WORKING paper

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EUROSYSTÈME

Stablecoins and the Financing of the Real Economy*

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Abstract

Stablecoins are crypto-assets that aim to maintain a stable value relative to a fiat currency. This paper documents one implication of their massive growth since 2020 for the financing of the real economy. The largest stablecoins manage their peg with the US dollar by holding short-term safe assets. We identify changes in the stablecoin demand for US dollar-denominated commercial papers (CP) by exploiting cross-sectional and time-varying heterogeneity in the main stablecoins' reserve assets policy. We show that CP issuers catered to the additional demand from stablecoins by issuing more, illustrating the implications of stablecoins for financial stability and the financing of the real economy.

Keywords: Crypto-Assets, Stablecoins, Financial Markets, Safe Assets

JEL classification: G14, G23, G29

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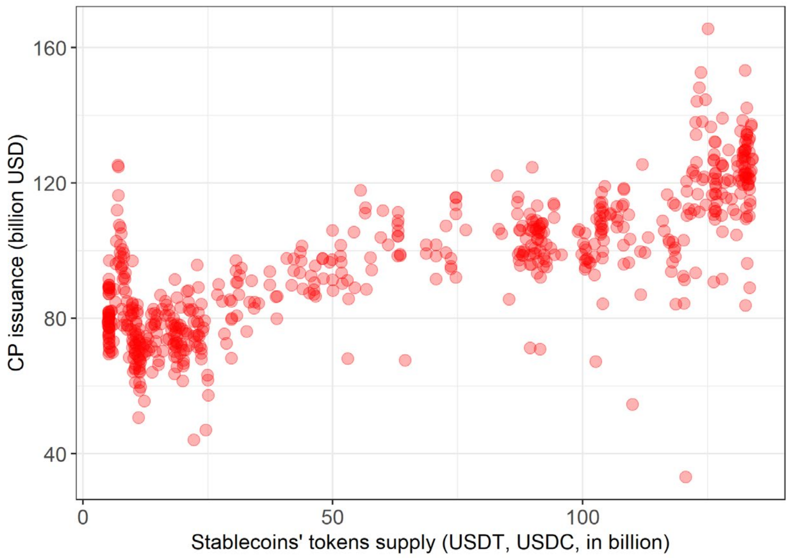
NON-TECHNICAL SUMMARY

The rapid development of crypto-assets raises questions about their potential interactions with the economy. Stablecoins, a specific category of crypto-assets, are designed to minimize their fluctuations against a fiat currency, usually the US dollar. Since 2020, their market capitalization has soared by around $150 bn. The largest stablecoins available today hold reserve assets – short-term debt denominated in US dollars -- to maintain their peg. In this paper, we investigate how this pegging mechanism creates interconnections between the crypto-asset sphere and conventional financial markets. We study how changes in stablecoins' issuers policies, regarding which assets are used as reserves, affect the markets for these assets. Specifically, we investigate whether the US commercial paper market was affected by the issuance of stablecoins when these securities were used as backing by stablecoins.

We first track the issuance of stablecoins on publicly available blockchain data and construct a dataset of daily change in the amount of stablecoin tokens in circulation, ie. tokens that need to be backed by reserve assets. We study the empirical link between stablecoin circulating tokens and the issuance of USD-denominated commercial paper (CP) by non-financial or financial corporates (Certificates of Deposits in the latter's case). Through several empirical strategies, we show that stablecoins have caused more issuance of CP while there were used as reserve assets for stablecoins, both statistically and economically significant, confirming the correlation in the figure below. These results suggest that the issuers of CP, notably US companies and US financial institutions, react to the increasing demand for stablecoins by issuing more CP, with no impact on CP rates. Thus, the development of crypto-assets indirectly affects the financing of the real economy.

Figure: Issuance of Commercial Papers and stablecoins' circulating tokens



Note: The x-axis stands for tokens issued by Tether and Circle in circulation and y-axis stands for the total issuance of CPs of any maturity, rating and issuer type, denominated in US dollars. Both series are expressed in billion and each dot relates to a working day from Jan 2019 to end-June 2022. ***Source***: Federal Reserve Board, Messari.

We confirm the causal interpretation of our results by exploiting the fact that reserve asset policies vary across stablecoins and over time. First, we find the relationship disappears when stablecoins stopped using CP as a reserve asset. Second, stablecoins not backed by US commercial paper did not affect the US market for CP. These results confirm that the relationship between stablecoins and CP market is effectively due to the purchase of CP by stablecoin issuers.

More generally, our paper highlights how markets react to the emergence of a new instrument with intended money-like properties and the subsequent increase in demand for reserve assets. Our results thus contribute to the ongoing debate on digital currencies and finance: the issuance of central bank digital currency (CBDC) as well as stablecoin regulation are likely to affect the demand for different categories of assets and hence the financing of the real economy even in normal times. The connection we document between the CP market and stablecoins might shift to other market segments, depending on stablecoin and CBDC developments.

Les stablecoins et le financement de l'économie réelle

RÉSUMÉ

Nous étudions l'impact du développement des stablecoins, ces crypto-actifs spécifiques qui cherchent à stabiliser leur valeur par rapport à une monnaie ayant cours légal et dont l'encours a significativement augmenté depuis 2020, sur le financement de l'économie réelle et des entreprises. Les principaux émetteurs de stablecoins cherchent à assurer une parité vis-à-vis du Dollar en détenant des actifs sûrs, tels des bons du Trésor américain, des titres de créances négociables ou des dépôts bancaires. En tirant partie de l'hétérogénéité dans les actifs de réserves des principaux émetteurs de stablecoins, au cours du temps et entre émetteurs, nous montrons que la variation du montant de stablecoins en circulation a contribué à l'augmentation des émissions de titres de créances négociables aux États-Unis, ce qui illustre les implications des stablecoins pour la stabilité financière et le financement de l'économie réelle.

Mots-clés : crypto-actifs, *stablecoins*, financement de marché, actifs sûrs

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1 Introduction

The rapid development of crypto-assets raises questions about their potential interactions with the economy. In this paper, we document the existence of a connection between crypto-assets, financial markets, and the real economy via the balance sheets of stablecoins – a kind of crypto-assets designed to minimize their fluctuations against a fiat currency. While extreme episodes of runs and crashes in crypto markets have received the most attention, we show that stablecoins also establish a bridge between crypto markets and the real economy in normal times.

The market capitalization of stablecoins has soared from 5 billion in 2020 to almost 200 billion US dollars in just two years. The three largest stablecoin tokens – Tether (USDT), USD Coin (USDC), and Binance USD (BUSD) – are all purported to be redeemable one-for-one for U.S. dollars by their issuers. To maintain their peg, tokens are primarily backed by traditional short-term safe assets held in reserves, such as U.S. Treasuries, bank deposits, or commercial papers.

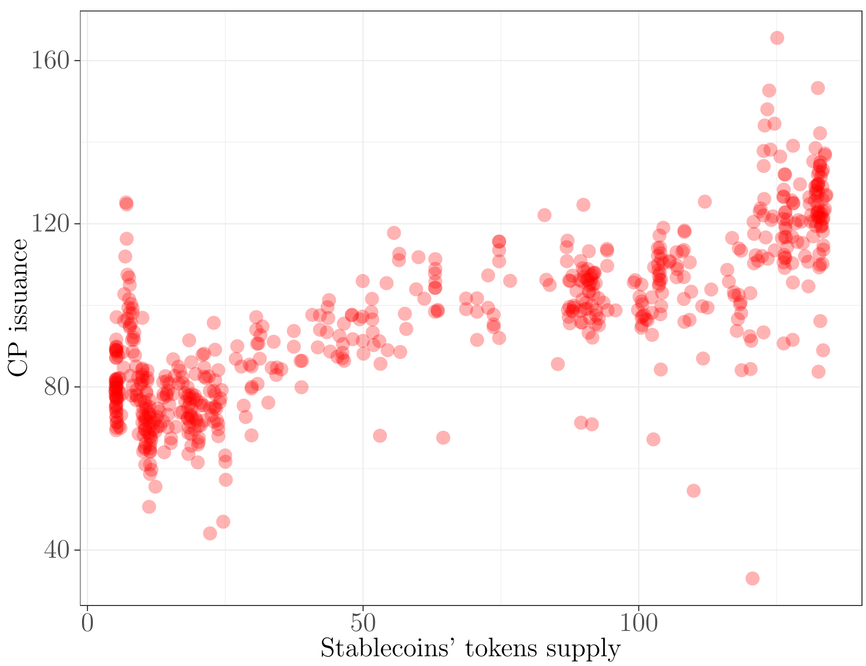
Such a pegging mechanism has created a new demand for US dollar-denominated short-term safe assets, within a very short period of time. Assessing how markets have absorbed this extra demand and whether it affected the price and/or quantities of the underlying reserve assets is key to understanding how crypto assets may spill over financial markets and eventually modify the funding structure of the economy.

To quantitatively address these questions, we identify stablecoin demand for reserve assets, exploiting cross-sectional and time-dimension heterogeneity in the reserve assets policy of the three largest stablecoins, between January 2019 and June 2022. We focus on one specific financial instrument, the US dollar-denominated commercial papers (CP hereafter), for three main reasons. First, we are most likely to detect a connection with stablecoins for this particular asset class: at the peak, Tether and Circle – resp. the issuers of USDT and USDC – allegedly held together up to 50 billion USD of CP, roughly 4% of the market outstanding. This is one order of magnitude larger than the share held in other asset classes, eg. US T-bill held by the main stablecoins represented less than 0.7 % of the outstanding as of June 30, 2021.[1] This rapid increase in CP holdings placed Tether on par with the largest US prime money market funds. Second, focusing on CP allows for proper identification of the impact of stablecoins on the financing of the economy: the three largest stablecoins had

[1] As of June 30, 2021, Tether and Circle held around 15.3 bn USD and 3.3 bn USD respectively. The holdings for BUSD was below 10 bn USD. These add up to 28.3 bn USD at maximum, representing less than 0.7% of the T-bill outstanding (4273 bn USD).

a very different approach regarding the use of CP as a reserve asset – BUSD never used CP, USDC ceased to use CP abruptly, and USDT decreased its CP holdings gradually. Third, CP have a direct impact on the real economy, as they are a significant source of funding for financial intermediaries and non-financial corporates. In addition, the financing of firms through CP issuance instead of longer-term financial instruments increases their exposure to rollover risk and thus may have implications for financial stability.

Figure 1: Total issuance of CP and stablecoins token supply



Note: The x-axis stands for tokens issued by Tether and Circle in circulation and y-axis stands for the total issuance of CPs of any maturity, rating and issuer type, denominated in US dollars. Both series are in billion and each dot relates to a working day from Jan 2019 to end-June 2022. Source: Federal Reserve Board, Messari.

Our paper makes five main contributions.

First, Fig. 1 suggests a correlation between stablecoin tokens and CP issuance. We show that this correlation holds in levels and in first differences, and after controlling for potential confounding factors such as monetary policy, the appetite for risk, and the evolution of risk-free rates and the usual determinants suggested by the liquidity premium literature.

Second, to identify more formally a "reserve assets channel", ie. the demand for CP emanating from stablecoins, we exploit the plausibly exogenous changes in reserve assets composition policy announced by stablecoin issuers and disclosed in accountant's reports. We also take advantage of the fact that the third largest stablecoin (BUSD) has never been backed by CP. In both cases, we find that the relationship between stablecoins and CP is only significant *if* and *when* the stablecoin issuer backs its tokens with CP and not otherwise.

Third, we show that stablecoins, as a new instrument with intended money-like properties, did not substitute for other money-like claims: the impact of stablecoins on CP issuance suggests that the inflows of dollars in stablecoins do not originate from outflows in other money-like claims with similar reserve asset backing. Put differently, the creation of a new money-like claim with specific characteristics – in the case of stablecoins, their availability on-chain – creates an additional demand for short-term safe assets instead of substituting for other sources of demand.

Fourth, the stablecoins' institutional setup offers a good laboratory to study and characterize the CP supply curve. We argue that stablecoins' demand is a plausibly exogenous demand shock on the CP market: (i) stablecoins' growth appears related to crypto markets developments, (ii) their reserve assets policy is unrelated to the market conditions of CP, (iii) the fact that stablecoins do not pay interest – contrary to MMFs – makes even more implausible that the demand for stablecoins can be motivated by a desire to be indirectly exposed to CP. Our econometric results suggest that the CP supply curve is vertical in the short run, that is, CP issuers strategically adapt their issuance to cater to an additional demand.

Fifth, we show that CP issuers may react to contemporaneous stablecoin demand because a large share of change in this demand is highly predictable by observable on-chain data. We reconstruct a time series of all tokens minted and burnt by Tether, extracting transaction-level data from the two main blockchains on which this stablecoin circulates and is issued: Ethereum and Tron. We show that a change in this mints/burns series predicts more than 70% of the following day change in circulating tokens. We finally show that a predicted increase in circulating tokens raises the issuance of CP, in a two-stage-least-square approach.

Our paper is the first, to the best of our knowledge, to outline a mechanism connecting crypto-assets, financial markets and the financing of the real economy through stablecoins' balance sheet and to empirically prove it using the CP market.

Our paper is connected to several strands of literature, and first to a growing literature investigating stablecoin's design and implications. Li and Mayer (2021); D'Avernas et al. (2022) explore the different stability strategies implemented by stablecoins from a theoretical perspective. Caramichael and Liao (2022) explain how, depending on the compositions of stablecoins' reserve assets, stablecoins may impact banking intermediation or safe assets scarcity (see also Garratt et al., 2022). Among others, Mizrach (2022); Kozhan and Viswanath-Natraj (2021) assess the stability of a number of stablecoins, while other studies have examined the crash of stablecoins projects (Adams and Ibert, 2022; Uhlig, 2022).

From a financial stability perspective, Frost et al. (2020); Gorton and Zhang (2021); Gorton et al. (2022) suggest some resemblances of stablecoins with historical experiments of early banking and free banking era. Bertsch (2022) models the fragility of stablecoins' peg and the drivers of their instability. A number of institutional publications evoke the financial stability risks posed by stablecoins, focusing mainly on the possibility of runs (G7, 2019; ECB, 2020; Arner et al., 2020; IMF, 2021; US, 2021), advocating for their regulation.

Our paper bears implications in terms of interactions between stablecoins and central bank digital currencies (CBDCs) (Cong and Mayer, 2022), the potential financial stability implications of their introduction, and their competing or complementary use along with stablecoins.

In terms of data, our paper is connected to a nascent literature exploiting information contained in the blockchains ("tokenomics"). This includes for instance papers studying the link between stablecoins and other crypto-assets (Makarov and Schoar, 2021; Lyons and Viswanath-Natraj, 2020; Griffin and Shams, 2020; Kristoufek, 2022; Saggu, 2022).

Empirically, our investigation borrows from the liquidity premium literature, where CP are usually exploited in a slightly different way, to measure the liquidity premium (Krishnamurthy and Vissing-Jorgensen, 2012; Sunderam, 2015; Nagel, 2016). Kacperczyk et al. (2021) study the production of short-term safe assets and how CP issuers anticipate and adjust contemporaneously to an additional demand. Facing increasing demand, firms may strategically issue more of this type of debt, which bears consequences for their exposure to roll-over risk, and ultimately for financial stability (Stein, 2012; Carlson et al., 2016).

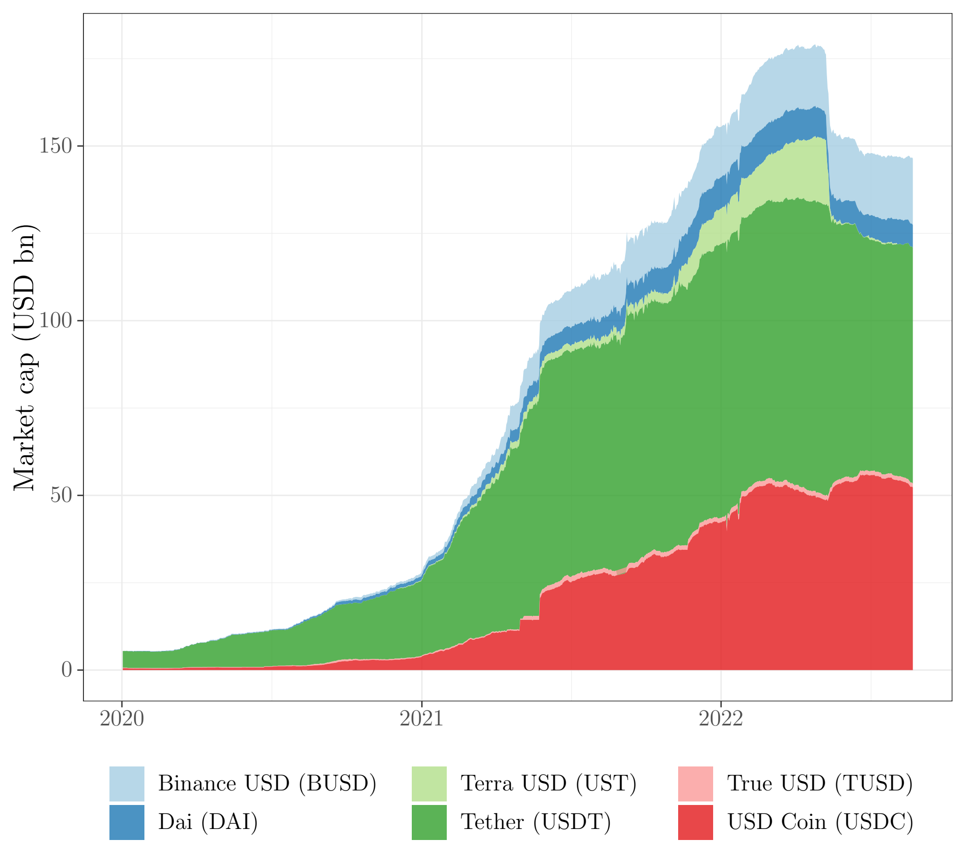
From a broader perspective, we connect with a growing literature on the role of supply and demand in asset pricing. In that sense, stablecoins can be seen as a new preferred habitat investor, emerging in just a couple of years. Examples include studies on the impact of pension reforms (Greenwood and Vayanos, 2010), central banks' quantitative easing (Vayanos and Vila, 2021; Koijen et al., 2021), MMF reforms (Cipriani and La Spada, 2021; Gissler et al., 2020), T-bill shortage (D'Avernas and Vandeweyer, 2021), or foreign demand for US Treasuries (Ahmed and Rebucci, 2022).

The remaining of the paper is organized as follows: Section 2 details the functioning of different types of stablecoins and explains how the dominant stablecoins are linked to the real economy, through their pegging mechanisms. Section 3 lays out our hypotheses on the possible links between the rise in the stablecoins demand and the commercial paper market.Section 4 describes our data and our empirical strategy to test these hypotheses. Section 5 presents our results and discusses the mechanism.

2 Stablecoins' demand for short-term safe-assets

In this section, we first document the rapid rise of stablecoins and the centrality they have gained in crypto markets. (2.1). We then show that asset-backed stablecoins dominate the market over other stablecoins and are the most stable. (2.2). The rise of stablecoins has led to a sizeable new demand for near-money assets (2.3).

Figure 2: Stablecoins' market capitalization



Note: This figure reports the evolution of the 6 largest stablecoins by market capitalization, as of October 2021. Latest observation: 2022-08-22. Market capitalization is the circulating supply times the market price. Source: Messari.

2.1 The rapid rise of stablecoins

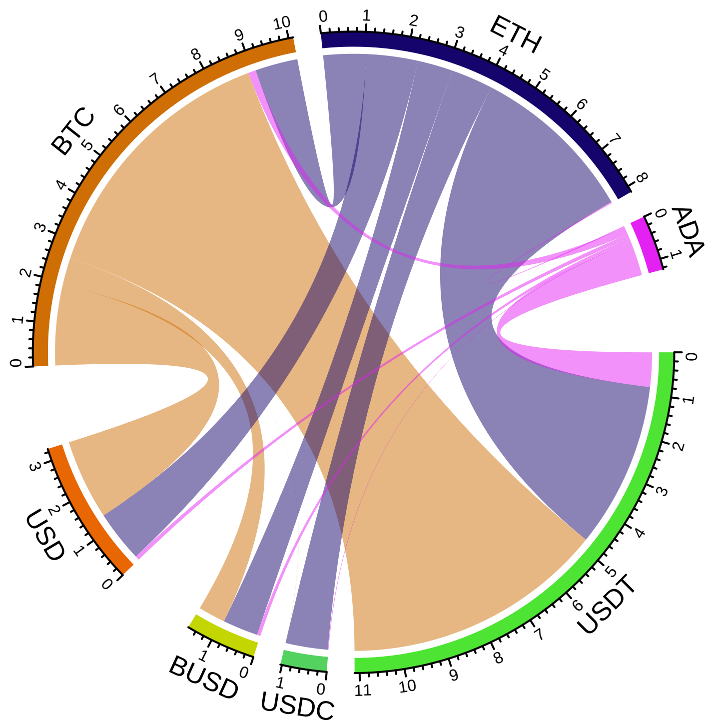
While the first stablecoin projects emerged in the mid-2010s with the publication of several whitepapers[2], their development took off in the last couple of years. In January 2020, the market capitalization of stablecoins was just below 5 billion USD. Within 2 years, they reached almost 200 billion USD. The crash of TerraUSD, in May 2022, halted this growth but had a somehow limited impact on the capitalization of the other stablecoins. Figure 2 shows the evolution of market capitalization of the main largest stablecoins. The four largest stablecoins are Tether (USDT), USD Coin (USDC), Binance USD (BUSD) and Dai (DAI) issued respectively by Tether Ltd, Circle/Paxos, Binance and MakerDAO, are all pegged to the US dollar. Tether and USD Coin concentrate by far the market capitalization.

The fast-growing adoption of stablecoins is linked to their multiple purposes in crypto markets. Their stability properties allow them to play the role of a store of value in crypto markets. Stablecoins also fuel the development of Decentralized Finance (DeFi), as collateral locked in smart contracts, or borrowed to build leveraged positions. As such, the development of stablecoins is linked to the growth of crypto markets in general, see for instance Arner et al. (2020); Adachi et al. (2022); Caramichael and Liao (2022) for an extensive review.

Maybe even more noticeable, stablecoins have acquired a central role in the crypto market as a medium of exchange: data from the main crypto exchanges suggest that a majority of transactions are settled with a stablecoin, as noted by Gensler (2021). Figure 3 shows the average daily volumes exchanged between the 3 largest stablecoins (USDT, USDC, BUSD), the 3 largest crypto-assets (BTC, ETH, ADA) – in terms of market capitalization in 2020. 2/3 of transaction volumes are concentrated between stablecoins and other crypto-assets. Additionally, direct transactions between fiat currencies (here the USD) and crypto-assets are a minor share of all volumes.

[2] https://www.wsj.com/articles/BL-MBB-23780

Figure 3: Average traded volumes between the 3 largest crypto and 3 largest stablecoins in terms of market capitalization and the US dollar, in USD bn



Note: Average daily volumes between pairs, over one year (Sept 2020-Sept 2021) based on Cryptocompare API data, which states they aggregate transaction data for each pair traded on about 70 exchanges. All volumes amount converted in US dollars. The chords' width reflects the volume traded in each pair, in billion USD.

2.2 Stabilization strategies and the dominance of asset-backed stablecoins

Different strategies have been implemented to stabilize stablecoins' value, with an uneven success that can be empirically measured (Mizrach, 2022), and theoretically grounded (D'Avernas et al., 2022; Bertsch, 2022). Achieving a peg with the US dollar echoes different types of arrangements and historical experiences in traditional finance and central banking. In the context of stablecoins, three main strategies have been implemented, both by centralized stablecoins issuers and decentralized autonomous organizations, ie. through smart contracts.

The first strategy, similar to MMFs and currency boards, relies on holding reserve assets denominated in US dollars in counterpart of tokens issued, and promising redemption at par. The second strategy relies on over-collateralization of crypto-assets locked via a smart contract, in charge of issuing stablecoins' tokens and managing the appropriate quantity of collateral to maintain the peg (and eventually automatically liquidate collateral positions to ensure it). The third strategy relies on providing incentives for arbitrageurs to defend the peg, in a way similar to foreign exchange interventions.

Table 1 summarizes the strategies adopted by different stablecoins and whether they are issued by a centralized institution or by a decentralized smart contract.

Table 1: Major stablecoins and their stabilization policy

Stablecoin project	Governance	Asset-backed	Algorithmic
Tether (USDT)	centralized	real assets	no
Circle (USDC)	centralized	real assets	no
Binance (BUSD)	centralized	real assets	no
DAI (DAI)	decentralized	crypto assets[(1)]	partially[(2)]
TerraUSD (UST)	decentralized	no	incentivized intervention

Note: (1) crypto-assets (including stablecoins) held in backing are not accepted at face value but with a haircut, a feature often nicknamed "over-collateralization". (2) *"The peg stability module (PSM) of the DAI stablecoin was introduced on December 18, 2020, as a solution to combat persistent peg-price deviations (...). Under the PSM, a smart contract enables users to swap the stablecoin USDC with DAI at a 1:1 rate without needing to create a vault and deposit collateral" (Kozhan and Viswanath-Natraj, 2021; Lyons and Viswanath-Natraj, 2020)*

The three largest stablecoins (USDT, USDC and BUSD) share very similar features and are all asset-backed. They promise the redeemability of their tokens at par against US dollars, on demand. For instance, Tether states *"All Tether tokens are pegged at 1-to-1 with a matching fiat currency (e.g., 1 USDT = 1 USD) and are backed 100% by Tether's reserves."*. Similarly, Circle claims *"Every digital dollar of USDC on the internet is 100% backed (...) so that it's always redeemable 1:1 for U.S. dollars"*.

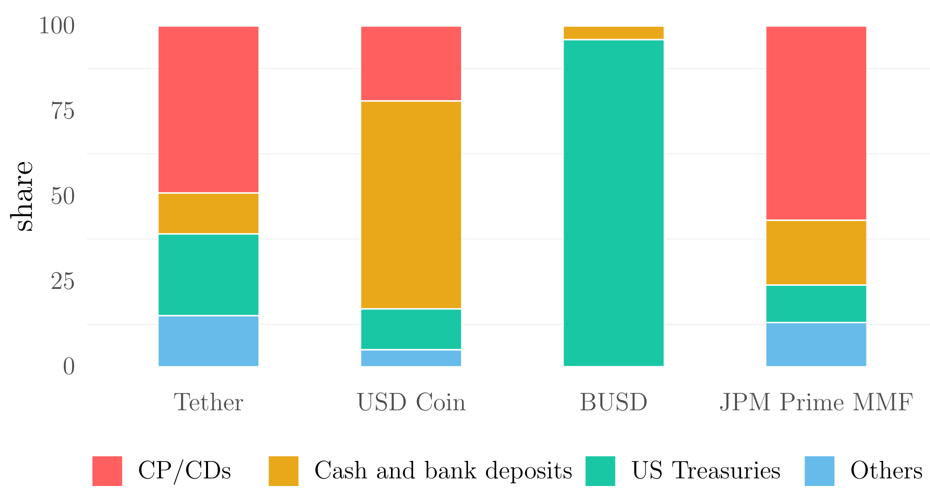
Their dominance in terms of market capitalization can be linked to their peg performance and their ability to effectively meet redemptions. Figure 8 shows that the dispersion of exchange rates against the US dollar since July 2020 of asset-backed stablecoins has been very limited, and comparable to the peg performance of other arrangements, like currency boards (see HKDUSD). On the contrary, algorithmic stablecoins exhibit the largest deviations, notably on the back of the crash of Terra USD in May 2022.

2.3 Reserve composition and the demand for short-term safe assets

Importantly, the dominance of asset-backed stablecoins means that the increasing demand for reserve assets has mirrored their rapid growth. However, little was known until mid-2021 on the composition of these reserve assets. The backing itself was unverifiable and subject to a number of controversies and rumors.

On April 25, 2019, the New York Attorney General filed a lawsuit against Tether Ltd and its parent companies iFinex and Bitfinex, questioning the reality of the 1:1 backing of USDT tokens, at all times between 2018 and 2019. Tether reached an agreement in February 2021 and committed to issue regular independent audit reports on its reserve assets.[3] Tether started to disclose some information in July 2021, certified by an independent accountant.[4]

Figure 4: Stablecoins' reserve assets composition and comparison with JP Morgan Prime Money market funds allocation



Note: Source: Circle (composition as of May 28, 2021), Tether (composition as of June 30, 2021), JPM Prime MMF (composition as of March 31, 2022). 13% of USDC reserves is composed of Yankee CDs; the split between CD and CP is unknown for Tether. For BUSD, we take the first available report, issued in January 2022. Before that, independent accountants reported that the reserve assets of BUSD were mainly held in cash deposits with US-regulated depository institutions.

To the surprise of many, the report showed that Tether tokens were mainly backed by Commercial Paper (CP) and Certificates of Deposits (CD) denominated in US dollars, and

[3] https://ag.ny.gov/press-release/2021/attorney-general-james-ends-virtual-currency-trading-platform-bitfinexs-illegal

[4] https://tether.to/wp-content/uploads/2021/08/tether_assuranceconsolidated_reserves_report_2021-06-30.pdf

not by cash (See Figure 4).

As of June 2021, Tether Holdings Limited held around 31 bn USD of CP/CDs. At the time, this *de facto* placed Tether on par with the largest Prime money funds in terms of CP holdings (Abate, 2021). By comparison, one of the largest money market funds, the "JPMorgan Prime Money Market Fund" has about 75 USD bn of assets under management, invested at 25% in CPs, 30% in CDs, and 15% in US Treasuries.[5]

In a similar move, USD Coin (USDC) issued an independent accountant report soon after that revealed USDC tokens were backed at 61 % by cash and securities with an original maturity less than or equal to 90 days, at 22% by commercial papers issued in the US or abroad ("Yankee CDs").[6] Since then, Circle publishes a monthly report on the composition of its reserves.

Binance USD is the most recent of these stablecoins and has been from its inception regulated by the New York State Department of Financial Services. Unlike the two former stablecoins, its reserves are mainly constituted of cash deposits, placed with US depository institutions and US Treasuries. Its first reserve assets composition report in January 2022 showed that 96% of its reserves were held in US Treasuries and T-bills.

Since 2021, the composition of reserves has however significantly changed, on the back of vivid controversies about the liquidity and credit risk taken with CPs.[7] In a separate case, CFTC considered that CP holdings contributed to misrepresenting the nature of the 1:1 backing promised by Tether to the tokens' holders.[8]

In 2021, Circle, the issuing company of USDC decided to cut its CP holdings to zero: *"Circle, with the support of Centre and Coinbase, has announced that it will now hold the USDC reserve entirely in cash and short-duration US Treasuries. These changes are being implemented expeditiously and will be reflected in future attestations by Grant Thornton. " (Aug 22, 2021)*

Tether announced a gradual reduction of CP holdings shortly after. While USDC was effectively not backed anymore by any CP from September 2021, Tether has adopted a

[5] https://am.jpmorgan.com/us/en/asset-management/adv/products/jpmorgan-prime-money-market-fund-morgan-4812a2702#/portfolio

[6] https://www.centre.io/hubfs/pdfs/attestation/Grant-Thorton_circle_usdc_reserves_07162021.pdf

[7] Rumours also suggested that Tether holdings were concentrated in Chinese CP. See also https://www.bloomberg.com/news/features/2021-10-07/crypto-mystery-where-s-the-69-billion-backing-the-stablecoin-tether

[8] *"Tether misrepresented to customers and the market that Tether maintained sufficient U.S. dollar reserves to back every USDT in circulation with the "equivalent amount of corresponding fiat currency" held by Tether and "safely deposited" in Tether's bank accounts."* https://www.cftc.gov/PressRoom/PressReleases/8450-21

smoother strategy of CP reduction over time. In June 2022, Tether CTO Paulo Ardoino declared: *"Tether also reduced its commercial paper exposure from 45B to 8.4B and is set to phase it out in full in the coming months. All the expiring CP have been rolled into US Treasury bills, and we'll keep going till CP exposure will be 0."*

Importantly, these changes in reserve asset policy appear exogenous to the market conditions of CP, motivated by the scrutiny of markets and regulators on the stablecoins' backing. This can be also interpreted as the outcome of an intense competition between stablecoins to offer the safest-perceived redeemability guarantees.

3 Stablecoins and the financing of the real economy

In this section, we explore the potential impact of reserve assets held by stablecoins on the financing of firms. We focus on commercial papers as the stablecoins' demand is the most sizeable. We first recall the importance of the commercial paper market in the US (3.1) and then discuss under which conditions the additional demand emanating from stablecoins can affect the financing conditions of firms (3.2).

3.1 The commercial paper market

Commercial papers (CP) are short-term promissory notes issued by non-financial corporations, banks and other financial institutions. While the majority of CP outstanding is unsecured, around 25% is issued in the asset-backed commercial paper segment by financial institutions. Maturities are typically short and range from 1 day up to 270 days. There is no secondary market for CP: they are usually held to maturity and not traded after the issuance. The CP market plays a critical role in the money market as an important source of financial institutions' unsecured funding, as noted by Eren et al. (2020).

The Federal Reserve also stressed the importance of the CP market for the real economy to justify its intervention during the Covid-19 crisis: *"Commercial paper markets directly finance a wide range of economic activity, supplying credit and funding for auto loans and mortgages as well as liquidity to meet the operational needs of a range of companies. By ensuring the smooth functioning of this market, particularly in times of strain, the Federal Reserve provided credit that supported families, businesses, and jobs across the economy."*[9]

[9] https://www.federalreserve.gov/monetarypolicy/cpff.htm

Table 2: Holders and Issuers of Commercial papers, 2021

Nonfinancial corporate business	253,5	138,2	Nonfinancial corporate business
State and local governments	81,1	134,9	U.S.-chartered depository institutions
Credit unions	0,3	60,4	Foreign banking offices in the U.S.
Property-casualty insurance companies	4,5	148,1	Issuers of asset-backed securities
Life insurance companies	41	41,3	Finance companies
Private pension funds	42,4	8,1	Holding companies
Public retirement funds	14,6	136,7	Other financial business
Money market funds	226,2		
Mutual funds	39,6		
Government-sponsored enterprises	4,7		
Security brokers and dealers	16,3		
Other financial business	226,9		
Rest of the world	138,3	421,7	Rest of the world
Total holders	1089,4	1089,4	Total issuers

Source: Flow of funds Table L.209, https://www.federalreserve.gov/releases/z1/20220909/html/l209.htm

Table 2 gives the breakdown in terms of holders and issuers of CP, from the Flow of Funds data, as of 2021.[10] First, while the bulk of CP issuers is financial institutions, a fraction is issued by non-financial corporates. Second, the CP market is not only important for the short-term funding of US-domiciled institutions but also for foreign issuers: around 40% of the CP outstanding is issued by non-US institutions. Third, CP holdings appear concentrated in money market funds, other financial businesses, and non-financial corporates. MMFs are traditionally large holders of CP, in particular Prime MMFs, who hold mainly corporate short-term debt.

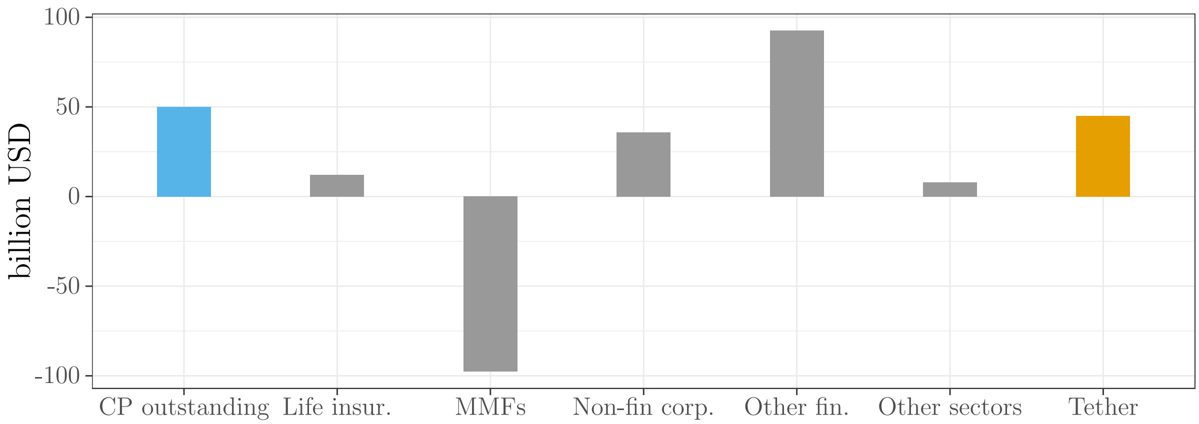
Based on available attestation reports, demand for CP emanating from stablecoins likely peaked around 40 billion dollars in mid-2021, compared to a market outstanding of 1089 billion dollars, ie. 3.6% of the market outstanding. Flow of funds reports show stablecoins' holding would have been on par with private pension funds and represented almost one-fifth of the size of money market funds holdings.[11]

Figure 5 shows the variation in CP issuance, and variations in holdings of selected sectors, for the 2019-2021 period. We put in comparison the approximate change derived from Tether attestation reports. Here again, the increase in Tether holdings appears sizeable compared to the other sectors. Interestingly, MMFs have markedly reduced their holdings of CP during the same period.

[10] See also https://fred.stlouisfed.org/release/tables?rid=86&eid=147706#snid=147717

[11] By contrast, the stablecoin holding of Treasury bill stands for around 0.4 % of the outstanding as of June 30, 2021, suggesting a lower issue share compared to the one for CP.

Figure 5: Change in total CP outstanding and holdings, 2019-2021 and change of Tether reported CP holdings for comparison



Source: Flow of funds, Table L.209. By accounting, grey bars (change in holdings) sum to the blue bar (change in outstanding). Tether shown for comparison – possibly comprised in the "Other financial" category. "Other sectors" comprise the other Flow-of-funds sectors, including rest-of-the-world. Tether's change in holdings estimated at 45 bn USD.

3.2 How could stablecoins matter for firms' financing?

The demand for CP emanating from stablecoins has been non-trivial compared to the CP outstanding and to the the largest investors (see sections 3.1 and 2.3). In this section, we discuss under which conditions the demand from stablecoins may affect the CP market and hence firms' financing. We highlight the role of other demand segments, especially the other providers of money-like claims that invest in the CP market, and of the issuers of CP. We organize this subsection by expositing three hypotheses that will guide our econometric investigation.[12]

Hypothesis 1: Stablecoins' demand for CP neither affects prices nor quantities of CP.

The stablecoins' demand has no effect whatsoever on the CP market if the aggregate demand for CP remains unaffected by the additional demand of stablecoin issuers — that is if other sources of demand exactly substitute for changes in stablecoins' holdings. Such a substitution can result from two types of mechanisms. First, demand for stablecoins itself may substitute for demand for more traditional money-like claims, such as MMF, which

[12]In Appendix C, we develop a simple model with two suppliers of money-like claims (eg. a stablecoin and an MMF) investing in the CP market. The model clarifie under which conditions the additional demand for stablecoin affects the CP market. The key determinants are (i) the degree of substitutability between the different types of money-like claims, (ii) the elasticity of the demand from other investors to CP rates, and (iii) the price-elasticity of CP suppliers.

may eventually trigger a decline in demand for CP. Overall, the aggregate demand for CP remains unchanged if the decline in the demand for CP from the other money-like issuers offsets the additional demand from stablecoins. Whether this substitution leads to lower, similar, or higher demand for CP depends on the elasticity of substitution among money-like claims and the share of CP in their respective portfolio.[13] If Hypothesis 1 is not satisfied, it suggests either that there is no or little substitution between stablecoins and other money-like claims or that the substitution does not lead to a sufficient fall in the demand for CP by traditional money-like issuers.

Second, other investors may reduce (increase) their demand for CP when stablecoin purchases (sells) CP. This stabilizing mechanism completely offsets the stablecoins' demand if and only if the investors react one-to-one to changes in stablecoins' holding. We usually anticipate such a mechanism for non-segmented markets in which arbitrageurs are infinitely price-elastic.[14] If hypothesis 1 is not satisfied it indirectly proves that markets are segmented and arbitrageurs are not infinitely price-elastic on the CP market. In the framework of Vayanos and Vila (2021), this echoes preferred habitat demand and limits to arbitrage.

Hypothesis 1 is not satisfied if the aggregate demand for CP increases with the rise of stablecoins. It remains to determine whether the rates or the quantities react to the net additional aggregate demand from stablecoins. We formulate two opposite hypotheses to analyze our empirical results.[15]

Hypothesis 2: Stablecoins have an effect on CP issuance but not on CP rate.

As seen above, stablecoins' demand for CP changes this market if and only if the net aggregate demand changes. A change in aggregate demand may either change prices and/or quantities. The CP market clearing dictates the prevalent interest rate. So if CP rate is unaffected it should be because the supply of CP fully adjusts to the additional demand.[16] Such behavior would reinforce the perception that CP issuance is opportunistic and easiliy adapts to changes in demand, a point made by Kacperczyk et al. (2021).

On the contrary, if firms are price inelastic when they issue CP, we should observe the opposite:[17]

[13]See proposition 2 in Appendix C for more precise conditions.

[14]The simplest example is if risk-neutral deep-pocket investors can arbitrage between the CP market and another equivalent market — one can think of the T-bill market (see the bottom-left panel in figure 16 in Appendix).

[15]Proposition 3 in Appendix formalizes them based on the demand and supply curves on the CP market.

[16]See the upper-left panel in Figure 16 for a vertical supply curve.

[17]See the upper-right panel in Figure 16 for a horizontal supply curve.

Hypothesis 3: Stablecoins have an effect on rates, but not on quantity.

Notice that we build hypotheses 2 and 3 artificially as two opposite cases while we could observe intermediate situations. In addition, we will only test these hypotheses in the short run, long-run stablecoins impact may however differ from its short-run one due to modification of firms' or other investors' behaviors.

Finally, under Hypothesis 3 stablecoins do not fundamentally change the funding structure of firms but only their costs while under Hypothesis 2 stablecoins lead to shortening the liability side of firms, and especially, their exposition to rollover risk (Greenwood et al., 2015).

4 Data and empirical strategy

We first explain how we build our crypto data series based on on-chain analytics (4.1). We describe the CP market data (4.2). We then outline our empirical strategy, testing the three hypotheses formulated in section 3.2.

4.1 Crypto data

In this subsection, we explain why we use the outstanding stablecoin tokens in circulation as our key time series to approximate the demand for CP from stablecoins and how this time series is constructed.

The prime source of data comes from the smart contracts governing the issuance, transfer, and destruction of tokens. Each stablecoin has its own smart contract on each blockchain, where its code is publicly available. A specific field can be requested to get in real-time the total supply of tokens, ie. the total number of tokens "minted" less tokens "burnt".

However, not all of these tokens need to be backed: only those issued *and* in the hands of the public need to be. The concepts of "circulating tokens" or "tokens in the hands of the public" or "free float" are often found with different definitions and computed according to different methodologies by crypto data providers. Coinmarketcap says for instance it excludes *"coins that are locked, reserved, or not able to be sold on the public market (...) that can't affect the price and thus should not be allowed to affect the market capitalization as well."*[18], and acknowledges that *"the network at large has no reliable knowledge of how much of the total supply is in active circulation, making the metric of circulating supply an imperfect*

[18] See https://coinmarketcap.com/faq/

approximation." Coinmetrics also excludes for instance *"Supply in addresses that have been inactive for over 5 years; supply staked in a smart contract to partake in governance"*[19]

At the opposite, for the purpose of our exercise, we need to isolate the amount of tokens that need to be backed by reserve assets, independently of whether the token is locked in DeFi or owned by inactive addresses. Total number of tokens minted less tokens burnt is already an approximation, and an extra step can be done to make sure to capture only tokens that command a backing by reserve assets, by subtracting the tokens held by the issuer's own addresses – or tokens that are said "authorized but not issued" when they never circulated. For the purpose of our analysis, we define therefore "circulating tokens" as tokens owned by all other addresses but those of the stablecoin issuer, as only these tokens need to be backed. The stablecoin issuer address is known, as it interacts with specific functions in the smart contract (eg. mint, burn), and as tokens must be sent to this address in case a coin holder asks for its redemption against US dollars.

We illustrate our definition of circulating tokens in the next two paragraphs for the two largest stablecoins.

Circulating USDC tokens Circle allows a set of issuers to issue tokens on approved blockchains (Algorand, Avalanche, Ethereum, Flow, Hedera, Solana, Stellar, and Tron). These allowed-but-not-issued tokens are not considered circulating yet and hence are not backed. Authorized issuers can issue new tokens up to their allowance limit in exchange for USD.[20] Circle can freeze tokens owned by blacklisted addresses, if "it receives blacklisting requests from law enforcement agencies" (Circle report, March 2021). Frozen tokens are suppressed from circulating USDC and not backed. Finally, when a token is redeemed (or burnt), the token definitively disappears from the outstanding. Thus, the circulating USDC is the sum of tokens allowed that are neither frozen nor allowed-but-not-issued.[21]

[19] https://coinmetrics.io/introducing-free-float-supply/

[20] "USDC is fully backed by an equivalent amount of U.S. Dollar-denominated assets held by Circle with U.S. regulated financial institutions in segregated accounts apart from Circle's corporate funds, on behalf of, and for the benefit of, Users (the "Segregated Accounts"). This means that for every USDC issued by Circle and remaining in circulation, Circle will hold on behalf of Users either one U.S. Dollar ("USD") or an equivalent amount of USD-denominated assets in its Segregated Accounts (the "USDC Reserves"). USDC is not designed to intrinsically create returns for holders, increase in value, or otherwise accrue financial benefit to the USDC holder."

[21] USDC smart contract in the Ethereum blockchain is accessible here: https://etherscan.io/token/0xa0b86991c6218b36c1d19d4a2e9eb0ce3606eb48

Circulating USDT tokens Tether has a similar functioning but instead of relying on multiple issuers, Tether uses its own addresses to authorize and issue tokens.[22] Tether authorizes the issuance of tokens on an increasing number of blockchains: 13 different blockchains as of October 2022 (mainly on Tron, Ethereum, Solana and Omni). As for Circle, the tokens officially backed by Tether are authorized tokens less those that are authorized but not issued and those that are quarantined. To be more concrete, Figure 6 shows the major flows of USDT tokens on the Ethereum blockchain from the first token issued to June 2022. The circulating USDT tokens on the Ethereum blockchain correspond to all tokens not held by Tether Treasury or quarantined (not mentioned in the figure), that is, the sum of tokens flowing out of the Tether Treasury address minus those flowing in.

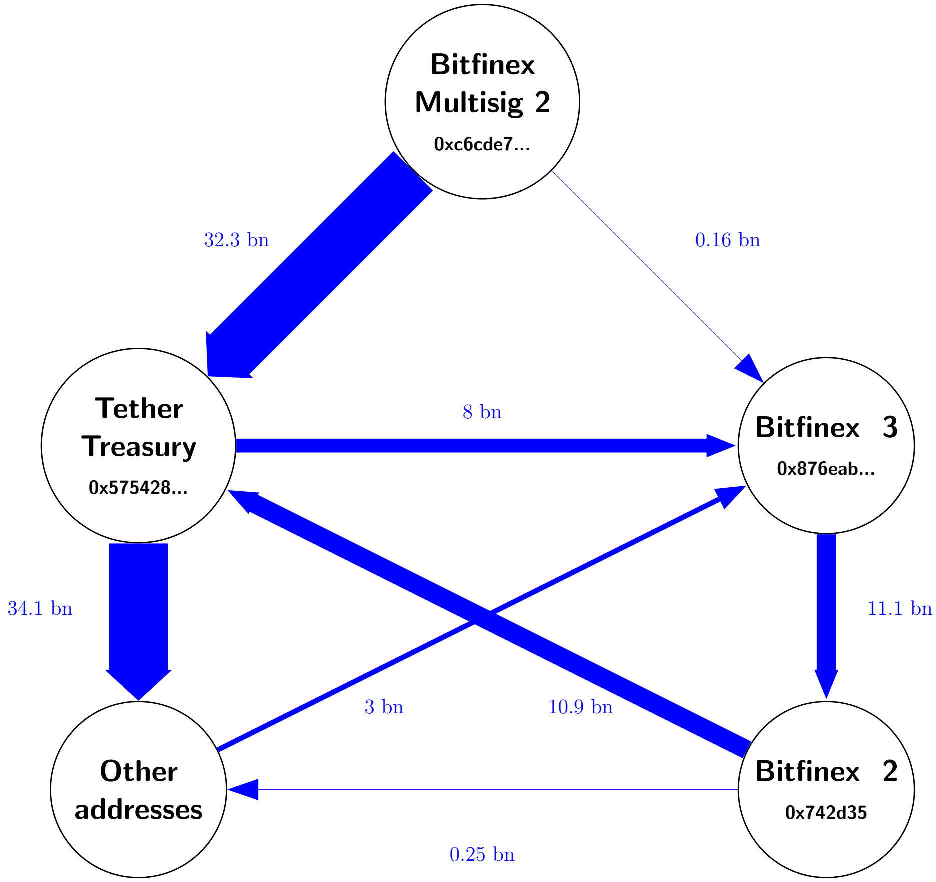
Time series While smart contracts are requestable in real-time and transactions recorded in public blockchains, building an exhaustive time series about circulating tokens can be quite complex, notably because of the amount of transactions to be retrieved and the multiple blockchains on which stablecoins are issued (8 for USDC and 13 for USDT). We proceed in two steps. For the sake of completeness and data availability, we use the time series provided by the crypto data provider Messari – as for instance in Uhlig (2022), Makarov and Schoar (2022). The "circulating supply" series reported by Messari match the authorized less not issued number of tokens computed for all blockchains and verifiable with the Tether API.[23] Second, we do multiple checks to verify that our results are not caused by errors in this time series (see subsection 5.4). In particular, we verify that we can confirm our results with data retrieved directly from the blockchains (see subsections 5.4 and 5.3). The advantage of using on-chain data is that we fully control the definition of the time series we construct compared to sometimes not-so-well-documented data by crypto data providers. Fig.10 plots the first differences in circulating tokens.

Attestation reports We retrieve directly from Tether, Circle and Paxos websites the reserve assets composition in regular accountant reports made public since July 2021, and announcements of intended changes in the composition of reserve assets. We list these documents in the appendix.

[22] USDT smart contract on the Ethereum blockchain accessible here: https://etherscan.io/address/0xdac17f958d2ee523a2206206994597c13d831ec7

[23] https://app.tether.to/transparency.json

Figure 6: Major net flows of Tether on the Ethereum blockchain



Source: Etherscan (Contract: 0xdac17f958d2ee523a2206206994597c13d831ec7); authors' computations

Note: Net flows in bn of USDT tokens between the first registered transactions to 19, June 2022. The aggregate inflows toward Tether Treasury are positive and coincide with an end-of-sample balance around 1 bn of tokens.

4.2 Commercial paper data

Data on commercial paper issuance and rates come from the Federal Reserve Board – derived from data supplied by DTCC (Depository Trust & Clearing Corporation). Data on issuance and rates are reported daily, based on CP of maturities of 270 days or less, directly issued or placed by dealers.[24]

We rely on breakdowns provided by the Federal Reserve. For instance, the reports aggregate in a bucket 'AA' commercial papers rated A1+ and A1 by Moody's Investors Service and Standard & Poor's.[25] Similarly, volume statistics for daily issuances are reported for

[24] Sources and methodology: https://www.federalreserve.gov/releases/cp/about.htm

[25] "Programs with at least one 1 or 1+ rating, but no ratings other than 1"https://www.federalreserve.gov/releases/cp/about.htm'

'Non-financials AA", "Non-financials A2/P2", "Financials AA" and "ABCP AA", as well as for the total market. As noted by the Fed, *"total market is not the sum of the four rate categories as there is additional issuance that does not fall in any of the rate categories"*. CP rates data are also reported for specific issuers and maturities (eg. rates for 90-day CP). We keep most of these categories unchanged for the analysis. We only group in the bucket "5d to 80d" the issuances reported by the Federal Reserve in 4 distinct maturities: 5-9 days; 10-20 days; 21-40 days and 41-80 days.

Turning to the commercial paper market, Fig. 9 reports the daily issuance of commercial papers, of all maturities and all issuer types, as reported by the Federal Reserve.

As the CP market experienced a period of stress following the Covid-19 crisis, we include as a control purchases of CP by the Federal Reserve. In March 2020, the Federal Reserve re-instated the Commercial Paper Funding Facility (CPFF)[26] to support the flow of credit to households and businesses. As detailed by Boyarchenko et al. (2021), the CPFF re-started purchases on March 17, 2020, focused on unsecured and asset-backed commercial paper rated A1/P1. CPFF ceased purchases on March 31, 2021.

All in all, our data sample goes from Jan 2, 2019, to June 30, 2022. at daily frequency. We keep business days in which the CP market is open, and we drop two dates from the sample: Dec 31, 2020 and Apr 19, 2019, two outliers in terms of CP reported by the Federal Reserve (the second date being Good Friday in 2019). Our sample covers the sheer growth period of the stablecoins but also the Terra crash that occurred in May 2022 and the subsequent short-lived but unusual deviations of Tether from its peg.

4.3 Empirical strategy

Our identification assumption is that circulating tokens reflect the stablecoins' demand for reserve assets. This information is available on-chain at high frequency, contrary to audits that are infrequent – and subject to controversies.[27] While only a fraction of a token issued is backed by CP – depending on the allocation policy of each stablecoin – we assume that the demand for CP is proportional to the tokens' circulating supply as we defined in the previous section.

Both the level of and change in tokens may affect the CP market. A permanent increase in the demand for short-term instruments may reflect in a permanent upward shift in the

[26] https://www.federalreserve.gov/monetarypolicy/cpff.htm

[27] For instance, Bloomberg, "Anyone Seen Tether's Billions?", 7 octobre 2021.

outstanding of CPs and in the issuance. This is the sense of Fig. 1, suggesting a relationship between the CP issuance and the stablecoins' supply. A change in the circulating tokens may also affect the CP market: an increase in the circulating tokens leads the stablecoin issuer to buy newly issued CPs to keep the ratio of CP holding over asset constant and therefore may be related to a change in the issuance of CP.

One option would be to directly relate these variables in level – CP issuance and stablecoins tokens – with a proper strategy to correct stationarity issues. For instance, in a slightly different context, Sunderam (2015) regresses the log ABCP issuance on the T-bill-OIS spread, with the lagged dependent variable as a control. Greenwood et al. (2015) regress the financial CP outstanding on the T-bill supply, both scaled by GDP, or the changes in these variables.

In our case, log-transforming and detrending our series may help, but given our short time frame related to the recent existence of stablecoins, our series are not necessarily mean-reverting. Hence, this procedure cannot fully ensure the absence of stochastic trends that may generate spurious correlation[28]. For this reason, in our baseline, we follow Nagel (2016) and Kacperczyk et al. (2021) in first differencing our variables. Our baseline specification for CP issuance is then as follows:

$$\Delta I_t^{CP} = \alpha + \beta * \Delta Tokens_t^{USDT/USDC} + Controls_t + FE^{day} + \epsilon_t \tag{1}$$

Where ΔI_t^{CP} is the daily change in issuance at date t of all or a subset of CP, split by maturity, issuer, or credit rating. $\Delta Tokens_t^{USDT/USDC}$ is the change in net circulating supply of tokens issued either by Tether or USD Coin, or the sum of the two. We reject hypothesis 1 of section 3.2 if β significantly differs from 0. If non-zero, we expect a positive coefficient, that is, an increase in the circulating supply is associated with an increase in CP issuance.

We include three sets of controls, to deal with plausible confounding factors. All are taken in first difference. First, controls related to monetary policy: accommodative monetary policy and large excess liquidity, for instance, might increase both the demand for CP and stablecoins. To capture these factors, we control for the Effective Fed funds, Excess reserves[29], and the CPFF holdings. Second, risk appetite might relate the demand for crypto in general and the demand for risky asset classes. We use the Nasdaq and VIX for that purpose. Third, a usual control in the liquidity premium literature is the quantity of safe assets. We use the Log(Debt/GDP) ratio in this respect. GDP is fixed at its January 2019

[28] In the appendix, we provide such estimates and show that the results hold.

[29] Weekly-frequency controls, as reserves, are linearly interpolated at a daily frequency.

level. All controls are taken from Fred database, and daily data on the US sovereign debt come from the US Treasury.[30] We use the total debt available to the public, ie. net of intra-governmental holdings. Finally, as suggested by Fig. 9, CP issuances exhibit a strong intra-week seasonality pattern. FE^{day} controls for weekday fixed effects.

For CP interest rates, we closely follow the literature on near-money assets. Krishnamurthy and Vissing-Jorgensen (2012) regress CP rates spread on log debt-to-GDP, while Nagel (2016) the CD/T-bill spread on Fed funds rate, VIX, and log debt-to-GDP, in level and in first differences. Our baseline specification for rates is again in first difference with a similar set of controls:

$$\Delta(r_{CP_{m,t}} - r_{f_{m,t}}) = \alpha + \beta * \Delta Tokens_t^{USDT/USDC} + Controls_t + FE^{day} + \epsilon_t \tag{2}$$

where the dependent variable is the change in CP spread against the risk-free rate of the same maturity, ie. either the Effective Fed Funds rate for the short maturities between 1 and 4 days, or the 3-month OIS rate for 90-day CP rates.

As above, we reject Hypothesis 1 if β significantly differs from 0. If non-zero, we expect a negative sign as we expect that a higher demand due to stablecoins tends to make issuing CP cheaper.

5 Results

In this section, we first show that a rise in circulating tokens is positively correlated with a rise in the issuance of commercial papers but not with CP rates. We then show that this connection only appears when the stablecoin is backed by CPs.

5.1 Baseline results

Documenting the connection between stablecoins and CP issuances Table 4 reports the baseline specification in first differences. Columns (1) to (4) include controls at once. Column (5) adds weekday fixed effects to account for intra-week seasonality and an end-of-month dummy. Weekday fixed effects are strongly significant and point to a CP issuance cycle that peaks on Mondays and fade progressively. The inclusion of these time fixed-effects reduces our coefficient of interest, suggesting that both tokens issuance and CP

[30] https://fiscaldata.treasury.gov/datasets/debt-to-the-penny/debt-to-the-penny

issuance are intra-week seasonal.

In any specification, a rise in the circulating supply of stablecoins is associated with a rise in the total CP issuance. Hypothesis 1 is thus rejected: the additional demand from stablecoins is not fully compensated by the reduction of other sources of demand.

We find similar results when considering regressions in levels and log levels (see Table 12). To account for auto-correlations in CP issuance, we add the lagged-dependent variable as a control variable. The coefficient of circulating supply is significant and positive as in the benchmark regressions in differences.

Our results suggest a strong reaction of CP issuance to the stablecoin circulating supply. According to the specification with all control variables (last column), a 1 bn variation in stablecoin circulating supply is associated with a 1.9 bn variation in CP issuance. In terms of standard deviation, it means that a 1 s.d. increase in the circulating supply of stablecoins is associated with $1.9 * 0.5/11.4 = 0.08$ s.d of the daily CP issuance change, that is, a modest share of daily CP issuance change.

Column (1) of Table 5 shows that changes in the circulating supply of both USDT and USDC are associated with changes in CP issuance.[31] This suggests further the absence of confounding factors affecting at the same time USDT, USDC and the CP market.

Turning to the breakdown of CP issuance by maturity, issuer and ratings, we find large heterogeneity in the reaction of CP issuance (see columns 2 to 8). In terms of maturity, our estimates suggest that an increase in the USDT circulating supply is associated with an increase in the CP issuance of short maturity (1 to 4 days) and ABCP AA. For USDC, we find that longer maturity CP (5 to 80 days) and Non-financial A2P2 CP react more. These differences between USDT and USDC may reflect different investment strategies.

Table 6 splits changes in tokens' circulating supply into negative and positive variations. Results suggest an asymmetric impact of changes in circulating supply. We find no effect from the reduction of USDC circulating supply on CP issuance and, for USDT, only a significant impact on financial AA issuance. By contrast, an increase in circulating supply is statistically significant for both USDC and USDT, for all maturities, and specific maturity/issuer/credit rating buckets. This asymmetry suggests that stablecoin issuers quickly purchase CP when the circulating supply increases, but do not reduce —or with sluggishness– their CP holding when the circulating supply decreases. This sluggish reaction could result from the near-impossibility to sell CP on a secondary market.

[31] Besides, Fig. 11 shows that the changes in USDT and USDC tokens appear not correlated and a linear regression confirm no significance at 5%.

Commercial paper rates Turning to CP interest rates, Tables 10 and 11 report the estimation of equation 2 for 4 different maturities and issuer/ratings of CP. The left-hand side variable is the first difference in CP spread, expressed in bps, computed as CP rates of each maturity minus the corresponding OIS rate, similar to Nagel (2016).

While most of the coefficients are negative, none is statistically significant at a 5% confidence level, leaving little evidence supporting a connection between stablecoins' token issuance and CP rates. If anything, the magnitude of the coefficients is low: the only two coefficients statistically significant at 10% – for – suggest a -0.3/-0.5 bps decline in CP spread for a 1 bn change in USDT and USDC tokens, respectively for 2-week ABCP AA and 3-month ABCP AA respectively (which stands for more than 3 times the standard deviation).[32]

In the appendix, we show the same regression results, but with CP rates in level at the right-hand side, in Table 15. This is not our preferred specification as stochastic trends might introduce spurious correlation. However, introducing controls once at a time is instructive on the source of variance in CP rates: Column (1), uncontrolled, would point to a strongly significant, negative correlation between the change in stablecoins' circulating tokens and CP rates. The magnitude of this coefficient is however implausibly large as every 1 bn change in stablecoins' supply would be associated with a 64 bps reduction in CP rates. In fact, CP rates are highly correlated with risk-free rates, as can be seen in Figure 12. Hence, controlling for the risk-free rate of the same maturity and the effective Fed funds rate, logically dwarf the previous coefficient and reduces its statistical significance, as can be seen in column (2). We then replicate the specification of Nagel (2016), with the same set of controls, adding Log(Debt/GDP) and VIX, in column (3). Stablecoins cease to have a statistical significance for CP rates, which suggests that the stablecoins do not change the determinants of CP rates outlined in the liquidity premium literature. The absence of effect on CP rates may also reflect that the CP spreads were already quite compressed over the period, set aside the Covid stress period, tackled by the Fed intervention.

The absence of connection strongly contrasts with the regressions of quantities and suggests that Hypothesis 3 is rejected by the data, contrary to Hypothesis 2. In plain words, our results suggest CP issuers adjust quantities to the point prices do not react.

5.2 Inspecting the mechanisms

In this subsection, we show that the connection between CP issuance and circulating tokens effectively results from changes in the demand from stablecoin issuers for CP. We first discuss

[32] A subsequent paper by Kim (2022) finds a significant negative impact of stablecoins on T-bill rates.

the exogeneity of the demand shock emanating from stablecoins and then exploit the cross-sectional and time heterogeneity in the reserve assets policy of the three largest stablecoins.

Exogeneity of the stablecoins' demand The demand for stablecoins is arguably unrelated to developments in the CP market. First, the fast-growing demand for stablecoins seems linked to crypto developments, as largely described in the literature, see for instance Arner et al. (2020); Adachi et al. (2022); Caramichael and Liao (2022). As documented by Fig. 3 in section 2.1, stablecoins serve to trade other crypto assets and, as such, their demand is likely to depend on profits and losses realized on these markets. They are also used in the nascent decentralized finance as collateral, which may concur with the demand for stablecoins. Finally, as a tool to avoid taxes and capital control or as a digital dollar in dollarized countries, the demand for stablecoins is likely to depend on shocks in emerging economies. Second, the demand for stablecoins is not similar to those addressed to traditional money-like claims like money market funds. At a daily frequency, the correlation between changes in a standard MMF fund like JPM Prime MMF and in stablecoin circulating tokens does not significantly differ from 0. Third, the demand for stablecoins is not related to the yields on the CP market. Prior to the first audit report of Tether and Circle, the holding of CP by stablecoin issuers was unknown and even unexpected given the surprise triggered by the disclosure of stablecoins' CP holding. In addition, the absence of yields on USDT and USDC tokens means that the decision to hold or not a stablecoin was not due to the willingness to be indirectly exposed to CP.

Time-heterogeneity in reserve assets policy Before June 2021, investors in stablecoins were unaware that stablecoin reserve assets were partly invested in CP. CP backing has been widely criticized and the object of many rumors on the back of a lack of transparency about the risks of these assets. This led Circle and Tether to divest from the CP market, policy steps that are the decision of the two stablecoins' issuers, and arguably unrelated to the CP market. Importantly, these decisions were not caused by a change in the CP rates or other rates. They especially took place before the first Fed's rate hike on March 2022.[33] This gives us a plausibly exogenous experiment to confirm that the relationship between circulating tokens and CP issuance exists only *when* CP are actually used as a reserve asset.

First, in Table 7, we interact our coefficients of interest with years. The result suggests that the relationship is already present in 2019 for USDT, and mostly in 2020 and 2021 for

[33]For Circle, the reduction to zero of the CP holdings took place in August 2021, that is, even before any upward repricing of the US yield curve.

USDT and USDC. We find no statistically significant coefficient in 2022.[34]

Circle announced complete disinvestment from CP in August 2021, effective in September 2021, see Annex D. We thus expect that our coefficient of interest for USDC becomes insignificant in 2021H2 and 2022H1. Tether also stated it will start to reduce its holding by stopping purchasing new CP from summer 2021 when the holding was around 45 bn \$. In June 2022, the CP holding of Tether was less than 9 bn \$. We thus could expect as for USDC that the significance and/or the size of the coefficient of interest will change after 2022H1. In Table 8, we zoom in at a semester frequency to test for this disinvestment timing. We show the results for USDT and USDC for different categories and maturities. As expected, we find that the circulating supply of USDC is no more significant from 2021H2 onward and 2022H1 for USDT. These results are consistent with Circle's announcement and with a more gradual disinvestment of Tether from the CP market. These findings also confirm that the channel through which stablecoins' tokens affect the CP issuance is through the effective demand from the stablecoin issuers and not through another transmission channel.

Falsification test We perform a falsification test with Binance USD (BUSD), the third largest stablecoin with 20 billion USD of market capitalization. At the difference of Tether and USD Coin, BUSD reserve assets have never comprised CP. BUSD reserves include cash accounts in US depository institutions, US Treasury bills with a maturity of less than 90 days and *"overnight loans secured only by US Treasury securities"*.[35] Table 9 shows no statistical significance for the coefficient of BUSD tokens on CP issuance, no matter the category or the rating. This sanity check further confirms that there are no omitted confounding factors that would link stablecoins *in general* and the CP market.

5.3 Dissecting the impact on CP issuance

In this subsection, we discuss our results and show first that this timing is consistent with the previous literature on CP, and demonstrate the changes in circulating tokens are in part predictable by the public. We then discuss how to interpret our larger-than-one coefficients.

Timing of purchases and CP market reaction Our regressions establish a contemporaneous effect of changes in circulating tokens on CP issuance, that is, CP issuers would have

[34] Importantly, it means that the CP market was disconnected from the stablecoins' demand *before* the Terra/Luna crash in May 2022, which may explain why the subsequent and relative decline in Tether capitalization, for instance, has been benign and unnoticed in the CP market.

[35] https://paxos.com/attestations/

been able to cater to additional CP demand

For this exercise, we focus on Tether and show "mints" and "burns" of USDT tokens, ie. the creation or destruction of tokens, predict well the future USDT circulating tokens. We collect on-chain data on the issuance of new tokens (mints) and their destruction (burns) for Ethereum and Tron blockchains. For the first blockchain, we collect data on all the transactions of the address allowed by the Tether smart contract (contract address is: 0xdac17...) to issue or remove a new token (issuer address is: 0xc6cde7...).[36] We then construct a time series of the total supply on Ethereum (first at a block level) by summing the outflows from minus the inflows to this address. We then redo the same operation on the Tron blockchain using the Trongrid API. For Tron, we take together the issuer address (THPvaU...) and the blackhole address (T9yD14N...). We then add the supply time series for these two blockchains to create the total supply on these two blockchains. Notice that, the circulating tokens (and total supply) on these two blockchains represent more than 95% of the total circulating tokens at the end of our sample. Finally, the daily supply change is computed as the change between the current day at 9:00 AM New York time (UTC-5) and the last working day at the same hour. This way we ensure that the change in supply is effectively observable by CP issuers in real-time.

Information about mints and burns is easily accessible, even with a low level of understanding of blockchains, by following whale alerts accounts on Twitter[37] that track the large transfers of USDT, and in particular from addresses known to be linked to the creation of USDT tokens (in particular those listed above).

Fig. 14 gives real-life examples of how mints raise first the balance of USDT tokens on the Tether Treasury address, and how this new supply is progressively absorbed by the market in the form of an increase in circulating tokens (reducing the balance of Tether treasury in the chart). We also notice that mints are unfrequent and of a standard rounded size (in June 2019 around 100 million, larger later on). These stylized facts reinforce the likelihood that CP issuers may pay attention to and monitor these mints and burns to predict actual demand from Tether.

More formally, we use this predictability in a two-stage least-square (2SLS) approach. We focus on USDT and modify the baseline equation 1 by instrumenting the change in USDT

[36] In section E, we specify the exact addresses and contracts used.

[37] This account has more than 2.2 million of followers (as of end of 2022) and is known to affect Bitcoin prices (Saggu, 2022)

tokens as follows:

$$\Delta I_t^{CP} = \alpha + \beta * \Delta \widehat{Tokens_t^{USDT}} + Controls_t + FE^{day} + \epsilon_t \quad (3)$$

where controls now include the change in USDC tokens. The first stage is:

$$\Delta \widehat{Tokens_t^{USDT}} = \alpha + \beta(Mints/Burns)_t^{USDT} + Controls_t + FE^{day} + \epsilon_t \quad (4)$$

Fig.13 shows how the mints/burns variable correlates with the change in circulating USDT tokens. As indicated in Table 13 the first stage in 2019-2021 has a 70% of R2 and largely passes the F-test rule-of-thumb (109). Table 13 reports the OLS and 2SLS estimations for two periods, 2019-2021 and 2021-2022, as we expect a link in the former period and not in the latter. Columns (1) and (4) show that the coefficients of OLS and 2SLS are significant, and not statistically different from each other. On the contrary columns (5) and (8) show no significant impact post-summer 2021, as expected. The results from the 2SLS show that the predicted circulating tokens cause a change in CP issuance confirming that the contemporaneous impact is plausible: CP issuers can anticipate the demand and hence can issue larger amounts when anticipating larger demand.

Magnitude of the impact In some of our regression results, the estimated coefficients of interest are larger than one. How can we make sense of this overreaction of the CP market to the demand from stablecoins? We investigate three (non-exclusive) hypotheses.

First, the above 1 coefficient may result from a catching-up in the CP holding of stablecoins, signaling a change in the targeted level of CP holding by the two stablecoin issuers. Prior to summer 2021, we do not know the composition of reserve assets. Stablecoins might have increased the share of CP in their reserve assets over time. This hypothesis is consistent with the large shifts in the estimated coefficients from 2019 to 2020 for USDT and from 2020 to 2021 (see Table 7). We thus cannot exclude that the above 1 coefficient in some of our regression results comes from a change in the targeted share of CP holding by Tether and Circle. According to this hypothesis, the two stablecoin issuers would have benefitted from larger demand to invest massively in CP market, more than the fund they effectively received these days but using available cash in their reserve asset.

Second, the above 1 coefficient may capture a correlation in demand, ie. stablecoins buy CP when other investors buy CP, which would not be controlled for. To check this hypothesis, we use the change in total net assets by the largest holder of CP (Abate, 2021), JPM Prime

MMF (VMVXX). We show in Table 14 that our coefficients of interest are unchanged. The size change in JPM Prime MMF only affects shorter-term CP issuance. The coefficient is half the one of USDT. Therefore, if other investors buy when stablecoins buy CP, these investors are likely not to be MMFs.

Third, auto-correlation in changes in stablecoin circulating tokens and CP issuances may increase our coefficient of interest if CP issuers or stablecoins "frontload" their issuance or purchase of CP, respectively. CP issuers may over-react, and issue more the day they perceive a demand for short-term safe assets but issue less the following days. To better understand the structure of the autocorrelations, we estimate the local projections of our baseline equation. Fig. 7 reports the impulse response functions corresponding to a 1 billion change in stablecoin circulating tokens. This latter variable is positively autocorrelated which could push stablecoins issuers to frontload their purchases of CP anticipating an inflow of dollars in the coming days. From the CP issuers' perspective, an increase in CP issuance is generally followed by a decrease the following days suggesting that shocks affecting the supply of CP are generally transitory.[38]

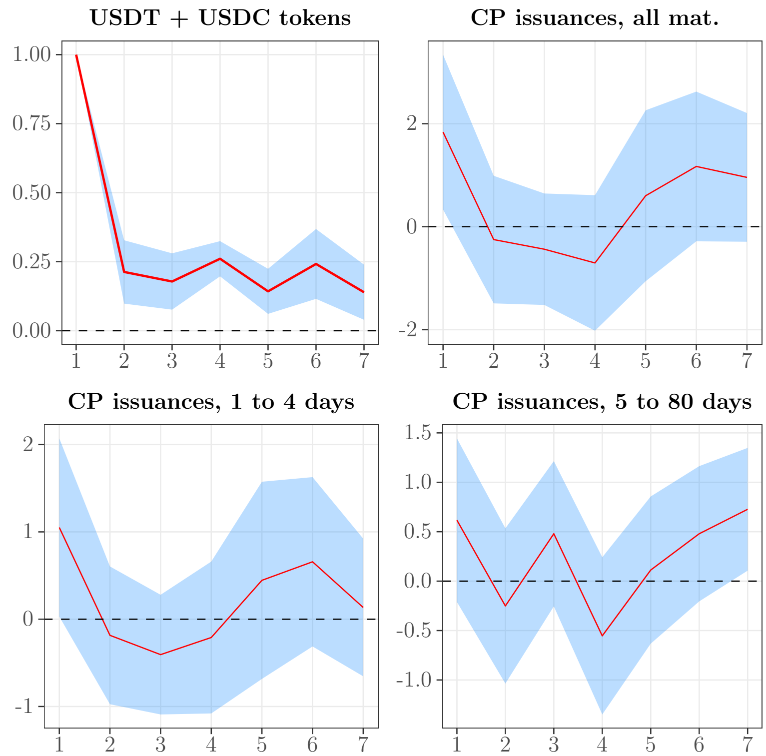
5.4 Robustness

Figures 9 and 10 suggest the presence of outliers in our data, both for CP issuance and change in circulating stablecoin tokens. To ensure our results are not driven by outliers, we conduct multiple robustness checks. Our results remain qualitatively unchanged in all the robust checks we ran.

To account for possible outliers in the circulating tokens data, in Table 14 we first add a dummy variable equal to 1 when the z-score of the stablecoin variable is greater than 3 (column 1) and winsorize our data at 2.5% (column 2). Then, we log-transform the dependent and independent variables to reduce the sensitivity to large fluctuations (column 3). To account for possible seasonality at a monthly level (we already control for weekday seasonality through fixed effects) we add a dummy variable equal to 1 for the last day of the month. Finally, we re-estimate equation 1 with the Huber estimator by iterated re-weighted least squares (IRLS), sometimes called robust estimator (see column 5 of table 14) and with a quantile regression (column 6), (with tau=0.5 ie. the median). All specifications confirm the magnitude and statistical significance of our results.

[38] A possibility is also that CP issuers overreact to the demand from stablecoins due to the lack of coordination among the issuers. Indeed, when deciding its issuance quantity, individual CP issuer has to anticipate the supply of others and the demand from stablecoins. If the opportunity cost of issuing too much is not very high, because the price elasticity of demand is low, then issuing a bit too much may well be optimal.

Figure 7: Impulse response for a 1bn stablecoin token shock



Note: Impulse responses computed following the local projection approach of Jordà (2005), based on first-difference equation 1. Blue areas denote 90 percent confidence bands. Time period in days.

A further robustness test on our main right-hand side variable is conducted in Table 13. Not only the 1st stage (columns (3) and (7)) shows the public data from Messari can be predicted with our own reconstructed blockchain data (Columns (2) and (6)), but using directly mint/burns as an alternative right-hand side variable (the "reduced form" of the 2SLS) confirm again our main result.

6 Conclusion

In this paper, we show that an increase in circulating tokens increases the issuance of CP only when CP are used as reserve assets by stablecoins' issuers validating a reserve assets channel through which stablecoins affect the financing of the real economy.

This result suggests that the different sources of demand for CP do not fully substitute for new demand and that CP issuers strategically time their issuance to meet higher demand for short-term safe assets.

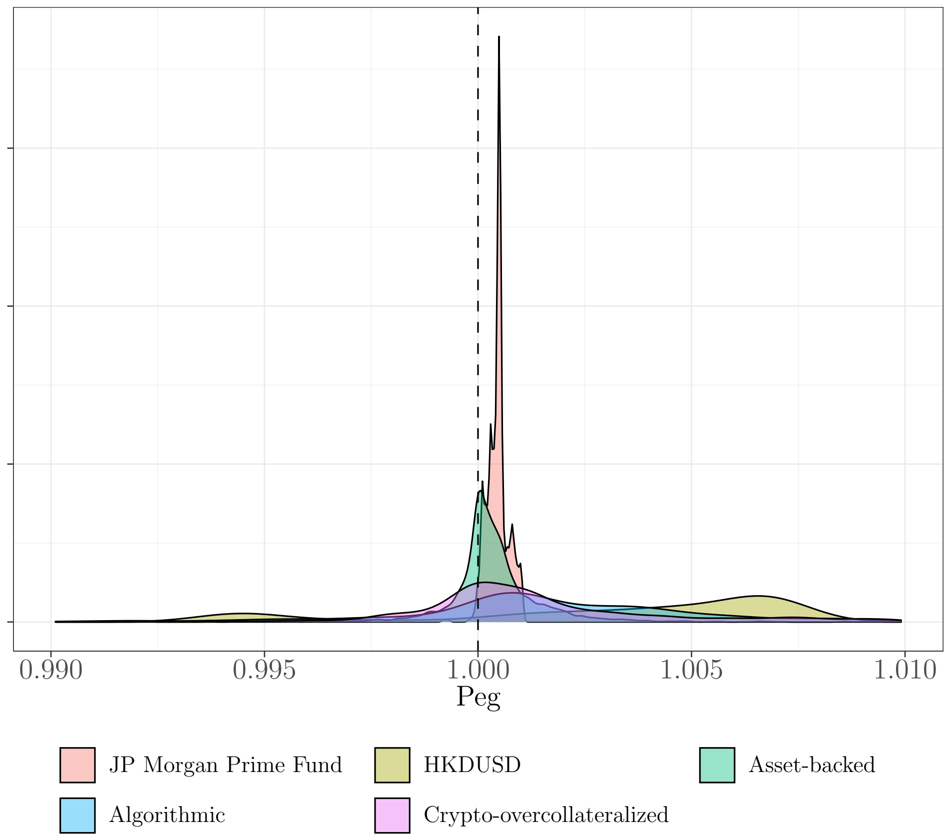
Beyond what we learn from the connection between stablecoins and the CP market, we can draw two main policy implications for digital currencies.

First, regulation on crypto-assets like stablecoins may well reduce the probability of runs and limit their consequences but the connection we establish in this paper is likely to operate under any regulation scheme. By requiring greater transparency on their asset side, or by influencing the type of reserve assets that stablecoins can hold, regulation may simply displace this connection from one asset class to another. Recent papers on MMFs show that fully transparent and Treasury-only money market funds may have an adverse impact on bond liquidity in times of stress, for instance (Ma et al., 2022). The increased transparency of stablecoins might also result in greater competition between them to hold the most liquid assets, which might have unintended consequences in terms of scarcity of safe assets Garratt et al. (2022).

Second, this connection also highlights one implication of issuing central bank digital currency (CBDC). Depending on the exact design, CBDC could become either a public substitute for stablecoins or reserve assets held by stablecoins. An open question for future research is hence to understand how coexisting stablecoins and CBDC could change the connection between crypto markets, financial markets, and the real economy.

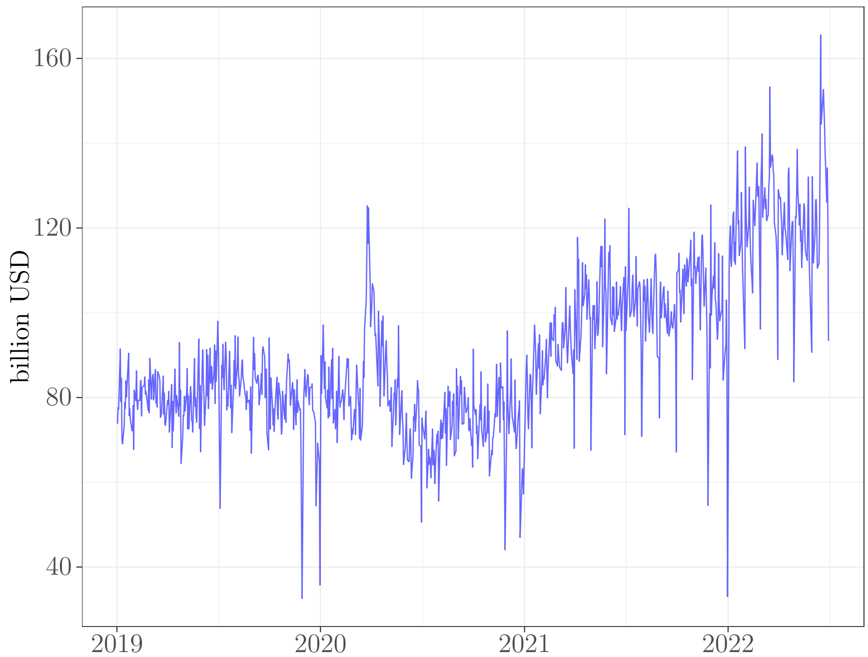
A Figures

Figure 8: Dispersion of exchange rates against the US dollar: Prime MMF share, pegged fiat currency (HKD), selected stablecoins by pegging strategy



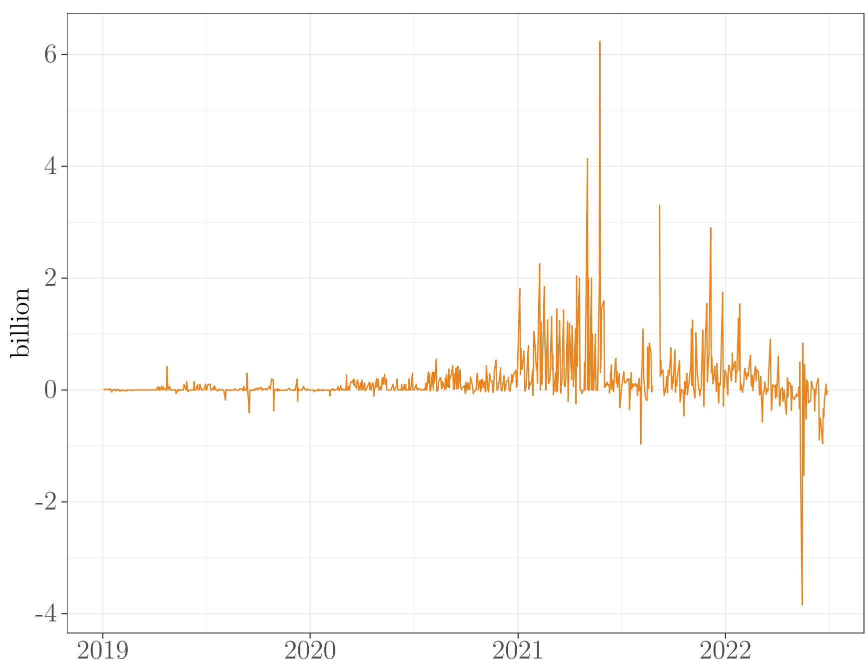
Note: Density plot of the daily end-of-day exchange rates data from Bloomberg, Messari, from January 2020 to August 2022. HKD is expressed in deviation from its mean over this period. Distribution trimmed to the [0.99-1.01] interval. Asset-backed: USDT, USDC, BUSD ; Algorithmic: UST ; Crypto-overcollateralized: DAI.

Figure 9: Total daily issuance of CP, all maturities



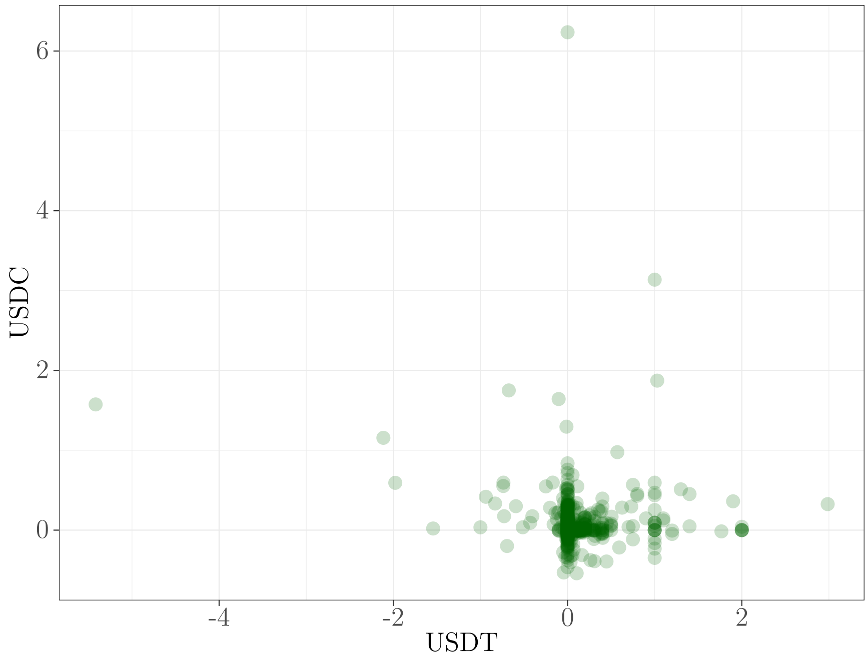
Source: Federal Reserve Board, DTCC.

Figure 10: Daily variations in stablecoins' tokens



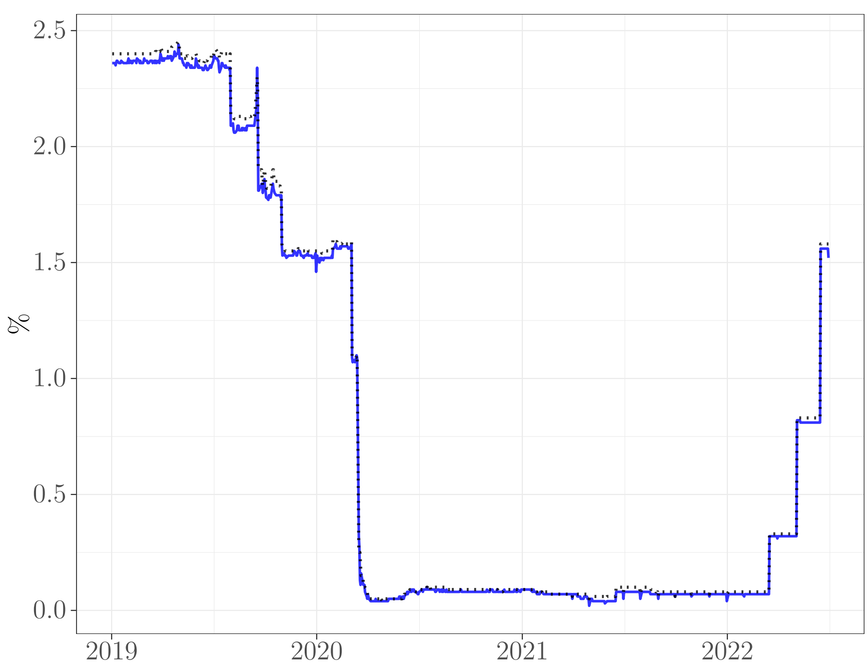
Note: variations in circulating tokens of USDT and USDC, on all blockchains.

Figure 11: Daily changes in USDT and USDC tokens



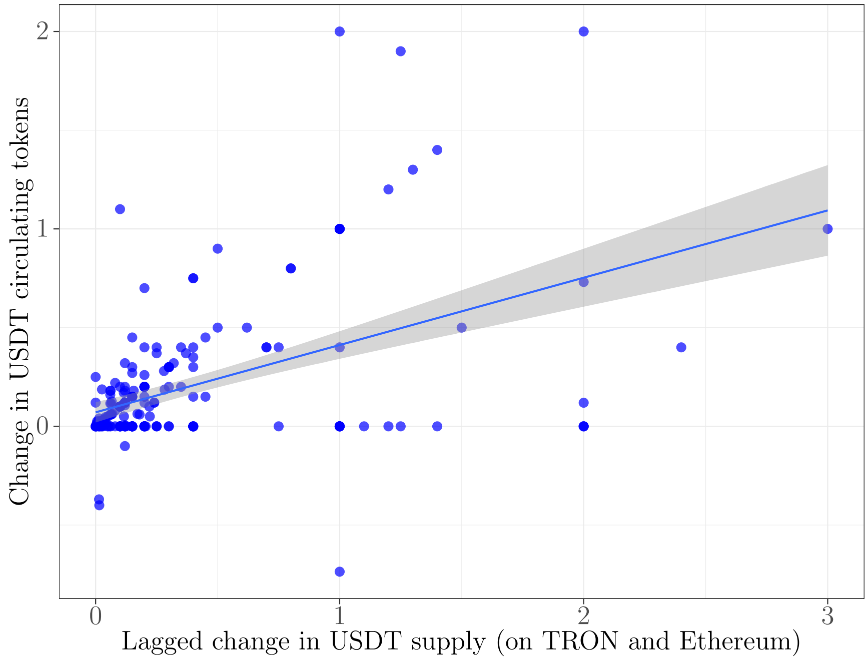
Note: in billion of tokens, source: Messari, on all blockchains.

Figure 12: CP rate (1d Fin AA) (plain) and Effective fed funds rates (dotted)



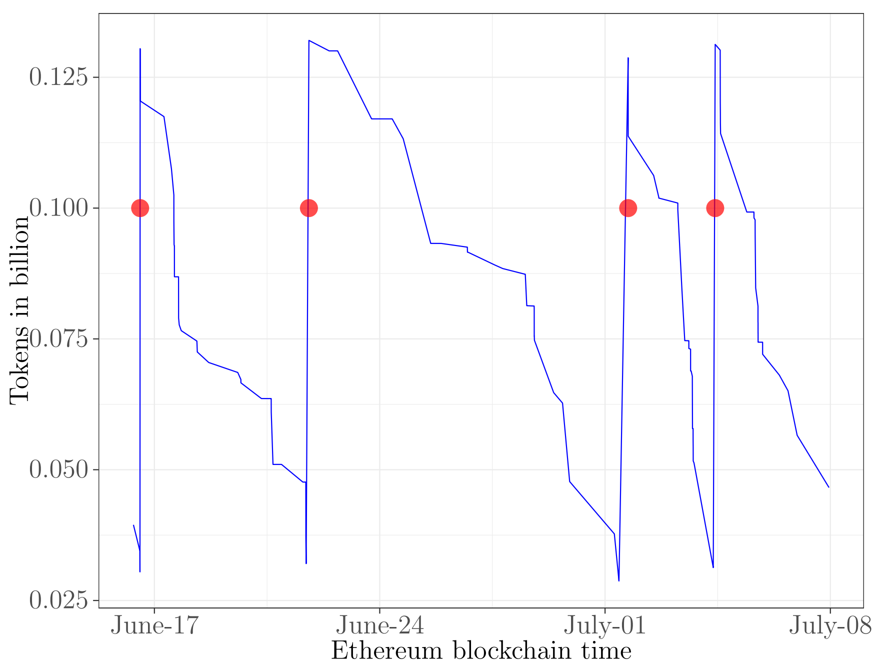
Source: Fred database.

Figure 13: Predicted change in USDT circulating tokens



Source: Trongrid API, Etherscan, author's calculations.

Figure 14: Example of mints (red dots) and Tether treasury balance (blue line)



Note: This graph shows the balance in USDT tokens of the Tether Treasury account on the Ethereum blockchain (Addr: 0x575...). Red dots correspond to "mints" authorized by the Multisig address (0xc6c...). Source: Etherscan.

B Tables

Table 3: Summary statistics

Statistic	N	Mean	St. Dev.	Pctl(25)	Median	Pctl(75)
Δ Tokens USDT+USDC	867	0.137	0.466	−0.001	0.013	0.150
Δ Tokens USDT	873	0.074	0.375	0.000	0.000	0.043
Δ Tokens USDC	867	0.064	0.304	−0.002	0.002	0.059
Δ Tokens BUSD	674	0.025	0.152	−0.008	0.000	0.030
Mints/Burns USDT	801	0.080	0.571	0.000	0.000	0.015
Δ CP issuance All mat.	873	0.022	11.390	−6.313	−0.433	5.238
Δ CP issuance 1d to 4d	873	0.018	7.652	−3.889	−0.564	3.667
Δ CP issuance 5d to 80d	873	−0.000	6.495	−3.578	0.068	3.706
Δ CP issuance >80d	873	0.005	2.511	−1.534	−0.075	1.605
Δ CP issuance Fin. AA	873	−0.005	2.079	−0.962	0.020	0.970
Δ CP issuance Non-fin. AA	873	−0.003	3.380	−1.862	−0.132	1.304
Δ CP issuance Non-fin. A2P2	873	0.002	1.525	−0.676	−0.036	0.645
Δ CP issuance ABCP AA	873	0.006	2.442	−1.323	0.013	1.402
Δ CP spread Fin. AA O/N	873	−0.002	1.208	0	0	0
Δ CP spread Non-fin. AA O/N	871	−0.014	9.555	−1	0	1
Δ CP spread Non-fin. A2P2 O/N	873	−0.006	8.115	−1	0	1
Δ CP spread ABCP AA O/N	873	−0.005	10.755	0	0	0
Δ CP spread Fin. AA 90d	621	0.377	9.603	−2.700	0.000	2.200
Δ CP spread Non-fin. AA 90d	536	−0.180	12.305	−1.200	−0.005	1.092
Δ CP rate Non-fin. A2P2 90d	586	0.527	17.456	−3.737	0.130	3.945
Δ CP spread ABCP AA 90d	852	−0.072	5.718	−1.355	−0.040	1.173
Δ Excess reserves	873	1.745	16.219	−5.530	1.634	9.134
Δ Fed CP purchases	873	0.000	0.200	0.000	0.000	0.000
Nasdaq (daily var. in %)	873	0.072	1.665	−0.588	0.161	0.909
VIX	873	0.006	2.474	−1.020	−0.200	0.750

Table 4: Total CP issuances, USDT and USDC tokens issuances

This table reports the estimation of Equation 1, introducing controls at once. The dependent variable is the daily variation in CP issuance, expressed in billion USD, for all maturities/issuer/credit rating categories reported by the Federal Reserve. Δ Tokens USDT+USDC is the daily change in tokens circulating supply, in billion of tokens. Significance levels are denoted: *** at 1%, ** at 5%, and * at 10%. Newey-West standard errors are shown in parentheses with a lag of 5.

			All mat.		
	(1)	(2)	(3)	(4)	(5)
Δ Tokens USDT+USDC	2.907***	2.940***	2.927***	2.933***	1.901**
	(0.7309)	(0.7214)	(0.7454)	(0.7698)	(0.6424)
Δ Excess reserves		0.0051	0.0046	0.0091	0.0110
		(0.0192)	(0.0197)	(0.0199)	(0.0189)
Δ Eff. Fed funds rate		0.1726*	0.1843*	0.1715	0.1497
		(0.1039)	(0.1036)	(0.1067)	(0.1012)
Δ Fed CP purchases		0.1210	0.1950	0.2301	0.6214
		(2.006)	(1.996)	(1.799)	(1.690)
Dummy: CP stress		-0.2114	-0.3833	0.6726	0.5139
		(0.7352)	(0.7315)	(0.8664)	(0.8343)
Δ Nasdaq			0.6578*	0.6532*	-0.0021
			(0.3898)	(0.3881)	(0.3464)
Δ VIX			0.3696	0.3578	-0.1741
			(0.3187)	(0.3170)	(0.2920)
Δ Log(Debt/GDP)				-606.0*	-680.4**
				(350.4)	(328.6)
Day = Monday					11.73***
					(1.665)
Day = Thursday					6.048***
					(1.315)
Day = Tuesday					9.475***
					(1.215)
Day = Wednesday					3.376**
					(1.139)
Observations	867	867	867	865	865
R^2	0.01418	0.01986	0.02362	0.02963	0.15484

Table 5: USDT, USDC and CP issuances by maturity, issuer and rating

This table reports the estimated coefficient of variation in tokens supply, separately for USDT and USDC. The dependent variable is the daily variation in CP issuance, expressed in billion USD, for different categories of maturity, issuer and credit rating. Δ Tokens USDT+USDC is the daily change in tokens circulating supply, in billion. Controls include, as before, variations in excess reserves, effective fed funds rate, Fed CP purchases, log(Debt/GDP), Nasdaq, VIX. Significance levels are denoted: *** at 1%, ** at 5% and * at 10%. Newey-West standard-errors are shown in parentheses with a lag of 5.

	Maturity				Issuer/Rating			
	All mat. (1)	1d to 4d (2)	5d to 80d (3)	>80d (4)	Fin. AA (5)	Non-fin. AA (6)	Non-fin. A2P2 (7)	ABCP AA (8)
Δ Tokens USDT	1.754*	1.446**	-0.0270	0.3351*	0.1810*	0.2601	0.0507	0.3492**
	(0.8996)	(0.7246)	(0.4161)	(0.1862)	(0.0977)	(0.3625)	(0.0741)	(0.1560)
Δ Tokens USDC	2.167**	1.268	1.017**	-0.1175	0.0103	0.4706*	0.1436**	0.2677*
	(0.9305)	(0.8689)	(0.5071)	(0.1823)	(0.1866)	(0.2787)	(0.0695)	(0.1404)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Weekday-FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	865	865	865	865	865	865	865	865
R^2	0.15490	0.22954	0.17753	0.06911	0.07241	0.45505	0.04713	0.11542

Table 6: USDT, USDC tokens and CP issuances by maturity, issuer and rating

This table reports the estimated coefficient of variation in tokens supply, separately for positive and negative variation, both for USDT and USDC. The dependent variable is the daily variation in CP issuance, expressed in billion USD, for different categories of maturity, issuer and credit rating. $\Delta-$ Tokens USDT is the eventual negative daily change in USDT tokens circulating supply at date t, in billion. Controls include, as before, variations in excess reserves, effective fed funds rate, Fed CP purchases, log(Debt/GDP), Nasdaq, VIX. Significance levels are denoted: *** at 1%, ** at 5% and * at 10%. Newey-West standard-errors with a lag of 5.

	Maturity				Issuer/Rating			
	All mat. (1)	1d to 4d (2)	5d to 80d (3)	>80d (4)	Fin. AA (5)	Non-fin. AA (6)	Non-fin. A2P2 (7)	ABCP AA (8)
$\Delta-$ Tokens USDC	-2.461	-1.907	0.6085	-1.163	-0.0843	0.3653	-0.0482	0.4646
	(5.898)	(3.968)	(2.387)	(0.9591)	(1.233)	(1.105)	(0.6636)	(1.100)
$\Delta+$ Tokens USDC	2.174**	1.252	0.9882*	-0.0656	0.0338	0.2888	0.1289**	0.2362*
	(1.006)	(0.9455)	(0.5710)	(0.2101)	(0.2036)	(0.2371)	(0.0645)	(0.1313)
$\Delta-$ Tokens USDT	0.5380	0.5224	-0.2598	0.2755	0.2558*	-0.5466	-0.0638	0.2674
	(0.8732)	(0.9690)	(0.5895)	(0.2068)	(0.1520)	(0.3466)	(0.0610)	(0.2707)
$\Delta+$ Tokens USDT	2.530**	2.037**	0.1240	0.3687	0.1314	0.7903*	0.1250	0.4041**
	(1.282)	(0.7557)	(0.6595)	(0.2991)	(0.1517)	(0.4232)	(0.1061)	(0.2038)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Weekday-FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	865	865	865	865	865	865	865	865
R^2	0.15643	0.23134	0.17765	0.06982	0.07252	0.45944	0.04763	0.11553

Table 7: USDT, USDC and CP issuances by maturity, issuer and rating - Interacted by year

This table reports the time-varying estimated coefficient of variation in tokens supply by Tether (USDT) and USD Coin (USDC) by year. It is the analogue of table 8 at the year level instead of semester. The dependent variable is the daily variation in CP issuance, expressed in billion USD, for different categories of maturity, issuer and credit rating. Controls include, as before, variations in excess reserves, effective fed funds rate, Fed CP purchases, log(Debt/GDP), Nasdaq, VIX and end-of-month dummy. Significance levels are denoted: *** at 1%, ** at 5% and * at 10%. Newey-West standard-errors are shown in parentheses with a lag of 5.

	Maturity				Issuer/Rating			
	All mat. (1)	1d to 4d (2)	5d to 80d (3)	>80d (4)	Fin. AA (5)	Non-fin. AA (6)	Non-fin. A2P2 (7)	ABCP AA (8)
Δ Tokens USDT × year = 2019	-1.304	-0.3381	-3.925	2.959**	-0.9920	-0.8541	1.197	2.274
	(6.748)	(3.298)	(5.919)	(1.366)	(1.439)	(2.531)	(1.247)	(2.512)
Δ Tokens USDT × year = 2020	11.00**	6.111**	3.549	1.338	1.321	2.834*	1.054*	1.776
	(5.446)	(2.877)	(2.695)	(1.551)	(1.193)	(1.476)	(0.5415)	(1.421)
Δ Tokens USDT × year = 2021	3.015**	2.626**	-0.0092	0.3974	0.1349	0.7347	0.1554	0.5064**
	(1.318)	(0.8816)	(0.7394)	(0.3083)	(0.1480)	(0.4500)	(0.1155)	(0.2166)
Δ Tokens USDT × year = 2022	-0.7447	-0.3482	-0.4273	0.0308	0.1805	-0.2961	-0.1258	0.1001
	(1.162)	(0.7995)	(0.4380)	(0.3084)	(0.2306)	(0.4260)	(0.1382)	(0.3186)
Δ Tokens USDC × year = 2019	-18.33	-16.13	4.277	-6.484	-4.669	-7.920	-1.664	12.80
	(48.41)	(26.74)	(32.23)	(16.05)	(9.080)	(17.09)	(7.242)	(12.79)
Δ Tokens USDC × year = 2020	-14.46	-4.466	-4.663	-5.333	-7.484**	0.2263	0.0542	2.322
	(11.33)	(8.993)	(7.240)	(3.305)	(2.925)	(4.397)	(1.340)	(3.259)
Δ Tokens USDC × year = 2021	2.908**	1.466	1.464***	-0.0213	0.1481	0.2723	0.1140*	0.3298**
	(1.065)	(1.039)	(0.4049)	(0.2191)	(0.2308)	(0.2111)	(0.0618)	(0.1176)
Δ Tokens USDC × year = 2022	-1.502	-0.2173	-0.5779	-0.7063	-0.3507	0.9567	0.1597	0.0224
	(2.876)	(1.847)	(1.190)	(0.5735)	(0.6887)	(0.6227)	(0.3200)	(0.5091)
Year	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Weekday-FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	865	865	865	865	865	865	865	865
R^2	0.16212	0.23597	0.18057	0.07349	0.07960	0.46127	0.05060	0.12006

Table 8: CP issuances - Interacted by semester

This table reports the time-varying estimated coefficient of variation in tokens supply by Tether (USDT) and USD Coin (USDC). Coefficients are shown only for 2021 and 2022, for the sake of readability. Table 7 reports a similar exercise with year interactions. The dependent variable is the daily variation in CP issuance, expressed in billion USD, for different categories of maturity, issuer and credit rating. Controls include, as before, variations in excess reserves, effective fed funds rate, Fed CP purchases, log(Debt/GDP), Nasdaq, VIX and end-of-month dummy. Significance levels are denoted: *** at 1%, ** at 5% and * at 10%. Newey-West standard-errors are shown in parentheses with a lag of 5.

	Maturity				Issuer/Rating			
	All mat. (1)	1d to 4d (2)	5d to 80d (3)	>80d (4)	Fin. AA (5)	Non-fin. AA (6)	Non-fin. A2P2 (7)	ABCP AA (8)
Δ Tokens USDT $\times$ semester = 2021H1	4.070**	2.495**	0.7937	0.7811*	0.2132	0.5815	0.0749	0.6713**
	(2.047)	(1.114)	(0.9612)	(0.4426)	(0.2216)	(0.4536)	(0.1458)	(0.3104)
Δ Tokens USDT $\times$ semester = 2021H2	1.498	3.095**	-1.355	-0.2434	-0.0004	1.112	0.2874	0.2705
	(1.535)	(1.528)	(1.071)	(0.4771)	(0.1596)	(0.8595)	(0.2499)	(0.3180)
Δ Tokens USDT $\times$ semester = 2022H1	-0.7126	-0.3263	-0.4252	0.0389	0.2005	-0.2864	-0.1230	0.0958
	(1.160)	(0.8029)	(0.4352)	(0.3048)	(0.2360)	(0.4290)	(0.1379)	(0.3213)
Δ Tokens USDC $\times$ semester = 2021H1	3.413**	1.835	1.603***	-0.0246	0.2372	0.1385	0.1120**	0.3683***
	(1.327)	(1.321)	(0.3178)	(0.2343)	(0.3077)	(0.1806)	(0.0509)	(0.0868)
Δ Tokens USDC $\times$ semester = 2021H2	0.5130	-0.1046	0.7238	-0.1062	-0.2959	0.9250	0.1327	0.1329
	(2.341)	(2.263)	(1.772)	(0.4090)	(0.3188)	(0.7980)	(0.2539)	(0.5069)
Δ Tokens USDC $\times$ semester = 2022H1	-1.463	-0.1929	-0.5640	-0.7059	-0.3423	0.9579	0.1636	0.0253
	(2.889)	(1.858)	(1.186)	(0.5802)	(0.6995)	(0.6304)	(0.3195)	(0.5138)
Semester	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Weekday-FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	865	865	865	865	865	865	865	865
R^2	0.16915	0.23960	0.18742	0.08154	0.09012	0.46580	0.05452	0.12951

Table 9: Falsification test with BUSD

This table reports the estimated coefficient of variation in tokens supply of BUSD. The dependent variable is the daily variation in CP issuance, expressed in billion USD, for different categories of maturity, issuer and credit rating. Δ Tokens BUSD is the daily change in tokens circulating supply, in billion of tokens. Controls include, as before, variations in excess reserves, effective fed funds rate, Fed CP purchases, log(Tbill/GDP), Nasdaq, VIX. Significance levels are denoted: *** at 1%, ** at 5% and * at 10%. Newey-West standard-errors are shown in parentheses with a lag of 5.

	Maturity				Issuer/Rating			
	All mat.	1d to 4d	5d to 80d	>80d	Fin. AA	Non-fin. AA	Non-fin. A2P2	ABCP AA
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Tokens BUSD	3.296	3.068	-0.3718	0.5998	0.3622	0.7061	0.1651	0.0735
	(3.913)	(2.516)	(1.703)	(0.7059)	(0.5071)	(0.8068)	(0.4475)	(0.4694)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Weekday-FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	674	674	674	674	674	674	674	674
R^2	0.15544	0.21390	0.21576	0.08438	0.07240	0.47606	0.03354	0.13823

Table 10: CP interest rates, in spread against the risk-free rate, first difference in bps

This table reports the estimation of Equation 2, for USDT and USDC tokens. The dependent variable is the first difference of the spread between the CP rates of each maturity/issuer/credit rating bucket, and the risk-free rate of the same maturity, expressed in bps. We take the Effective Fed Funds rate for the O/N and the corresponding OIS for the 7-day CP rates. Δ Tokens USDT is the daily change in tokens circulating supply, in billion of tokens. Significance levels are denoted: *** at 1%, ** at 5% and * at 10%. Newey-West standard-errors are shown in parentheses. The uneven observation numbers by category is due to missing data, as CP especially for longer-term maturities are not issued every day.

	O/N				1-week			
	Fin. AA	Non-fin. AA	Non-fin. A2P2	ABCP AA	Fin. AA	Non-fin. AA	Non-fin. A2P2	ABCP AA
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Tokens USDT	0.0106	0.0115	-0.0992	-0.1979	-0.8679	-0.1139	-0.4185	0.1697
	(0.0354)	(0.1539)	(0.3131)	(0.2363)	(0.7534)	(0.4043)	(0.5013)	(0.2552)
Δ Tokens USDC	0.0784	-0.1343	-0.0058	-0.1137	0.1206	-0.4568	-0.2151	0.1499
	(0.0810)	(0.1977)	(0.1968)	(0.2235)	(0.2971)	(0.2799)	(0.2777)	(0.1970)
Weekday-FE	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Standard-Errors	L=5				L=4	L=5		
Observations	865	863	865	865	595	628	862	864
Adjusted R^2	-0.00573	0.00421	0.02867	0.00373	0.05627	-0.00392	0.08260	0.02588

Table 11: CP interest rates, in spread against the risk-free rate, first difference in bps

This table reports the estimation of Equation 2, for USDT and USDC tokens. The dependent variable is the first difference of the spread between the CP rates of each maturity/issuer/credit rating bucket, and the risk-free rate of the same maturity, expressed in bps. We take the corresponding OIS of the same maturity. Δ Tokens USDT is the daily change in tokens circulating supply, in billion of tokens. Significance levels are denoted: *** at 1%, ** at 5% and * at 10%. Newey-West standard-errors are shown in parentheses. The uneven observation numbers by category is due to missing data, as CP especially for longer-term maturities are not issued every day.

	2-week				3-month			
	Fin. AA	Non-fin. AA	Non-fin. A2P2	ABCP AA	Fin. AA	Non-fin. AA	Non-fin. A2P2	ABCP AA
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Tokens USDT	-0.3489	0.0515	-0.3360	-0.3691*	-0.9320	-1.110	-0.5207	-0.1840
	(0.7545)	(0.6545)	(0.5072)	(0.1978)	(0.9373)	(0.9349)	(1.210)	(0.3427)
Δ Tokens USDC	0.0919	0.2003	0.0612	0.1202	0.3250	-0.2115	-0.4522	-0.5153*
	(0.2173)	(0.3698)	(0.2486)	(0.2055)	(0.7329)	(1.034)	(0.7417)	(0.2957)
Weekday-FE	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Standard-Errors	L=4		L=5		L=4			L=5
Observations	295	600	862	804	613	533	582	844
Adjusted R^2	0.02925	0.01283	0.04314	0.01388	0.09741	0.03667	0.07976	0.01823

Table 12: Total CP issuances, USDT and USDC tokens issuances – in levels

This table reports the estimation of the analogue of Equation 1, in level and log level, with the lagged dependent variable as a control. The dependent variable is the level and log level of CP issuance, expressed in billion USD, for all maturities/issuer/credit rating categories reported by the Federal Reserve. Tokens USDT+USDC is the daily circulating supply, in billion of tokens. Controls are as described before, in level, aside Nasdaq which is expressed in daily growth. Significance levels are denoted: *** at 1%, ** at 5% and * at 10%. Newey-West standard-errors are shown in parentheses with a lag of 5.

	CP issuance				Log(CP issuance)	
	(1)	(2)	(3)	(4)	(5)	(6)
Tokens USDT+USDC	0.2247***	0.1887***				
	(0.0502)	(0.0566)				
Δ Tokens USDT+USDC			2.093**	1.821**		
			(0.7007)	(0.6527)		
Log(Tokens USDT+USDC)					0.1551***	0.1608***
					(0.0221)	(0.0347)
Excess reserves	0.0002	0.0017	0.0038**	0.0053***	-0.00001	-0.00001
	(0.0015)	(0.0018)	(0.0012)	(0.0013)	(0.00002)	(0.00003)
Eff. Fed funds rate	1.362	2.581	6.272***	6.980***	0.0497**	0.0482**
	(2.302)	(2.486)	(1.474)	(1.486)	(0.0173)	(0.0186)
Fed CP purchases	0.0358	0.2338	-0.8516***	-0.3110*	-0.0034**	-0.0037*
	(0.1837)	(0.1786)	(0.1428)	(0.1831)	(0.0016)	(0.0020)
Dummy: CP stress	-0.7118	-0.9533	-0.0384	-0.5041	0.0430**	0.0457*
	(1.768)	(1.778)	(1.620)	(1.620)	(0.0214)	(0.0266)
Δ Nasdaq	0.4248**	0.4386**	0.4169**	0.4442**	0.0056**	0.0056**
	(0.1723)	(0.1752)	(0.1752)	(0.1803)	(0.0020)	(0.0021)
VIX	0.1996**	0.2026**	0.2165**	0.2173**	0.0030**	0.0030**
	(0.0775)	(0.0794)	(0.0743)	(0.0775)	(0.0010)	(0.0010)
Log(Debt/GDP)	-19.18	-57.99**	51.88***	-28.24	-0.6304**	-0.5901**
	(22.07)	(22.58)	(12.12)	(22.63)	(0.1971)	(0.2745)
CP issuance (t-1)	0.4593***	0.4465***	0.5126***	0.4783***		
	(0.0455)	(0.0444)	(0.0438)	(0.0438)		
Log(CP issuance) (t-1)					0.3728***	0.3730***
					(0.0474)	(0.0475)
Time-trend		✓		✓		✓
Weekday-FE	✓	✓	✓	✓	✓	✓
Observations	867	867	866	866	867	867
R^2	0.77161	0.77315	0.76464	0.76919	0.71170	0.71172

Table 13: 2SLS - Predicted changes in USDT circulating tokens

This table reports the estimation by OLS and 2SLS analogue to Table 5 for two different samples: 2019- June 2021 and July 2021-2022. Columns (1) and (5) give the simple OLS estimates. Columns (3-4) and (7-8) present the first and second stage of the 2SLS. In second stages, Δ Tokens USDT is predicted by the change in mints and burns by Tether a day before. Columns (2) and (6) are the 2SLS "reduced form", ie. where the change in mints and burns are directly the explanatory variable at the right-hand side. Controls are as before. Significance levels are denoted: *** at 1%, ** at 5% and * at 10%. Newey-West standard-errors are shown in parentheses.

	OLS (2019-2021)		2SLS (2019-2021)		OLS (2021-2022)		2SLS (2021-2022)	
	Δ CP	Δ CP	1S	2S	Δ CP	Δ CP	1S	2S
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Tokens USDC	2.871**	2.695**	0.0175	2.592**	0.3498	-0.2717	-0.2787	-0.6404
	(1.157)	(1.045)	(0.0165)	(0.9945)	(2.290)	(2.212)	(0.2259)	(2.522)
Δ Tokens USDT	3.468**			5.898**	0.6580			-1.323
	(1.518)			(2.117)	(1.071)			(1.718)
Mints/Burns USDT		4.707**	0.7980***			-0.3621	0.2737**	
		(1.546)	(0.0569)			(0.4869)	(0.1000)	
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Weekday-FE	✓	✓	✓	✓	✓	✓	✓	✓
Standard-Errors	L=5		L=4		L=3			
Observations	661	591	591	591	204	204	204	204
Adjusted R^2	0.18376	0.21853	0.69957	0.20367	0.17773	0.17770	0.28434	0.17252
F-test	12.680	14.000	109.09	14.000	5.2746	5.2737	8.8098	5.2737

Table 14: USDT, USDC and CP issuances - Controlling for BUSD and JP Morgan Prime MMF

This table is the analogue of Table 5 with the change in BUSD circulating tokens and the change in JP Morgan Prime MMF (VMVXX) total assets as controls. Other ontrols include, as before, variations in excess reserves, effective fed funds rate, Fed CP purchases, log(Debt/GDP), Nasdaq, VIX. Significance levels are denoted: *** at 1%, ** at 5% and * at 10%. Newey-West standard-errors are shown in parentheses with a lag of 5.

	Maturity				Issuer/Rating			
	All mat. (1)	1d to 4d (2)	5d to 80d (3)	>80d (4)	Fin. AA (5)	Non-fin. AA (6)	Non-fin. A2P2 (7)	ABCP AA (8)
Δ Tokens USDT	1.785**	1.443**	0.0099	0.3322*	0.1682*	0.2482	0.0703	0.3475**
	(0.8975)	(0.7040)	(0.4380)	(0.1871)	(0.0998)	(0.3597)	(0.0799)	(0.1561)
Δ Tokens USDC	2.089**	1.124	1.104**	-0.1395	-0.0426	0.4224	0.1719**	0.2757*
	(0.9685)	(0.9076)	(0.5006)	(0.1859)	(0.1933)	(0.2773)	(0.0776)	(0.1474)
Δ Tokens BUSD	2.941	2.844	-0.5198	0.6162	0.3580	0.6338	0.1434	0.0427
	(3.952)	(2.557)	(1.720)	(0.7106)	(0.5132)	(0.8090)	(0.4515)	(0.4724)
Δ MMF	0.6196	0.7277*	-0.1641	0.0560	0.1277	0.1290	-0.0407	-0.1075
	(0.6259)	(0.4093)	(0.3213)	(0.1197)	(0.1035)	(0.1210)	(0.0707)	(0.1377)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Weekday-FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	674	674	674	674	674	674	674	674
R^2	0.16398	0.22622	0.21918	0.08834	0.07573	0.47954	0.03549	0.14304

Table 15: CP rates (Fin. 90d AA), in levels, and changes in USDT and USDC tokens

The dependent variable is the interest rate of CP issued by financial institutions, rated AA for a maturity of 90-days. Δ Tokens USDT+USDC is the daily change in circulating tokens of the two stablecoins, in billion of tokens. We introduce controls once at a time. In column (2), we introduce the US OIS 3-month of the same maturity. Column (3) corresponds to Nagel (2016)'s specification, with Effective funds rates, VIX and Log(Debt/GDP) as controls. Column (4) includes all of our controls, as before. Significance levels are denoted: *** at 1%, ** at 5% and * at 10%. Newey-West standard-errors are shown in parentheses with a lag of 5.

	Fin. AA			
	(1)	(2)	(3)	(4)
Δ Tokens USDT+USDC	-0.6449***	-0.0365**	-0.0016	0.0083
	(0.1431)	(0.0127)	(0.0083)	(0.0075)
Eff. Fed funds rate		0.2510***	-0.0086	-0.1406
		(0.0636)	(0.1564)	(0.1887)
Swap OIS 3M		0.7493***	0.9560***	0.9896***
		(0.0740)	(0.1050)	(0.1273)
VIX			0.0148***	0.0154***
			(0.0040)	(0.0040)
Log(Debt/GDP)			-0.9245*	-1.436*
			(0.5099)	(0.8331)
Δ Nasdaq				0.0164**
				(0.0081)
Excess reserves				5.53×10^{-6}
				(0.00005)
Fed CP purchases				-0.0152***
				(0.0035)
Dummy: CP stress				-0.1538
				(0.1064)
Weekday-FE				✓
Observations	709	708	707	707
R^2	0.09163	0.95953	0.97667	0.98087

Table 16: USDT and USDC tokens interacted with interpolated share of CP, and CP issuances

This table reports the estimated coefficient of variation in tokens supply, separately for USDT and USDC and interacted with the share of CP in reserve assets interpolated from regular accountant's reports. The dependent variable is the daily variation in CP issuance, expressed in billion USD, for different categories of maturity, issuer and credit rating. Δ Tokens USDT+USDC is the daily change in tokens circulating supply, in billion, times the share of CP. Controls include, as before, variations in excess reserves, effective fed funds rate, Fed CP purchases, log(Debt/GDP), Nasdaq, VIX. Significance levels are denoted: *** at 1%, ** at 5% and * at 10%. Newey-West standard-errors are shown in parentheses with a lag of 5.

	Maturity				Issuer/Rating			
	All mat.	1d to 4d	5d to 80d	>80d	Fin. AA	Non-fin. AA	Non-fin. A2P2	ABCP AA
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Tokens USDT * CP	3.702***	4.291***	-0.5668*	-0.0216	0.8868***	0.2055	-0.0231	0.0879
	(0.5668)	(0.4701)	(0.3011)	(0.2751)	(0.1637)	(0.2774)	(0.0618)	(0.2179)
Δ Tokens USDC * CP	8.423**	4.648	4.022*	-0.2464	0.3642	0.3901	0.3461	1.250**
	(4.171)	(3.472)	(2.321)	(0.8877)	(0.7414)	(0.7135)	(0.2307)	(0.4081)
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Weekday-FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	865	865	865	865	865	865	865	865
R^2	0.15777	0.25545	0.16837	0.06605	0.09181	0.45268	0.04618	0.11279

Table 17: Robustness checks

This tables a series of robustness checks. Column (1) add a dummy for all observations of change in USDT+USDC tokens larger than 3 z-scores, computed on a 50-day rolling window. Column (2) winsorizes the right-hand side variable by 2.5% symmetrically. Column (3) replaces both the left-hand and right-hand side variables in delta logs. Column (4) add end-of-month dummies to take into account additional volatility these particular days. Column (5) reports the estimation of the robust OLS (Huber estimator), column (6) reports the results of a quantile regression in which we estimate the median instead of the mean.

	Z-score (1)	Winsor. (2)	DLog (3)	EoM (4)	Rob.OLS (5)	QuantReg (6)
Δ Tokens USDT+USDC	1.355**	2.599**		1.078*	1.647***	1.783**
	(0.6657)	(1.175)		(0.5548)	(0.608)	(0.775)
I(z-score>3)	3.163*					
	(1.916)					
Δ Log Tokens USDT+USDC			0.7894*			
			(0.4190)			
End-of-month				-12.12***		
				(2.034)		
End-of-month (t-1)				24.00***		
				(2.753)		
Controls	✓	✓	✓	✓	✓	✓
Weekday-FE	✓	✓	✓	✓	✓	✓
Observations	856	865	865	865	865	865
R^2	0.15853	0.15313	0.14569	0.40357	–	–

C Model

In this section, we build a simple model in which a stablecoin and a money market fund serve as liquidity vehicles. Both produce a liability —Tokens and MMF shares— that offers liquidity services, that we will call money-like claims. On their asset side, they hold a mix of short-term safe assets that may differ by their liquidity risk (eg. CP are safe but rather illiquid). The key assumption is that tokens provide a better liquidity service for digital investments, *inter alia* because they are readily on-chain contrary to MMF shares. The model builds on a simplified version of Holmström and Tirole (2001) with two types of projects: digital and real. We derive the conditions under which a positive shock on the return in the digital sector leads to an increase in the demand for and the issuance of CP.

Setting Time is discrete and indexed by $t \in \{0, 1, 2\}$. There is a unit mass of atomistic and risk-neutral investors with a large endowment at date 0 and valuing consumption only at date 2. The economy features two types of projects: digital and real (denoted by d and r respectively). In addition, two money-like claims are available on-demand for investors: stablecoin and money market fund. They invest part of their assets in CP, while the rest is invested in an outside (unmodeled) risk-free asset, e.g. T-bill. Finally, the rest of the demand for and the supply of CP are modeled through reduced-form elastic demand and supply functions. Contrary to money-like claims, CP cannot be used as a liquidity vehicle directly by investors.

At date 0, investors invest in each sector an amount $I_X \geq 0$ where $X \in \{d, r\}$. At date 1, some projects may require reinvestment $\rho_X I_X$ to continue. At date 2, continued investments pay off $R_X I_X$, discontinued ones pay 0.

More precisely, at date 1, with probability p_X, the investment in sector $X \in \{d, r\}$ requires reinvestment, which is not the case for the other sector. For simplicity, we exclude that both sectors require reinvestment simultaneously. The investor cannot borrow against the future investment return and should sell some liquid assets: stablecoins (M_d) and MMF shares (M_r). The two money-like claims differ in terms of liquidity services. Only stablecoins can be used at date 1 to reinvest in the digital economy. The programmability of stablecoins could be one rationale for this assumption — decentralized finance and protocols-based finance usually require collateral in the forms of stablecoins. Both assets can be used in case real projects need to be reinvested. Using stablecoins for reinvestment in the real sector project costs $c \in [0, 1]$ per stablecoin, standing for the fees and taxes to convert stablecoins into real dollars. The date-2 returns of stablecoins and MMF shares are r_d and r_r, respectively.

Investors are price-takers. At the aggregate level, the gross return R_X in sector X decreases with the *aggregate* investment I_X and is given by:

$$R_r = R(I_r) \quad \texttt{and} \quad R_d = \alpha_d R(I_d),$$

where α_d denotes the relative return of digital investment over real one for the same level of investment $I_d = I_r$. Function R is strictly decreasing with investment.

The demand from money-like issuers for CP Since the investors are deep-pocket and risk-neutral, they simply maximize expected date-2 profit subject to date-1 liquidity constraints:[39]

$$\max_{(I_X, M_X)_{X\in\{d,r\}}} (R_D - r)I_d + (R_r - r)I_r + (1-p_r)r_r M_r + (1-p_d-p_r)r_d M_d - r(M_d + M_r),$$
$$\texttt{s.t.}\, M_d \geq \rho_d I_d \quad \texttt{and} \quad (1-c)M_d + M_r \geq \rho_r I_r,$$

where r stands for the risk-free interest rate of an asset that does not provide liquidity service at the interim date. The first two terms of the maximization stand for the excess return of both investments, assuming no discontinuation along the equilibrium, the third and the fourth terms correspond to the gross return on money-like claims while the last term reports their opportunity cost.

First-order conditions lead to:

$$\frac{R_d - r}{\rho_d} + \frac{R_r - r}{\rho_r}(1-c) = r - (1-p_d-p_r)r_d,$$
$$\frac{R_r - r}{\rho_r} = r - (1-p_r)r_r.$$

Plugging the second equation into the first one and observing that in equilibrium $M_d = \rho_d I_d = \rho_d R^{-1}[R_d/\alpha_d]$, we get the demand for stablecoins:

$$M_d = \rho_d R^{-1}\left[\frac{r(1+\rho_d c) + \rho_d[(1-p_r)(1-c)r_r - (1-p_d-p_r)r_d]}{\alpha_d}\right]. \tag{5}$$

This demand equation (5) plus the perfectly elastic supply of stablecoins leads to:

Proposition 1 *The amount of stablecoins in circulation, M_d, increases with the return of*

[39] No reinvestment is suboptimal when the excess return on investment is sufficiently large; assuming small cost c and $r_r > r_d$, the exact condition is: $R_X > r + \rho_X r_X$ for $X \in \{d, r\}$.

digital investment, α_d, and the return on stablecoins, r_r, but decreases with the riskfree rate r, the convertibility cost c (if $r > (1-p_r)r_r$), and the return on MMF shares r_r.

Proposition 1 directly results from equation (5) and the fact that R^{-1} is monotonously decreasing.

Suppose now that MMF and stablecoins asset managers follow a rule of thumb such that the demand from each sector $D_X \geq 0$ is simply proportional to the asset size $D_X = \delta_X M_X$, where $\delta_X \in [0,1]$ is the CP share in the portfolio.

Proposition 2 *The CP demand from near-money issuers ($D_d + D_r$) increases with the perceived return of digital investments α_d if and only if $\delta_d \geq \delta_r(1-c)$.*

This necessary and sufficient condition results from the fact that the two money-like claims are substitutes. Since the investment in the real economy is not affected by an increase in α_d, the demand for MMF falls with the rise of stablecoins demand: $\frac{\partial M_r}{\partial \alpha_d} = -(1-c)\frac{\partial M_d}{\partial \alpha_d}$. Therefore, the total demand for CP from near-money issuers increases if the demand from stablecoins is not compensated by the fall in the demand from MMF. Notice that, more generally, the cost c measures the substitutability between the two money-like claims in the real economy, see Sunderam (2015) for insights on the substitutability among money-like claims.

CP market We now model the behavior of the rest of the investors on the CP market and the CP issuers. We denote by $D^*(r_{CP})$ the upward-sloping demand curve excluding money-like issuers, where r_{CP} is the CP rate.[40] Finally, we denote by $S(r_{CP})$ the downward-sloping supply curve of CP. The market clearing on the CP market leads to:

$$D_c + D_r + D^*(r_{CP}) = S(r_{CP}).$$

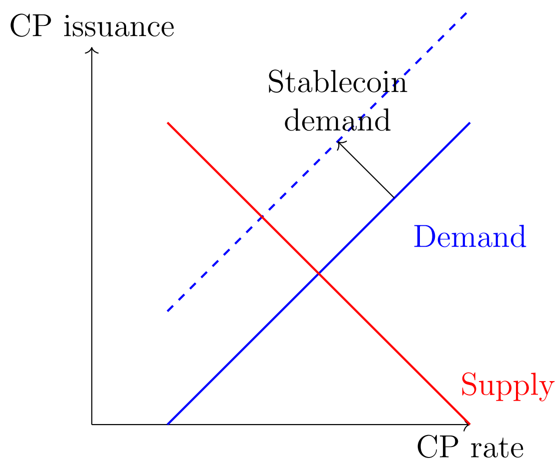
Simple algebra gives the following proposition.

Proposition 3 *The quantity of CP increases with the excess return of the crypto investment if and only if $\delta_c \geq \delta_r$, the demand D^* is not vertical and the supply S is not horizontal. CP rate does not fall with α_d if the supply curve is vertical or the demand curve D^* is vertical.*

Figures 15 and 16 sum up proposition 3 depending on the slopes of supply and demand curves.

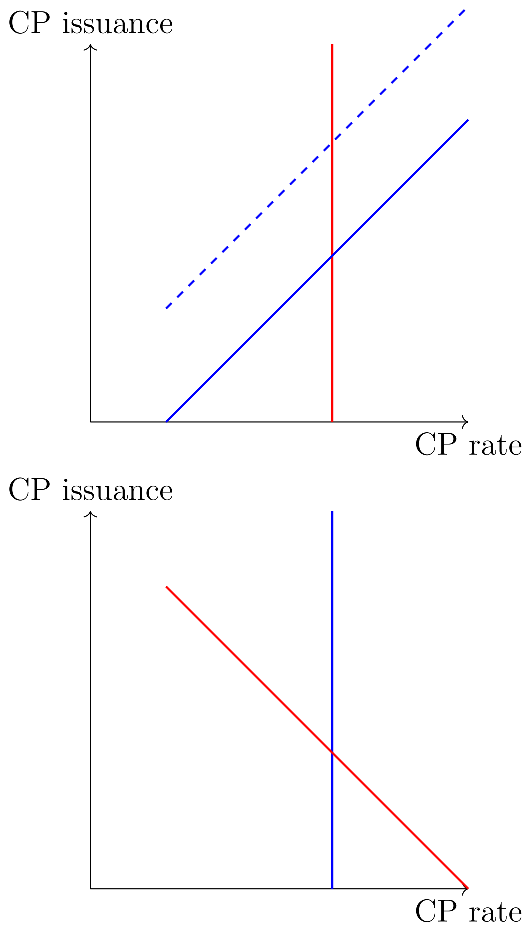
[40] Notice that, by assuming a constant CP share in total MMF and stablecoin assets, we implicitly assume that the demand from money-like issuers is price inelastic.

Figure 15: Impact of stablecoin demand on CP rate and issuance



Note: These stylized demand and supply curves are consistent with linear downward-sloping supply S and linear upward-sloping demand from other sectors D^*. In this case, a positive shock on the perceived excess return on digital investment leads to a positive net demand shock and hence, lower CP rate and higher issuance (see Proposition 3).

Figure 16: Impact of stablecoin demand on CP rate and issuance



Note: Each panel reports the impact of additional demand from stablecoins depending on the slope of the demand and supply curves. In the upper-left panel, the supply is vertical, quantities increase but rates are unaffected. The reverse happens in the upper-right panel whereby the supply is horizontal. In the bottom-left panel, the demand from other investors is vertical, the extra demand from stablecoins is completely offset by the reduction of the demand from other investors. Finally, in the bottom-right panel the demand is horizontal, the price and quantity impacts are maximal.

D Reserve composition of USDT, USDC and BUSD

Reserves composition and attestation reports used in this paper can be found online:

- For Tether: https://tether.to/en/transparency/#reports
- For USD Coin: https://www.centre.io/usdc-transparency
- For BUSD: https://paxos.com/busd-transparency/

Table 18: Information on Circle's CP holdings

Publication date	Event	CP holding
2018-09-01	Creation of the first token	
2021-07-16	First breakdown of USDC reserve (Grant Thornton LLP)	4.9B as of May 28, 2021
2021-08-13	Breakdown of USDC reserve (Grant Thornton LLP)	6.1B as of June 30, 2021
2021-08-22	*"Circle, with the support of Centre and Coinbase, has announced that it will now hold the USDC reserve entirely in cash and short duration US Treasuries. These changes are being implemented expeditiously and will be reflected in future attestations by Grant Thornton."*	
2021-09-01	Breakdown of USDC reserve (Grant Thornton LLP)	6.7B as of July 30, 2021
2021-09-20	Breakdown of USDC reserve (Grant Thornton LLP)	1.8B as of August 31, 2021
2021-10-27	Breakdown of USDC reserve (Grant Thornton LLP)	0 as of September 30, 2021

Table 19: Information on Tether's CP holdings

Date	Event	Information on CP holding
2014-10-06	First issuance (on Omni blockchain)	
2018-01-22	First issuance on Ethereum blockchain	
2021-05-13	*"Today, Tether Holdings Limited made available a breakdown of the categories of assets forming the basis of Tether's issued token reserves at March 31, 2021. We will be releasing this breakdown on a quarterly basis for the next two years."* (First release of reserves breakdown by Tether Holding Limited)	approx. 20B as of March 31, 2021
2021-05-17	*"Tether's reserves show that cash, cash equivalents, and other short-term deposits and commercial paper make up 75% of a highly conservative and liquid reserve allocation. (...) Commercial paper makes up almost two thirds of the cash and cash equivalents and other short-term deposits and commercial paper. Commercial paper is short-term debt issued by corporations. The vast majority of the commercial paper we hold is in A-2 and above rated issuers. In order to ensure it has diversified exposure, Tether imposes limits on individual issuers and on regional exposure. These are in line with Tether's investment policy and industry practice. The commercial paper we hold is purchased through recognized issuance programmes. Accordingly, wild speculation that this includes commercial paper issued by crypto exchanges is absolutely false; no such commercial paper, if it exists, is held by Tether. No commercial paper purchased by Tether is issued by any affiliated entities."* (Stuart Hoegner, Blog post)	approx. 29B as of May 17,2021
2021-06-10	*"But this reported accumulation [of CP] has largely gone unnoticed on Wall Street, according to several of the biggest players in the market including bank traders, analysts and money market funds."*, Financial Times	
2021-08-06	First accountant's report published with the breakdown of reserve assets as of 30 June 2021 (Moore Cayman)	30.8B as of June 30, 2021
2021-12-03	Moore Cayman accountant's report	30.6B as of Sept. 30, 2021
2022-02-19	MHA Cayman accountant's report	24.1B as of December 31, 2021
2022-05-18	MHA Cayman accountant's report	20.1B as of March 31, 2022
2022-06-27	*"Tether also reduced its commercial paper exposure from 45B to 8.4B and is set to phase it out in full in the coming months.* ***All the expiring CP have been rolled into US Treasury bills, and we'll keep going till CP exposure will be 0****." (Tweet by Tether CTO P. Ardoino)*	8.4B as of June 27, 2022
2022-07-01	*"Currently, Tether has 8.4B of these [CP] holdings, of which 5B will expire on July 31. This will result in a significant reduction in commercial paper assets to a low of 3.5B, which is on track with* ***Tether's commitment to the community****. The goal remains to bring the figure down to zero. While both commercial paper and treasury reserves are commonly held liquid assets and cash equivalents, U.S. treasuries will now make up an even larger percentage of Tether's reserves." (Tether press release)*	3.5B as of July 31, 2022
2022-08-10	BDO auditors' report	8.4B as of June 30, 2022
2022-10-13	*"Tether announced that it has eliminated commercial paper from its reserves, replacing these investments with U.S. Treasury Bills (T-Bills). "* (Tether press release)	0 as of Oct. 13, 2022

E Blockchain addresses

To build the mints/burns data series for Tether, we download all the transactions involving the following addresses:

- For the Ethereum blockchain: contract 0xdac17f958d2ee523a2206206994597c13d831ec7
  - The issuer address: 0xc6cde7c39eb2f0f0095f41570af89efc2c1ea828
- For the Tron blockchain: contract TR7NHqjeKQxGTCi8q8ZY4pL8otSzgjLj6t
  - The issuer address: THPvaUhoh2Qn2y9THCZML3H815hhFhn5YC
  - The blackhole address: T9yD14Nj9j7xAB4dbGeiX9h8unkKHxuWwb

Figure 14 uses the Tether treasury address on the Ethereum blockchain: 0x5754284f345afc66a98fbb0a0afe71e0f007b949

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