The Crumbling Wall between Crypto and Non-crypto Markets: Risk Transmission through Stablecoins

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Abstract: The crypto and non-crypto markets used to be separate from each other. However, we argue that risks are now being transmitted across the two markets via stablecoins, which are pegged to non-crypto assets and hold a crucial role in crypto trading. Employing copula-based CoVaR approaches, we identify significant risk spillovers between stablecoins and cryptocurrencies, as well as between stablecoins and non-crypto markets. We also find that the risk spillovers between crypto and non-crypto markets become significant only after stablecoins are widely accepted. This finding underscores the function of stablecoins as a bridge for risk transmission across these distinct markets, while also highlighting the progressively blurring boundaries between the two spheres. Additionally, we document that the risk spillovers from the US dollar to the crypto market are stronger than vice versa, indicating an ongoing process of re-dollarization in the crypto market.

Keywords: cryptocurrencies, stablecoins, risk spillover, risk transmission

1. Introduction

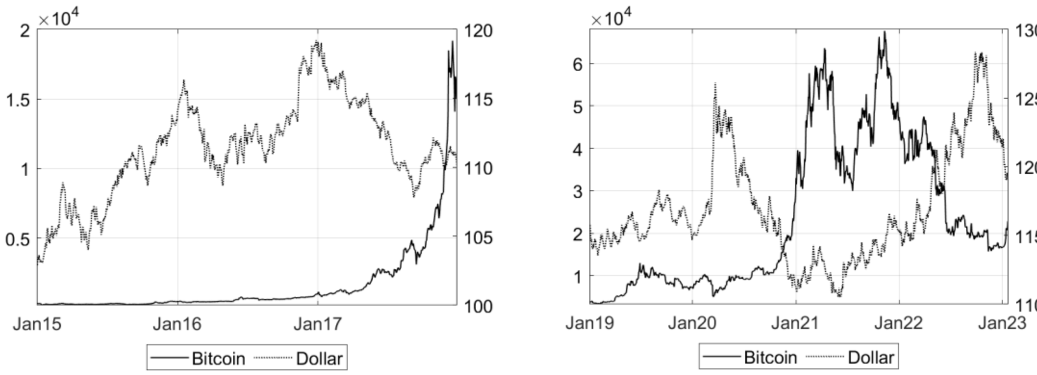
As cryptocurrencies are based on fundamentally new technologies enabling decentralized trading, the general perception is that the crypto market is independent of central banks. The crypto market has even been perceived as an island isolated from the traditional financial market (also known as non-crypto market). However, if an invisible wall once blocked the transmission of risk between the crypto and traditional financial markets, it seems to be crumbling. In March 2020, Bitcoin fell about 25% during the turmoil in stock markets precipitated by the outbreak of the COVID-19 pandemic.[1] On June 21, 2021, the overall crypto market fell soon after the Federal Reserve Board announced plans to increase interest rates.[2] The recent co-movement of the crypto market with the traditional financial market and its responsiveness to US monetary policy contradict the view that cryptocurrencies are non-dollarized and the finding that the crypto market is isolated from the non-crypto market (Borri, 2019; Liu and Tsyvinski, 2021). Given these observations, regulators and investors are facing a critical question: what is causing the recent breach of the risk-blocking wall between the crypto and non-crypto markets?

This paper examines one potential explanation for the emerging link between the crypto and non-crypto markets: the recent rise of stablecoins. Distinguished by their stable prices, stablecoins constitute a unique category of cryptocurrency, in contrast to traditional cryptocurrencies known for their extreme price fluctuations. On one hand, stablecoins are pegged to traditional assets such as fiat currencies and commodities, establishing a connection with the non-crypto market. On the other hand, the price

[1] Accessed from https://www.bloomberg.com/news/articles/2020–03–31/bitcoin-s-march-plunge-is-worst-since-the-crypto-bubble-burst.
[2] Accessed from https://coindesk.cc/bitcoin-price-falls-after-fed-shifts-interest-rate-hikes-forward-amid- inflation-fears-27978.html.

stability of stablecoins has positioned them as the primary transaction medium in cryptocurrency trading and an indispensable collateral for decentralized finance (DeFi) within the crypto ecosystem. Consequently, stablecoins have been dubbed “digital fiat” in the crypto market (Kristoufek, 2021). In summary, by anchoring to non-crypto assets and serving a pivotal role in the crypto market, stablecoins possess the capacity to bridge the gap between these two markets.

Figure 1 illustrates the price trends of two key assets—Bitcoin and the US dollar—across different stages of stablecoin development. From 2015 to 2017, when stablecoins were not yet popular, Bitcoin and US dollar prices appeared to be uncorrelated. However, during 2019 to 2023, as stablecoins gained widespread adoption in the crypto market, a distinct negative correlation emerged between the two assets. This paper will provide evidence that stablecoins serve as a conduit for transmitting risk between crypto and non-crypto markets.



(1) Pre-stablecoin period (2) Post-stablecoin period

Figure 1
Bitcoin prices and US Dollar Index during Pre- and Post- Stablecoin Periods
Notes: This figure displays daily Bitcoin prices and the US Dollar Index during two periods: the pre-stablecoin period (January 1, 2015 - December 31, 2017), when stablecoins were not widely used, and the post-stablecoin period (Feb 2, 2019 - Jan 24, 2023), when they gained popularity. Bitcoin prices in USD are shown on the right axis, and the US Dollar Index is depicted on the left axis.

To establish the role of stablecoins as risk transmitters, we first develop a set of testable hypotheses concerning risk spillovers among three asset categories: stablecoins, cryptocurrencies, and non-crypto assets. By examining how stablecoins are pegged to non-crypto assets and their roles within the crypto ecosystem, we argue that although the crypto and non-crypto markets are not directly connected, their indirect connection through stablecoins leads to significant risk spillovers between them.

We then conduct empirical tests for risk-spillover effects based on the daily returns of different assets. Using copula-based CoVaR approaches, we find significant risk spillover from cryptocurrencies to stablecoins, as well as from stablecoins to the non-crypto market, indicating that stablecoins may serve as a conduit for transmitting risks from the crypto market to non-crypto assets. Furthermore, we find that the risk spillover from cryptocurrencies to the non-crypto market only became significant after the widespread adoption of stablecoins, which further reinforces our earlier argument. Similarly, we also detect risk spillovers from the non-crypto market to cryptocurrencies through stablecoins. By combining these bidirectional pieces of evidence, we conclude that stablecoins play a crucial role as risk transmitters between the crypto and non-crypto markets.

Additionally, we have found that the risk spillovers are asymmetric: the spillovers originating from non-crypto assets, primarily from the dollar, to cryptocurrencies are more pronounced than those in the opposite direction. These findings challenge the widely held belief that cryptocurrencies promote de-dollarization and instead indicate a re-dollarization effect in the crypto market. Figure 2 provides a visual representation of our main results.

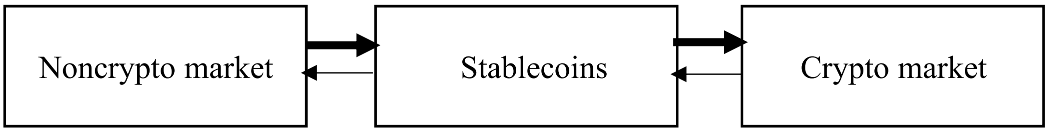


Figure 2
Risk Spillovers among Stablecoins, the Noncrypto Market, and the Crypto Market
Notes: The arrows indicate the existence of risk-spillover effects, and their direction indicates the direction of the effects. The bold arrows indicate stronger spillover effects.

In further analyses, we consider several alternative explanations for the recent link between the crypto and non-crypto markets, including a series of factors such as crypto market capitalization, institutional investors, investor attention, and DeFi development. First, we regress a simple measure of risk spillover on a range of possible factors and find that stablecoins remain significant after controlling the possible confounding factors. To address endogeneity concerns, we use instrumental variables (IVs) to capture exogenous shocks in both the crypto and non-crypto markets. Specifically, stablecoins' transaction volume, instrumented by IVs originating from the crypto market (mining difficulty), is associated with an increase in the risk spillover to the US dollar index, while stablecoins' transaction, instrumented by IVs originating from the non-crypto market (M2 growth of the US dollar), is associated with an increase in the risk spillover to Bitcoin. This suggests that stablecoins have transmitted the shocks between the crypto and non-crypto markets. Taken the evidence together, we argue that, even taken other confounding factors into consideration, stablecoins still are at least one important channel for the spillovers between crypto and non-crypto markets.

Afterward, we carried out multiple robustness checks employing alternative proxies for both the crypto market and stablecoins, and our primary conclusion remained unaltered across all tests. Additionally, we analyzed the interactions between cryptocurrencies and the traditional capital market. We detected significant tail dependency between Bitcoin and the stock market in recent years, consistent with the risk-transmission role of stablecoins.

Our findings have important policy implications. First, regulators must be aware of the potential risks that stablecoins pose to the financial system. While stablecoins, particularly those backed by reserved assets, are able to maintain stable prices and appear risk-free, they can still transmit risks from the volatile crypto market to the traditional financial system. It is crucial that the risky nature of stablecoins as risk transmitters is not overlooked and is closely monitored by central banks. Second, our findings suggest that the risk-spillover effects between crypto and non-crypto markets are asymmetric, indicating that US monetary policy can have a significant impact on price fluctuations in the cryptocurrency market. As a result, investors should reconsider the commonly held belief that cryptocurrencies serve as safe havens or act as risk diversifiers. While the development of the crypto market is often viewed as a sign of de-dollarization, as demonstrated by El Salvador's recent adoption of Bitcoin as legal tender, our results cast doubt on this interpretation.

Our study contributes to the ongoing debate regarding the relationship between crypto and non-crypto markets, specifically whether they are isolated or integrated. While Jiang et al. (2023) have discovered a cointegration between cryptocurrency prices and equity prices, the majority of previous research (Cong et al., 2022; Foley et al., 2019; Griffin and Shams, 2020; Liu and Tsyvinski, 2021; Liu et al., 2022; Makarov and Schoar, 2020) has consistently depicted the crypto market as separate from other financial markets. The most pertinent study in this context is by Liu and Tsyvinski (2021), which demonstrated that only crypto-specific factors can account for fluctuations in crypto markets, and that the crypto market does not move in tandem with other financial markets or macroeconomic factors. However, our findings indicate that stablecoins have established connections between cryptocurrencies and their non-crypto pegs, thereby leading to the integration of crypto and non-crypto markets.

Our paper also adds to the expanding body of research on stablecoins. There has been a surge in concerns regarding the potential regulatory challenges posed by stablecoins (Arner et al., 2020; Financial Stability Board, 2020; G7 Working Group on Stablecoins, 2019; President's Working Group on Financial Markets, 2020). In light of these concerns, several researchers have investigated the inherent risks and instability associated with stablecoins, focusing on the evaluation of stability strategies using theoretical models (Bertsch, 2022; D'Avernas et al., 2022; Gu et al., 2021; Li and Mayer, 2022; Lyons and Viswanath-Natraj, 2019) and assessing the stability of stablecoins through historical experiments of early banking or recent crashes of multiple stablecoin projects (Frost et al., 2020; Kozhan and Viswanath-Natraj, 2021; Gorton et al., 2022; Gorton and Zhang, 2022; Uhlig, 2022; Adams and Ibert, 2022). Although there is some evidence on the interconnectedness between stablecoins and other crypto assets (Baur and Hoang, 2021; Griffin and Shams, 2020; Kristoufek, 2021; Makarov and Schoar, 2022), as well as between stablecoins and the non-crypto market (Barthélémy et al., 2023; Garratt et al., 2022; Liao and Carmichael, 2022), direct evidence regarding the role of stablecoins in transmitting risks between crypto and non-crypto markets remains scarce. To the best of our knowledge, we are the first to connect the dots and reveal the risk transmission role of stablecoins.

Finally, our study also provides preliminary evidence on the ongoing discussion of the interaction between stablecoins and central bank digital currencies (CBDCs). Adrian (2019) suggested that central banks should engage with eMoney, including stablecoins, and proposed "synthetic CBDCs" as a viable option. Cong and Mayer (2021) argue that when stablecoins are backed by reserve assets denominated in a specific country's currency, this country can capture part of the seigniorage generated from stablecoin usage, which in turn strengthens the fiat currency of that country. In line with their theoretical prediction, our empirical evidence shows asymmetric risk spillovers among cryptocurrencies, stablecoins, and the US dollar, suggesting that stablecoins backed by US dollar-denominated reserve assets have bolstered the dollar and led to dollarization in the crypto market.

The rest of the paper is organized as follows. Section 2 provides background information and develops the hypotheses to be tested. Section 3 outlines the empirical methodology and describes the data set used in the study. Section 4 presents the main empirical results, including evidence of stablecoins' risk-transmission role and asymmetric spillover effects. Section 5 discusses alternative explanations and conducts robustness checks. Finally, Section 6 concludes the paper.

2. Background and Hypotheses

2.1 Background, Definitions, and Representative Assets

To explore the risk spillovers among stablecoins, cryptocurrencies, and non-crypto assets, this section provides an overview of the evolution of the crypto market, establishes distinct definitions for each asset type, and selects representative assets for analysis. We begin by clarifying the relevant asset categories and providing typical examples of stablecoins, cryptocurrencies, and non-crypto assets.

The crypto market, which is based on blockchain technology and public key encryption, has gained significant attention from both investors and regulators. By the end of 2022, its market capitalization reached $828 billion. Decentralized finance (DeFi) products have experienced substantial growth. However, the lack of price stabilization mechanisms has resulted in high volatility for cryptocurrencies such as Bitcoin and Ether. To address this issue, stablecoins have emerged as a new type of cryptocurrency designed to maintain a stable value relative to a fiat currency or other reference assets. As a result, they have become a popular transaction medium in crypto trading and an important collateral in DeFi (Arner et al., 2020). The circulating supply of stablecoins has surged from under $5 billion in 2019 to over $133 billion in 2022 and their transaction volumes have surpassed those of all other cryptocurrencies, including Bitcoin (Cermak et al., 2021; Mizrach, 2022).

In our paper, we will use the term "*stablecoins*" to refer to the type of cryptocurrency that is designed to maintain a relatively stable price range. The terms "*crypto assets*," "*traditional cryptocurrencies*," and "*crypto market*" will be used interchangeably to refer to cryptocurrencies other than stablecoins. These types of cryptocurrencies are characterized by extreme price fluctuations and lack collateral or price pegs. In addition to cryptocurrencies and stablecoins, we will also use the terms "*non-crypto assets*" and "*non-crypto market*" interchangeably to refer to traditional financial markets, including fiat currencies and financial securities.

This study investigates risk spillovers between stablecoins, cryptocurrencies, and non-crypto markets by examining typical assets from each category. We focus on the top two stablecoins, Tether (USDT) and USDC, which together represent over 90% of the stablecoin market capitalization. Both share similar design features, which include being issued by intermediary companies, pegged to the US dollar, and backed by reserve assets denominated in US dollars as collateral.[3] We use Tether in the baseline estimation and repeat the analyses for USDC in robustness checks. For traditional cryptocurrencies, we focus on the most famous one, Bitcoin (BTC), which accounts for nearly half of the crypto market's capitalization and is strongly correlated with the returns of almost all other cryptocurrencies (Hu et al., 2019). Additionally, we consider Ether (ETH) in further analyses. For non-crypto assets, we focus on the dollar as it is the most important reserve currency in global financial markets and the most important reference asset for stablecoins—both Tether and USDC are pegged to the dollar. Therefore, the dollar maintains a closer connection with stablecoins and serves as a good representative of non-crypto assets in examining spillover effects. In further analysis, we include stock market indexes to corroborate our main findings.

[3] There are other types of stablecoins in existence which do not share similar design features as the top three stablecoins. For example, DAI is a type of stablecoins using cryptocurrencies as collateral; TerraUSD is another type of stablecoins using certain algorithm to reduce price fluctuations. However, since these stablecoins represent less than 10% of the total market share and function differently in the transmission process, we only focus on the most popular stablecoins which are widely adopted.

2.2 Hypothesis Development

Given that stablecoins are widely used for crypto trading and are pegged to the US dollar, they have the potential to transmit risks between crypto and non-crypto markets. In this subsection, we detail the mechanisms of risk transmission and present hypotheses to guide our econometric analysis.

The first two hypotheses describe how stablecoins can transmit risks from cryptocurrencies to non-crypto markets. The existence of such risk transmission is dependent on two linkages: the first is the risk spillover from cryptocurrencies to stablecoins, and the second is the risk spillover from stablecoins to the US dollar. We propose the following hypothesis:

Hypothesis 1: There are significant risk spillovers from cryptocurrencies to stablecoins and from stablecoins to non-crypto assets.

We justify the risk spillover from cryptocurrencies to stablecoins as follows: Stablecoins are cryptographically secured on public blockchains, allowing for near-instantaneous, always-open trading without the need for financial intermediaries. As a result, they serve as a store of value on public blockchain-based markets and become a preferred choice over fiat currency during crypto market distress as investors rush to liquidate their speculative positions. Baur and Hoang (2021) document that Bitcoin investors seek out stablecoins when Bitcoin experiences extreme negative price changes, while Liao and Carmichael (2022) attribute the fluctuations of stablecoins to changes in cryptocurrencies' trading demand. Consequently, stablecoins tend to rise in response to busts in cryptocurrencies and fall during crypto-market booms. For example, during the crypto-market downturns in March 2020 and May 2021, when the price of Bitcoin fell by more than 30%, the prices of major stablecoins spiked upward. Therefore, we expect significant risk spillovers from cryptocurrencies to stablecoins.

Moving on to the risk spillovers from stablecoins to non-crypto markets, shocks on stablecoins could change the demand for their reserve assets and thus affect the non-crypto financial system (Arner et al., 2020). This is identified as a “reserve assets channel” in Barthélémy et al. (2023). By exploiting the exogenous changes in the composition of stablecoins’ reserve assets, Barthélémy et al. (2023) find that the additional demand for stablecoins’ collateral significantly affects the issuance of US dollar-denominated commercial papers. This suggests the risk associated with stablecoins could spill over to the commercial paper market, impacting firms that rely on commercial paper issuance for financing. Similarly, Garratt et al. (2022) argue that a spike in stablecoins’ supply would increase the demand for reserve assets and lead to a scarcity of safe assets in the financial market. Liao and Carmichael (2022) have analyzed the balance sheets of the banking system and argue that stablecoins’ demand for reserve assets might lead to financing disintermediation in the banking sector. In addition to the increased demand for reserve assets, stablecoins could also affect the non-crypto market through fire sales of reserve assets. Stablecoins are subject to runs (Gorton and Zhang, 2022), which could lead to a self-reinforcing cycle of redemptions, fire sales of reserve assets, and a slump in returns of short-term financial assets in the non-crypto market.[4] Combining the evidence above, we expect significant risk spillovers from stablecoins to non-crypto markets and will test this empirically.

Conditional on the existence of the two linkages mentioned in Hypotheses 1, we expect the popularity of stablecoins to facilitate risk spillover from crypto to non-crypto markets. Moreover, considering previous evidence on the isolation between crypto and non-crypto markets (e.g., Liu and Tsyvinski, 2021), we expect the risk spillovers from crypto to non-crypto markets to become significant only after stablecoins are widely used, as described in Hypothesis 2.

Hypothesis 2: The risk spillover from crypto to noncrypto markets becomes significant only when stablecoins gain widespread popularity.

Our next discussion pertains to the risk spillover in the opposite direction, specifically from non-crypto markets to cryptocurrencies through stablecoins. This risk transmission is dependent on two additional linkages: the risk spillovers from non-crypto markets to stablecoins, and the risk spillovers from stablecoins to cryptocurrencies. We present Hypothesis 3 below.

Hypothesis 3: There are significant risk spillovers from noncrypto assets to stablecoins, as well as from stablecoins to cryptocurrencies.

In Hypothesis 3, the first linkage involves risk spillovers from non-crypto assets to stablecoins, driven by the design of stablecoins to mechanically follow their non-crypto

[4] Regulators such as the US's Financial Stability Board, the President's Working Group on Financial Markets (in the US), the US's Financial Stability Oversight Council, the European Central Bank, and the Bank of England have all raised concerns about the potential risks posed by stablecoins to the broader financial system.

pegs. Specifically, the depreciation or appreciation of the dollar can lead to fluctuations of dollar-pegged stablecoins in cross-border trading within the crypto market. The possibility of de-pegging increases when stablecoins' reserve assets are at risk in the non-crypto market. Bertsch (2022) highlights that stablecoin holders are sensitive to adverse information regarding the quality of issuers' assets and exposure to custodial risks. Li and Mayer (2022) also argue that stablecoin issuers are exposed to operational risks, and their reserve assets are often held in risky assets in practice. For instance, a significant portion of the reserve assets of the stablecoin Tether comprises commercial papers, which are highly exposed to the financing conditions in the non-crypto market. The issuers of another major stablecoin, USDC, have deposited some of their reserve assets in Silicon Valley Bank (SVB), and USDC experienced de-pegging during the bankruptcy of SVB in 2023.[5] Therefore, we anticipate significant risk spillover from non-crypto assets to stablecoins.

Regarding the second linkage, we anticipate significant risk spillover from stablecoins to cryptocurrencies, as stablecoins play a critical role in crypto-exchange settlements and serve as the major collateral in DeFi transactions, thereby functioning as a significant source of liquidity for the crypto ecosystem. Cermak et al. (2021) reported that over 60% of cryptocurrency transactions in 2021 were denominated in stablecoins, compared to over 50% denominated in Bitcoin in 2017. Griffin and Shams (2020) demonstrated the potential inflationary effects on cryptocurrencies due to

[5] See https://www.circle.com/blog/an-update-on-usdc-and-silicon-valley-bank.

excessive Tether issuance, while Kristoufek (2021) showed that the increasing demand for stablecoins reflects their role as "digital fiat" in the crypto market. Furthermore, Makarov and Schoar (2022) argue that a run on stablecoins could become a significant source of systemic risks in crypto ecosystem. Thus, we anticipate significant risk spillovers from stablecoins to cryptocurrencies.

Given the two linkages mentioned in Hypothesis 3, we also anticipate that the popularity of stablecoins may transmit risks from non-crypto to crypto markets. To test the risk transmission role of stablecoins in this direction, we examine whether the spillover of risks from non-crypto to crypto markets becomes significant only after stablecoins are widely used, as described in Hypothesis 4.

Hypothesis 4: The risk spillover from non-crypto to crypto markets only becomes significant once stablecoins gain popularity.

Last but not least, we look into the asymmetric effects of risk spillovers. Even though we have discussed risk spillovers in both directions, the actual effects are likely to be asymmetric due to multiple factors. First, there are significant differences in the market size of crypto and non-crypto markets, which would lead to larger spillover effects from non-crypto markets to stablecoins (and subsequently to cryptocurrencies) than in the reverse direction. For example, the dollar enjoys a daily volume of nearly $5 trillion in the foreign exchange market, which is nearly one hundred times larger than Tether's daily trading volume. Consequently, any shock to the dollar will be transmitted to Tether through the pegging mechanism, whereas a shock to Tether's price, although it might trigger fire sales and contagion effects in the dollar market, is less likely to substantially influence the considerably larger dollar market. Second, given the design features of stablecoins, they automatically follow the non-crypto peg, resulting in more direct and potentially stronger risk spillovers from non-crypto pegs to stablecoins. Similarly, due to the digital-fiat function of stablecoins in the crypto ecosystem, a shock to stablecoins can influence overall liquidity in crypto trading, leading to stronger risk spillovers from stablecoins to cryptocurrencies than in the opposite direction. Therefore, we expect that the risk spillovers from the non-crypto market to cryptocurrencies through stablecoins will be stronger than those in the opposite direction. The asymmetric effects are summarized below.

Hypothesis 5: The risk spillovers from non-crypto assets to cryptocurrencies through stablecoins are larger than those in the opposite direction.

3. Methodology and Data

In this section, we will outline our empirical strategies, discuss copula-based CoVaR measures, and provide an overview of our dataset and variables. Before delving into the methodology, it is important to emphasize that risk-spillover measures do not necessarily imply causality. Generally, causal statements can only be made within a specific structural model (Adrian and Brunnermeier, 2016). In an unpublished draft, we extended the model from Adrian and Brunnermeier (2016) to illustrate a stylized financial system consisting of three submarkets: crypto, noncrypto, and stablecoin. By comparing systems with and without stablecoins, we discovered that risk spillovers can occur even when markets are not directly connected. Our findings are in line with Allen and Gale (2000), who demonstrated that financial contagion can occur among disconnected components. The structural model is available upon request.

3.1 CoVaR Measures based on Copula Method

In assessing asset risks, we focus on tail risks due to their particular relevance for two reasons. First, the high volatility of cryptocurrencies renders standard measures like return variance less reliable, emphasizing the importance of extreme risks. Second, global regulatory concerns about the impact of cryptocurrencies and stablecoins on overall financial stability necessitate an examination of their role during market turmoil. To quantify individual asset tail risk, we employ the widely accepted measure, value-at-risk (VaR).

The VaRs for asset i are defined as the α quantiles of the returns r^i:

$$\Pr\left(r^i \leq VaR_\alpha^i\right) = \alpha \text{ and } \Pr\left(r^i > VaR_{1-\alpha}^i\right) = \alpha \tag{1}$$

Here, VaR_α^i and $VaR_{1-\alpha}^i$ measure the downside and upside tail risks, respectively. For example, with $\alpha = 10\%$ for asset i, $VaR_{10\%}^i$ measures the downside tail risk, reflecting the maximum losses that long-position holders of asset *i* may experience from a dramatic price decline at a 90% confidence level. Conversely, $VaR_{90\%}^i$ denotes the upside tail risk, indicating the maximum losses that short-position holders may suffer due to a sharp price increase. For brevity, we predominantly focus on downside risk measures.[6]

Expanding on the definition of VaR, which measures extreme risks for an individual asset, we employ Conditional Value at Risk (CoVaR) as proposed by Adrian

[6] We also repeated the analyses for upside tail risks and found that the main results still hold.

and Brunnermeier (2016) to examine risk spillovers among various assets. CoVaR is defined as the VaR of one asset, conditional on another asset being under distress. By focusing on these conditional relationships, CoVaR captures the interconnectedness of risks. For example, we can examine Bitcoin's tail risk conditional on stablecoins' distress. If Bitcoin's CoVaR does not differ significantly from its VaR, we can conclude that stablecoins do not influence Bitcoin's tail risk, and no risk spillover effects exist from stablecoins to Bitcoin. Conversely, if Bitcoin's CoVaR differs significantly from its VaR, it indicates that the distress of stablecoins has a notable impact on the tail risk of Bitcoin, suggesting the presence of a spillover effect.

Specifically, we define CoVaR as follows:

$$\Pr\left(r^i \leq CoVaR_{\alpha}^{i|j} | r^j \leq VaR_{\beta}^{j}\right) = \alpha \qquad (2)$$

$$\Pr\left(r^i \leq CoVaR_{\alpha}^{i|j} | r^j > VaR_{1-\beta}^{j}\right) = \alpha \qquad (3)$$

In this context, $CoVaR_{\alpha}^{i|j}$ measures the downside tail risk of asset i under the condition that asset j is experiencing downside risk, characterized by $r^j \leq VaR_{\beta}^{j}$ in Equation (2), or under the condition that asset j is experiencing upside risk, characterized by $r^j > VaR_{1-\beta}^{j}$ in Equation (3). Hence, Equation (2) defines the downside-to-downside CoVaR while Equation (3) defines the upside-to-downside CoVaR. When investigating the risk spillovers between stablecoins and the dollar, we rely on the CoVaR measure as presented in Equation (2). This is because a downturn in the dollar typically corresponds to a decline in both the value and demand for stablecoins. In contrast, when examining risk spillovers between cryptocurrencies and stablecoins, or between cryptocurrencies and the dollar, we use the CoVaR measure as shown in Equation (3).

This is because a decrease in cryptocurrency returns is typically associated with an increase in both the demand for, and the subsequent returns of stablecoins. This surge can, in turn, lead to a rise in the returns of the US dollar. We set $\alpha = \beta = 0.1$, which corresponds to a confidence level of 90%.

To estimate VaR and CoVaR, we rely on the copula-based CoVaR approach, following Oh and Patton (2018). We did not choose quantile regression (as used in Adrian and Brunnermeier, 2016) or multivariate GARCH models (as in Girardi and Ergün, 2013) due to the challenging task of our study, which involves jointly modeling the returns of three asset classes that exhibit very different patterns. Since the crypto market is known for its high volatility and the stablecoin market is known for its stability, the copula approach is suitable due to its flexibility in separately specifying the marginal distributions of individual asset returns and their dependence structure.[7]

According to Patton (2006) and Oh and Patton (2018), the joint distributions $F(r_t^i, r_t^j)$ can be decomposed into the marginal distributions $F_i(r_t^i)$ of individual assets and a copula function $c_t(.)$ as a linking function:

$$F\left(r_t^i, r_t^j\right) = c_t(F_i\left(r_t^i\right), F_j\left(r_t^j\right)) \tag{4}$$

We first model the marginal distributions and then fit the copula function to the transformed series. For the marginal distribution, denoted as $F_i\left(r_t^i\right)$, of the return on asset i, we consider the following ARMA-GARCH specification:

$$r_t^i = u_{it}(\theta_1) + e_t^i, \quad e_t^i = \epsilon_t^i \sigma_{it}(\theta_2)$$

[7] Quantile regression requires specific state variables and GARCH relied on correctly specifying the joint distribution of returns, which are both difficult for crypto market due to extreme price volatility.

Here, $u_{it}(\theta_1)$ and $\sigma_{it}^2(\theta_2)$ are the conditional mean and conditional variance of r_t^i given the information set available at time t, and ϵ_t^i is the standardized innovation. θ_1 and θ_2 are the finite-dimensional unknown parameters to be estimated.

Next, we fit the copula model $c_t(.)$ with the filtered asset returns. To accommodate possible time-varying dependence between asset returns, we use the copula model with the Generalized Autoregressive Score (GAS) dynamics proposed by Creal et al. (2013). With the copula-based methods, we obtain the joint distribution, denoted as $F\left(r_t^i, r_t^j\right)$, for different assets, from which we calculate the VaRs and the CoVaRs. The econometric model specification, marginal-distribution estimations, and copula estimations are provided in the Appendix.

3.2 Kolmogorov-Smirnov Test and a Simple Measure for Risk Spillovers

Based on CoVaR and VaR values estimated through the Copula method, we follow the approach of Bernal et al. (2014), Reboredo et al. (2016), and Mensi et al. (2017) to conduct a one-sided (two-sample) bootstrap Kolmogorov-Smirnov (KS) test to examine the existence of risk spillovers. The null hypothesis of no spillover risks transmitted from asset j to asset i can be formulated by equating the cumulative distribution functions (CDFs) of CoVaR and VaR as follows:

$$\textbf{H0:}\ CoVaR_\alpha^{i|j} = VaR_\alpha^i$$

The one-sided alternative hypothesis assumes that the downside risk of asset *i* increases when asset j is in an extreme condition, formulated as follows:

$$\textbf{H1:}\ CoVaR_\alpha^{i|j} < VaR_\alpha^i$$

To test the null hypothesis H0, we employ the following one-sided KS test:

$$\mathrm{KS}_{mn} = (\frac{mn}{m+n})^{0.5} \sup_x |F_m(x) - G_n(x)|$$

Here, F_m and G_n are the empirical CDFs of $CoVaR_\alpha^{i|j}$ and VaR_α^i, respectively, and *m* and *n* are the sizes of the two samples. To account for the estimation errors arising from the estimation of CDFs, we rely on the bootstrap KS test proposed by Abadie (2002). When the null hypothesis H0 is rejected in favor of the alternative H1, we conclude that the tail risk of asset *j* has spillover effects on tail risk of asset *i*.

In addition to testing the existence of risk spillovers, we also need a simple measure to quantify the magnitude of risk-spillover effects. Following Reboredo et al. (2016), we propose a standardized measure of risk spillovers, RCoVaR, defined as the ratio of CoVaR to VaR:

$$RCoVaR_\alpha^{i|j} = {CoVaR_\alpha^{i|j}}\Big/{VaR_\alpha^i} \tag{5}$$

Here, $RCoVaR_\alpha^{i|j}$ measures the spillover effects of asset *j* on the tail risk of asset *i*. For example, suppose $RCoVaR_\alpha^{i|j} = 1.1$. That means the distress of asset *j* is associated with a 10% increase in asset *i*'s tail risk. The higher the RCoVaR is, the larger the spillover effect is. Note that RCoVaR is a standardized measurement that is insensitive to the original magnitude of returns, which helps us to test for asymmetry in risk-spillover effects among different asset classes. We also calculate $\overline{RCoVaR}$, the ratio of the average CoVaR to the average VaR, as a simple and intuitive measure of risk-spillover effects.

3.3 Data Sources and Variables

In the baseline analysis, we use the most typical assets to represent the crypto market, the non-crypto market, and stablecoins. We focus on the cryptocurrency Bitcoin, stablecoins Tether, and the US dollar. In further analyses, we also include the cryptocurrency Ether, stablecoin USDC, and stock indexes. We obtain the variables from different sources: prices for stablecoins and cryptocurrencies are obtained from the CoinGecko database; the US Dollar Index is retrieved from the Federal Reserve Economic Data (FRED) database; stock indexes are obtained from the WIND Economic Database. To avoid spurious co-movements due to the variation of a single numeraire, we use the US Dollar Index's basket of currencies as the numeraire to capture the movements of different assets against *a set of currencies*.[8] In further analyses, we consider confounding factors to explain the linkage between the crypto and non-crypto markets by exploiting several other variables: stablecoins' trading volume and value locked in DeFi from the Glassnode database, crypto market capitalization from the CoinGecko database, whale account numbers (defined as the number of accounts that hold more than 1000 bitcoins) from the Glassnode database, CBOE Volatility Index (VIX) from the WIND database, M2 growth in the US from the Federal Reserve, and mining difficulty from Nasdaq's Quandl Institutional Data Platform's Blockchain Database.

Our sample covers the period from January 1, 2015, to January 24, 2023. We define the period before 2017 as the pre-stablecoin period since stablecoins' trading volume was quite low before 2017. In contrast, we categorize the period from 2019 to

[8] We calculate the price indexes as a weighted geometric mean of the assets' value relative to the following currencies: Euro (EUR), Japanese yen (JPY), Pound sterling (GBP), Canadian dollar (CAD), Swedish krona (SEK), and Swiss franc (CHF). The calculation formula is as follows: 50.14348112×Price_in_EUR0.576×Price_in_JPY0.136×Price_in_GBP0.119×Price_in_CAD0.091×Price_in_SEK 0.042×Price_in_CHF0.036.

2023 as the post-stablecoin period, as stablecoins' trading value has spiked since 2019. In our baseline results, we primarily focus on the post-stablecoin period to demonstrate the role of stablecoins in risk transmission. We refer to the results from the pre-stablecoin period only for comparison purposes.

Table 1
Summary Statistics

	Bitcoin	Dollar Index	Ether	Tether	USDC
Mean（%）	0.150	0.007	0.174	0.004	0.004
Std. dev.（%）	3.866	0.332	4.885	0.447	0.454
Skewness	-0.674	0.121	-1.259	0.106	-0.036
Kurtosis	12.889	5.966	16.851	7.574	5.050
Jarque-Bera	12243.8***	741.2***	12295.1***	1301.3***	261.9***
ARCH-LM	112.9***	20.1***	45.4***	163.7***	102.9***
Obs.	2945	2001	1484	1483	1484

Notes: The table represents the summary statistics for the returns of traditional cryptocurrencies, stablecoins, and the US dollar index. The return data for Bitcoin and the Dollar Index cover the period from January 1, 2015, to January 24, 2023, while those for Ether, Tether, and USDC cover the period from January 1, 2019 to January 24, 2023. Stablecoins and cryptocurrencies are traded seven days a week, while the US dollar does not have values on weekends. *** indicate rejection of the null hypothesis at the 1% significance level.

Table 1 presents the summary statistics for different asset returns. All return series are skewed and exhibit excess kurtosis. The Jarque-Bera test of normality rejects the normality assumption of these return series at the 1% level. Moreover, the ARCH-LM statistic indicates that ARCH effects are present in all return series at the 5% level.

4. Empirical Results for Risk Spillovers

To test the hypotheses outlined in Section 2, we first fit univariate ARMA-GARCH models to individual asset returns and then construct copula functions to capture the dependence structure among asset returns.[9] Based on that, we calculate the VaR and CoVaR values, and report the KS test results in this section. In the baseline results, we use the Dollar Index as a

[9] The results are available upon request.

proxy for the non-crypto market, Bitcoin for the cryptocurrency market, and Tether for stablecoins.

4.1 Risk Spillovers from the Crypto to the Non-Crypto Markets through Stablecoins

We begin by testing Hypotheses 1 and 2 to determine if tail risk in the cryptocurrency market can propagate to the non-crypto market through stablecoins, leading to a decline in the non-crypto market. The findings are presented in Table 2.

Table 2 first reports the testing results for Hypothesis 1, which examines risk spillovers from cryptocurrencies to stablecoins (Panel A) and from stablecoins to the non-crypto market (Panel B). If significant risk spillovers exist in both Panel A and Panel B, we have reason to expect an indirect risk spillover from the crypto to the non-crypto market through stablecoins.

Regarding the spillover effects from cryptocurrencies to stablecoins, as shown in Panel A, the average tail risk (VaR) of Tether is −0.486%, indicating that the maximum daily loss for stablecoins is 0.486% at the 90% confidence level. The average of the corresponding CoVaR is −0.669%, suggesting a higher maximum loss of −0.669% if the crypto market experiences significant fluctuations. To formally compare the cumulative distribution of VaR and CoVaR, we refer to the KS test results and find evidence of significant risk spillovers from cryptocurrencies to stablecoins at the 1% level. Moreover, we quantify the magnitude of risk spillovers by calculating the ratio of average CoVaR to average VaR, reported in the column labeled $\overline{RCoVaR}$, which equals 1.379. This ratio implies that distress in the crypto market is associated with an additional 37.9% increase in the average tail risk of stablecoins relative to their tail risk in isolation.[10] Such results support Hypothesis 1 by demonstrating significant risk spillovers from cryptocurrencies to stablecoins. This finding aligns with Baur and Hoang (2021) and Liao and Carmichael (2022), who suggest that changes in cryptocurrency trading demand contribute to fluctuations in stablecoin values.

Table 2
Risk Spillovers from the Crypto to the Non-Crypto Market through Stablecoins

	VaR (%)	CoVaR (%)	KS test	$\overline{RCoVaR}$
Panel A: From cryptocurrencies to stablecoins	-0.486	-0.669	0.403***	1.379
	(0.171)	(0.239)	[0.000]	
Panel B: From stablecoins to non-crypto market	-0.358	-0.404	0.189***	1.128
	(0.124)	(0.141)	[0.000]	
Panel C: From cryptocurrencies to non-crypto market	**Pre-stablecoin period**			
	-0.406	-0.352	0.000	0.867
	(0.065)	(0.075)	[1.000]	
	Post-stablecoin period			
	-0.360	-0.387	0.119***	1.075
	(0.124)	(0.130)	[0.000]	

Notes: The table presents risk spillovers during the post-stablecoin period (from January 1, 2019, to January 24, 2023), with the pre-stablecoin period (from January 1, 2015, to December 31, 2017) included for comparison, but only presented in the first half of Panel C. The first two columns provide the means and standard errors (in parentheses) for the VaRs and CoVaRs. The third column provides the KS test statistics and their corresponding p-values (in square brackets), with *** indicating significance at the 1% level. The last column reports the term $\overline{RCoVaR}$, which is the average CoVaR divided by the average VaR. We use the returns of typical assets as proxies for the fluctuations in the corresponding asset types, with cryptocurrencies proxied by Bitcoin, stablecoins proxied by Tether, and the non-crypto market proxied by the dollar.

Panel B demonstrates significant spillover effects from stablecoins to the non-crypto market. The average CoVaR (-0.404%) is much lower than the average VaR (-0.358%), which provides preliminary evidence that distress in stablecoins is associated with a larger

[10] We caution that the magnitude of 37.7% is not an absolute measurement; it represents the relative value compared to an individual asset's VaR.

tail risk in the non-crypto market. As suggested by the KS test and $\overline{RCoVaR}$, turbulence in the stablecoin market could significantly exaggerate the maximum loss of the non-crypto market by 12.8%, lending supportive evidence to Hypothesis 1. This finding also aligns with Barthélémy et al. (2023), Garratt et al. (2022), and Liao and Carmichael (2022), who argue that fluctuations in stablecoins impact the traditional financial system through the reserve assets required by stablecoin issuers.

Having examined the evidence in Panels A and B, we proceed to test Hypothesis 2, which posits that even in the absence of direct risk spillovers between crypto and non-crypto markets, a link might be established through stablecoins. Panel C offers supportive evidence, indicating that risk spillovers from cryptocurrencies to the non-crypto market become significant only after stablecoins gain widespread acceptance. Specifically, the upper half (pre-stablecoin period) of Panel C presents the test based on data prior to the widespread use of stablecoins. We cannot reject the null hypothesis of no spillover effects from cryptocurrencies to the non-crypto market. This absence of risk spillovers before 2018 aligns with previous literature, such as Liu and Tsyvinski (2021), which demonstrates the independence of the crypto market.

However, as shown in the lower half (post-stablecoin period) of Panel C, after stablecoins gain popularity, the alternative hypothesis of a spillover effect from cryptocurrencies to the non-crypto market is strongly supported. This finding is consistent with Panels A and B. Given that risk spillovers are observed from cryptocurrencies to stablecoins, and from stablecoins to the non-crypto market, it can be inferred that a spillover effect from cryptocurrencies to the non-crypto market through stablecoins is indeed present.

By synthesizing the evidence from both pre- and post-stablecoin periods, we can conclude that Hypothesis 2 is supported and stablecoins serve as a bridge for transmitting risk from the crypto to non-crypto markets.

Using the $\overline{RCoVaR}$ in the last column as a "rule of thumb," we can provide a straightforward interpretation of the risk transmission from cryptocurrencies to the non-crypto market via stablecoins: First, turbulence in cryptocurrencies would increase stablecoins' tail risk by 37.9%. Second, an increase in stablecoin distress is associated with a 12.8% rise in the average tail risk of the US dollar. Third, since risk spillovers from cryptocurrencies to non-crypto market (proxied by the dollar) are indirectly transmitted through stablecoins, the increase in the dollar's tail risk is more modest at 7.5%. This observation supports Hypotheses 1 and 2.

4.2 Risk Spillovers from Non-crypto Market to Cryptocurrencies through Stablecoins

Next, we conducted analyses to examine whether the risk from the non-crypto market can spread to stablecoins and whether the risk from stablecoins can spread to the cryptocurrency market. The results are presented in Table 3.

Panel A shows that the average CoVaR for stablecoins is lower than its average VaR. The $\overline{RCoVaR}$ value stands at 1.132, suggesting that the turbulence in the non-crypto market could exacerbate the tail risk of stablecoins by 13.2%. The KS statistics further confirm the existence of risk spillovers from the non-crypto market to stablecoins. This finding aligns with Bertsch (2022) and Li and Mayer (2022), both of which highlight stablecoins' sensitivity to risks in their non-crypto reserve assets. Similarly, Panel B provides evidence of risk spillover from stablecoins to cryptocurrencies. As expected, the tail risk of cryptocurrencies increases by approximately 42.9% when stablecoins experience turmoil. The significant risk spillover from stablecoins to cryptocurrencies can be attributed to their central role in the crypto market, primarily as a major source of liquidity (Cermak et al., 2021; Griffin and Shams, 2020; Kristoufek, 2021). This finding corroborates the arguments made by Makarov and Schoar (2022) that risks in stablecoins represent a significant source of systemic risks in the crypto ecosystem. Panel A and B together offer supportive evidence for Hypothesis 3.

Table 3
Risk Spillovers from the Non-Crypto to the Crypto Market through Stablecoins

	VaR (%)	CoVaR (%)	KS test	$\overline{RCoVaR}$
Panel A: From non-crypto market to stablecoins	-0.590 (0.183)	-0.668 (0.207)	0.222*** [0.000]	1.132
Panel B: From stablecoins to cryptocurrencies	-3.478 (1.006)	-4.970 (1.442)	0.56*** [0.000]	1.429
Panel C: From non-crypto market to cryptocurrencies	**Pre-stablecoin period**			
	-3.446 (2.000)	-2.798 (1.583)	0.000 [1.000]	0.812
	Post-stablecoin period			
	-4.240 (1.175)	-4.667 (1.353)	0.179*** [0.000]	1.101

Notes: The table presents risk spillovers during the post-stablecoin period (from January 1, 2019, to January 24, 2023), with the pre-stablecoin period (from January 1, 2015, to December 31, 2017) included for comparison, but only presented in the first half of Panel C. The first two columns provide the means and standard errors (in parentheses) for the VaRs and CoVaRs. The third column provides the KS test statistics and their corresponding p-values (in square brackets), with *** indicating significance at the 1% level. The last column reports the term $\overline{RCoVaR}$, which is the average CoVaR divided by the average VaR. We use the returns of typical assets as proxies for the fluctuations in the corresponding asset types, with cryptocurrencies proxied by Bitcoin, stablecoins proxied by Tether, and the non-crypto market proxied by the dollar.

Based on the findings in Panels A and B, which show that stablecoins' tail risks can be influenced by the non-crypto market and can spill over into cryptocurrencies, we further confirmed the risk transmission effect described in Hypothesis 4 through Panel C. During the pre-stablecoin period (2015-2017), the null hypothesis of no difference between cryptocurrencies' CoVaR and their VaR cannot be rejected, as evidenced by the insignificant KS test result. However, this hypothesis is overwhelmingly rejected during the post-stablecoin period (2019-2023), suggesting that risk spillovers exist from the non-crypto market to cryptocurrencies. As shown in the last column of the lower half of Panel C, turmoil in the non-crypto market is associated with a 10.1% increase in cryptocurrencies' tail risk when stablecoins become widely accepted. This finding corroborates the findings in Panels A and B. Given the two linkages presented from the non-crypto market to stablecoins and from stablecoins to cryptocurrencies, the popularity of stablecoins could transmit risks from non-crypto to crypto markets. Contrary to the direction observed in Table 2, Table 3 here confirms Hypothesis 4, that the spillover of risks from non-crypto to crypto markets only becomes significant following the widespread adoption of stablecoins.

4.3 The Asymmetric Effects of Risk Spillovers

We proceed to test Hypothesis 5, which examines whether spillover effects are asymmetric, with significantly larger effects from non-crypto markets to cryptocurrencies than in the opposite direction. We conduct KS tests on the spillover measurement, RCoVaR, as defined in Equations (5), and report the results in Table 4 to compare risk spillovers in different directions. Since RCoVaR is a standardized measurement, it remains unaffected by differences in fluctuation magnitudes among various assets. As a result, it does not generate artificial or misleading asymmetric spillover effects due to these differences in fluctuation magnitudes.

Table 4
Asymmetric Spillover Effects between Non-Crypto and Crypto Markets

	KS test
Panel A	
H0: Spillovers from non-crypto market to stablecoins= Spillovers from stablecoins to non-crypto market	
H1: Spillovers from non-crypto market to stablecoins < Spillovers from stablecoins to non-crypto market	0.011 [0.898]
H1': Spillovers from non-crypto market to stablecoins > Spillovers from stablecoins to non-crypto market	0.056^{**} [0.027]
Panel B	
H0: Spillovers from stablecoins to cryptocurrencies = Spillovers from cryptocurrencies to stablecoins	
H1: Spillovers from stablecoins to cryptocurrencies < Spillovers from cryptocurrencies to stablecoins	0.010 [0.856]
H1': Spillovers from stablecoins to cryptocurrencies > Spillovers from cryptocurrencies to stablecoins	0.157^{***} [0.000]
Panel C	
H0: Spillovers from non-crypto market to cryptocurrencies = Spillovers from cryptocurrencies to non-crypto market	
H1: Spillovers from non-crypto market to cryptocurrencies < Spillovers from cryptocurrencies to non-crypto market	0.020 [0.657]
H1': Spillovers from non-crypto market to cryptocurrencies > Spillovers from cryptocurrencies to non-crypto market	0.159^{***} [0.000]

Notes: The table presents the KS test statistics and their corresponding p-values (in square brackets) for the null hypothesis of symmetric spillover effects between: (Panel A) the dollar and Tether, (Panel B) Tether and Bitcoin; and (Panel C) the dollar and Bitcoin. The sample period covers from January 1, 2019, to January 24, 2023. Risk spillovers between two markets are measured using RCoVaR, as defined in Equations (5). *** indicates significance at the 1% level. We use the returns of typical assets as proxies for the fluctuations in the corresponding asset types, with cryptocurrencies proxied by Bitcoin, stablecoins proxied by Tether, and the non-crypto market proxied by the dollar.

Panel A of Table 4 provides evidence regarding the asymmetric risk spillovers between stablecoins and the non-crypto market. Given the pegging mechanism of stablecoins, we conjecture that any shock to the dollar, one of the most important non-crypto assets in financial system, would be substantially transmitted to stablecoins, while the contagion effect of stablecoins on the non-crypto market would be less direct. To test whether the spillover effect is asymmetric, we consider the null hypothesis (H0) that the spillover effects are symmetric in both directions. To further test that the effect is larger from stablecoins to non-crypto market than in the opposite direction, we consider two mutually exclusive alternative hypotheses: one assumes that the risk spillovers are stronger in the direction from Tether to the dollar (H1), while the other assumes that the risk spillovers are stronger from the dollar to Tether (H1').

As expected, the KS tests in Panel A reject H0 in favor of H1', implying that risk spillovers are stronger from the dollar to stablecoins than in the reverse direction. This result aligns with Hypothesis 5 and is economically understandable, as stablecoins are pegged to the dollar and are more directly influenced by its fluctuations.

Next, Panel B presents the results for asymmetric spillover effects between stablecoins and cryptocurrencies. Due to the role of stablecoins as digital fiat in the crypto market, we expect that risk spillovers are significantly larger from stablecoins to cryptocurrencies than in the opposite direction. We also consider a null hypothesis assuming symmetric effects, as well as two mutually exclusive alternative hypotheses with asymmetric effects in different directions. The KS tests support our conjecture and provide additional evidence for Hypothesis 5, that is, the risk spillover effects are larger from stablecoins to cryptocurrencies.

Based on the evidence from Panels A and B, we expect asymmetric spillover effects directly between crypto and non-crypto markets, which are presented in Panel C. Given the observed asymmetric effects between the dollar and stablecoins, as well as between stablecoins and cryptocurrencies, we expect the risk spillovers from the dollar to cryptocurrencies to be stronger than in the opposite direction. As indicated by the KS statistics for H1 and H1’ in Panel C, the risk spillovers from the non-crypto market to cryptocurrencies are indeed larger than those in the opposite direction. This supports Hypothesis 5.

Moreover, the findings in Table 4 suggest stablecoins have bolstered the dollar and led to dollarization in the crypto market, indicating that US monetary policy can have a significant impact on price fluctuations in the cryptocurrency market. Our finding aligns with those of Cong and Mayer (2021), who argue that stablecoins, backed by reserve assets denominated in a specific country’s currency will, in turn, strengthen the fiat currency of that country.

5. Further Analyses

In this section, we will conduct robustness tests by considering confounding factors and using alternative representative assets as proxies for cryptocurrencies and stablecoins. Additionally, given the increasing linkage between the crypto and non-crypto worlds through stablecoins, we will examine the interactions between cryptocurrencies and the traditional capital market.

5.1 Accounting for confounding factors

A major concern in our analysis is that there may be other explanations for the increased risk spillovers over time. We take four factors into consideration: The first factor is the COVID-19 pandemic and the associated increase in uncertainty. During financial crises, all assets tend to be correlated with each other (Hartmann et al., 2004), and COVID-19 served as an exogenous shock to the global economy, leading to a spike in uncertainty and affecting nearly all types of assets (Harford, 2021). The second factor is the involvement of institutional investors in the crypto market. An increasing number of institutions have added crypto exposure to their portfolios (Huang et al.,2022), and their co-holding of non-crypto and crypto assets is likely to induce contagion effects between the two markets. The third factor is the growing market capitalization of cryptocurrencies and the fourth factor is the development of DeFi in the crypto world; both have increased significantly during recent years and might lead to changes in global investors' behavior.

To address potential confounding factors, we begin by regressing risk spillover measurements on a set of variables, including stablecoin development and other relevant factors. We then employ the instrumental variable approach to isolate the risk transmission role of stablecoins while controlling for these potential confounding factors.

(1) Variable Definition and Correlation Analyses

First, we specify the following regression and define the variables to account for the possible alternative explanations for risk spillovers:

$$Risk\_spillover_t = \alpha + \beta lnstablecoin\_vol_t + \gamma Control_t + \varepsilon_t \quad (1)$$

In this context, $Risk\_spillover_t$ represents the time-varying risk spillover measurement, RCoVaR, on day *t*. We consider three proxies for spillover effects as independent variables: the risk spillovers from cryptocurrencies to non-crypto markets, the risk spillovers from non-crypto markets to cryptocurrencies, and the average risk spillover effect. The first two variables are well-defined by the time-varying daily RCoVaR based on the copula model with GAS dynamics, as specified in Equations (4) and (5), while the last variable is the mean value of the two aforementioned variables.

Our main explanatory variable, $lnstablecoin\_vol_t$, represents the logarithm of daily transaction volume of the top four stablecoins, which account for over 90% of the stablecoin market. In addition to $lnstablecoin\_vol_t$, we have included a set of control variables $Control_t$ that may offer alternative explanations in for the spillover effects. These variables are: (1) *VIX*, the CBOE Volatility Index reflecting market uncertainty; (2) *Whale_account*, a proxy to institutional holders; (3) *Lncrypto_marcap*, the logarithm of the total market capitalization of all crypto assets; (4) *Defi_growth*, the differences on logarithm of the total value of stablecoins locked in DeFi. We also add year fixed effects to capture other year-specific shocks such as the COVID-19 pandemic. Our hypothesis is that the coefficient on $lnstablecoin\_vol_t$ would remain positive and significant even after controlling for other possible explanations, suggesting that stablecoins play a crucial role in the risk spillover between crypto and non-crypto markets.

Before presenting the regression results, we first report the pairwise correlation coefficients between the dependent (risk spillover measures) and independent variables in Table 5. Not only are stablecoin transaction values significantly correlated with risk spillover measures, but the other four confounding factors also exhibit positive correlations with the risk spillover measures. Specifically, market uncertainty proxied by *VIX*, institutional holders represented by *Whale_account*, and crypto market capitalization measured by *Lncrypto_marcap*, are all significantly correlated with risk spillover measures at a 1% significance level. This indicates that these factors may have also facilitated risk spillovers to some extent. While the correlation with DeFi development measured by *Defi_growth* is insignificant, the *p-values* are marginal at around 0.1, suggesting a possible correlation. The correlation between risk spillover measures and variables other than stablecoins necessitates further investigation to determine whether stablecoins remain a significant explanatory variable for risk spillovers after accounting for these additional factors.

Table 5
Correlation between Risk Spillover Measures and Confounding Factors

Spillover measures	*lnstablecoin_vol*	*VIX*	*Whale_account*	*Lncrypto_marcap*	*Growth_Defi*
Average measures	0.772*** (0.000)	0.316*** (0.000)	0.559*** (0.143)	0.644*** (0.000)	0.042 (0.143)
From non-crypto to crypto	0.775*** (0.000)	0.306*** (0.000)	0.557*** (0.143)	0.651*** (0.000)	0.039 (0.173)
From crypto to non-crypto	0.755*** (0.000)	0.323*** (0.000)	0.553*** (0.143)	0.624*** (0.000)	0.043 (0.142)

Notes: The significance level (*p-value*) of each correlation coefficient in parentheses. *** indicates rejection of the null hypothesis of zero correlation at the 1% significance level.

(2) Regression Analyses

Table 6 presents the regression results for average risk spillover, risk spillovers from non-crypto to crypto markets, and risk spillovers from crypto to non-crypto markets in Panels A, B, and C, respectively. Column (1) of Panel A reveals a statistically significant positive relationship between the transaction volume of stablecoins and the average spillover effect, thereby confirming the role of stablecoins in explaining the risk spillovers between crypto and non-crypto markets. In Column (2), we control for several factors that could potentially explain the risk spillover, as previously described. Despite these additional controls, the coefficients of the main variable, stablecoins, remain significant. This suggests that stablecoins continue to be one of the primary driving forces behind the risk spillover effect, even after accounting for other factors. Furthermore, the coefficients of the confounding factors are no longer significantly positive. Although other factors may contribute to the risk spillovers, as indicated in Table 5, the regression in Table 6 demonstrates that they lose explanatory power when included alongside stablecoins.

Table 6
Controlling for confounding factors explaining risk spillovers

	Panel A Average spillover		Panel B Spillover from non-crypto to crypto		Panel C Spillover from crypto to non-crypto	
	(1)	(2)	(3)	(4)	(5)	(6)
lnstablecoin_vol	0.494**	0.584**	0.639***	0.655**	0.349*	0.513**
	(0.199)	(0.237)	(0.226)	(0.270)	(0.183)	(0.218)
VIX		-0.0593*		-0.0946**		-0.0239
		(0.032)		(0.037)		(0.030)
Whale_account		0.000168		0.00266		-0.00233
		(0.003)		(0.003)		(0.003)
Lncrypto_marcap		-0.538		-0.627		-0.449
		(0.649)		(0.740)		(0.598)
Defi_growth		0.0353		0.0435*		0.0270
		(0.022)		(0.025)		(0.020)
Constant	62.54***	112.8***	58.22***	111.5***	66.86***	114.1***
	(3.656)	(17.092)	(4.163)	(19.474)	(3.374)	(15.749)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,248	1,184	1,248	1,184	1,248	1,184
Adjusted R-squared	0.158	0.066	0.154	0.066	0.173	0.096

Notes: 1. We use typical assets as proxies for corresponding asset types: Bitcoin for cryptocurrencies, Tether for stablecoins, and the US dollar for non-crypto markets. 2. Since the data for our main explanatory variable, $lnstablecoin\_vol_t$, is only available from 2018 onwards, we restrict the sample period to 2018-2023. We also conducted analyses for the 2015-2023 period with imputed zeros for missing values before 2018, and our conclusions remain consistent. 3.Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Panels B and C present the results for risk spillovers in different directions, from non-crypto market to cryptocurrencies as well as from cryptocurrencies to non-crypt market, respectively. The coefficient of stablecoins' transaction volume remains significantly positive in both panels, regardless of whether we control for other factors. This indicates that the development of stablecoins is still one of the primary driving forces behind the risk spillover, both from the non-crypto market to cryptocurrencies, as shown in Columns (3) and (4), and from the crypto market to non-crypto assets, as shown in Columns (5) and (6).

Upon comparing the results across the three panels, our findings indicate that the development of stablecoins remains as the underlying driving force of the spillover effects between the crypto and non-crypto markets, even after accounting for other possible explanations. These results are consistent with our hypothesis and suggest that stablecoins play a crucial role in facilitating risk spillover between the crypto and non-crypto markets.

(3) Instrumental Variable Approach

To further investigate the role of stablecoins in risk transmission, we employ the Instrumental Variable (IV) method, building on the work of Angrist (1990) and Card (1993), to shed light on causal relationships while addressing potential endogeneity concerns. Our study has two primary objectives: First, we aim to show that idiosyncratic shocks originating within the cryptocurrency market affect stablecoin transactions, which in turn spill over into the non-crypto market. Second, we intend to demonstrate that exogenous shocks in the non-crypto market lead to changes in stablecoins, subsequently impacting the cryptocurrency market. To accomplish these goals, we must identify a crypto market-specific shock (related to stablecoins but exogenous to the non-crypto market) to serve as an IV for stablecoins when examining risk spillover to the non-crypto market, and vice versa.

To examine risk spillovers from the crypto to non-crypto market, we use mining difficulty—an attribute unique to the cryptocurrency market, related to stablecoin transactions on the blockchain, and unrelated to the non-crypto market—as the IV for stablecoin transaction volume. As a quasi-random exogenous factor, mining difficulty enables us to isolate the crypto market's specific impacts on stablecoin activity, akin to the analytical isolation achieved by Angrist (1990) and Card (1993). This approach allows us to investigate whether fluctuations in mining difficulty lead to significant risk spillovers to the non-crypto market via stablecoins. Conversely, to study risk spillover to cryptocurrencies, we employ the growth rate of the US dollar M2 money supply—a metric in the non-crypto market that impacts dollar-pegged stablecoins' activities while remaining unrelated to the crypto market—as the IV for stablecoins. This measure helps determine whether changes in non-crypto fiat supply can cause increased risk spillovers to the cryptocurrency market through stablecoins. By utilizing these instrumental variable approaches, we carefully disentangle the mediating role of stablecoins. Table 7 presents the results of the first and second stage regression analyses for risk spillovers in both directions.

Panel A of Table 7 reports the results of the two-stage regression analyses for risk spillovers from the crypto market to the non-crypto market. Based on the Local Average Treatment Effect in Angrist's (1990) and Card's (1993) work, the coefficient on the predicted value of stablecoin transaction volume in this regression reveals the effect of crypto shocks on risk spillovers to the non-crypto market through stablecoins. In Column (1), we find that the coefficient on *Mining_difficulty* is significantly correlated with stablecoin transaction volume at the 1% level, validating the relevance requirement for the instrumental variable. Meanwhile, since *Mining_difficulty* has no direct influence on the non-crypto market due to the decentralized nature of cryptocurrencies and their independence from central banks, it satisfies the exogeneity requirement as well. In Column (2), the coefficient on *Lnstablecoin_vol* remains significant and positively associated with the risk spillover from the crypto to non-crypto market. This suggests that changes in stablecoins caused by the crypto factor *Mining_difficulty* have contributed to the increase in risk spillover to the non-crypto market.

Table 7
Instrumental Variables approach to identify risk transmission

	Panel A From crypto to non-crypto		Panel B From non-crypto to crypto	
	(1)	(2)	(3)	(4)
	First-stage	Second-stage	First-stage	Second-stage
IV: Mining_difficulty	1.997***			
	(0.123)			
IV:M2_growth			-0.131***	
			(0.033)	
Lnstablecoin_vol		1.496***		6.449**
		(0.510)		(2.775)
VIX	0.0149***	-0.0332	0.0180***	-0.149***
	(0.004)	(0.030)	(0.004)	(0.051)
Whale_account	0.00257***	-0.00733**	0.00502***	-0.0268*
	(0.000)	(0.003)	(0.000)	(0.015)
Lncrypto_marcap	0.370***	-0.775	0.328***	-2.551**
	(0.072)	(0.620)	(0.079)	(1.263)
Defi_growth	-0.000945	0.0263	0.00110	0.0391
	(0.002)	(0.020)	(0.003)	(0.029)
Constant	-54.04***	106.2***	4.381**	81.06***
	(4.116)	(16.950)	(2.228)	(27.120)
Year Fixed Effect	YES	YES	YES	YES
Observations	1,184	1,184	1,184	1,184
Adjusted R-squared	0.943	0.080	0.931	0.0678
IV F-stat	265.3		15.48	
Durbin pval	0.0312		0.0131	

Notes: 1. We use typical assets as proxies for corresponding asset types: Bitcoin for cryptocurrencies, Tether for stablecoins, and the US dollar for non-crypto markets. 2. Since the data for our main explanatory variable, *lnstablecoin_vol*$_t$, is only available from 2018 onwards, we restrict the sample period to 2018-2023. We also conducted analyses for the 2015-2023 period with imputed zeros for missing values before 2018, and our conclusions remain consistent. 3.Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Panel B of Table 7 reports the risk transmission from non-crypto market to cryptocurrencies. Column (3) validates *M2_growth* as a valid instrumental variable, while Column (4) suggests that *M2_growth*-driven changes in stablecoins contribute to increased risk spillover to cryptocurrencies, as shown by the significant positive association between *Lnstablecoin_vol* and risk spillover from the non-crypto to crypto market.

Taken together, the results from both Panel A and Panel B of Table 7 provide strong evidence for the risk transmission role of stablecoins. These results demonstrate that stablecoins can transmit risk from the crypto to non-crypto markets and vice versa, depending on the source of the shock.

5.2 Alternative proxies for cryptocurrencies and stablecoins

In this section, we consider alternative proxies for cryptocurrencies and stablecoins to check for robustness.

(1) Alternative proxy for the crypto market

Our baseline setup followed previous studies in choosing the largest cryptocurrency, Bitcoin, to proxy the crypto market. Now we turn to the second-largest cryptocurrency, Ether, for a robustness check by repeating the baseline analysis for risk spillovers.

Table 8 reports the summary statistics and tests for risk spillover between stablecoins and Ether. In Panels A and B, we find significant risk spillovers in both directions between Ether and the stablecoins considered. Panels C and D compare the pre- and post- stablecoin periods. As shown in Panel C and D, the risk spillover between Ether and the non-crypto market only becomes significant in the post-stablecoin period, suggesting that the popularity of stablecoins has facilitated risk transmission between the crypto and non-crypto markets.

Table 8
Risk Spillovers Using an Alternative Proxy for the Crypto Market

	VaR (%)	CoVaR (%)	KS test	$\overline{RCoVaR}$
Panel A:	-0.486	-0.645	0.355^{***}	1.327
From Ether to stablecoins	(0.171)	(0.240)	[0.000]	
Panel B:	-4.875	-6.572	0.463^{***}	1.348
From stablecoins to Ether	(1.554)	(2.206)	[0.000]	

Panel C: From Ether to non-crypto market	**Pre-stablecoin period**			
	-0.392 (0.067)	-0.369 (0.063)	0.000 [1.000]	0.941
	Post-stablecoin period			
	-0.359 (0.120)	-0.454 (0.148)	0.339*** [0.000]	1.265
Panel D: From the non-crypto market to Ether	**Pre-stablecoin period**			
	-7.566 (5.059)	-7.080 (4.864)	0.000 [1.000]	0.936
	Post-stablecoin period			
	-5.645 (1.444)	-7.600 (1.752)	0.682*** [0.000]	1.346

Notes: The table presents risk spillovers during the post-stablecoin period (from January 1, 2019, to January 24, 2023), with the pre-stablecoin period (from January 1, 2015, to December 31, 2017) included for comparison, but only presented in the first half of Panel C. The first two columns provide the means and standard errors (in parentheses) for the VaRs and CoVaRs. The third column provides the KS test statistics and their corresponding p-values (in square brackets), with *** indicating significance at the 1% level. The last column reports the term $\overline{RCoVaR}$, which is the average CoVaR divided by the average VaR. We use the returns of typical assets as proxies for the fluctuations in the corresponding asset types, with cryptocurrencies proxied by Ether, stablecoins proxied by Tether, and the non-crypto market proxied by the dollar.

(2) Alternative proxy for stablecoins

Our baseline setup follows previous studies in choosing the largest stablecoin, Tether, to proxy stablecoins. Now we turn to the second-largest stablecoin, USDC, for a robustness check. Table 9 reports the summary statistics and tests for risk spillover between USDC and cryptocurrencies. As shown in Panels A and B, we find significant risk spillovers in both directions between USDC and the crypto market; As shown in Panels C and D, risk spillovers are significant in both directions between the non-crypto market and USDC. Together, the evidence in Table 9 supports the risk transmission role of stablecoins.

Table 9
Risk Spillovers Using an Alternative Proxy for Stablecoins

	VaR	CoVaR	KS test	$\overline{RCoVaR}$
Panel A: From cryptocurrencies to USDC	-0.517 (0.163)	-0.708 (0.229)	0.464*** [0.000]	1.369
Panel B: From USDC to cryptocurrencies	-3.475 (1.002)	-5.012 (1.455)	0.655*** [0.000]	1.442

Panel C: From USDC to non-crypto market	-0.359 (0.120)	-0.473 (0.153)	0.387*** [0.000]	1.318
Panel D: From non-crypto market to USDC	-0.612 (0.177)	-0.803 (0.226)	0.428*** [0.000]	1.312

Notes: The table presents risk spillovers during the post-stablecoin period (from January 1, 2019, to January 24, 2023), with the pre-stablecoin period (from January 1, 2015, to December 31, 2017) included for comparison, but only presented in the first half of Panel C. The first two columns provide the means and standard errors (in parentheses) for the VaRs and CoVaRs. The third column provides the KS test statistics and their corresponding p-values (in square brackets), with *** indicating significance at the 1% level. The last column reports the term $\overline{RCoVaR}$, which is the average CoVaR divided by the average VaR. We use the returns of typical assets as proxies for the fluctuations in the corresponding asset types, with cryptocurrencies proxied by Ether, stablecoins proxied by Tether, and the non-crypto market proxied by the dollar.

In unreported results, we also repeated the baseline analyses for different time spans (2019-2020) and with value measurements based on different denominations (Euro and the dollar), the main conclusions remain unchanged.

5.3 Risk Spillovers between Cryptocurrencies and the Stock Market

We will now discuss the connection between cryptocurrencies and the traditional stock market, with stablecoins playing a crucial role in this relationship. Since stablecoins move in sync with the dollar and provide liquidity for cryptocurrencies, just as the dollar provides liquidity for the stock market, the crypto market makes a parallel version, or shadow, of the traditional capital market. In this parallel market, stablecoins act as a counterpart to the dollar, while other cryptocurrencies can be seen as counterparts to stocks. The dual role of the dollar, both in the traditional stock market and as the pegs of stablecoins, establishes it as a potential conduit for risk spillovers between cryptocurrencies and the stock market. The interconnectedness between these markets challenges the prevailing notation that cryptocurrencies are entirely separate from traditional financial assets, and raises questions about the widely accepted perception regarding the de-dollarization nature of the crypto market.

Table 10 reports the test for risk spillovers between cryptocurrencies and the two major stock indexes (MSCI World Index and S&P 500). The null hypothesis of no risk spillovers is overwhelmingly rejected in favor of the alternative of significant bidirectional risk spillovers between Bitcoin and the two stock indexes. As shown in Panel A to D, the risk spillovers remain significant with different stock market proxies and in different directions; that is, a loss in the stock market exaggerates the tail risks in cryptocurrencies and vice versa. These results align with market performance during the global COVID-19 outbreak in March 2020 and during Russia's invasion of Ukraine in February 2022, when both stocks and cryptocurrencies crashed.

Our findings of the interdependent tail risks is consistent with the findings in Jiang et al. (2023) and significantly challenge the widely perceived diversification advantages of cryptocurrencies. Although the fully decentralized nature of cryptocurrencies may suggest diversification benefits (Bouri et al., 2017), we caution investors to reconsider their perceptions of cryptocurrencies as safe-haven and risk-diversifiers: the crypto market has been integrating into the non-crypto world and comoving with stock markets since stablecoins gained popularity.

Table 10
Risk spillovers between Cryptocurrencies and the Stock Market

	CoVaR	VaR	KS test	$\overline{RCoVaR}$
Panel A: From S&P 500 to cryptocurrencies	-4.513 (0.900)	-4.175 (0.848)	0.219*** [0.000]	1.081
Panel B: From cryptocurrencies to S&P 500	-1.48 (0.872)	-1.372 (0.820)	0.071*** [0.005]	1.079
Panel C: From MSCI AC World Index to cryptocurrencies	-4.683 (0.929)	-4.175 (0.848)	0.314*** [0.000]	1.122

Panel D: From cryptocurrencies to MSCI AC World Index	-1.243 (0.705)	-1.115 (0.642)	0.115^{***} [0.000]	1.115

Notes: The table presents the spillover effects between cryptocurrencies and the stock indices (S&P 500 index and MSCI AC World Index) for the period from January 1, 2019, to January 24, 2023. The first two columns provide the means and standard errors (in parentheses) for the VaRs and CoVaRs. The third column provides the KS test statistics and their corresponding p-values (in square brackets), with *** indicating significance at the 1% level. The last column reports the term $\overline{RCoVaR}$, which is the average CoVaR divided by the average VaR. We use the returns of typical assets as proxies for the fluctuations in the corresponding asset types, with cryptocurrencies proxied by Bitcoin in this table. The value of Bitcoin is denominated in US dollars to match the denomination of the stock indices.

6. Conclusions

We examined the role of stablecoins as a bridge between the crypto and noncrypto markets. We explore risk spillovers among three types of assets: stablecoins, noncrypto assets, and traditional cryptocurrencies using copula-based CoVaR approaches. We found significant bidirectional risk spillovers for stablecoins in relation to both the crypto and noncrypto markets. Our findings suggest that risks are transmitted between the crypto and noncrypto markets through stablecoins. We also found that the risk spillovers are asymmetric, being stronger from the dollar to the traditional crypto market than from the traditional crypto market to the dollar.

Our findings have important policy implications for regulators and investors. First, in light of the rapid growth of stablecoins, central banks should bring stablecoins into their regulatory perimeter and develop rules and standards governing the issuance and trading of stablecoins. Early in 2021, Visa became the first major payment network to settle transactions in stablecoins.[11] Our finding that stablecoins serve as risk transmitters suggests that regulators should thoroughly investigate the potential risks of

[11] Accessed from https://www.bloomberg.com/press-releases/2021–03–29/visa-becomes-first-major-payments-network-to-settle-transactions-in-usd-coin-usdc on July 28, 2021.

stablecoins before more financial institutions accept stablecoins as payment. Second, the integration between the crypto and noncrypto markets calls into question investors' perception of cryptocurrencies as safe havens and risk diversifiers. Investors should be cautious about introducing cryptocurrencies into their portfolios given the comovement between the noncrypto and crypto markets. Third, with the majority of stablecoins pegged to the dollar and with their widespread use in crypto trading, crypto markets are re-dollarizing, which might magnify the spillover of US monetary policy to global financial markets. Our finding of stronger risk spillover from the dollar to the crypto market through stablecoins than in the opposite direction suggests dollarization is occurring, which partly explains the Federal Reserve vice chair's optimistic attitude about stablecoins.[12] Although some small developing countries are counting on stablecoins or other cryptocurrencies to de-dollarize their economies,[13] our results suggest that these economies might be vulnerable to digital dollarization.

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[12] In a speech in June 2021, the Federal Reserve's vice chair for supervision, Randal K. Quarles, said, "I believe that we must take strong account of the potential benefits of stablecoins, including the possibility that a U.S. dollar stablecoin might support the role of the dollar in the global economy." Available at https://www.bis.org/review/r210705c.htm.

[13] For example, Venezuela accepted foreign aid in stablecoins in 2020 and considered stablecoins as a payment solution countrywide. El Salvador announced Bitcoin as the legal tender in 2021.

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