleness of money. We show that although cryptodollars occupy a low position in the hierarchy of money —comparable to Eurodollars— they have

consistently maintained par under various market conditions.

Key cryptodollars such as USDC and DAI undergo significant redemption cycles without losing par. On average, 20% of USDC in circulation is redeemed for higher-level money every 30 days. Even during stressed conditions like the Silicon Valley Bank (SVB) crisis, cryptodollars maintained par, with timely redemptions within regulatory standards, showcasing their resilience.

Cryptodollars are not without volatility, particularly when judged by traditional finance standards though. This volatility is expected given the current state of crypto market infrastructure and the unfinished process of integrating with traditional financial systems. Sensible regulatory frameworks, such as the NYDFS's, support their role in the hierarchy of money. Our analysis of primary market issuance and redemptions indicates that stablecoins reliably maintain par and provide value, underscoring their potential within the broader financial ecosystem.[13]

Looking forward, cryptodollars have the potential to play a more significant role in traditional finance if certain conditions are met. First, further sensible regulation or similar risk management practices, must be established. Second, market infrastructure must mature, allowing for deeper integration with traditional financial systems and allowing for 24/7 redemptions. These advancements could enhance the stability and functionality of cryptodollars, facilitating their broader adoption and impact in the financial ecosystem.

In conclusion, the hierarchy of money involving cryptocurrencies pegged to fiat is expected to evolve. Full reserve cryptodollars with central bank access could become a primary level, followed by fractional reserve cryptodollars. This potential shift indicates a future where cryptodollars play an integral role in the broader financial ecosystem, supported by more advanced regulatory frameworks and market in-

[13]We recommend looking at BUSD and GUSD for example of even more wilder fluctuation (net outflow ¿ 50%) while keeping par.

frastructures.

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