Are the stabilities of stablecoins connected?

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Abstract

This study analyzes the interconnection of the stability of prominent stablecoins including Tether (USDT), USD Coin (USDC), Paxos Standard (PAX), TrueUSD (TUSD) and DAI from 23/11/2019 to 1/04/2021. We find (i) market price fluctuations vary across stablecoins, (ii) instabilities in USDT and USDC significantly drive those of other stablecoins but less convincing evidence for the reverse impact, and (iii) that increases (decreases) in USDT market prices significantly depress (raise) the market prices of the other stablecoins. Interestingly, the algorithmic stablecoin, DAI, is found to be less stable than its USD-backed counterparts.

Keywords Cryptocurrency · Stablecoin · Vector Autoregression

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1 Introduction

Cryptocurrencies have attracted a lot of attention from academia in the last years with a large part of the literature focusing on the return and volatility of cryptocurrencies (e.g., Dyhrberg, 2016; Demir et al., 2018; Nguyen et al., 2019 and Nguyen et al., 2019). Other works investigate Bitcoin's suitability to act as money and most studies point out that Bitcoin has not been primarily used as a medium of exchange. Baur et al. (2018) find a small proportion of users who treat Bitcoin as a medium of exchange and conclude that investors and a large percentage of users consider Bitcoin as a speculative investment instead of an alternative currency or a medium of exchange. According to Beigel (2020), Bitcoin is not universally accepted as a medium of exchange although several multinational corporations accept Bitcoin payments. In addition, de la Horra, de la Fuente and Perote (2020) and Hazlett and Luther (2019) show that Bitcoin transactions only take up a negligible proportion of all global transactions (including cash and non-cash) and Bitcoin is only used as a medium of exchange in a relatively small domain. The biggest problem with Bitcoin or most cryptocurrencies lies in their high volatility due to the inability to place a correct valuation (Smales, 2019). If goods and services are priced in Bitcoin, businesses would incur high price-changing costs due to the high volatility of Bitcoin (de la Horra et al., 2020). This highly volatile nature of most cryptocurrencies might result in the fluctuation of purchasing power relative to the supply and prices of goods denominated in other currencies. Given the high volatility of cryptocurrencies, stablecoins have been introduced to the market and are expected to have stable value as they are pegged to another asset (Allen et al., 2021).

Given the exponential rise of the cryptocurrency market, a new strand of literature has investigated the role of stablecoins in the cryptocurrency market. Baur and Hoang (2020), for instance, indicate that Bitcoin investors use stablecoins when Bitcoin exhibits an extreme negative decrease in price and their results show that stablecoins might not live up to their name and fail to fulfil their initial purposes (i.e. being a stable cryptocurrency) because they provide a strong crypto safe haven against Bitcoin. Similarly, Bullmann et al. (2019) find a trade-off between the innovations of the stabilization mechanism of a stablecoin and its ability to maintain a stable market value. Regardless of the potential importance of stability in the cryptocurrency market, a few studies have examined if stablecoins are truly stable. With the regard to the stability of stablecoins, Hoang and Baur (2020) identify Bitcoin as a source of excess volatility in stablecoins and also provide evidence that stablecoins contribute to the excess volatility of Bitcoin. In addition, Grobys (2021) find the spillover effects of Bitcoin volatility on stablecoins. We extend the scope of the studies of Hoang and Baur (2020) and Grobys (2021) and ask if there exists a volatility spillover among stablecoins. The connectedness in the cryptocurrency market has been extensively studied for traditional cryptocurrencies, but not for stablecoins, so our study attempts to fill this gap. The literature on the correlation among traditional cryptocurrencies largely agrees that Bitcoin is the center of the connectedness. For example, Moratis (2021) examines the pairwise directional spillover shocks for the 30 largest cryptocurrencies (including 1 stablecoin) and finds that Bitcoin dominates others in the risk transmission process. In addition, by investigating the tail-risk interdependence

among 23 cryptocurrencies, Xu et al. (2021) document the increasing connectedness of traditional cryptocurrencies and point out Bitcoin as the largest systemic risk receiver. By examining the return connectedness of seven largest traditional cryptocurrencies, Bouri et al. (2021) find that connectedness measures are higher in the left and right tails than those in the mean and median, indicating that return shock spillover is more intense during extreme events. Ferreira et al. (2020) examine the serial correlation structure of six traditional cryptocurrencies and document that the serial correlations become insignificant during the first 30 days, indicating the relatively faster decay compared to stock indices. These previous studies focus only on traditional cryptocurrencies, the volatility spillover among stablecoins remains unexplained in the literature.

Considering the increasing adoption of stablecoins by the market participants, it is crucial to expand the knowledge of stablecoins as most studies only analyze the stablecoins' reaction to extreme movement in non-stable coins' price movement or the interaction between stablecoins and Bitcoin while neglecting the interconnection of the stability of stablecoins themselves. The current study seeks to contribute to the literature by analyzing the relationship of the stabilities of the largest five stablecoins. In this regard, we argue that signaling theory plays a significant role in explaining the interrelation between stablecoins. As cryptocurrency market and stablecoins are in their early stage of development, the tech-savvy in this market may create information asymmetry to investors for their trading decisions. This is in line with the arguments from Philippi et al. (2021) that the technological nature of Initial Coin Offerings (ICOs) is the source of information asymmetry, and hence, publishing a source code is an effective signal vehicle for ICO fundraising success. In the context of stablecoins, we argue that the price movement of large-cap stablecoins can be interpreted as signals on trading opportunities for smaller-cap stablecoins by investors. Therefore, large-cap stablecoins tend to drive smaller ones. The findings are expected to show how larger stablecoin price changes influence the prices of lower market cap stable coins because stablecoins users can easily switch between different types of stablecoins in the cryptocurrency market.

The rest of the paper is organized as follows. Section 2 describes the data and the econometric model; Sect. 3 presents the estimation results and Sect. 4 concludes the paper.

2 Data and econometric model

We use a sample of five largest stablecoins in terms of market capitalization including Tether (USDT), USD Coin (USDC), Paxos Standard (PAX), TrueUSD (TUSD) and Multi Collateral DAI (DAI) from 23/11/2019 to 1/04/2021. The stablecoins have the nominal value of \$1 and the daily data are fetched from coinmarketcap.com. We select this sample period due to the data availability whereby Multi Collateral DAI is only available from 23/11/2019. According to Coinmarketcap, the price of any cryptoassets is a volume-weighted average of market pair prices in several exchanges such as Binance or Huobi. DAI is the only algorithmic stablecoin in our sample that is created through users using Ether and other Ethereum-based cryptocurrencies as

collateral to effectively borrow DAI, whereas the other stablecoins are backed by USD. The cryptocurrency market has several distinct features compared to the traditional financial market. Cryptocurrencies are traded 24/7 and the crypto exchanges are effectively never closed. There are cryptocurrency exchanges in almost every country in the world allowing investors to invest with any fiat currency. Those features make the cryptocurrency market a global market and allow traders to react to new information rapidly.

We use the two following measures of the stability of stablecoins:

- *Measure (1)*: The deviation of the stablecoin's market price from its nominal value.

$$M1_i_t = ClosePrice_t - 1 \quad (1)$$

where $ClosePrice_t$ denotes the end of the day price of the respective stablecoin i on day t , respectively. *Measure (1)* captures how close the market prices of the stablecoins stick to their nominal values; the closer to zero, the better the stablecoin's behavior sticking to its nominal value. A positive (negative) *Measure (1)* means that investors have paid a higher (lower) price for the stablecoin than its nominal value. An increase in this *Measure (1)* means that the market price of stablecoin is increasing.

- *Measure (2)*: The realized volatility measure inspired by Parkinson (1980) High-Low measure and utilized by Bollen and Inder (2002).

$$M2_i_t = \sqrt{\frac{(\ln High_t - \ln Low_t)^2}{4 \ln 2}}, \quad (2)$$

where High and Low denote the highest and lowest price for cryptocurrency i on day t , respectively.

Fig. 1 Stability *Measure (1)* of the stablecoins over time, 23/11/2019–1/04/2021

Figure 1 displays *Measure (1)*, the deviation of stablecoins market prices from their nominal values, and Fig. 2 illustrates *Measure (2)*, the realized volatility measure of the stablecoins over the sample period. Although the market prices of stablecoins are moderately stable and exhibit mean-reverting processes, there are numerous episodes associated with great deviations from the nominal price and high market price volatility. For example, the highly volatile market prices of stablecoins can be observed around March 2020.

Table 1 captures the descriptive statistics of those two measures of stablecoin market price stability. The widest range of *Measure (1)* can be observed for DAI with market prices exceeding and undershooting the nominal price by up to \$0.09 (or 9%¹) and \$0.035 (or 3.5%), respectively, translating to a range of \$0.125 or 12.5%. The volatility DAI's *Measure (1)* is with \$0.0107 (or 1.07%) the highest among all stablecoins. Moreover, the algorithmic stablecoin DAI also displays the highest average *Measure (2)* suggesting that its value is overall less stable compared to its USD-backed counterparts. This could be interpreted as higher (perceived) risk of DAI compared to the USD-backed stablecoins, since DAI is algorithmically backed by Ethereum and Ethereum-based cryptocurrencies which are more volatile in value than USD. Interestingly, the Ethereum-based USDC has been increasingly used as collateral to mint DAI in recent times even surpassing the amount of Ethereum that is being used as collateral to create DAI at times. Moreover, the deviation of the market price of a stablecoin from its nominal value could reflect the excess or under demand for the respective stablecoin compared to its supply. Particularly, a deviation to the downside of the market price could reflect a lower degree of trust to the sufficient backing of the stablecoin (e.g., Griffin and Shams (2020) find that USDT may not being adequately backed by USD). Table 2 shows the average market capitalization and daily trading volume for the cryptocurrencies in our sample. While the market

Fig. 2 Stability *Measure (2)* of the stablecoins over time, 23/11/2019–01/04/2021

¹ \$0.09 deviation translates to 9% deviation, since the nominal price of DAI (and all other Stablecoins in the paper) is \$1.

Table 1 Descriptive statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
BTC	496	0.017307	0.014836	0.003001	0.176525
M1_USDT	496	0.000702	0.004368	-0.0258	0.05
M1_USDC	496	0.001462	0.00644	-0.0299	0.04
M1_PAX	496	0.000395	0.004725	-0.0292	0.05
M1_TUSD	496	0.000341	0.004186	-0.0291	0.04
M1_DAI	496	0.005683	0.010775	-0.0352	0.09
M2_USDT	496	0.004255	0.005437	0	0.065959
M2_USDC	496	0.003611	0.004750	0	0.047501
M2_PAX	496	0.004685	0.004995	0	0.073472
M2_TUSD	496	0.003965	0.005107	0	0.055301
M2_DAI	496	0.006084	0.006488	0	0.05414

The table shows the descriptive statistics of the stability *Measure (1)* and *Measure (2)*, 23/12/2019–01/04/2021

price of the various stablecoins are often not exactly \$1, substantial deviations from the nominal values can be observed for limited time periods only.

Table 3 shows the correlation coefficients of the stability measures of the stablecoins. Interestingly, M1_USDT is negatively correlated with all other stablecoins' *Measure (1)* whereas the correlation turns positive in the other stablecoins, indicating that the other stablecoins might potentially act as substitutes for USDT. All correlations of the stability *Measure (2)* are statistically significant and positive, suggesting that the market price volatilities of the stablecoins are mainly positively related.

To further analyze the dynamic relationship of the stablecoin stability *Measure (1)* and *Measure (2)*, we utilize a Vector Autoregression (VAR) model to estimate the impulse responses of each stablecoin's stability measure to shocks in the other stablecoins. A representation of the VAR(p) is

$$Y_t = \sum_{i=1}^p A_i Y_{t-i} + \epsilon_t(1) \quad (3)$$

where A contains the coefficient matrix, ϵ_t is the vector of errors and Y_t is the vector containing all endogenous variables including *Measure (2)* of Bitcoin and the measures of stability of the stablecoins. Y_t can be represented as follows.

Table 2 Average trading volume and market capitalization

Variable	Average 24-hour Trading Volume (in USD)	Average Market Capitalization (in USD)	Obs
Bitcoin	38,465 Million	317,074 Million	496
Tether	54,935 Million	13,813 Million	496
USD Coin	759 Million	2421 Million	496
True USD	263 Million	237 Million	496
Paxos Standard	289 Million	290 Million	496
Single_Collateral DAI	112 Million	687 Million	496

The table shows the average 24-hour trading volume and the average market capitalization of the stablecoins, 23/11/2019–01/04/2021

Table 3 Correlations of stability *Measure (1)* and *Measure (2)*

	USDT			USDC			TUSD			PAX			DAI		
	Measure 1	Measure 2	Measure 1	Measure 2	Measure 1	Measure 2	Measure 1	Measure 2	Measure 1	Measure 2	Measure 1	Measure 2	Measure 1	Measure 2	Measure 1
USDT	1.0000	1.0000													
USDC	-0.2343***	0.8081***	1.0000	1.0000											
	0.0000	0.0000													
TUSD	-0.313***	0.8617***	0.7019***	0.8431***	1.0000	1.0000									
	0.0000	0.0000	0.0000	0.0000											
PAX	-0.3965***	0.8411***	0.7000***	0.7913***	0.8407***	0.8784***	1.0000	1.0000							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000									
DAI	-0.1247***	0.6867***	0.0885**	0.7104***	0.0611	0.6833***	0.0645	0.5939***	1.0000	1.0000					
	0.0054	0.0000	0.0489	0.0000	0.1743	0.0000	0.1517	0.0000							

The table shows the correlation matrix of the stability *Measure (1)* and *Measure (2)* of the stablecoins, 23/11/2019–1/04/2021. *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level

$$\begin{pmatrix} \text{BitcoinMeasure}(2)_t \\ \text{Tetherstabilitymeasure}_t \\ \text{USDCoinstabilitymeasure}_t \\ \text{TrueUSDstabilitymeasure}_t \\ \text{PaxosStandardstabilitymeasure}_t \\ \text{DAIstabilitymeasure}_t \end{pmatrix} \quad (4)$$

We estimate Eq. (3) for *Measure (1)* and *Measure (2)* separately. We include the realized volatility *Measure (2)* of Bitcoin price to test whether Bitcoin price volatility also affects the stability of the stablecoins. We select the optimal lag length based on the recommendation of the AIC, SC, HQ criteria and sequential modified LR test statistic to use five lags. Note that the stability measures for all stablecoins are found to be stationary².

3 Estimation results and discussion

Figure 3 shows the impulse responses of the stability *Measure (1)* of the stablecoins to shocks in stability *Measure (1)* of all cryptocurrencies. An increase in USDT significantly decreases all other stablecoins and further suggests that the smaller-cap stablecoins are used as substitutes for Tether. Interestingly, an increase (decrease) in USDC (the second-largest stablecoin in terms of market capitalization) also significantly increases (decreases) all other smaller-cap stablecoins including PAX, TUSD and DAI, suggesting that if the market price of USDC goes up, the market price for PAX, TUSD and DAI increases as well. We find less statistically significant evidence to prove that *Measure (1)* of the smaller-cap stablecoins drive those of the larger-cap stablecoins such as USDT and USD Coin. Moreover, an increase in Bitcoin *Measure*

Fig. 3 VAR impulse responses of the stablecoin stability *Measure (1)*—The deviation of the market price from the nominal price \$1, 23/11/2019–1/4/2021

² Data is available upon request.

(2) raises the price of USDT which indicates that there may be a higher demand for USDT when the Bitcoin price is volatile.

Figure 4 shows the VAR impulse response estimations for the stability *Measure (2)* to shocks in the stability *Measure (2)* of all cryptocurrencies. An increase in USDT market price volatility significantly raises the market price volatility of the remaining stablecoins, whereas the reverse effects are mostly not significant. Similarly, the USD Coin market price volatility significantly drives the market price volatility of the smaller market-cap coins, such as TUSD, PAX and DAI. We find less statistically significant evidence for the small-cap coins affecting the large-cap cryptocurrencies. The findings further suggest that when the USDT price fluctuates, investors allocate their capital to smaller capitalization stablecoins. These results support our arguments the price movement of large-cap stablecoins can send some signals to investors on trading opportunities for small-cap stablecoins.

Furthermore, an increase in the Bitcoin price volatility leads to a surge in *Measure (2)* of all stablecoins, indicating that Bitcoin price volatility is an important driver of stablecoin price volatilities. This finding is consistent with those of Lyons and Viswanath-Natraj (2020) who find USDT is traded at a premium when there is an increased risk in cryptocurrency markets. For robustness check, we estimate various specifications of Structural Vector Autoregression Models (SVAR) to impose different order restrictions on the contemporaneous relationships of the stablecoins, employ different lag lengths in the VAR and SVAR estimation, and find consistent results.

4 Conclusions

This study sheds light on the stability of the five largest stablecoins in terms of market capitalization and their interconnection. Besides the counterparty risk of privately issued stablecoins as pointed out by Griffin and Shams (2020), any instability of stablecoins can be a significant obstacle for users who want to use a digital cryptocurrency-version of the US dollar to settle transactions. We find occasional periods

Fig. 4 VAR impulse responses of the stablecoin stability *Measure (2)*—The realized volatility of the stablecoin market price, 23/12,019–1/04/2021

in which the market prices of stablecoins substantially deviate from their nominal values that question the level of the self-acclaimed stability feature of the stablecoins in those periods. A Central Bank Digital Currency that is issued directly by the central banks could potentially eliminate those issues and provide a stable medium of exchange for settling transactions as discussed by Eichengreen (2019) and Hairudin et al. (2020). Our results also show that algorithmic stablecoins perform worse compared to privately issued stablecoins.

In addition, the study reveals strong interconnections of the stability of the stablecoins, with USDT and USD Coin driving the stability of their low-cap counterparts, but less statistically significant evidence for the reverse impact. This finding provides an interesting fact that higher market-cap stablecoins drive the smaller market-cap counterparts. Due to the limited number of stablecoins included in this study, this observation should be interpreted with caution, and future research should extend the sample with a significant number of coins for statistical validation. The findings also suggest that users could easily substitute stablecoins when they have the same nominal value, particularly, if the market price of a stablecoin is higher than its nominal price. The estimation results also suggest that USDC, TUSD, PAX and Dai are used as substitutes for USDT.

Authors contributions BNT is the lead author and has developed the idea of the study as well as has drafted the work. TNVH has substantively revised the paper. HP has provided the literature review and has reshaped the paper. TNC has collected and analyzed the data. TPTA has visually depicted and interpreted the data.

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Availability of data and materials The cryptocurrency data are collected from <https://coinmarketcap.com/>.

Declarations

Conflict of interest The authors declare that they have no competing interests.

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