

Analysis of Stablecoins during the Global COVID-19 Pandemic

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Abstract—One of the major concerns with cryptocurrencies is their price instability, driven by market speculation, underlying technology, and applications. Stablecoins were introduced to address volatility and to provide means for an electronic payment and a value store remaining stable, often being supported by physical assets or fiat currency (e.g., gold or US dollars, respectively). However, different collateralization mechanisms exist and different assets are pegged with the coin that can affect their stability in different ways. This work overviews stablecoin stability mechanisms, the current stablecoin market landscape, and the performance of major stablecoins during the 2020 financial market crisis due to the COVID-19 pandemic. Results from this analysis indicate that stablecoins’ performance during the financial crisis and, in particular, the market crash present a direct relation with their specific behavior attributed to different design aspects, including their popularity.

I. INTRODUCTION

Cryptocurrencies evolved into a multi-billion dollar market since the release of Bitcoin more than a decade ago [1]. One of the major obstacles toward a wide-spread use of cryptocurrencies as a means of payment and investment is price volatility [2]. Selected factors can be attributed to the emergence of the cryptocurrency market, in contrast to fiat currencies and gold, and to the fact that distributed ledgers are still in a relative early stage of development. The growth of public perception due to the popularity of cryptocurrencies and the possibility of using technology in different cryptocurrencies being specific to certain use cases, cause several investors to speculate, and in turn, this generates volatility.

In theory, stablecoins target a system immune to the volatility of market-traded cryptocurrencies, such as Bitcoin [1]. Like other cryptocurrencies, stablecoins have enjoyed a rising popularity in recent years, now also amassing a market capitalization of many billion USD [3]. This prompted economic organizations like G7 and the European Central Bank to assess their impact on the global economy [4], [5]. Therefore, this paper details different stablecoins and their role and behavior during the 2020 financial market crisis.

Stablecoins are cryptocurrencies designed to maintain a stable value [6], [7]. However, there are different interpretations concerning the meaning of stability and, therefore, different approaches to achieve it. A popular stablecoin mimics the value of the US Dollar (USD) by using it as a collateral and then tokenizing funds. This design requires a central institution (a custodian) managing these funds. Also, there are stablecoins

using other cryptocurrencies as a collateral, resulting in a more decentralized system. For these stablecoins the law of supply and demand is often not sufficient to achieve price stability, which is why some of them use sophisticated mechanisms to secure the stablecoin’s value.

Price stability of stablecoins was analyzed in various studies both theoretically [8], [9], [10] and empirically [11], [12]. [2] states that a crucial aspect of a stablecoin system is how well the stablecoin performs during times of financial crisis. Thus, this paper takes the 2020 financial market crisis as an opportunity to assess empirically the performance of a selection of stablecoins, including Tether, DAI, and DGX. The analysis is based on stablecoin classification frameworks described in [7] and [5] and on basic methods from quantitative finance to measure market risk (*cf.* Section III-C).

To the best of the authors’ knowledge, currently no studies exist, which investigate the performance of different stablecoin designs during a financial crisis. After all, the current 2020 financial market crisis is the first global financial market crisis during which stablecoins were operational. Thus, this investigation is centered around the following questions:

- How did stablecoins perform during the 2020 financial market crisis with respect to stability and popularity?
- How was the stablecoin performance during that period related to different design aspects of stablecoins?

To answer these questions, this paper introduces the basic concepts of stablecoins and their different design features, in particular different stability mechanisms (*cf.* Section II). Following, an overview of the stablecoin market is given and the different types of risks associated with stablecoin investments are discussed, most importantly market risk. In particular, a unified approach is presented to measure and compare price volatility for stablecoins with different pegs, *i.e.*, a definition of volatility. Finally, the analysis is based on historic market data for stablecoin prices, market capitalization, and trade volume.

The remainder of this paper is organized as follows. Section II overviews the fundamentals of stablecoins, while Section III describes the stablecoin market and different types of investment risks. Section IV details the performance of six selected stablecoins during the 2020 global financial crisis. Finally, Section V summarizes the paper and adds final considerations.

II. BACKGROUND

This section outlines the basics of a stablecoin system, describing design variants, stability mechanisms, and examples.

A. Stablecoins Basics

According to the classification suggested in [7], stablecoins can be characterized by the following attributes, besides stability mechanisms and price information:

- **Peg:** The asset whose value the stablecoin attempts to maintain. Examples are traditional currencies or commodities, *e.g.*, US dollar or gold.
- **Collateral:** The asset that is pledged as security. Examples include fiat currencies, gold, cryptocurrencies, and mixtures of the above.
- **Collateral Amount:** The amount of circulating stablecoins that are collateralized, if any. Variants are none, partial, full, or over-collateralization.

Peg: One major aspect of a stablecoin is the pegged value and how it is maintained. There is no need for intrinsic connections between the peg and the collateral. Nevertheless, a popular choice for stablecoin designs is pegging a currency (mainly USD) and holding the collateral in the pegged asset [13]. Apart from fiat currencies, such as USD and EUR, stablecoins are pegged to gold or even another cryptocurrency.

Collateral: Collateral choices are fiat currencies, commodities (mainly precious metals), other cryptocurrencies, or any mix of the aforementioned. Often, a distinction is made between off-chain and on-chain collateralization (*cf.* Section II-B).

Collateral Amount: In a *full collateralization* the coin issuer holds reserves that amount or surpass the market capitalization of the stablecoin. In a *partial collateralization* there is a risk that the coin issuer is not able to redeem all coin holders in case of a bank run. This lessens the trust of coin holders, negatively affecting the stability of the coin itself. For *uncollateralized* coins, the issuer may issue a fixed income instrument to compensate coin holders for their risk [8].

B. Stability Mechanisms

Although there is no consensus on a formal definition of stablecoins, they shall provide stability to a cryptocurrency through a different asset considered to be stable. Different stability mechanisms exist to achieve this goal [5]:

- **Off-chain Collateralized:** Value is pegged by traditional currencies or commodities, often requiring a trusted third party to control the collateral.
 - **Tokenized Funds:** Funds transferred by users in fiat currency are converted into the corresponding amount of tokens.
- **On-chain Collateralized:** Backed by a cryptocurrency or a set of cryptocurrencies in a decentralized manner, often in combination with mechanisms to decouple the stablecoin price from the collateral value.
- **Algorithmic Stablecoins:** Rely on a combination of algorithms and Smart Contracts (SC), being supported by users' expectation on future purchase of their assets.

Off-chain collateralized stablecoins offer the simplest design, often having a collateral of the pegged asset, supported by the arbitrage principle. For example, if the price of a USD pegged stablecoin drops below \$1, redemption is incentivized, since coin holders can trade something worth less than \$1, the stablecoin, against something worth \$1, namely the collateral. However, if the stablecoin's price rise above \$1, traders have an incentive to generate coins in turn for a collateral, thereby increasing the supply of coins and lowering the coin price. Many of the most widely used stablecoins are based on this design, for example Tether, USD Coin, and Paxos [7], [14].

Tokenized Funds is a subcategory of off-chain collateralized relying on a custodian maintaining users' funds and a coin issuer keeping a Smart Contract (SC). The SC determines the allocation of stablecoins and is maintained on a blockchain. Therefore, users must trust the entity backing the stablecoin.

On-chain collateralized stablecoins require no central party in the following process, which offers a design of stablecoins entirely on-chain. A cryptocurrency's collateral is deposited and supported by a SC and, in return, stablecoins are proportionally issued. When the stablecoins are redeemed, the SC unlocks the collateral.

An **Algorithmic Adjustment** of a stablecoin can be achieved through interest rates or by inflating/deflating balances proportionally to the price. However, continuously adjusted balances are not useful as a value store.

C. Examples of Active Stablecoins

Table I, whose data was obtained from Coinmarketcap [3] on May 15, 2020, presents the different stablecoins design variants based on [7], [14], [3]. Tether (USDT) is by far the most capitalized stablecoin and one of the earliest stablecoins, too. Its closest competitor is USD Coin (USDC), which uses the same stability mechanism, peg, and collateral. Currently, DAI is the leading on-chain collateralized stablecoin, but it is still far from its largest off-chain collateralized competitors. Another on-chain collateralized stablecoin is the Synthetix USD (sUSD), which plans to offer tokens with exposure to a wide range of asset classes, including stocks. Both coins are stabilized through leveraged loans [7].

Two examples of gold-pegged stablecoins are Paxos Gold (PAXG) and Digix Gold (DGX), in which PAXG is currently the most significant gold-collateralized stablecoin in terms of capitalization. For each of these coins in circulation there must exist a corresponding amount of gold held as collateral. The market share of these two stablecoins is relatively small.

Examples of uncollateralized stablecoins have similar market capitalizations ranging between \$5 M to \$50 M. They all differ by their stability mechanism: Ampleforth (AMPL) uses the algorithmic supply adjustment mechanism mentioned before. SteemDollar (SBD), which is one of the older stablecoins, uses interest rates to stabilize its value. Terra (LUNA) underlies a dual coin mechanism that also finds application in leveraged loans. Moreover, Terra does not offer an explicit peg, but still amasses a notable capitalization due to its support by Asian e-commerce companies [14].

TABLE I: Selection of Currently Active Stablecoins

Name	Ticker	Peg	Collateral	Stability Mechanism	Year of Launch	Market Cap [USD] (based on [3])
Tether	USDT	USD	Fiat	Off-chain collateralized	2014	\$8858 M
USD Coin	USDC	USD	Fiat	Off-chain collateralized	2018	\$726 M
DAI Stablecoin	DAI	USD	Crypto	On-chain collateralized	2017	\$110 M
sUSD Coin	sUSD	USD	Crypto	On-chain collateralized	2018	\$7 M
Ampleforth	AMPL	USD	None	Algorithmic Adjustment	2019	\$6 M
Steem Dollars	SBD	USD	None	Algorithmic Adjustment	2016	\$6 M
Paxos Gold	PAXG	Gold oz	Gold	Off-chain collateralized	2019	\$43 M
Digix Gold Token	DGX	Gold gram	Gold	Off-chain collateralized	2018	\$6 M
Terra Luna	LUNA	None	None	Dual coin	2019	\$34 M

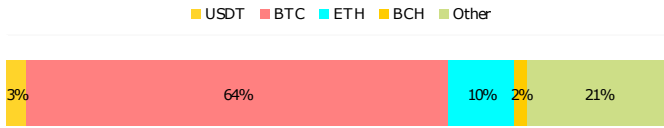


Fig. 1: Relative Market Share of Cryptocurrencies: Total Market Capitalization at \$218 Billion as of April 2020 [3]

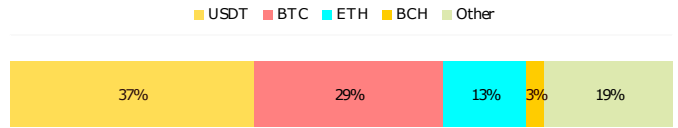


Fig. 2: Relative Trade Volume of Popular Cryptocurrencies: Avg. Daily Trade Volume at \$123 Billion as of April 2020 [3]

III. STABLECOINS AND FINANCIAL MARKETS

Based on data obtained from [3] the cryptocurrency market is introduced and general vulnerabilities of stablecoin systems and their market risks are discussed.

A. Current Cryptocurrency Market Share

The cryptocurrency market has reached a market capitalization of over \$200 Billion in April 2020 for which relative market shares of the largest cryptocurrencies are listed in Figure III-A. Bitcoin [1] accounts for roughly two thirds of the total cryptocurrency market capitalization as of 25th of April 2020. Since Bitcoin price changes frequently, the total capitalization of the market also varies accordingly. The second largest cryptocurrency is Ether [15] at approximately 10% share. With a share of roughly 3% Tether is by far the largest stablecoin. For remaining cryptocurrencies market shares are in the magnitude of Tether and Bitcoin Cash (BCH). It is estimated that the market capitalization of other (self-declared) stablecoins accounts for less than 1% of the total market capitalization, so less than 5% of other cryptocurrencies. Although Tether’s market capitalization is small, it is the cryptocurrency with the largest monthly trading volume as of April 2020. Bitcoin and Tether account for one third of the monthly cryptocurrency trading volume. One reason is that Tether is often used to liquidate speculative cryptocurrency positions, in particular in Bitcoin [16].

The average daily trade volume in the cryptocurrency market was \$123 Billion, which is more than half of the total market capitalization (*cf.* Figure 2). In particular, the daily trading volume of Tether was a multiple of its market capitalization, implying high liquidity. An exchange review from March 2020 [16] discloses the monthly volume traded from Bitcoin into fiat or stablecoins. In the last two years there has been a shift in how Bitcoin positions were liquidated. While in 2017 essentially all liquidations were trades against

fiat currencies, these kinds of trades accounted for only around 30% of the Bitcoin liquidation volume in 2019. In particular, by 2019 approximately two thirds of the Bitcoin liquidation volume was due to exchanges against Tether. This figure shows that USD Coin gained popularity since late 2019 as a means of Bitcoin liquidation. One reason for the rising popularity of stablecoins as a means to trade other cryptocurrencies is that on-chain transactions are faster than wire transactions.

B. General Vulnerabilities of Stablecoin Systems

Stablecoins are exposed to a variety of risks specific to their ecosystem, many common to other cryptocurrency investments. Three vulnerability types are distinguished [6]:

- 1) **Financial Vulnerability** involves market, credit, and liquidity risk, whereas the magnitude of these risks depends on the specific stablecoin. While off-chain collateralized stablecoins are exposed to traditional credit risks of the custodian, on-chain and uncollateralized stablecoins are not affected by this kind of risk. However, all stablecoin systems are vulnerable to market and liquidity risk.
- 2) **Infrastructural Vulnerability** is concerned with the distributed ledger network and also the custodian. As before, uncollateralized stablecoin designs do not rely on a custodian. However, stablecoin designs rely on a distributed ledger and around half of them are developed on the Ethereum network [13], [2]. Thus, many stablecoins depend on the availability and the validation speed of Ethereum, which becomes a systematic risk in case of many transactions.
- 3) **Service Application Vulnerability** regards applications used for holding and exchanging of stablecoins. For instance, there is the risk that service operators behave fraudulently by manipulating prices, committing theft, or are even affected by theft themselves.

Service application risks are not related to global economic events. However, economic crises may result in infrastructural stresses. In particular, an increased demand for liquidity results in an increased trading volume. This may significantly increase the network load, since transactions (trades) need to be verified; in particular, Proof-of-Work-based blockchains show the known limitation on the capacity to process transactions [17].

Certain arguments determine that a stablecoin can only sustain its value in the long-term, when it is fully non-collateralized and decentralized, thereby avoiding credit risk and vulnerabilities associated with the issuer or the custodian [10]. This suggests that stablecoins not following these principles are inherently unstable, in the sense that they cannot sustain their peg in the long-term. However, the analysis of market data performed in Section IV shows that this is not the case. Widely used stablecoins are without exception partially or fully collateralized, and centralized at a certain degree. This can be interpreted as a trustworthiness of these kinds of implementations, meaning that they are considered less vulnerable. Therefore, it is important to consider the relevance of market and liquidity risk rather than credit risk.

C. Market Risk of Stablecoins

1) *Volatility*: To assess stablecoins during the crisis period, a definition of volatility is necessary to assess their variation over a period of time. Let X_1, \dots, X_T be a discrete time series with T prices for a financial asset. Also, let $r_t := \ln X_t - \ln X_{t-1}$ with $1 < t \leq T$ be the *logarithmic returns* of the asset. The *mean* log-returns at time $t \leq T$ for a period of length $n \leq T$ is now defined as:

$$\mu_t := \frac{1}{n} \sum_{i=t-n+1}^t r_t. \quad (1)$$

Correspondingly, the time series *volatility* is defined as:

$$\sigma_t := \sqrt{\frac{1}{n-1} \sum_{i=t-n+1}^t (r_t - \mu_t)^2}. \quad (2)$$

Since (2) is not particularly suitable to display short-term changes in volatility, the estimator proposed by RiskMetrics [18] is used. It is recursively defined as the Exponentially Weighted Moving Average (EWMA) volatility:

$$\sigma_{t,\lambda} := \sqrt{(1-\lambda)r_{t-1}^2 + \lambda\sigma_{t-1,\lambda}^2}, \quad (3)$$

where r_t represent the log-returns and $\lambda := 0.94$ is an arbitrarily chosen decay factor. Moreover, $\sigma_{t,\lambda}$ is recursively defined for $t > t_0 := 30$. The initial value is set to $\sigma_{t_0,\lambda} := \sigma_{t_0}$, where σ_{t_0} is as in Equation (2) with $n = 30$ days. Thus, it is possible to obtain a volatility estimator that assigns a higher weight to recent events and decays exponentially in time.

2) *Stability*: To measure stability (or instability), a formal definition is needed to establish boundaries toward stability levels. Moreover, to evaluate the stability of stablecoin's mechanisms and not fluctuations of their pegged collateral (a stablecoin pegged to an other currency will automatically

be considered unstable due to fluctuations in the currency exchange rate), a Stablecoin Exchange (SX) rate is defined:

$$X_t := \frac{S_t}{P_t}, \quad (4)$$

where S_t denotes the value of the stablecoin and P_t denotes the value of its peg at a given time t . The definition of SX rates is an adaption of Foreign Exchange (FX) rates, which measure the exchange rate between two fiat currencies. However, the SX rate is not an exchange rate between two currencies, it defines the rate at which the stablecoin can be redeemed. For instance, if the SX rate falls below one unit (of pegged collateral), coin holders are incentivized to redeem, since they can liquidate the deposited collateral and profit.. To measure instability, the EWMA volatility estimator (3) is applied to the SX rate log-returns.

D. Stablecoin Data Set and Price Distributions

Data Sets used were obtained from [19] and consist of end-of-day prices, daily trade volume, and end-of-day market capitalization of the stablecoins Tether (USDT), USD Coin (USDC), Digix Gold (DGX), Paxos Gold (PAXG), DAI, and Synthetix USD (sUSD). The time period ranges from November 19, 2019 (when the multi-collateral version of DAI was released [20]) to May 1, 2020. This stablecoin sample set comprises three different collaterals (fiat, gold and cryptocurrency), two different pegs (USD and gold), and two different stability mechanisms (off-chain reserve and on-chain loans).

Price distribution. Classical stochastic calculus models suggest a log-normal distribution for asset prices, such as stocks and currencies [21]. Hence, the distribution of the SX rate defined is compared to this model. For a given stablecoin, let $r_t, t > 1$ be the log-return of the SX rate X_t at time $t > 1$. Then, one could assume that $r_t \sim \mathcal{N}(0, \sigma^2)$, where σ^2 is constant at all times. In this case, σ is estimated according to Equation (2) using all data points. Therefore, if stablecoin log-returns are distributed with a constant standard deviation, there are no extreme events, where the SX rate deviates significantly from 1. Moreover, due to symmetry and the centering at zero, it would then be equally probable for stablecoin returns to be positive or negative, which speaks for the stability mechanism.

A boxplot is used to analyze how stablecoins fit into this model (*cf.* Figure 3). Normally distributed values are symmetrical and one can calculate that only 0.7% of the data should be classified as outliers, which corresponds to one to two outliers. However, none of the selected stablecoins matches this second criterion, the closest being USDC with only three outliers. The high number of boxplot outliers indicates that their log return distributions have heavier tails than a normal distribution. Concerning the symmetry, none of the distributions is significantly skewed.

USDT and USDC are less volatile than the other four stablecoins. Although the box for USDT is slightly narrower than for USDC, the latter has fewer outliers and, therefore, narrower tails in the distribution. PAXG is less volatile than its competitor DGX, and DAI is less volatile than its competitor

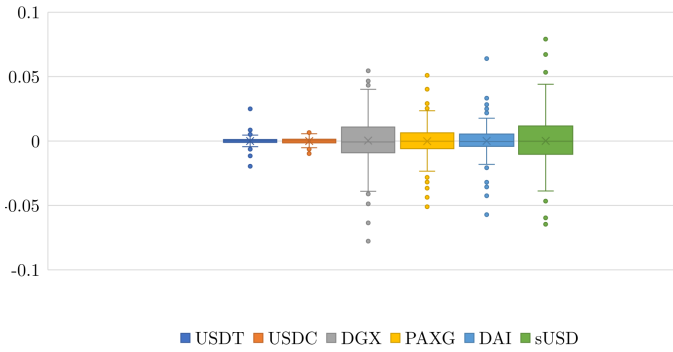


Fig. 3: Stablecoin Log-returns of Six Stablecoins: Prices from November 19, 2019 to May 1, 2020

sUSD for which not even all outlier values are displayed. A boxplot of Tether and DAI in comparison with other cryptocurrencies can be found in [12], in which the time series is different, but findings are in accordance with Figure 3.

IV. STABLECOIN PERFORMANCE DURING THE 2020 GLOBAL FINANCIAL CRISIS

Driven by the discussion of market performance during the start of the 2020 financial crisis, an analysis of market performance of stablecoins was performed with the particular attention to stablecoin’s volatility. Data on stablecoins analyzed was obtained from [19]. Economic key figures regarding financial market performance are published by various market data providers.

A. General Market Performance

Global financial market data showed a significant downturn in March 2020. Major stock indices from the US, Asia, and Europe dropped around 30% in mid March 2020, with some reporting historical daily losses on March 12, 2020 [22]. On one hand, with measures of nation-wide economic and social lockdowns taking effect due to the global COVID-19 pandemic, crude oil prices also dropped more than 50% in March 2020. On the other hand, gold, which had been on the rise for more than a year, also dropped more than 10%, but quickly recovered within a few days, thereby providing a store of value during this period of global economic distress. Starting in February 2020, exchange rates for major currency pairs such as USD/EUR showed significant increases in volatility.

Concerning the cryptocurrencies’ world, the two largest ones - Bitcoin and Ether - dropped around 50% of their price from beginning to mid March 2020, with losses of around 30% on March 12, 2020. Since then, both Bitcoin and Ether rallied to original levels from the beginning of February. The significant daily drop in mid March resulted in heavy strains on blockchain infrastructures and service applications, such as cryptocurrency exchanges [9]. For instance, the network congestion experienced by DAI holders was caused by an increased amount of collateral liquidations of the DAI due

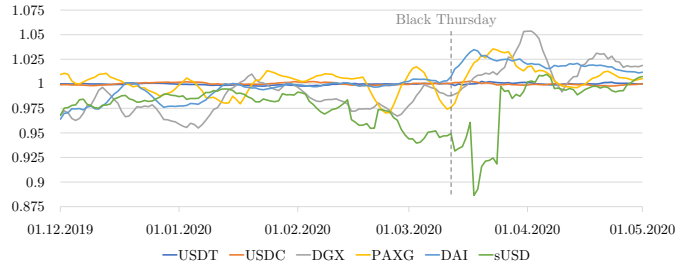


Fig. 4: 7-Day Mean of Six Stablecoin End-of-Day SX Rates: Before and During Financial Crisis in 2020

to the Ether price crash on March 12, 2020. Due to the on-chain loans stability mechanism deployed by DAI, there are automatic liquidations in case of large devaluations of the cryptocurrency collateral. The result of many liquidation actions was a failure of the liquidation system, with some liquidations being carried out at almost zero prices [23].

B. Stablecoins Market Performance

The performance is analyzed by considering the trade volume data and the EWMA volatility estimator applied to SX rate log-returns. The EWMA volatility of daily SX rate log-returns is considered due to similar models already used for other financial assets. Also, the analysis was shaped by the granularity and the range of the available data and in particular the used prices were one price per day.

To this end, end-of-day prices of the six stablecoins Tether, USD Coin, Paxos Gold, Digix Gold, DAI, and Synthetix USD are used. The following figures highlight March 12, 2020 as the “Black Thursday”, since it denotes the stock market crash during the COVID-19 pandemic.

1) *Stablecoins SX rates:* 7-day averages of SX rates are considered to smoothen the data. Concerning USDT’s and USDC’s SX rate 7-day averages, since they are within 1 ± 0.01 their peg is maintained within 1%. However, other stablecoins deviate from their peg by multiple percent points, sometimes for multiple months. DAI mostly traded below 1\$ before the market crash and above 1\$ afterwards. Gold-pegged stablecoins show a similar trend, but less pronounced. Concerning sUSD, its 7-day average SX rate was below 1 at all times before and during the market crash, with SX rates surprisingly close to 1 afterwards. So although SX rate log-returns seem to be symmetrically distributed around zero over the entire period, this is not the case for all coins, if distributions before and after the crash are considered separately.

2) *Trade Volume and Volatility:* To analyze changes in trading volume, daily trading volumes reported were normalized in two ways. Firstly, the 7-day trading volume was calculated to smoothen curves. Secondly, values were normalized by dividing 7-day volumes by individual stablecoins’ trading volume in the preceding week and including December 1, 2019. This starting points marks first news regarding COVID-19 [24], whose emergence into a pandemic and subsequent uncertainty around countermeasures arguably contributed significantly to the 2020 financial crisis.

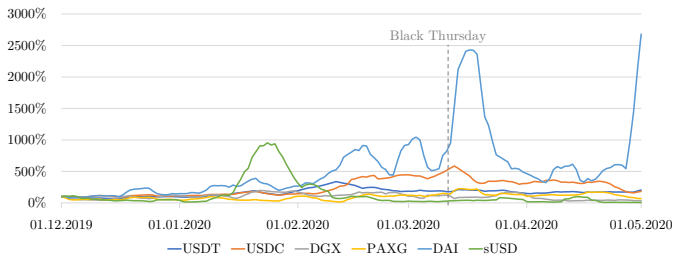


Fig. 5: Mean Weekly Trade Volume Relative to the Week of December 1, 2019

Throughout December and January, the 7-day trade volume did not increase more than three-fold for any stablecoin until mid January 2020. However, there exists a clear difference between the different groups of stablecoins. For USDT and USDC, the 7-day trade volume was constant throughout December before showing an increased volume in January and February throughout April. Until mid March, the USDC 7-day trading volume had increased more than five-fold compared to the volume in December, while the Tether trade volume showed a slight decrease starting mid February. Compared to the two previous examples, the PAXG and DGX trade volumes changed only moderately. The 7-day trade volume mostly varied between 50% and 200% of volumes from December, with no obvious trends. However, PAXG saw its highest daily trade volume one day after Black Thursday (around 10 times the normal daily trade volume), so during the financial market crash. For DGX such an increase was not observed.

In contrast to the four off-chain collateralized stablecoins in that sample, DAI and sUSD showed larger fluctuations in their daily trade volume. This is intuitive, since these two systems use on-chain loans as a stability mechanism, which results in automatic liquidations. The large amount of automatic liquidations for DAI are presented in Figure 5. In mid March, the 7-day DAI trade volume was around 10 to 20 times the level of December, with historical highs of a daily trade volume reported on the March 13 and 14, 2020. For sUSD a notable increase in trade volume was observed at the end of January, which was unrelated to global economic events, since other stablecoins did not present a similar behavior.

The findings of literature show that for the exchange of currency pairs, trade volume and volatility are correlated [25]. However, comparing Figures 5 and 6 indicate that this is not the case for all stablecoins.

In case of DAI, it can be assumed that the mass triggering automatic liquidations lead to instability in its price, hence increased the volatility. As for sUSD, prices dropped to around \$0.4 in a single day (*cf.* Figure 4), but this anomalous event did not seem to have a significant impact on the trade volume. Concerning Tether, there was a sharp increase in volatility during the financial market crash, but trade volume showed a tendency to decrease. One possible explanation is that since Tether mainly functions as a means of liquidating Bitcoin, the trade volume (which is measured in USD) decreased due to the

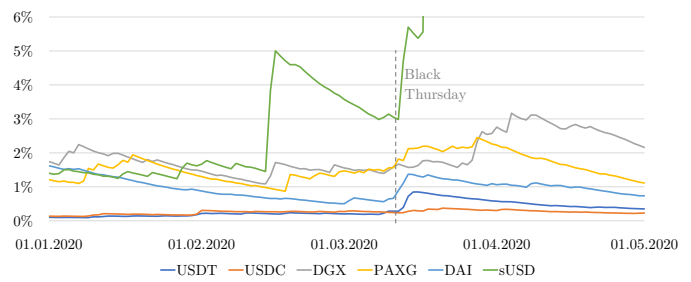


Fig. 6: SX Rate Daily Log-return EWMA Volatilities: Before and During 2020 Market Crash

significant decrease of the Bitcoin price. As far as USD Coin is concerned, a possible explanation is that the trade volume profited from an increase in popularity as a means of Bitcoin liquidation [16].

With the exception of USDC, which appears exceptionally stable at all times, the other three USD-pegged stablecoins showed a significant jump in volatility during the financial market crash. This holds for both Tether, which is off-chain collateralized, and DAI as well as sUSD, which is on-chain collateralized. On a relative scale, the increase in volatility is pronounced for Tether, which showed almost no volatility in the months foregoing the crash. On a relative and absolute scale, the price crash of sUSD is the most dramatic one, with EWMA volatility levels reaching almost 30% (*cf.* Figure 6, which is truncated at this point). During the financial crisis, the EWMA volatility of Tether behaved similarly to the one of DAI, in the sense there is one large spike at the same time period during the market crash and a convergence to previous levels after that.

As opposed to these three USD stablecoins, the gold stablecoins did not show such a pronounced volatility increase during the financial market crash. There existed moderate increases in volatility, which were attributed to the fact that the gold price volatility itself increased during the period, making it more difficult to keep track of its exact price. Thus, it is possible to conclude that gold collateralized stablecoins can also function as a reliable value store even in times of economic downturn, just like gold itself. Nonetheless, overall volatility levels of these two stablecoins are generally higher than those of the two USD collateralized stablecoins (USDT and USDC), which can be considered as the undisputed winners with respect to stability during the financial crisis.

3) *Market Capitalization*: Market capitalization is also considered to provide additional insights into stablecoin performance analysis. Figure 7 presents the market capitalization of selected stablecoin samples from February to April 2020 (data collected from [coingecko.com](https://www.coingecko.com) on 1st of May 2020). Data is normalized by expressing the market capitalizations as a percentage of the capitalization on February 1, 2020. Market capitalization figures from between December 2019 and January 2020 are intentionally excluded due to the migration of an earlier version of DAI (now called SAI) to the current version [20].

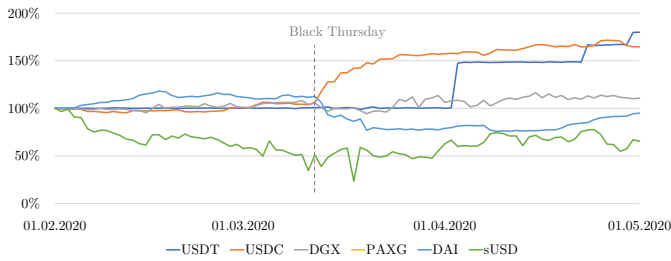


Fig. 7: Stablecoin Market Capitalization Relative to February 1, 2020

This migration from SAI to DAI resulted in an increase of the market capitalization of DAI from zero in mid November to over \$100 Million by the end of January, which does not deliver a major influence on the analysis. The market capitalization of other stablecoins are constant during this period except for sUSD, which shows the same downward trend as in February.

Market capitalization of both USDC and Tether increased by more than 60% by the end of April compared to the beginning of February. Both coins had relatively stable market capitalizations throughout February and March until the financial market crash. At that point, USDC experienced a surge in market capitalization of around 50% within one week. Tether followed up only about three weeks later. However, it is suspected that the unnatural looking kinks in the USDT market capitalization plot are artefacts of uncontrolled reporting mechanisms and that the USDT market capitalization plot in March and April should look similar to the one of USDC.

The DAI market capitalization fell by roughly 30% in the days during and following the financial market crash. This is following the large amount of automatic DAI liquidations mentioned earlier. The price drop and subsequent liquidations came with an increase in trade volume, followed by network congestion and collateral liquidations at near-zero prices. An overall decrease in market capitalization was observed also in sUSD.

A noticeable point is the fall of market capitalization on March 18, 2020, from approximately 60% to just around 25% relative to February 1, 2020. It is recalled that its price directly influences the market capitalization of a stablecoin. Knowing that on March 18, 2020, the sUSD price dropped from roughly \$1.0 to around \$0.4, this serves as the logical explanation for the short term decrease in sUSD market capitalization.

Lastly, DGX market capitalization was relatively constant throughout the entire period. More precisely, the DGX market capitalization fluctuated around $\pm 5\%$ in February and increased by roughly 10% in April 2020. This corresponds to the relative increase in the gold price during this period, so the number of DGX coins in circulation was stable. Data accessible at [3] shows that the PAXG market capitalization followed a pattern similar to DGX during the same period.

C. Discussion

The most stable stablecoins in terms of volatility and price stability were USDT and USDC. They also outperformed the other stablecoins in terms of growth, both increasing their market capitalization by more than 50% during the financial crisis. So these two stablecoins enjoyed the most trust by investors. This is in accordance with the view of [2] and [8] that trust in a stablecoin system depends on how well the stablecoin can maintain its peg. Of these two stablecoins, USDC performed better than Tether, which showed a spike in volatility. There is no obvious reason, why USDC maintained its peg within 1% on all days and Tether did not. It would be interesting to know, whether this still holds true, when intraday prices (in particular daily lows and highs) are considered also.

Comparing Tether to DAI, both stablecoins show an increased volatility during the market crash, with a rapprochement to lower levels afterwards. Like Tether, DAI did not crash. Thus, DAI was able to withstand the price crash that its collateral suffered. This robustness is also one of the findings in [12]. Indeed, instead of crashing, DAI rose and stayed a few percent above its peg in the first weeks of the financial crisis (*cf.* Figure 4), whereas Tether only shows fluctuations around its peg. Thus, the design of Tether and DAI worked similarly well for stabilizing SX rates, but not equally well for accurately maintaining their peg.

The behavior of the DAI is in contrast to the behavior of sUSD, which uses the same peg and stability mechanism. On the one hand, sUSD suffered a major price crash shortly after the financial market crash. On the other hand, sUSD prices recovered within a week and the stablecoin was able to maintain its peg in the weeks after the crash. Also, in contrast to DAI, the market crash did not result in a permanent loss of market capitalization for sUSD. In contrast to the USD-pegged stablecoins, the two gold-backed stablecoins appeared to be less affected by the market crash. They only showed a moderately increasing volatility in SX rate log-returns that could be attributed to an increased price volatility. Moreover, when accounting for the price increase in gold, it is found that the number of stablecoins in circulation was not affected by the market crisis. A positive aspect is that they rose in value during the market crisis. In contrast with their fiat-collateralized counterparts their SX rate volatility was higher at all times. The market capitalization of gold-backed stablecoins did not increase significantly although the increase in the gold price implies an increased demand for gold during that period.

Also, it is important to note that apart from sUSD, all of the observed stablecoins were traded at prices at or above their peg in the weeks following the financial market crash. This shows *a* an increased demand for stablecoins after the financial market crash and *b* that stablecoins are a valid option for cryptocurrency investors looking to secure their holdings. Lastly, due to the space limitation, an extended discussion of this paper was published as technical report in [26].

V. SUMMARY AND CONCLUSIONS

This paper analysed the stability of stablecoins based on a distinction of different types of stablecoins and on an overview of the stablecoin market landscape. A crucial step was the introduction of SX rates enabling the measurement of stablecoins' price volatility independently of their pegs. These measurement techniques and the understanding of stablecoin design variants were used to assess the performance of six stablecoins during the start of the 2020 financial crisis. *Major findings include* that the market performance during this period was individual and the respective reasons are due to different stablecoin designs. All in all, the USD pegged off-chain collateralized stablecoins in our sample performed best in terms of stability and popularity. These two stablecoins enjoyed the most trust by investors as their market capitalization each grew by over 50% in the first weeks during and after the financial market crash. At the time of analysis they were also the most largely capitalized stablecoins.

After the financial market crash, DAI users have voted on different measures to enhance stability of the stablecoin [23]. For instance, to allow Tether and USD Coin as a collateral for mining DAI [27]. Leveraged loans stablecoins profit from more stable collaterals, such as other stablecoins, in terms of stability. This vote could be considered a defeat for DAI: if one already owns Tether or USD Coin, it is not straightforwardly the reason one should use it to mine DAI. However, it is an example of what could be a trend to use multiple collaterals for a stablecoin instead of just one (both Tether and DAI have introduced additional collaterals over the time). The use of multiple collaterals helps to diversify risk and it also offers larger possibilities to users, who prefer to mine stablecoins, presumably at the cost of complicating the stability mechanism.

The analysis of stablecoins during the COVID-19 pandemic showed that the two largest capitalized and fiat collateralized stablecoins provided liquidity and stability during the crash of the cryptocurrency market in 2020. As a major finding in this research, it is possible to state that on-chain stablecoins displayed many flaws during the crisis, providing insight that the on-chain collateral design will not win a larger market share. Hence, there is a potential for future developments following the approach of tokenized funds. In particular, there is potential for implementations of government-backed cryptocurrencies in the form of digital fiat money for large economies. The US federal reserve has recently mentioned researching this opportunity [28]. Should such a government-backed digital fiat currency ever be launched, this will change clearly the stablecoin market landscape.

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REFERENCES

- [1] S. Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System," 2008. [Online]: <https://bitcoin.org/bitcoin.pdf>
- [2] John Shipman, George Samman, "Stable Coin evolution and market trends," *PwC's market analysis*, 2018.
- [3] CoinMarketCap, "Cryptocurrency Market Capitalizations - CoinMarket-Cap," 2020, <https://bit.ly/3gGmPnB>.
- [4] G7 Working Group on Stablecoins, "Investigating the Impact of Global Stablecoins," *Bank for International Settlements, Committee on Payments and Market Infrastructures*, 2019.
- [5] European Central Bank, "Stablecoins - No Coins, but are they Stable?" *European Central Bank - In Focus*, Vol. 230, 2019.
- [6] Financial Stability Board, "Addressing the Regulatory, Supervisory and Oversight Challenges Raised by "Global Stablecoin" Arrangements: Consultative document," 2020, <https://bit.ly/2DcxKYz>.
- [7] Amani Moin and Emin Gün Sirer and Kevin Sekniqi, "A Classification Framework for Stablecoin Designs," <https://arxiv.org/pdf/1910.10098>, 2019.
- [8] Chohan, Usman W., "Are Stable Coins Stable?" *Notes on the 21st Century (CBRI), UNSW Business School, Critical Blockchain Research Initiative (CBRI) (March 29, 2020)*, 2019.
- [9] Ariah Klages-Mundt and Andreea Minca, "While Stability Lasts: A Stochastic Model of Stablecoins," <https://arxiv.org/abs/2004.01304>, 2020.
- [10] Makiko Mita, Kensuke Ito, Shohei Ohsawa, Hideyuki Tanaka, "What is Stablecoin? A Survey on Price Stabilization Mechanisms for Decentralized Payment Systems," <https://arxiv.org/abs/1906.06037>, 2019.
- [11] William Gee, Henri Arslanian, Duncan Fitzgerald, Chun Yin Cheung, Daniel Wang, Jay Zhou, Matthew Finestone, Terrence Lam, "Emergence of Stable Value Coins and A Trust Framework For Fiat-Backed Versions," 2019, <https://bit.ly/3jGW4BJ>.
- [12] Dirk Bullmann, Jonas Klemm, Andrea Pinna, "In Search for Stability in Crypto-assets: Are Stablecoins the Solution?" *European Central Bank - Occasional Paper Series*, Vol. 230, 2019.
- [13] blockdata.tech, "An Overview of the Current State of Stablecoins," 2019, <https://bit.ly/32JHous>.
- [14] Blockchain, "The State Of Stablecoins," 2019, <https://bit.ly/32ImCLE>.
- [15] G. Wood, "Ethereum: A Secure Decentralised Generalised Transaction Ledger," *Ethereum Project Yellow Paper*, Vol. 151, pp. pp. 1–32, 2014.
- [16] Cryptocompare, "March 2020 Exchange Review," 2020, data.cryptocompare.com/reports/exchange-review-march-2020.
- [17] Shehar Bano, Alberto Sonnino, Mustafa Al-Bassam, Sarah Azouvi, Patrick McCorry, Sarah Meiklejohn, George Danezis, "SoK: Consensus in the Age of Blockchains," *Proceedings of the 1st ACM Conference on Advances in Financial Technologies*, 2017.
- [18] M. S. Jacques Longestae, *RiskMetrics - Technical Document, Fourth Edition*. J.P.Morgan/Reuters, 1996.
- [19] CoinGecko, "CoinGecko: Cryptocurrency Prices & Market Capitalization," 2020, <https://bit.ly/2YO03nT>, last visit June 18, 2020.
- [20] DeFi Pulse, "What is SAI? Where is my DAI? Migrating to Multi-Collateral Dai," <https://bit.ly/2EyzFHT>.
- [21] M. Baxter and A. Rennie, *Financial Calculus: An Introduction to Derivative Pricing*. Cambridge University Press, 1996.
- [22] Fred Imbert, Thomas Franck, "Dow Plunges 10% Amid Coronavirus Fears for Its Worst Day Since the 1987 Market Crash," <https://cnb.cx/2G6l46E>.
- [23] MakerDAO, "Black Thursday Response Thread," <https://bit.ly/2YRbGKC>.
- [24] Callaway, Ewen and Cyranoski, David and Mallapaty, Smriti and Stoye, Emma and Tollefson, Jeff, "The Coronavirus Pandemic in Five Powerful Charts," *Nature*, Vol. 579, 03 2020.
- [25] Ulrich A. Müller, Michel M. Dacorogna, Richard B. Olsen, Olivier V. Pictet, Matthias Schwarz, Claude Morgeneegg, "Statistical Study of Foreign Exchange Rates, Empirical Evidence of a Price Change Scaling Law, and Intraday Analysis," *Journal of Banking & Finance, Volume 14, Issue 6*, 1990.
- [26] C. Jeger, "Analysis of Stablecoins during the 2020 Global Financial Crisis," Technical Report, Zürich, Switzerland, Tech. Rep., jun 2020. [Online]: <https://bit.ly/32EOHnk>
- [27] MakerDAO, "TUSD and USDC-B Approved by Maker Governance as Collateral Types in the Maker Protocol," <https://bit.ly/2GgCOMZ>.
- [28] Lael Brainard, "The Digitalization of Payments and Currency: Some Issues for Consideration," *Board of Governors of the Federal Reserve System, Symposium on the Future of Payments*, 5 February 2020.