Stablecoins: Adoption and Fragility

- Preliminary and incomplete -

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Abstract

We offer a theoretical framework to study the rapidly developing market for stablecoins. Stablecoins are a new form of digital private money that promises a stable and secure way for investors to park their funds in the crypto universe. The dominant stablecoins are pegged one-to-one to the US dollar. Much like banks and money market funds, stablecoin issuers face the risk of runs. A large demand for redemptions can only be met if the issuer is able to quickly raise sufficient funds. As a result, investors are sensitive to adverse information about the quality of the issuer's assets and potential exposures to operational risks (e.g. cyber risk). Key determinants of the fragility of a stablecoin are its adoption, transaction costs and network effects, as well as the issuer's ability to earn revenue from seignorage and from transaction fees. A higher adoption may be destabilizing in case the marginal investor becomes more flighty or stabilizing due to cost advantages. Both, positive network effects (that increase the relative convenience of stablecoins and their role as a means of payment) and negative network effects (that cause congestion and higher transaction costs) can improve stability. The existence of a large speculator is unambigously destabilizing.

Keywords: Stablecoins, currency attacks, money, payments, financial stability, global games.

JEL Classification: D83, E4, G01, G28.

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1 Introduction

Stablecoins are at the forefront of the rapidly developing crypto universe. Figure 1 shows the evolution of the market capitalization of the top stablecoins since 2020. In April 2022, the total market capitalization stood at close to 190bn US dollars, with the two dominant stabelcoins Tether (USDT) and USD Coin (USDC) exceeding a capitalization of 83bn and 49bn US dollars, respectively. After a breakneck expansion at an annualized growth rate of 483% in 2021, the pace slowed down markedly in 2022. Amidst the crypto market turmoil in May and June 2022, the total stablecoin market capitalization fell to arround 155bn US dollars.

While most crypto assets like Bitcoin or Ether have no intrinsic value and are highly volatile, the leading stablecoins are backed by a fiat currency or by other assets and promise a stable and secure way for crypto investors to park their funds and to reduce trading costs across cryptocurrency exchanges, as well as to reduce costs for remittances. This makes stablecoins suitable as a form of private money, with a potential for wider adoption in cross-border transactions, payments and financial markets more generally. It is, however, questionable whether stablecoins in their current form can serve as an effective medium of exchange due to their inherent susceptability to runs (Gorton and Zhang 2021).[1]

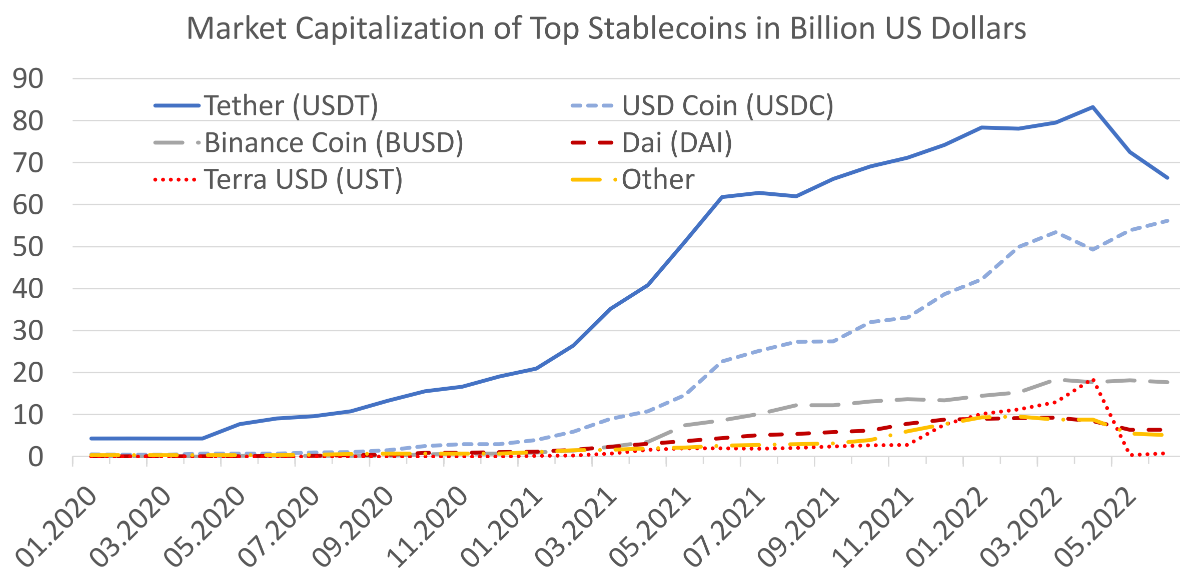

Figure 1: End of month market capitalization of top stablecoins over the period from January 2020 to April 2022. Source: coingecko.com.

There have already been instances of destructive runs against stablecoins. Most prominently, the run against the algorithmic stablcoin Terra USD, which is shown in Figure 2. Up until May, UST has been trading in a narrow band around its peg to the US dollar for almost a year, which includes a period of rapid growth in its market capitalization from 2.8bn US dollars at the end of October 2021 to 18.7bn US dollars in early May 2022. On May 9, 2022 UST suffered from a wave of redemptions that resulted in the unmooring of the

[1]Gorton and Zhang (2021) also document the first ever stablecoin run against the IRON stablecoin, which is now defunct.

peg to the US dollar, the halting of the Terra blockchain and a rapid collapse of the market price during the subsequent days. UST is now defunct, which is also visible in Figure 1. It's end of May market capitalization fell to around 0.3bn US dollars and its price to 0.03. Around the same time also Tether suffered a short-lived price drop to 0.95 on May 12 after a redemption wave of 3-4bn US dollars. While the market capitalization of USDC and BUSD increased moderately after the period of distress, USDT and DAI experienced sustained outflows, as can be seen in the substantially lower end of June market capitalizations depicted in Figure 1.

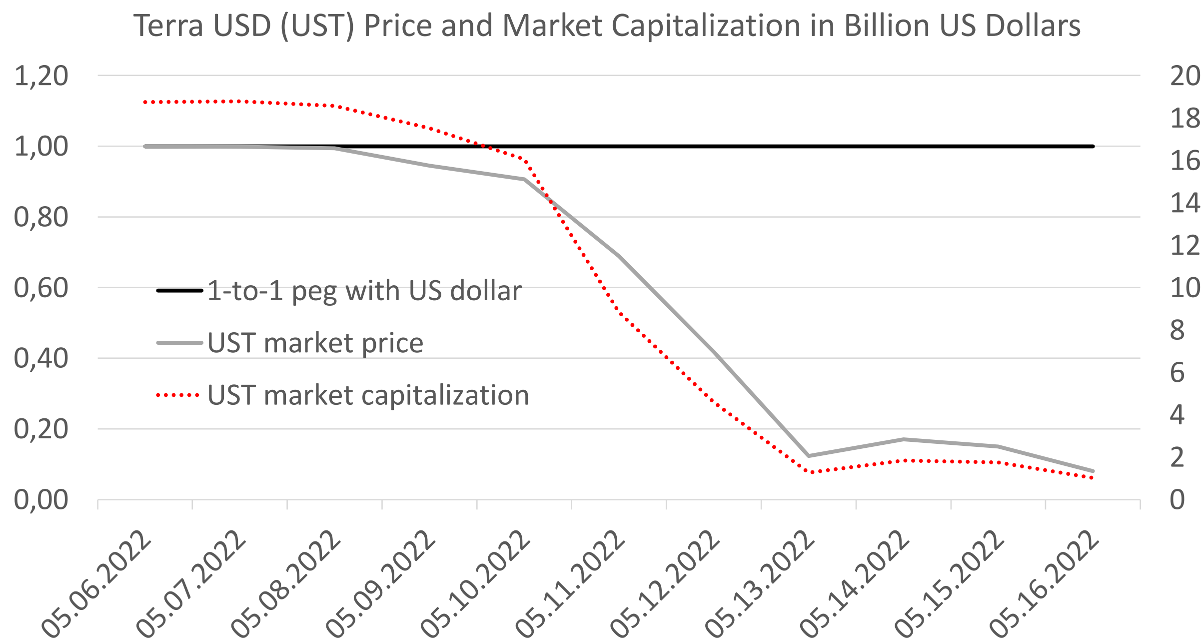

Figure 2: End of day (CEST) price in US dollars (left axis) and market capitalization in bn US dollars (right axis) of Terra USD over the period from May 6, 2022 to May 16, 2022. Source: coingecko.com.

The risk of runs emerges because most stablecoins involve some degree of maturity and liquidity transformation, similar to money market funds. Stablecoin issuers also hold assets with varying degrees of risk. Moreover, the actual exposure of stablecoin issuers to risks is often difficult to assess for coin holders due to a lack of detailed and verifiable information on the issuers' asset holdings. A case in point is the largest stablecoin USDT, which is pegged to the US dollar. While Tether claims that every "token is always 100% backed by our reserves", this has been contested in court[2] and the transparency regarding the asset composition and risk profile remains insufficient. Table 1 shows the self-reported asset breakdown by Tether in December 2021, when it was backed by a range of risky assets, including corporate bonds, secured loans, investments in digital tokens, (lower rated) commercial paper and deposits in non-US regulated financial institutions. More granular data on Tether's asset holdings is not available. As Tether's reserves are located in Cayman Islands, the existence of the reserves are not verifiable and the bankruptcy procedure is unclear. Hence, Tether's exposure to asset return and liquidity risk is potentially substantial, but ultimately unknown

[2]Tether was sued by New York State Attorney General Letitia James for not fully backing every Tether at all times and agreed to pay a fine of 18.5m US dollars in February 2021.

to coin holders. Besides, issuers are also exposed to operational and technological risks. Consequently, the value of coins and, hence, the decision of investors to demand conversion to cash is information sensitive (Dang, Gorton and Holmström 2021), which is in stark contrast to insured bank deposits.

Assets			**Value in bn USD**
Commercial Paper & Certificates of Deposit			24,166
	A-1+ rating	0,625	
	A-1 rating	11,179	
	A-2 rating	11,812	
	A-3 rating	0,245	
	Other	0,305	
Cash & Bank Deposits			4,187
Money Market Funds			3,000
Treasury Bills			34,528
Secured Loans			4,143
Corporate Bonds, Funds & Precious Metals			3,629
Other Investments (including digital tokens)			5,023
Total			78,676

Table 1: Tether asset breakdown, 31 December 2021.

Besides the described risks associated with the leading stablecoins USDT, USDC and Binance Coin (BUSD), which are backed, the so called alghorithmic stablecoins like Dai (DAI) and Terra USD (UST) are unbacked, which exposes them to additional vulnerabilities. Unlike backed stablecoins, alghorithmic stablecoins rely on algorithmic stabilization mechanisms that are designed to maintain the peg with a fiat currency. In the case of DAI the stablecoins are collateralized with other crypto assets, while UST relies on an arbitrage relationship with another crypto asset called Luna. This exposes algorithmic stablecoins to the risk that the underlying crypto assets abruptly loose value or become illiquid, as in the case of the collapse of UST, thereby compounding the inherent vulnerabilities described above.

Amid the breathtaking speed of expansion of the stablecoins market and spurred by BigTech's interest in entering the arena, the regulatory and central banking community expressed potential concerns to financial stability and the existing monetary order. Most prominently, an announcement in June 2019 by the social media platform Facebook to launch its own digital currency called "Libra" was a wake-up call and stoked an extensive policy discussion (G7 2019; FSB 2019; Brainard 2019; Cœuré 2019; Adrian and Mancini-Griffoli 2019). Subsequently, multiple G7 statements expressed that "no global stablecoin project should begin operation until it adequately addresses relevant legal, regulatory, and oversight requirements through appropriate design and by adhering to applicable standards".[3] While the regulatory headwinds caused Facebook to modify and, eventually, abandon the idea to launch a stablecoin in January 2022,[4] the

[3]Almost identical language was used in subsequent G7 statements in 2019, 2020 and 2021: `https://www.gouvernement.fr/en/chair-s-statement-on-stablecoins`, `https://home.treasury.gov/news/press-releases/sm1152` and `https://home.treasury.gov/news/press-releases/sm1152`.

[4]Facebook's initial plan was to introduce a global stablecoin backed by a basket of fiat currencies, leveraging its existing network of more than 2bn users. Subsequently, revised plans foresaw a backing by the US dollar and the project was rebranded as "Diem".

regulation of stablecoins remains an important policy concern with notable initiatives on both sides of the Atlantic.[5] Furthermore, also the development of central bank digital currencies (CBDCs) has been motivated by the rapid growth of stablecoins (Arner, Auer and Frost 2020; Landau and Brunnermeier 2022; FSR 2022).

This paper focuses on the fragility of stablecoins that use a peg to a single fiat currency. Specifically, we study the determinants of fragility. How is fragility affected by stablecoin adoption? What is the role of crypto investor heterogeneity, network effects and transaction fees? How is the fragility of stablecoins affected by monetary policy, competition with bank deposits and changes in the regulatory environment?

To answer these questions, we offer a theoretical framework. A stablecoin run is modelled as a global game of regime change (Carlsson and van Damme 1993). Global games of regime change have been applied extensively to study bank runs, currency attacks and sovereign debt runs. We believe that this class of models is particularly suitable to study stablecoin runs, because stablecoins operate a unilateral exchange rate peg and share the same vulnerabilities as uninsured bank debt, as described above. Moreover, the global games methodology allows us to derive the probability of a run and to study its determinants. Specifically, we adopt a modified version of the bank run model by Goldstein and Pauzner (2005).

The model has three dates. At the initial date, investors decide whether to invest their cash in stablecoins or in insured bank deposits. Thereby, investors take into account the relative convenience benefit from adopting stablecoins instead of bank deposits, as well as the likelihood that stablecoins or bank deposits are the preferred means of payment in the terminal period. In the intermediate period a *stablecoin run* occurs if enough stablecoin holders demand conversion to cash, such that the stablecoin issuer becomes insolvent. Before deciding whether or not to demand conversion, coin holders receive a noisy private signal that is correlated with the fundamental of the issuer. The fundamental captures the issuer's profitability, which may be affected by an adverse shock due to a lower than expected asset return, by costly operational problems or by a cyber attack. There exists a unique monotone equilibrium of the conversion game where stablecoin holders optimally demand conversion in the intermediate period whenever they receive a private signal that is below a certain threshold, suggesting an unfavorable fundamental realization. We analyze how this signal threshold and, hence, the incidence of stablecoin runs depends on various factors that play an important role in the stablecoin market.

We find that most factors that increase the attractiveness of holding stablecoins also reduce the fragility of the stablecoin. This is because factors that promote adoption also tend to make the stablecoin holdings of the marginal investor, who is indifferent between keeping her stablecoins and demanding conversion to cash at the interim period, less flighty. This is the case for an increase in the likelihood that stablecoins are the preferred means of payment in the terminal period and for a higher convenience benefit from holding stablecoins instead of bank deposits. Both factors could be driven by positive network effects and are

[5] The European Commission's Digital Finance Package updated in November 2021 foresees that only regulated credit and e-money institutions can obtain a license to issue stablecoins (EC 2020) and a report by the US President's Working Group on Financial Markets in November 2021 proposed that only insured depository institutions should be allowed to issue stablecoins (US 2021). On both sides of the Atlantic the legal and policy frameworks are expected to take shape by the end of 2022 (EU MiCA and White House Digital Asset Executive Order).

associated with a higher stablecoin adoption and with a lower fragility of the stablecoin.

Contrastingly, negative network effects may be caused by an increase in transaction fees when transaction volumes are higher. This phenomenon is widespread for the dominant stablecoins that build on decentralized blockchain technologies such as the Ethereum blockchain, which due to capacity limits dynamically adjusts the transaction costs for on-chain transactions depending on trading volumes. Interestingly, negative network effects tend to be negatively associated with stablecoin adoption, but they promote the stability of the stablecoin. This latter effect is especially strong when considering potential congestion effects that increase transaction fees in the interim period in case a large number of coin holders demand conversion. Anticipating such a spike in transaction fees, the marginal coin holder may become less flighty, thereby, reducing the fragility of the stablecoin. What is more, unlike other negative network effects, the anticipation of congestion effects at the intermediate date in case of a run can not only promote stability, but also the stablecoin adoption at the initial date. This is because a less fragile stablecoin is a more attractive investment.

In practise, crypto investors are highly heterogeneous and their demand for stablecoins is influenced by preferences, such as love for anonymity, the convenience relative to other means of payment and potential transaction cost advantages for certain use cases such as for remittances.[6] Arguably, a broader stablecoin adoption involves tapping market segments of investors who have a lower (possibly even negative) relative convenience benefit from holding stablecoins instead of bank deposits. We find that this effect of a wider stablecoin adoption can be destabilising, because the marginal coin holder becomes more flighty.

In a further extension to our model, we discuss the case where the stablecoin issuer does not receive revenues from transaction fees, as well as the case where the issuer sets transaction fees and can commit to a certain transaction fee schedule at the initial date. In the former case, the issuer's profitability is reduced, leading to a higher fragility. In the latter case, the issuer trades off the revenue benefits of a higher adoption due to lower transaction fees with the costs of an increase in fragility. Generally, the issuer prefers to make transaction fees at the intermediate date to respond positively to the conversion demand, if possible. In this way she can generate the aforementioned congestion effect and, thereby, promote stability.[7] Another factor influencing the profitability of stablecoin issuers is the nominal interest rate. While stablecoin adoption is higher in a low rate environment when interest rates on bank deposits are less attractive, a negative relationship between the profitability of the issuer and the remuneration of reserves threatens stability.

There is a growing body of empirical studies of the stablecoins market. A paper by Hoang and Baur (2021) suggests that stabelcoins play a key role in the 2tn US dollar crypto asset market. Moreover, there is an increasingly closer link with traditional financial markets. In recent work Barthelemy, Gardin and Nguyen (2021) document how changes in the stablecoin market capitalization affect the market for US dollar denominated commerical paper, due to the large commercial paper holdings by stablecoin issuers.

[6] Cryptocurrency exchange platforms see remittances as an area with growth potential. In 2022 the platform Coinbase started to offer crypto remittances to Mexico. The new service allows to instantly send crypto assets and stablecoins, promising $25-50\%$ lower transaction costs when compared to traditional cross-border transactions.

[7] Leading stablecoin operators use different instruments to deal with peaks in conversion demand, such as administrative fees and temporary deviations of the price on the open market from the peg (see Gorton and Zhang (2021) for more details).

Gorton, Ross and Ross (2022) measure the frictions faced by stablecoin holders when transacting and converting their coins to fiat currency, documenting a negative association with the convenience yield and a high co-movement within the stablecoins universe, raising the risk of a contagious stablecoin runs.[8] Our work suggests that positive and negative network effects, as well as the value of stablecoins as a means of payment can contribute to stability. The model implications can be tested empirically. Empirical measures to gauge the strength of network effects in the stablecoins market include measures for platform user retention (possibly by user cohort, e.g. early adopters vs. late adopters), for market depth, for the concentration of supply and demand, and for the cost of switching between different coins. The value of stablecoins as a means of payment can be assessed by measuring the scope to use stablecoins to purchase goods and services, and by measuring the transaction costs for purchasing crypto assets.

From a policy viewpoint, our paper highlights the build-in fragility of the latest innovation in the history of private money. The determinants of fragility identified in this paper can inform the ongoing policy discussion. While the focus of this paper is exclusively on the fragility of stablecoins and abstracts from important implications for monetary systems, traditional financial intermediaries and the payments landscape, our findings do bear relevance for the stability of the broader financial system due the increasing interconnectedness between crypto asset markets and traditional financial markets in conjunction with the critical role played by stablecoins in the crypto universe (see, e.g., FSB (2022)).

The US is moving towards a regulation that only allows federally insured banks and non-bank financial institutions subject to a 100% reserve requirement to issue stablecoins. Indeed, tightly regulated stablecoins issued by insured depository institutions and by narrow banks may be preferred over a US retail CBDC (Waller 2021; Andolfatto 2021b). If implemented and accompanied by adequate safeguards for operational and technological risks, such a policy would make regulated stablecoins essentially riskless and suitable as a medium of exchange that fulfils the *no-questions-asked* principle put forward by Gorton and Zhang (2021).

In China a similar outcome was achieved after the Chinese central bank decided in 2019 that the dominant payments platforms Alipay and WeChat Pay have to invest all funds backing their e-monies exclusively in deposits with state-owned commercial banks. In Europe and in other parts of the world policy markers are also determined to step up the regulation of stablecoins, as to limit their exposures to liquidity risk, return risk and operational risks. The European Markets in Crypto-Assets (MiCA) regulation proposal classifies stablecoins that are pegged to a fiat currency as "e-money tokens" (EC 2020). After the implementation of MiCA, which is scheduled for 2024, the provision of crypto-asset services in the European Union (EU) requires companies to obtain a license and to adhere to requirements regarding their capitalization, the governance model, the asset separation, the safekeeping of funds and more. However, MiCA does not foresee that issuers of e-money tokens in the EU are subject to a reserve requirement.

While domestic regulation is flanked by an effort to coordinate policies internationally (primarily in the

[8] Grobys, Junttila, Kolari and Sapkota (2021) show that Bitcoin volatility is an important factor driving the volatility of stablecoins. In related work, Lyons and Viswanath-Natraj (2020) show that Tether's peg to the US dollar is primarily stabilized by arbitrage traders, rather than by the issuer.

Basel Committee on Banking Supervision and in the Committee on Payments and Market Infrastructures,[9] the global nature of crypto asset markets[10] and the speed of innovation, especially in decentralized finance,[11] remain challenges when attempting to adequately regulate all stablecoin issuers. Therefore, some risks are likely to remain in the foreseeable future, especially in corners of the market that are hard to regulate. Consequently, we expect our analysis to stay relevant going forward.

Our paper relates to the extensive research on currency attacks (Krugman 1979; Flood and Garber 1984; Obstfeld 1986; Morris and Shin 1998; Corsetti, Dasgupta, Morris and Shin 2004) and on bank runs (Rochet and Vives 2004; Goldstein and Pauzner 2005). In a recent paper Routledge and Zetlin-Jones (2021) analyze a currency attack model and study the vulnerability of a currency, or stablecoin, that is not 100% backed by a reserve currency and study how a commitment to devalue the currency conditional on the size of a speculative attack can successfully stabililize the exchange rate. Li and Mayer (2022) develop a dynamic model of stablecoin and crypto shadow banking to characterize an instability trap where tokens are debased in states where the issuer has a low level of reserves. In a related d'Avernas et al. (2022) study different stabilization mechansims. Our focus differs in that we are not interested in studying the issuer's incentives to stabilize the price of tokens with open market operations or alternative stabilization mechanisms (see also Klages-Mundt and Minca (2021)), but in offering a closer examination of the determinants of fragility and adoption. Chiu and Wong (2021) study the business model of online platform such as Amazon or Alibaba, who have the choice between accepting cash and issuing digital money, and whether to allow the digital money they issue to circulate outside the platform. Adoption plays an important role for the success of platforms and Cong et al. (2021) study how user network externalities shape crypto asset adoption and increase the price, which in turn accelerates adoption.

Our model is a modified version of the bank run model by Goldstein and Pauzner (2005). Similar to Goldstein and Pauzner, our model of stablecoin runs exhibits a payoff structure that does not satisfy global strategic complementarities. Using their approach we establish the existence of a unique threshold equilibrium in the conversion game at the intermediate date. Moreover, we allow for heterogeneous payoffs and players as in Corsetti et al. (2004) and Sákovics and Steiner (2012).[12] In addition, we also model a stablecoin adoption game ex-ante, which may re-introduce a multiplicity of equilibria indexed by different adoption rates, a feature shared with coordination games with strategic complementarities and information acquisition (Hellwig and Veldkamp 2009).

Our paper also relates to the growing literatures on digital money, crypto assets and central bank digital currencies. Agur, Ari and Dell'Ariccia (2022) study the optimal design of a CBDC and with an emphasis

[9]See, e.g., BIS (2021, 2022) and CPMI-IOSCO (2020).

[10]The leading stablecoin Tether is domiciled in the British Virgin Islands and it's partner bank Deltec Bank & Trust is domiciled in the Bahamas. Similarly, many crytpocurrency exchanges are domiciled in off-shore locations with opaque ownership structures.

[11]The natural starting point for financial regulators are intermediaries such as cryptocurrency exchanges and wallet providers. Therefore, the emergence of decentralized autonomous organizations (DAOs) based on smart contracts further complicates effective regulation, because DAOs not only obscure traditional concepts of ownership, but they also rely less on intermediaries.

[12]See Garcia and Panetti (2022) for an application with wealth heterogeneity and Basteck, Daniëls and Heinemann (2013) for heterogeneous investor payoffs and equilibrium selection in global games.

on network effects and the convenience of means of payment, which we also incorporate in this paper. Andolfatto (2021a) and Chiu, Davoodalhosseini, Jiang and Zhu (2022) argue that the introduction of a CBDC does not lead to undesirable disintermediation and can enhance the competitiveness of the banking sector. Other papers on the effect of an introduction of a CBDC on disintermediation and the stability of the banking sector include Barrdear and Kumhof (2021), Davoodalhosseini (2021), Schilling, Uhlig and Fernández-Villaverde (2021), Keister and Monnet (2020) and Williamson (2021).

The paper proceeds as follows. Section 2 describes the model. Section 3 solves for the equilibrium of the conversion game at the intermediate date and analyzes how different factors affect the fragility of stablecoins. Section 4 solves the equilibrium of the adoption game at the initial date and discusses potential choices of the stablecoin issuer that can affect adoption and fragility. Thereafter, Section 5 discusses policy implications and testable implications for future empirical work, as well as extensions and the robustness of our findings to alternative model specifications. Finally, Section 6 concludes. All proofs are in the Appendix.

2 Model

We study a game with two periods and three dates, $t = 0, 1, 2$. It comprises an initial investment (or adoption) game played at $t = 0$ and a withdrawal game played at $t = 1$, which takes the form of a global game of regime change with heterogeneous agents. There is a unit continuum of risk-neutral *investors* $i \in [0, 1]$ who each have an endowment of one unit of fiat money (cash) at the beginning of $t = 0$ and who are interested in consuming a homogeneous consumption good at $t = 2$. The consumption good is produced and sold at $t = 2$ by a large number of competitive *sellers* at a price that is normalized to one. At $t = 0$ investors can either store their cash endowment, deposit it with a *traditional bank* or invest it in stablecoins issued by a monopolistic *stablecoin issuer*.[13] At $t = 1$ investors can decide whether to reallocate their funds.

Storing cash has a return of one in each period. The traditional bank offers insured (risk-less) deposits at $t = 0$ that are pegged to the fiat currency and can be converted to cash at any time at no cost. If held till $t = 2$, bank deposits yield a return of r_d per unit invested. If withdrawn at $t = 1$, each unit of deposits is converted into one unit of cash. Resultingly, the return on bank deposits dominates the return of storing cash if $r_d \geq 1$, which is the case of interest in our baseline model.[14] The stablecoin issuer offers the possibility to convert cash into a digital token (stablecoin) and visa versa at a one-to-one conversion rate at dates $t = 0, 1, 2$. Unlike the bank, the stablecoin issuer offers no interest and she may not always be able to keep her promise of a one-to-one conversion at dates $t = 1, 2$ due to the risk of insolvency, which we will describe in more detail below. In addition, we assume that the stablecoin issuer collects transaction costs at dates $t = 0, 1, 2$ for

[13]The assumption of a monopolistic stablecoin issuer focuses our attention on a relevant benchmark, because network effects play an important role in the payments market (Rochet and Vives 2004) where many participants tend to *single home* on their preferred means of payment (Rysman 2007), which is likely to give rise to a high degree of concentration in the emerging market for stablecoins. Gorton et al. (2022) argue that the high co-movement of stablecoin prices suggests that they may be treated as a single coin when analyzing stablilty. As of early March 2022, the the market was already highly concentrated with Tether and USD Coin accounting for around 45% and 31% of the total stablecoin market capitalization (coingecko.com).

[14]In Section 5.3 we consider an extension with a low interest rate environment where $r_d < 1$.

exchanging coins against cash or bank deposits, which we denote with $\tau_0 \in [0,1)$, $\tau_1 \in [0,1)$ and $\tau_2 \in [0,1)$. The transaction costs are exogenously given and proportional to the amount of currency converted.[15]

Our model has two key features that govern the adoption of stablecoins and the stability of the stablecoin issuer. The first feature is a convenience benefit that affects the relative attractiveness of stablecoins vis-à-vis bank deposits. Specifically, investors are potentially heterogeneous in the relative convenience benefit that they derive from holding stablecoins. We assume that the population of investors consists of G groups indexed by $g \in \{1,...,G\}$. Each group has a measure m_g, where $\Sigma_{g=1}^{G} m_g = 1$, meaning that the groups sum up to the unit continuum of investors. All investors belonging to group g share the same relative convenience benefit b_g, with $b_{j+1} > b_j, \forall j \in \{1,...,G-1\}$, $b_g \in [\underline{b}, \overline{b}], \forall g$ and $\underline{b} < 0 < \overline{b}$. As a result, some investor groups may have a higher convenience benefit from holding stablecoins, i.e. $b_g > 0$, while other groups find them less attractive, i.e. $b_g < 0$. The relative convenience benefit is accures if the stablecoins are held till $t = 2$.[16]

The second feature is uncertainty about the preferred means of payment to purchase the consumption good at $t = 2$. Specifically, we assume that investors are randomly assigned to one seller who only accepts payment in stablecoins with probability $0 \leq \alpha(N) \leq 1$, provided the stablecoin issuer is solvent at $t = 2$ (which implies that the issuer is also solvent at $t = 2$, as we will show). With probability $0 \leq \beta \leq 1$ the randomly assigned seller only accepts payment with cash (or bank deposits) and with probability $0 \leq 1 - \alpha(N) - \beta \leq 1$ she accepts all means of payment. As a result, if the stablecoin issuer is solvent at $t = 2$, a population fraction $\alpha(N)$ of investors must use stablecoins to pay and a population fraction β must use cash. Hence, an investor holding a different money must first convert it to the seller's preferred means of payment and incur transaction costs. If the stablecoin issuer is insolvent, then all investors must use cash as means of payment. Importantly, we allow α to depend on N, which is the mass of investors adopting the stablecoin. Moreover, we assume that $\alpha'(N) \geq 0$, which holds with strict inequality if there are positive network effects.[17]

At $t = 0$ investors play a simultaneous move game where they decide on whether to invest their cash endowment of one unit bank deposits, i.e. to choose the action $a_{0,i} = 0$, or to convert it into $1 - \tau_0 \in (0,1]$ units of stablecoins, i.e. to choose the action $a_{0,i} = 1$. The stablecoin adoption rate is defined as $N = \int_0^n a_{0,i} di$. Importantly, we assume that investments in stablecoins are risky. This risk may stem from the quality of the stablecoin issuer's assets or from potential exposures to operational or technological risks (e.g. cyber risk). Formally, we assume that after collecting funds at $t = 0$, the issuer invests them into a risky asset that pays

[15] In Sections 5.3 we also consider an extension where setting the transaction costs is a policy choice by the issuer. Moreover, we discuss what happens if the transaction costs do not generate income for the issuer. In practise, transaction costs for on-chain transactions and for peer-to-peer transactions are outside the control of the issuer (e.g. they depend on the transaction costs on the Ethereum blockchain or of a peer-to-peer exchange). Instead, issuers may have some influence over the transaction costs on exchange platforms (e.g. USD Coin is co-owned by the Coinbase cryptocurrency exchange platform and Bianance USD is owned by the Binance crytocurrency exchange platform), which also offer VISA or MasterCard payment cards that are linked to a cryptocurrency wallet and can also be used for ATM withdrawals (e.g. Coinbase offers a VISA card issued by MetaBank that allows to spend USD Coins).

[16] The qualitative results are the same if we assume that the relative convenience benefit only accrues if stablecoins are repaid in full at $t = 2$. However, the analysis of the case with more than two different groups of coin holders is facilitated by a convenience benefit that is not contingent on the aggregate action of coin holders, which allows to apply the Belief Constraint of Sákovics and Steiner (2012).

[17] Network effects can arise from a positive feedback loop between consumer adoption and merchant acceptance of a means of payment (Rochet and Tirole 2003) and we model them in a tractable way (Belleflamme and Peitz 2021) similar to Agur et al. (2022), who analyze the role of network effects for the demand for central bank digital currency, cash and bank deposits.

off θ units of cash at $t = 2$ per unit of cash invested at $t = 0$, where $\theta \sim U[\underline{\theta}, \overline{\theta}]$, with $0 \leq \underline{\theta} < 1$ and $\overline{\theta} \geq 1$. Furthermore, we assume that if liquidated prematurely at $t = 1$ the asset pays off $R(\theta)$ units of cash per unit of cash invested at $t = 0$ and that there exists a threshold $\theta_h \in (1, \overline{\theta})$ such that $R(\theta) = \theta_h$ for all $\theta \geq \theta_h$ and $R(\theta) = r < \min\{1, \overline{\theta}(1 - \tau_1)/(1 - \tau_2)\}$ for all $\theta < \theta_h$. This modelling trick from Goldstein and Pauzner (2005) assures the existence of an upper dominance region (which we will explain in more detail in Section 3).

Following Carlsson and van Damme (1993), there is incomplete information about θ. Each investor who invested in the stablecoin at $t = 0$ receives a noisy private signal x_i at the beginning of $t = 1$:

$$x_i = \theta + \varepsilon_i. \tag{1}$$

The idiosyncratic noise is independently and uniformly distributed, $\varepsilon_i \sim U[-\sigma\varepsilon, +\sigma\varepsilon]$ with $\varepsilon > 0$ and $\sigma \geq 0$. Let g_i denote the group to which investor i belongs and note that g_i and ε_i are uncorrelated. Upon receiving their private signal, stablecoin investors simultaneously decide whether to demand conversion of the stablecoin to cash at the promised one-to-one conversion rate, knowing that the issuer serves redemption request sequentially and that she may not be able to meet all requests. The action to demand conversion is denoted with $a_{1,i} = 1$ and the action to keep the stablecoins with $a_{1,i} = 0$. Table 2 summarizes the game.

Date 0	Date 1	Date 2
1. **Adoption game:** agents choose whether to invest their cash in bank deposits, $a_{0,i} = 0$, or in stablecoins, $a_{0,i} = 1$ 2. Stablecoin issuer invests all the funds received	3. Fundamental θ is realized but unobserved 4. **Stablecoin conversion game:** Stablecoin investors receive private information x_i and choose whether to demand conversion to cash, $a_{1,i} = 1$, or not, $a_{1,i} = 0$ 5. Stablecoin issuer liquidates assets to meet conversion requests sequentially	6. Bank depositors, stablecoin holders and cash holders are randomly assigned to sellers, convert their money (if necessary), purchase goods and consume

Table 2: Timeline of events.

3 Stablecoin runs at $t = 1$

The model is solved backwards. Section 3 analyzes the continuation equilibrium at $t = 1$ for a given rate of stablecoin adoption, N, and for given promised repayments by the issuer in case of conversion at dates $t = 1$ and $t = 2$. Section 3.1 presents conditions under which the issuer is able to meet her payment obligations at $t = 1, 2$. Thereafter, we discuss in Section 3.2 how the expected utility payoff of a stablecoin holder depends on whether or not she demands conversion to cash at $t = 1$, the decision of other coin holders and the solvency of the issuer. Building on these results we state in Section 3.3 the decision problem of coin holders and solve the conversion game for the $t = 1$ continuation equilibrium.

3.1 Solvency of the stablecoin issuer at $t = 1$ and $t = 2$

The stablecoin issuer is insolvent at $t = 1$ or at $t = 2$, whenever she is unable to redeem the coins at par that have been issued at $t = 0$, meaning that she does not have sufficient resources to convert the stablecoins to cash at the promised one-to-one conversion rate. Let $p_1 = (1-\tau_0)(1-\tau_1)$ and $p_2 = (1-\tau_0)(1-\tau_2)$ denote the promised cash repayments at $t = 1$ and $t = 2$ net of the transaction costs, which are taken as given. Conditional on the adoption rate N, the proportion of coin holders who demand conversion is $A = \int_0^n a_{1,i}di/N$. If only investors of groups $g \in \{k,...,G\}$ invest in the stablecoin, then $A = \int_0^n a_{1,i}di/(\Sigma_{g=k}^G m_g) \in [0,1]$, where $(a_{1,i}|g_i = g) = 0$ for all $g \in 1,...,k-1$. The issuer is cash-flow insolvent at $t = 1$, i.e. unable to meet her immediate payment obligations, NAp_1, if:

$$R(\theta) < Ap_1. \tag{2}$$

Similarly, she cannot meet her $t = 2$ payment obligations, $N(1-A)p_2$, if $R(\theta) \leq Ap_1$ or if $R(\theta) > Ap_1$ and:

$$\frac{R(\theta)-Ap_1}{(1-A)R(\theta)}\theta < p_2. \tag{3}$$

Note that solvency of the issuer at $t = 2$ implies that she is also able to meet her payment obligations at $t = 1$. Moreover, observe that inequality (3) holds if $\theta \geq \theta_h$, because of our assumption that $R(\theta) \geq 1$ for $\theta \geq \theta_h$ and $p_1, p_2 \leq 1$. As a result, the issuer is *fundamentally solvent* for very high realizations of θ, when all redemption requests at $t = 1$ and $t = 2$ can be met because of a high liquidation value at $t = 1$ and a high cash payout of the issuer at $t = 2$ from her investment at $t = 0$.

Isolating θ in inequality (3) allows us to define a critical threshold $\hat{\theta}(A) \in [\underline{\theta}, \theta_h)$, such that for a given fraction of coin holders demanding conversion, the issuer is insolvent for all $\theta < \hat{\theta}(A)$, where:

$$\hat{\theta}(A) \equiv p_2\frac{(1-A)r}{r-Ap_1} < 1. \tag{4}$$

In the same vein, we can define a critical threshold $\hat{A}(\theta)$, such that for a given fundamental realization, the issuer is insolvent for all $A > \hat{A}(\theta)$, where:

$$\hat{A}(\theta) \equiv \frac{(\theta-p_2)r}{p_1\theta - p_2 r}. \tag{5}$$

Note that $\hat{A}(\theta)$ is strictly increasing in θ for all $\theta \in (\theta_\ell, \theta_h)$, meaning that when θ is higher the issuer is only insolvent at $t = 2$ for higher levels of conversion demand at $t = 1$. Moreover, $\hat{\theta}(A) \leq \overline{\theta}$ requires $A < \hat{A}(\overline{\theta})$.

Based on equation (4) there exists a lower bound p_2 such that for all $\theta < p_2$ the issuer has insufficient resources at $t = 2$ to meet her promise even if there are no demands for conversion at $t = 1$, i.e. if $A = 0$. We assume that $p_2 \in (\underline{\theta}, \overline{\theta})$. As a result, the issuer is *fundamentally insolvent* for all $\theta < \theta_\ell$.

Next, we analyze equation (4) for $\hat{\theta}(A) > \theta_\ell$, with $A < \hat{A}(\overline{\theta})$ to trace out how the solvency of the issuer is governed by the fraction of coin holders demanding conversion:

$$\frac{d\hat{\theta}(A)}{dA} = p_2 \frac{r(p_1 - r)}{(r - Ap_1)^2} > 0, \qquad \frac{d^2\hat{\theta}(A)}{dA^2} > 0,$$

by the promised repayment (net of the known transaction costs) at $t = 1$:

$$\frac{d\hat{\theta}(A)}{dp_1} = p_2 \frac{(1-A)rA}{(r - Ap_1)^2} > 0, \tag{6}$$

and by the promised repayment (net of the known transaction costs) at $t = 2$:

$$\frac{d\hat{\theta}(A)}{dp_2} = \frac{(1-A)r}{r - Ap_1} > 0. \tag{7}$$

Figure 3 summarizes how the realization of the fundamental θ and the population fraction A of stablecoin holders demanding conversion govern the solvency of the stablecoin issuer. Importantly, the decision of coin holders does not matter for $\theta \geq \theta_h$ when the issuer is always solvent, or *fundamentally solvent*, which we depict as the lightly shaded region. Similarly, the decision of coin holders does not matter for $\theta \leq p_2$ when the issuer is always insolvent, or *fundamentally insolvent*, which we depict as the darkly shaded region. In the intermediate region, $\theta \in (p_2, \theta_h)$, the issuer is for a given θ solvent (insolvent) *conditionally* on A being sufficiently low (high) such that $\theta \geq \hat{\theta}(A)$ ($\theta < \hat{\theta}(A)$).

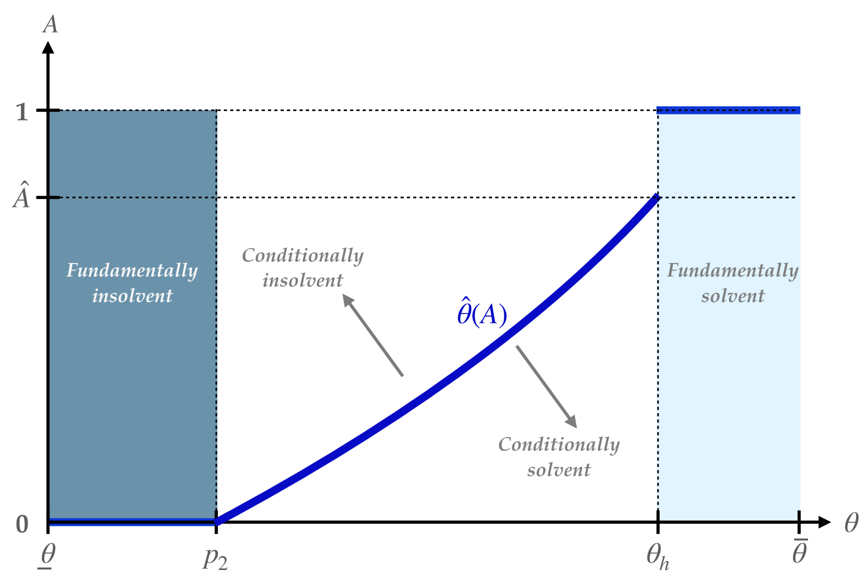

Figure 3: Solvency of the stablecoin issuer as a function of the fundamental realization θ and the population fraction A of coin holders demanding conversion.

3.2 Payoffs

The risk of insolvency only affects stablecoins, since bank deposits are insured. When deciding whether to demand conversion of her stablecoins at $t = 1$ into $(1 - \tau_0)$ units of cash, coin holder i compares the expected utility payoff from doing so with the alternative to keep her coins, knowing that the stablecoin issuer is cash-flow insolvent at $t = 1$ if $A > R(\theta)$ and cash-flow insolvent at $t = 2$ if $A > \hat{A}(\theta) \equiv (\theta - 1)R(\theta)/(\theta - R(\theta))$, where we used equations (4) and (5).

Table 3 shows the utility payoffs of coin holder i of group g_i associated with the actions to demand conversion, $a_{1,i} = 1$, and to keep her coins, $a_{1,i} = 0$. Importantly, the payoffs depend on the realization of θ, on the average action A of others and on b_{g_i}, as well as the expectations about the payment preference of the consumption good seller at $t = 2$, with whom investors are randomly matched. Recall that we assume in our baseline that the relative convience benefit accrues if the stablecoins are held till $t = 2$, i.e. $b^S_{g_i} = b^I_{g_i} = b_{g_i}$.[18]

aggregate action / *individual action*	$A \leq \hat{A}(\theta)$, issuer is **solvent**	$A > \hat{A}(\theta)$, issuer is **insolvent**
Demand conversion, $a_{1,i} = 1$	$p_1(\alpha(N)(1-\tau_2) + (1-\alpha(N)))$	$\begin{cases} p_1 & \text{w.p. } \min\{\frac{r}{Ap_1}, 1\} \\ 0 & \text{w.p. } 1 - \min\{\frac{r}{Ap_1}, 1\} \end{cases}$
Keep coins, $a_{1,i} = 0$	$(1-\beta)(1-\tau_0) + \beta p_2 + b^S_{g_i}$	$\max\{0, \frac{r - Ap_1}{(1-A)r}\theta\} + b^I_{g_i}$

Table 3: Ex-post utility payoffs of the stablecoin conversion game at $t = 1$.

If the stablecoin issuer is insolvent, i.e. if $A > \hat{A}(\theta)$, then, because of sequential service, each stablecoin holder i who demands conversion at $t = 1$ receives redemption at par only if she has a place in line that assures her to be served before the issuer runs out of resources, which occurs with probability $\min\{r/(Ap_1), 1\}$ for all $\theta < \theta_h$. Whenever, $\hat{A}(\theta) < A < r$, meaning that the issuer has sufficient resources to meet all redemption requests at $t = 1$, but insufficient resources to meet the redemption requests at $t = 2$, all coin holders demanding conversion at $t = 1$ are served and receive p_1 each. Instead, if $A > r/p_1$, only a fraction $r/(Ap_1)$ of the coin holders demanding conversion is served, while the payoff from the action to keep the coins is zero whenever the stablecoin issuer is insolvent because she runs out of resources at $t = 1$. If $\hat{A}(\theta) < A < r/p_1$ the insolvent issuer has some remaining cash resources after $t = 1$, which are distributed pro rata, i.e. each remaining coin holder receives $(r - Ap_1)\theta/((1 - A)r) > 0$, as well as the relative convenience benefit.

If the stablecoin issuer is solvent, i.e. $A \leq \hat{A}$, then the issuer is able to meet her payment obligations in full to both coin holders demanding conversion at $t = 1$ and coin holders who keep their coins till $t = 2$. In the former case, coin holders demanding conversion receive p_1 and face with probability $\alpha(N)$ a seller who only accepts stablecoins, meaning they have to pay the additional transaction cost τ_2 to convert the cash back to stablecoins. In the latter case, the payoff from the action to keep the coins includes the relative convenience benefit b_{g_i} and coin holders keeping their coins face with probability β a seller who only accepts cash, they also have to pay the transaction cost τ_2.

[18]The qualitative results are unchanged if the convenience benefit only accrues when coins are redeemed at par at $t = 2$, but the analysis of the case with more than two groups of coin holders is facilitated by a benefit that is not contingent on the aggregate action.

Let $\Delta(A;\theta,b_{g_i},N) \equiv E[u(A;\theta,b_{g_i},N,a_{0,i}=1,a_{1,i}=1)] - E[u(A;\theta,b_g,N,a_{0,i}=1,a_{1,i}=0)]$ denote the differential utility payoff of coin holder i from demanding conversion, instead of keeping her coins till $t=2$:

$$\Delta(A;\theta,b_{g_i},N) = \begin{cases} p_1(1-\alpha(N)\tau_2) - (1-\tau_0)(1-\beta\tau_2) - b_{g_i} & \text{if } A \leq \hat{A}(\theta) \\ \min\{\frac{r}{Ap_1},1\}p_1 - (1+b_{g_i})\max\{0,\frac{r-Ap_1}{(1-A)r}\theta\} & \text{if } A > \hat{A}(\theta), \end{cases} \quad (8)$$

where we used the fact that coin holders are risk neutral. Note that $\Delta(A;\theta,b_{g_i},N)$ is weakly decreasing in θ, in b_{g_i} and in N. The differential expected utility payoff is positive if the stablecoin issuer is insolvent. If the issuer is solvent, then it is negative. This is because investor i belonging to group g_i would not have adopted the stablecoin if $(1-\tau_1)(1-\alpha(N)\tau_2) > (1-\beta\tau_2) + b_{g_i}$, as we will show in Section 4.

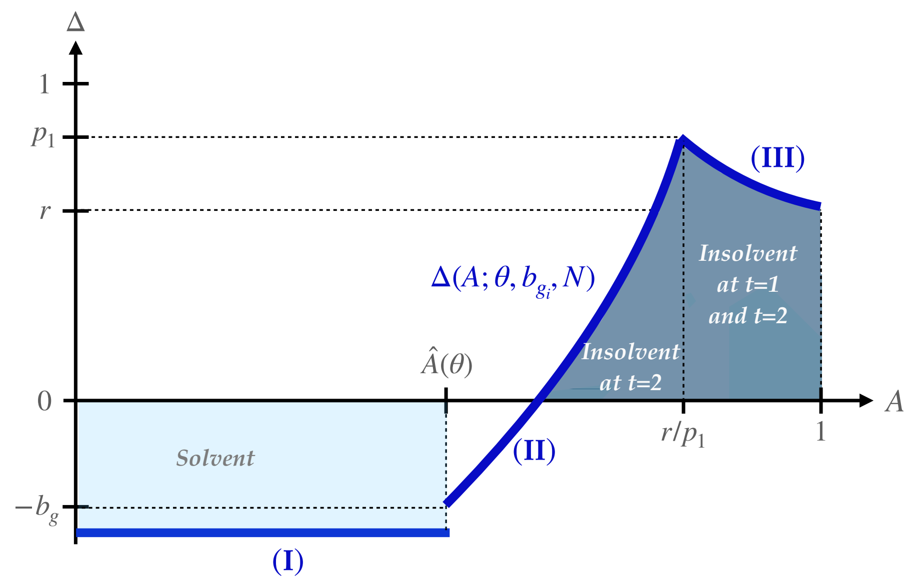

Figure 4: Differential utility payoff of a coin holder with relative convenience benefit b_{g_i} from demanding conversion at $t=1$ instead of keeping her coins for a given θ and A.

Figure 4 shows how $\Delta(A;\theta,b_{g_i},N)$ varies with $A \in [0,1]$ for a given $\theta \in (p_2,\theta_h)$ and b_{g_i}. We can see that Δ is (locally) independent of A and θ if $A \leq \hat{A}(\theta)$, depicted as region (I). For all $A > \hat{A}$ the stablecoin issuer is insolvent at $t=2$ and for all $A > r/p_1 > \hat{A}$ she is insolvent at $t=1$ and $t=2$. Region (II) shows the former case, where Δ is increasing in A, because the resources available for coin holders not demanding conversion are reduced, while coin holders demanding conversion are repaid in full. Region (III) shows the latter case, where Δ is decreasing in A, because coin holders demanding conversion receive a lower pro rata repayment, the higher the conversion demand:

$$\frac{d}{dA}\left(\min\{\frac{r}{Ap_1},1\}p_1-\max\{0,\frac{r-Ap_1}{(1-A)r}\theta\}-b_{g_i}\right)=\begin{cases}\frac{p_1-r}{r(1-A)^2}\theta>0 & \text{if } A\in(\hat{A}(\theta),r/p_1]\\ -r/A^2<0 & \text{if } A>r/p_1.\end{cases} \tag{9}$$

Importantly, there exists a $A^0\in(\hat{A}(\theta),r/p_1)$ such that $\Delta(A;\theta,b_{g_i},N)$ is positive for all $A>A^0$, but there is no global strategic complementarity in actions, because a higher population fraction of coin holders demanding conversion does not increase the incentives for other coin holders to demand conversion for all $A>r/p_1$.[19]

3.3 Continuation equilibrium of the stablecoin conversion game at $t=1$

In this section we analyze the decision problem of stablecoin holders at $t=1$ and derive the continuation equilibrium of the conversion game at $t=1$ for given promised cash repayments p_1 and p_2 at $t=1$ and $t=2$.

3.3.1 Complete information benchmark

We proceed by first discussing the complete information benchmark, i.e. the case of $\sigma=0$, where coin holders obtain a precise signal at $t=1$ about the resources available to the stablecoin issuer at $t=2$.

Suppose that an individual coin holder i believes that others keep their coins, i.e. $a_{1,-i}=0$. She optimally demands conversion if and only if the differential payoff from conversion relative to keeping the coins is weakly positive. Weak preference for demanding conversion holds if $\theta\leq p_1\leq p_2$, which gives us a lower bound for θ such that it is the (weakly) dominant action to demand conversion if $\theta\leq p_1$.

Following the same logic, we can derive the upper bound from the weak preference for not demanding conversion if coin holder i believes that all others demand conversion, i.e. if $a_{1,-i}=1$. Since $(1-\tau_0)(1-\beta\tau_2)+b_{g_i}$ is increasing in the relative convenience benefit, we have that it is the (weakly) dominant action for all coin holders to keep their stablecoins if $\theta\geq\theta_h$ and:

$$\hat{b}\geq(1-\tau_1)(1-\alpha(N)\tau_2)-(1-\beta\tau_2), \tag{10}$$

where $\hat{b}$ is the lowest level of the convenience benefit such that an investor is just willing to adopt the stablecoin (see Section 4). As the analysis of the conversion game at $t=1$ requires that stablecoins are adopted at least by some investors, We henceforth assume that inequality (10) holds at least for investors of group G and potentially also for other groups, which intuitively requires that for a given level of b_G the transaction cost τ_2 at $t=2$ is not too large relative to the transaction cost τ_1 at $t=1$. Observe, that in an economy where sellers only accept cash, i.e. $\beta=1$, inequality (10) simplifies to $\hat{b}\geq\tau_2-\tau_1$.

We next analyze what happens in the intermediate region $\theta\in[p_1,\theta_h]$. Suppose the intermediate region

[19] See Goldstein and Pauzner (2005) for bank run models with a payoff structure not satisfying global strategic complementarities.

is non-empty, i.e. $\theta_h > p_1$, which is assured because θ_h can be arbitrarily large. Then for any $\theta \in [p_1, \theta_h]$, multiple belief-driven equilibria exist. Specifically, there always exist a pure strategy Nash equilibrium where all coin holders demand conversion and a pure strategy Nash equilibrium where all coin holders keep their stablecoins. Proposition 1 summarizes the results.

Proposition 1 ***(Continuation equilibrium under complete information)*** *Let $\sigma = 0$ and consider a promise to convert stablecoins at $t = 1$ into $p_1 \leq (1-\tau_0)(1-\beta\tau_2)\hat{b}/(1-\alpha(N)\tau_2)$ units of cash. There exists a unique equilibrium where all stablecoin holders demand conversion if $\theta \in [\underline{\theta}, p_1)$ and where no stablecoin holder demands conversion if $\theta \in (\theta_h, \overline{\theta}]$. In the intermediate range, $\theta \in [p_1, \theta_h]$, there exist multiple equilibria.*

3.3.2 Incomplete information game with one group of stablecoin holders

We next discuss the incomplete information game, i.e. the case of $\sigma > 0$, where coin holders obtain a noisy private signal at $t = 1$ that is correlated with the amount of resources available to the stablecoin issuer at $t = 2$. To ease the exposition, we start by focusing on the special case where all stablecoin holders have the same relative convenience benefit, meaning there is only one group of investors who have adopted stablecoins at $t = 0$, which is group G with the highest level of the relative convenience benefit. There is, however, a potentially large number of groups of investors with $b_j < b_G$ and $j \in \{1, G-1\}$, who do not adopt stablecoins. The special case allows us to obtain many of the key insights that also hold for the general case with coin holders who are heterogeneous in their convenience benefit, which is analyzed in Section 3.3.3.

Based on equation (8), we first define the differential expected utility payoff of coin holder i in group g from choosing the action to demand conversion, i.e. $a_{1,i} = 1$, conditional on her private signal x_i as:[20]

$$\begin{aligned} E[\Delta(A;\theta,b_g,N)|x_i] \quad \equiv \quad & Prob\{A \leq \hat{A}(\theta)|x_i\}\left(p_1(1-\alpha(N)\tau_2) - (1-\tau_0)(1-\tau_2\beta)\right) \\ & + Prob\{\hat{A}(\theta) < A \leq r/p_1(\theta)|x_i\} \int_{\underline{\theta}}^{\overline{\theta}} \left(p_1 - \frac{r - Ap_1}{(1-A)r}\theta\right) h(\theta|x_i)d\theta \\ & + Prob\{A > r/p_1|x_i\} \int_{\underline{\theta}}^{\overline{\theta}} \left(\frac{r}{A}h(\theta|x_i)\right) d\theta - b_g, \end{aligned} \tag{11}$$

where $h(\theta|x_i)$ denotes the posterior probability of a fundamental realization of θ, after observing the private signal x_i. While coin holders potentially face heterogenous type-specific payoff functions, they all share an identical differential expected utility payoff conditional on the type-specific benefit and the private signal x_i.

We use the global games approach (Morris and Shin 2006; Goldstein and Pauzner 2005) to analyze the converstion game at $t = 1$. This allows us to establish conditions for the existence of a monotone Bayesian equilibrium. Recall that $\theta \sim U[\underline{\theta}, \overline{\theta}]$ and $x_i = \theta + \varepsilon_i$, where $\varepsilon_i \sim U[-\sigma\varepsilon, +\sigma\varepsilon]$ is independently and identically distributed. The posterior belief about the probability that the fundamental threshold realization θ exceeds

[20]Observe that the stablecoins issuer can only collect transaction costs if she is able to honor the promised repayments p_1 and p_2.

a certain level $y \in [\underline{\theta} + \sigma\varepsilon, \overline{\theta} - \sigma\varepsilon]$ is given by:

$$Prob\{\theta \geq y | x_i\} = Prob\{x_i - \varepsilon_i \geq y | x_i\} = \begin{cases} 1 & if \; x_i > y + \sigma\varepsilon \\ \frac{1}{2} + \frac{x_i - y}{2\sigma\varepsilon} & if \; x_i \in [y - \sigma\varepsilon, y + \sigma\varepsilon] \\ 0 & if \; x_i < y - \sigma\varepsilon. \end{cases} \tag{12}$$

We next establish the existence of an upper and lower dominance region of very favorable and very unfavorable private signal realizations, respectively, such that the actions of coin holders observing a private signal that falls in these regions do not depend on the decisions of others. To establish the dominance regions, we invoke the additional assumption that $p_1 - \sigma\varepsilon > (1 + b_G)\underline{\theta}$ and $\theta_h + \sigma\varepsilon < \overline{\theta}$. Then there exist two dominance regions of private signals, $[\underline{\theta} - \sigma\varepsilon, \underline{x})$ and $(\overline{x}, \overline{\theta} + \sigma\varepsilon]$. We derive $\underline{x}$ and $\overline{x}$ in Appendix A.1.

Continuation equilibrium. Based on the existence of the dominance regions we can show that iterated elimination of dominated strategies leads to a unique outcome. Recall that this requires that the investor group with the higher level of the relative convenience benefit satisfies $b_G \geq \hat{b}$. Otherwise, investors of type b_G would not have adopted the stablecoin in the first place (see Section 4).

When solving for the equilibrium of the continuation game with incomplete information we use the proof strategy of Goldstein and Pauzner (2005), which allows us to establish the existence of a unique continuation equilibrium that is characterized by threshold strategies despite the absence of a global strategic complementarity in actions. Specifically, the differential utility payoff from demanding conversion reaches its peak at r/p_1 and falls thereafter, as illustrated in Figure 4. This feature of the the payoff structure, which is common to classical Diamond-Dybvig bank run models, is also present in our model of stablecoin runs.

Suppose all coin holders use the signal threshold x^* and demand conversion for all $x_i < x^*$. We can then define the deterministic function $A(\theta, x^*)$ that specifies the population fraction of coin holders demanding conversion for a given fundamental θ as:

$$A(\theta, x^*) = \begin{cases} 1 & \text{if } \theta \leq x^* - \sigma\varepsilon \\ \frac{1}{2} + \frac{x^* - \theta}{2\sigma\varepsilon} & \text{if } \theta \in (x^* - \sigma\varepsilon, x^* + \sigma\varepsilon) \\ 0 & \text{if } \theta \geq x^* + \sigma\varepsilon. \end{cases} \tag{13}$$

The existence of the upper and lower dominance regions assures that $\theta \in (x^* - \sigma\varepsilon, x^* + \sigma\varepsilon)$ must hold. Together with $\hat{A}(\theta)$, i.e. the critical level of demand for conversion at $t = 1$ that triggers insolvency at $t = 2$, we can derive the critical mass condition:

$$A(\theta^*, x^*) = \frac{1}{2} + \frac{x^* - \theta^*}{2\sigma\varepsilon} = \hat{A}(\theta^*) = \frac{r(\theta^* - p_2)}{p_1\theta^* - p_2 r}. \tag{14}$$

A second equilibrium relationship follows from the indifference condition of coin holders:

$$\begin{aligned} & E[\Delta(\theta^*, A(\theta, x^*), b_G, N)|x^*] \\ = & \int_{\theta^*}^{x^*+\sigma\varepsilon} (p_1(1-\alpha(N)\tau_2) - ((1-\beta)(1-\tau_0)+\beta p_2))\, d\theta \\ & + \int_{x^*+(1-2r/p_1)\sigma\varepsilon}^{\theta^*} \left(p_1 - \frac{r - A(\theta,x^*)p_1}{(1-A(\theta,x^*))r}\theta\right) d\theta + \int_{x^*-\sigma\varepsilon}^{x^*+(1-2r/p_1)\sigma\varepsilon} \frac{r}{A(\theta,x^*)} d\theta - b_G = 0. \end{aligned} \tag{15}$$

Equations (14) and (15) implicitly define the two unknowns θ^* and x^*.

Proposition 2 establishes existence and uniqueness of a monotone equilibrium for the limit case vanishingly private noise. Moreover, it offers an implicit solution to the fundamental threshold θ^* in one equation by using the Laplacian property (Morris and Shin 1998) that the belief over the actions of other investors at $t = 1$ is uniformly distributed in $[0,1]$. The existence of a unique equilibrium in threshold strategies can be established by iterated elimination of dominated strategies following Goldstein and Pauzner (2005).

Proposition 2 ***(Continuation equilibrium under incomplete information with one coin holder type)*** *Let $\varepsilon \to 0$. There exist a unique equilibrium characterized by threshold strategies in which coin holders demand conversion if and only if they receive a private signal that is below a common signal threshold x^*, i.e. for $x_i \leq x^*$, and where the stablecoin issuer faces a run at $t = 1$ for all $\theta < \theta^*$. $\theta^* \in (\theta_\ell, \theta_h)$ solves:*

$$\begin{aligned} I_1(\theta^*) \equiv & \int_0^{\frac{(\theta^*-p_2)r}{p_1\theta^*-p_2r}} (p_1(1-\alpha(N)\tau_2) - ((1-\beta)(1-\tau_0)+\beta p_2))\, dA \\ & + \int_{\frac{(\theta^*-p_2)r}{p_1\theta^*-p_2r}}^{r/p_1} \left(p_1 - \frac{r-Ap_1}{(1-A)r}\theta^*\right) dA + \int_{r/p_1}^{1} \frac{r}{A} dA - b_G = 0. \end{aligned} \tag{16}$$

Proof See Appendix Section A.2.1.

As in Goldstein and Pauzner, we use the limit of vanishing private signal noise for tractability. This also allows us to perform a comparative statics analysis using the implicit function theorem. The results are summarized in Proposition 3. In Section 3.3.3 we demonstrate that the qualitative results generalize when allowing for heterogeneous stablecoin holders. Moreover, we discuss in Appendix Section A.3 the robustness of the results for the alternative model where the relative convenience benefit only accrues when the stablecoins are redeemed at par at $t = 2$, i.e. $b^S_{g_i} = b_{g_i}$ and $b^I_{g_i} = 0$ instead of $b^S_{g_i} = b^I_{g_i} = b_{g_i}$.

Proposition 3 ***(Comparative statics for the model with one coin holders)*** *Let $\varepsilon \to 0$ and $\tau_2 \leq \tau_1/\beta$, then the incidence of stablecoin runs increases in*

- *the level of the promise p_1*
- *the sellers' preference for cash payments, $d\theta^*/d\beta > 0$*

and it decreases in

- *the sellers' preference for stablecoin payments, $d\theta^*/d\alpha < 0$*
- *the level of the relative convenience benefit, $d\theta^*/db_G < 0$.*

For $p_2 \to 1$ the incidence of stablecoin runs decreases (increases) in the level of the promise p_2 if $\beta > p_1\alpha$ (if $\beta < p_1\alpha$).

Proof See Appendix Section A.2.2.

Proposition 3 imposes a sufficient condition, $\tau_2 \le \tau_1/\beta$, to ease the comparative statics analysis. The sufficient condition imposes a mild bound on the transaction cost at $t = 2$ relative to the transaction cost at $t = 1$. We find that a larger relative convenience benefit from holding stablecoins translates into a lower incentive to demand conversion at $t = 1$, thereby reducing the flightiness of investors and, hence, the incidence of stablecoin runs. Intuitively, the same is true for an increase in the sellers' preference for stablecoin payments, while the opposite holds for an increase in the sellers' preference for cash payments. As a result, a positive network externality, i.e. $\alpha'(N) > 0$, lowers the fragility of the stablecoin. We will revisit this result in Section 5 where we study jointly how stablecoin adoption and fragility are affected.

Furthermore, we find that a higher promise p_1 is destabilizing, as it amplifies the depletion of resources of the issuer in the face of conversion demands. Conversely, the a higher promise p_2 can be stabilizing, as it allows for a larger participation of coin holders in the "upside" when the fundamental of the stablecoin issuer is favorable. This is the case if $\beta > p_1\alpha$. However, a higher p_2 also affects the critical mass condition by lowering $\hat{A}(\theta^*)$, which makes the overall effect ambiguous. The latter effect vanishes if $p_2 \to 1$.

3.3.3 Incomplete information game with heterogeneous stablecoin holders

We next extend the analysis of the previous section by allowing for heterogeneous stablecoin holders. Define group $j \in \{1,...,G\}$ as the group of investors with the lowest relative convenience benefit among the population of investors adopting the stablecoin, meaning that a potentially large number of groups of investors with $g \ge j$ adopts the stablecoin, where $g \in \{j, G\}$.

Suppose that $x^*(b_{g+1}) \ge x^*(g), \forall g \in \{k, G\}$, meaning the coin holders with the higher convenience benefit are less inclined to demand conversion. For stablecoin adoption by at least one and up to $G - j + 1$ groups of investors, the general version of the critical mass condition is given by:

$$\Sigma_{g=j}^{G} \frac{m_g}{\Sigma_{g=j}^{G} m_g} \max\{0, \min\{\frac{1}{2} + \frac{x^*(b_g) - \theta^*}{2\sigma\varepsilon}, 1\}\} = \hat{A}(\theta^*, x^*(b_j), ..., x^*(b_G)) = \frac{r(\theta^* - p_2)}{p_1\theta^* - p_2 r}. \tag{17}$$

There are $G - j + 1$ indifference conditions, one equation for the stablecoin holders in each group, that depend on the fundamental threshold θ^* and the group-specific signal thresholds $x^*(b_j), ..., x^*(b_G)$.

It turns out that for the limiting case $\varepsilon \to 0$ the solutions for all signal thresholds are interior. Specifically, the signal thresholds cluster and for vanishing noise of the private signals the cluster collapses to a point that coincides with the equilibrium fundamental threshold θ^*. We apply the "Belief Constraint" of Sákovics and Steiner (2012), which states that the Laplacian Property holds on average across the different groups of investors adopting the stablecoin, meaning that investors' posterior distribution of A is uniform over $[0, 1]$. The equilibrium fundamental threshold can then be determined by averaging over the indifference conditions, as in equation (18). We can show that there exists a unique equilibrium among the class of monotone equilibria. Proposition 4 summarizes the results.

Proposition 4 ***(Continuation equilibrium under incomplete information with heterogeneous coin holders)*** *Let $\varepsilon \to 0$ and $j \in \{1, G\}$. There exist a unique threshold equilibrium in which coin all holders in groups $g \in \{j, G\}$ demand conversion if and only if they receive a private signal that is below their group-specific signal threshold $x^*(b_g)$, i.e. for $x_g \leq x^*(b_g)$, and where the stablecoin issuer faces a run at $t = 1$ for all $\theta < \theta^*$, where $\theta^* \in (\theta_\ell, \theta_h)$ solves:*

$$I_2(\theta^*) \equiv \int_0^{\frac{(\theta^*-p_2)r}{p_1\theta^*-p_2r}} (p_1(1-\alpha(N)\tau_2) - ((1-\beta)(1-\tau_0)+\beta p_2))\, dA + \int_{\frac{(\theta^*-p_2)r}{p_1\theta^*-p_2r}}^{r/p_1} \left(p_1 - \frac{r-Ap_1}{(1-A)r}\theta^*\right) dA + \int_{r/p_1}^{1} \frac{r}{A} dA - \Sigma_{g=j}^{G} \frac{m_g}{\Sigma_{g=j}^{G} m_g} b_g = 0. \quad (18)$$

Proof See Appendix Section A.2.3.

We again use the implicit function theorem for simultaneous equations for the comparative statics analysis. Specifically, we are interested in whether the levels of convenience benefit of both types of coin holders matter and in the change of the incidence of stablecoin runs when the composition of coin holders changes. The results are summarized in Proposition 5.

Proposition 5 ***(Comparative statics for the model with heterogeneous coin holders)*** *Let $\varepsilon \to 0$ and $\tau_2 \leq \tau_1/\beta$. The results of Proposition 3 continue to hold with the modification that the incidence of stablecoin runs decreases in*

- *the levels of the convenience benefit for each group, $d\theta^*/db_g < 0, \forall g \in \{j, G\}$*
- *the population fraction of coin holders with a higher convenience benefit, e.g. for any change in the population fraction of the type $dm_{k+1} = -\Sigma_{g=j}^{k} dm_g$ with $k \in [j, G)$ we have that $d\theta^*/dm_{k+1} < 0$.*

Proof See Appendix Section A.2.4.

4 Stablecoin adoption game at $t = 0$

After analyzing the continuation equilibrium at $t = 1$ for a given stablecoin adoption, N, we next turn to the stablecoin adoption game at $t = 0$. Section 4.1 analyzes the equilibrium of the adoption game and Section 4.2 potential policies by the issuer to influence stablecoin adoption.

4.1 Equilibrium analysis

Having analyzed the continuation game at $t = 1$, we now move to the initial date $t = 0$. The risk of insolvency only affects stablecoins, since bank deposits are insured. Nevertheless, the expected utility payoff from depositing one unit of cash at $t = 0$, $E[u(b_g, a_{0,g,i} = 0)]$, depends not only on the adoption rate N

and the deposit rate r_d, but also on the issuer's solvency:

$$u(b_g, N, a_{0,i} = 0) = \begin{cases} (1-\alpha(N)\tau_2)r_d & if\ A \leq \hat{A}(\theta) \\ r_d & if\ A > \hat{A}(\theta). \end{cases} \tag{19}$$

The dependency on the issuer's solvency arises, because it affects the probability that sellers only accept stabelcoins, which is $\alpha(N)$ if the issuer is solvent at $t = 2$ and zero, otherwise. In the former case when the stablecoin is a viable means of payment at $t = 2$, investors who hold bank deposits need to convert them with probability $\alpha(N)$ into stablecoins at $t = 2$ and incur the proportional transaction cost τ_2.

The problem of an investor i with convenience benefit $b_{g_i} = b_g$ can be written as:

$$\max_{a_{0,i} \in \{0,1\}} \left(\begin{array}{c} (1-a_{0,i})r_d \left(\int_{\theta^*}^{\overline{\theta}} (1-\alpha(N)\tau_2) d\theta + \int_{\underline{\theta}}^{\theta^*} d\theta \right) \\ +a_{0,i} \left(\int_{\underline{\theta}}^{\theta^*} r d\theta + \int_{\theta^*}^{\overline{\theta}} ((1-\beta)(1-\tau_0) + \beta p_2) d\theta + b_g \right) \end{array} \right), \tag{20}$$

where we use equation (19) and the utility payoffs from Table 3. Observe that the first summand is strictly decreasing in b_g, while the second summand is strictly increasing. By continuity and monotonicity, we can establish the existence of a unique threshold $\hat{b}(\theta^*) \in [\underline{b}, \overline{b}]$ such that, for a given θ^*, an investor optimally invests in stablecoins if her relative convenience benefit exceeds the threshold and she optimally invests in deposits, otherwise. To ease the analysis, we assume that there exists a (virtual) group v of investors with $b_v = \hat{b}$ and $m_v = 0$. Consequently, $\hat{b}$ denotes the smallest possible benefit among the group of coin holders.

The general equilibrium requires us to take into account how θ^* is affected by $\hat{b}$ and how both are affected by stablecoin adoption. We analyze necessary and sufficient conditions for the existence of an interior equilibrium where all investors belonging to groups $g \in \{j, G\}$ with $j > 1$ adopt stablecoins, while all others invest in bank deposits, i.e. $b_G \geq \hat{b} > b_1$.

Suppose that $j = G$ and $N = m_G$. From the problem in (20) the corresponding choices, $a_{0,i} = 1$ if $g_i = G$ and $a_{0,i} = 0$ if $g_i < G$, are optimal for investors if:

$$r_d \left(\int_{\theta^*}^{\overline{\theta}} (1-\alpha(N)\tau_2) d\theta + \int_{\underline{\theta}}^{\theta^*} d\theta \right) \leq \left(\int_{\underline{\theta}}^{\theta^*} r d\theta + \int_{\theta^*}^{\overline{\theta}} ((1-\beta)(1-\tau_0) + \beta p_2) d\theta + b_g \right) \tag{21}$$

holds when evaluated at $b_g = b_G$ and is violated when evaluated at $b_g = b_{G-1}$, where $\theta^*(b_G)$ solves equation (16). Instead, if inequality (21) holds when evaluated at $b_g = b_G$ and also when evaluated at $b_g = b_{G-1}$ for some $N \in (m_G, m_G + m_{G-1}]$, then we can follow an iterative process to determine $j \leq G-1$, which holds with strict inequality if and only if $N = m_G + m_{G-1}$. Given that the equilibrium fundamental threshold θ^* falls when adding groups with a lower relative convenience benefit as stablecoin adopters (Proposition 5), we have that an interior equilibrium exists if inequality (21) holds when evaluated at $b_g = b_G$ with $\theta^*(b_G)$ solving equation (16), while it is violated when evaluated at $b_g = b_1$ with θ^* solving equation (18) at

$j = 1$. Conversely, no investor adopts stablecoins if the first condition is violated and all investors invest in stablecoins if the second condition is violated.

Following the same logic as in Section 3.3.1, we can derive the upper bound from the weak preference from adopting stablecoins if $\theta \geq \theta_h$ as:

$$\hat{b} \geq r_d(1 - \alpha(N)\tau_2) - (1 - \beta\tau_2), \tag{22}$$

For $r_d > 1 - \tau_0$, which holds in the baseline, we have that an implication of inequality (22) is that inequality (10) must hold as well. Intuitively, if it is certain that the stablecoin issuer is solvent, then an investor who adopts stablecoins also finds it optimal to keep them at $t = 1$.

Absent a positive network externality, i.e. if $\alpha(N) = \alpha > 0$, the described equilibria are unique. In the presence of a positive network externality, i.e. if $\alpha(N) = \alpha + \gamma(N)$ with $\gamma'(N) > 0$, multiple equilibria may co-exist. For the special case with one type of stablecoin holder, this is the case if there exists an adoption rate $\tilde{N} \in (0, m_G)$ such that inequality (21) holds with equality when evaluated at $\alpha(\tilde{N})$, b_G and $\theta^*(b_G)$. Then there exists one equilibrium where all investors in group G adopt stablecoins ($N = m_G$), one equilibrium with no stablecoin adoption ($N^* = 0$) and one equilibrium where some investors in group G adopt stablecoins ($N^* = \tilde{N}$). For the case with heterogeneous stablecoin holders, there can be multiple j's such that inequality (21) holds when evaluated at b_j, while it is violated when evaluated at b_{j-1}. Proposition 6 summarizes.

Proposition 6 ***(Equilibrium of the adoption game)*** *Let $\varepsilon \to 0$ and $\tau_2 \leq \tau_1/\beta$.*

- *For the case $\alpha'(N) = 0$, there exists a unique equilibrium of the adoption game at $t = 0$ where $N^* = 0$ if $\hat{b} > b_G$ and where $N^* = 1$ if $\hat{b} < b_1$. Moreover, if $b_G > \hat{b} > b_1$, then there exists and a unique equilibrium of the adoption game with $N \in (\Sigma_{g=j+1}^{G} m_g, \Sigma_{g=j+1}^{G} m_g + m_j]$, where all investors belonging to a group $g \geq j$ with $b_g > \hat{b}$ optimally invest in stablecoins and all investors belonging to a group $g < j$ with $b_g < \hat{b}$ optimally invest in bank deposits. Investors belonging to group j are indifferent if $b_j = \hat{b}$.*
- *For the case $\alpha'(N) > 0$, there exists a unique equilibrium of the adoption game with $N^* = 0$ if inequality (21) is violated when evaluated at $b_g = b_G$ and $\alpha(m_G)$, and a unique equilibrium with $N^* = 1$ if inequality (21) holds when evaluated at $b_g = b_1$ and $\alpha(0)$. Otherwise, multiple equilibria of the adoption game co-exist.*

At the presence of a positive network externality associated with stablecoins, $\alpha'(N) > 0$, multiple equilibria indexed by different stablecoin adoption levels emerge. Nevertheless, the continuation equilibrium is unique for a given level of adoption. This model feature is shared with coordination games with strategic complementarities and information acquisition (Hellwig and Veldkamp (2009)). The intuition for this result is that different beliefs about the stability can lead to different stablecoin adoption levels. Everything else equal, more favorable beliefs about the stability of the issuer foster stablecoin adoption. Since a higher adoption rate is associated with a lower incidence of stablecoin runs, i.e. with a lower θ^*, more favorable beliefs about stability can lead to a higher adoption rate that turns out to be consistent with higher stability.

4.2 Issuance policy and stablecoin adoption

The issuer has different policy choices to affect stablecoin adoption. However, she has to be mindful how the various policy choices affect the incidence of stablecoin runs. For $\varepsilon \to 0$ the issuer's profits are given by:

$$\pi = \int_{\theta^*}^{\overline{\theta}} N(\theta - p_2) d\theta. \tag{23}$$

We first consider the policy option to reduce the payment promise p_1, i.e. to increase the proportional transaction cost τ_1. For $\varepsilon \to 0$ the direct effect of this action on the revenues of the issuer is approximately zero, since conversion demands only accrue in case when issuer is insolvent, meaning that her payoff is zero and unaffected by τ_1. There is, however, an indirect effect via the impact of changes in p_1 on the equilibrium fundamental threshold θ^*. From Proposition 3 we know that $d\theta^*(b_G)/dp_1 > 0$, a result that readily extends to the general case with heterogeneous stablecoin holders. Starting from a situation where $b_G \geq \hat{b} > b_{G-1}$, the issuer can increase the right-hand side of inequality (21) by lowering p_1. For $b_{G-1} \to \hat{b}$, we have that a small reduction in p_1 is sufficient to move from an equilibrium with only type b_G coin holders to an equilibrium with a positive mass of type b_{G-1} coin holders, i.e. $N \in (m_G, m_G + m_{G-1}]$. Evidently, an increase in the mass of type b_{G-1} coin holders has a destablizing effect (Proposition 5). As a result, only a larger reduction in p_1 can lead to a full adoption by type b_{G-1} coin holders, i.e. $N = m_G + m_{G-1}$.

An inspection of equation (23) reveals that both the positive impact of a higher adoption rate, i.e. a higher N, and the net reduction in fragility are profit enhancing. The robustness of this result hinges on the assumption that all investors consume at $t = 2$. The introduction of a liquidity of some investors at $t = 1$ would imply that a reduced payment promise p_1 is likely to be associated with a lower stablecoin adoption.

Second, consider the issuer's policy option to increase the payment promise p_2, i.e. to decrease the proportional transaction cost τ_2. This has the direct effect to increase the right-hand side of inequality (21). However, it also has an indirect effect in the same direction for $p_2 \to 1$ if $\beta > \alpha p_1$, when increasing p_2 decreases the incidence of stablecoin runs (Proposition 3). In addition, a higher level of p_2 has a direct negative effect on the revenues of the issuer. Consequently, the instrument to lower p_1 may be preferable.

Next, consider the issuer may be able to take measures to increase the relative convenience benefit of stablecoin holders, e.g. with the help of promotions. Note from equation (18) that it does not matter whether a specific group $g \in \{j, ..., G\}$ are all are targeted. The result is a decrease in the incidence of stablecoin runs (Propositions 3 and 4). The costs of increasing the relative convenience benefits of stablecoin holders have to be compared to the benefits from an increased revenue from a higher stablecoin adoption in equation (23).

Finally, consider the issuer's policy option to increase the probability that sellers prefer stablecoins as a means of payment, i.e. to take measures that increase α. Such an action may be costly to the issuer. These costs have to be compared to the benefits from an increased revenue from a higher stablecoin adoption in equation (23). Again starting from a situation where $b_G \geq \hat{b} > b_{G-1}$, the issuer can decrease the left-hand side and increase the right-hand side of inequality (21) by increasing α. The latter effect arises because $d\theta^*(b_G)/d\alpha < 0$ from Proposition 3, a result that extends to the general case with heterogeneous coin holders. For $b_{G-1} \to \hat{b}$, we have that a small increase in α is sufficient to move from an equilibrium with only type b_G coin holders to an equilibrium with a positive mass of type b_{G-1} coin holders. Similar to before, an increasing mass of type b_{G-1} coin holders has a destablizing effect, but this time there is also a direct stabilizing effect from stemming from the increase in α. Proposition 7 summarizes the results.

Proposition 7 ***(Issuance policy)*** *Let $\varepsilon \to 0$, $\tau_2 \leq \tau_1/\beta$ and $\alpha'(N) = 0$. Suppose there exists an interior equilibrium (Proposition 6). The stablecoin issuer can facilitate stablecoin adoption by decreasing p_1, by increasing α, by increasing the relative convenience benefit for some groups and, for $p_2 \to 1$ and $\beta > \alpha p_1$ also by increasing p_2. In all cases the incidence of stablecoin runs strictly decreases.*

5 Discussion

5.1 Policy implications

5.2 Testable implications

5.3 Alternative model specifications and robustness

6 Conclusion

The crypto universe is expanding rapidly and stablecoins play an important role for investors when trading crypto assets and to park their funds. We analyze stablecoin adoption and the fragility of stablecoin issuers. Therefore, we develop a global games model of stabelcoin runs that allows us to study the determinants of fragility. We find that most factors increasing the attractiveness of stablecoins also reduce their fragility. An exception are negative network effects, which reduce both, stablecoin adoption and fragility. Moreover, a higher stablecoin adoption is not per se reducing fragility, because it may imply that the marginal investor becomes more flighty. Since the profitability of the stablecoin issuer is a key factor, income from transaction fees and the remmuneration on the issuer's reserves show to be important. An environment of low nominal rates can impair the issuer's profitability and, therefore, have a destabilizing effect.

Our theory offers novel testable implications and it can inform the ongoing policy discussion on the regulation of stablecoins. Moreover, our findings bear relevance for the debate on CBDCs. Empirically, crypto assets are highly interconnected and market spillovers dwarf the variation caused by idiosyncratic characteristics (Ferroni 2022). This is also true for stablecoins universe, which displays a high co-movement between stablecoins and with other crypto assets (Gorton et al. 2022). As result, regulation should not only focus on the fragility of the dominant stablecoins in isolation. Moreover, not only potential risks from a maturity mismatch and from the operational side should be mitigated, but also the stabilization mechanisms should be hardened, such that large regulated stablecoin issuers can seamlessly meet a large conversion demand in the event of runs against smaller unregulated stablecoins. To this end, the access of regulated stablecoin issuers to (potentially dedicated) central bank lending facilities constitute an important backstop and could be used to facilitate large flows between regulated stablecoins and a retail CBDC.

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A Appendix

A.1 Derivation of dominance regions

We characterize the upper and lower dominance region for the baseline with $b_G^S = b_G^I = b_G$.

Upper dominance region. A coin holder with convenience benefit b_G and private signal $x_i > \bar{x}$ strictly prefers to keep her stablecoins even when all other coin holders demand conversion, i.e. $A = 1$, where:

$$\begin{aligned} & Prob\{\theta \geq \theta_h | x_i = \bar{x}\} \left(p_1(1-\alpha(N)\tau_2) - (1-\tau_0)(1-\beta p_2)\right) + Prob\{\theta < \theta_h | x_i = \bar{x}\} r + b_G^I = 0 \\ \Leftrightarrow & Prob\{\theta \geq \theta_h | x_i = \bar{x}\} = \frac{r - b_G^I}{((1-\beta)(1-\tau_0)+\beta p_2) - p_1(1-\alpha(N)\tau_2) + r}. \end{aligned} \tag{24}$$

Given that the right-hand side of equation (24) is strictly decreasing in b_G, the $\bar{x}$ solving the equation is strictly decreasing in b_G as well. Hence, a sufficient condition for no conversion demands by all coin holders (i.e. investors of group G) solves equation (24). Observe that the right-hand side of equation (24) is independent of x_i, while the left-hand side takes a value of zero (one) if $x_i < \sigma\theta_h - \varepsilon$ (if $x_i > \theta_h + \sigma\varepsilon$) and it is continuous and monotonically increasing in x_i. As a result, there exists a unique $x_i = \bar{x}$.

Lower dominance region. Analogously, a coin holder with a private signal $x_i < \underline{x}$ strictly prefers to demand conversion even when all other coin holders keep their stablecoins, i.e. $A = 0$, where $\underline{x}$ solves:

$$\begin{aligned} & Prob\{\theta \leq p_1 | x_i = \underline{x}\} \left(p_1(1-\alpha(N)\tau_2) - \frac{\int_{\underline{\theta}}^{p_1} \theta h(\theta, \underline{x}) d\theta}{\int_{\underline{\theta}}^{p_1} h(\theta, \underline{x}) d\theta} \right) - b_G \\ & + Prob\{\theta > p_1 | x_i = \underline{x}\} \left(p_1(1-\alpha(N)\tau_2) - \frac{\left(\begin{array}{c} \int_{p_1}^{\min\{\theta_h, p_2\}} \theta h(\theta, \underline{x}) d\theta \\ + \int_{\min\{\theta_h, p_2\}}^{\overline{\theta}} ((1-\beta)(1-\tau_0) + \beta p_2) h(\theta, \underline{x}) d\theta \end{array} \right)}{\int_{p_1}^{\overline{\theta}} h(\theta, \underline{x}) d\theta} \right) = 0 \\ \Leftrightarrow \quad & Prob\{\theta \leq p_1 | x_i = \underline{x}\} = \frac{p_1(1-\alpha(N)\tau_2) - \frac{\int_{p_1}^{\min\{\theta_h, p_2\}} \theta h(\theta, \underline{x}) d\theta + \int_{\min\{\theta_h, p_2\}}^{\overline{\theta}} ((1-\beta)(1-\tau_0)+\beta p_2) h(\theta, \underline{x}) d\theta}{\int_{p_1}^{\overline{\theta}} \theta h(\theta, \underline{x}) d\theta}}{\frac{\int_{\underline{\theta}}^{p_1} \theta h(\theta, \underline{x}) d\theta}{\int_{\underline{\theta}}^{p_1} h(\theta, \underline{x}) d\theta} - \frac{\int_{p_1}^{\min\{\theta_h, p_2\}} \theta h(\theta, \underline{x}) d\theta + \int_{\min\{\theta_h, p_2\}}^{\overline{\theta}} ((1-\beta)(1-\tau_0)+\beta p_2) h(\theta, \underline{x}) d\theta}{\int_{p_1}^{\overline{\theta}} \theta h(\theta, \underline{x}) d\theta}} - b_G \in (0, 1). \end{aligned} \tag{25}$$

Observe that the left-hand side of equation (25) is continuous and monotonically decreasing in $\underline{x}$, while the right-hand side is increasing in $\underline{x}$ and decreasing in b_G. Moreover, the left-hand side takes a value of zero (one) if $x_i < p_1 - \sigma\varepsilon$ (if $x_i > p_1 + \sigma\varepsilon$). Consequently, there also exists a unique $x_i = \underline{x}$ solving equation (25), such that it is the dominant action for all coin holders to demand conversion for all $x_i < \underline{x}$.

A.2 Proofs

A.2.1 Proof of Proposition 2

This Proof proceeds as follows. First, we derive equation (16) in Proposition 2. Thereafter, we establish the existence and uniqueness of a monotone equilibrium of the $t = 1$ conversion game following Goldstein and Pauzner (2005). We have that $\theta \in (x^* - \sigma\varepsilon, x^* + \sigma\varepsilon)$ must hold due the existence of the upper and lower dominance regions. As a result, we can rewrite the indifference condition in equation (15) as:

$$\begin{aligned} E[\Delta(\theta^*, A(x^*, x^*), b_G, N)|x^*] \quad = \quad & \int_{\theta^*}^{x^*+\sigma\varepsilon} (p_1(1-\tau_2\alpha(N)) - (1+b_G)((1-\beta)(1-\tau_0)+\beta p_2))\, d\theta \\ & + \int_{x^*-\sigma\varepsilon}^{\theta^*} \mathbb{1}_{A(\theta,x^*)\leq r/p_1} \left(p_1 - (1+b_G)\frac{r - A(\theta,x^*)p_1}{(1-A(\theta,x^*))r}\theta \right) d\theta \\ & + \int_{x^*-\sigma\varepsilon}^{\theta^*} \frac{r}{A(\theta,x^*)} d\theta = 0. \end{aligned} \tag{26}$$

Equation (16) follows, where we use that $x^* + (1-2r/p_1)\sigma\varepsilon > x^* - \sigma\varepsilon$. First, investors' posterior distribution of θ is uniform over $[\theta^* - \sigma\varepsilon, \theta^* + \sigma\varepsilon]$. Second, investors have a uniform posterior distrubtion of A over $[0,1]$. Taken together, this allows us to write the indifference condition at the limit of vanishingly private noise, $\sigma \to 0$, as in equation (16).

Establishing the existence of a unique monotone equilibrium comprises two steps. In *Step 1* we restrict attention to monotone (or threshold) equilibria and establish existence and uniqueness. In *Step 2* we show that no other non-monotone equilibrium exists, meaning that there is one solution to equations (14) and (15), which describes the unique equilibrium of the conversion game.

Step 1. The proof follows Part B of the Proof of Theorem 1 in Goldstein and Pauzner (2005).

Step 2. The proof follows Part C of the Proof of Theorem 1 in Goldstein and Pauzner (2005).

A.2.2 Proof of Proposition 3

We establish the comparative static results summarized in Proposition 3 by either analyzing equations (14) and (15), or by analyzing equation (16). We obtain:

$$\begin{aligned} \frac{dI_1}{db_G} &= -1 < 0 \\ \frac{dI_1}{d\alpha} &= -\int_0^{\frac{(\theta^*-p_2)r}{p_1\theta^*-p_2r}} p_1\tau_2 d\theta < 0 \\ \frac{dI_1}{d\beta} &= -\int_0^{\frac{(\theta^*-p_2)r}{p_1\theta^*-p_2r}} (p_2-(1-\tau_0))d\theta \geq 0, \end{aligned}$$

which holds with strict inequality if $\tau_2 > 0$ and:

$$\begin{aligned}\frac{dI_1}{d\theta^*} &= \frac{rp_2(p_1-r)}{(p_1\theta^*-p_2r)^2}\left(p_1(1-\tau_2\alpha(N))-((1-\beta)(1-\tau_0)+\beta p_2)\right) \\ &\quad -\frac{rp_2(p_1-r)}{(p_1\theta^*-p_2r)^2}\left(p_1-\frac{r-Ap_1}{(1-A)r}\theta^*\right) \\ &\quad -\int_{\frac{(\theta^*-p_2)r}{p_1\theta^*-p_2r}}^{r/p_1}\frac{r-Ap_1}{(1-A)r}\theta^* dA < 0,\ if\ \tau_2 \leq \tau_1/\beta.\end{aligned}$$

The sufficient condition $\tau_2 \leq \tau_1/\beta$ imposes a mild condition to ensure that the first term in the previous derivative does not take an opposite sign. Finally:

$$\begin{aligned}-\frac{dI_1}{d\tau_1}=\frac{dI_1}{dp_1} &= \frac{-\theta^*(\theta^*-p_2)r}{(p_1\theta^*-p_2r)^2}\left(p_1(1-\tau_2\alpha(N))-((1-\beta)(1-\tau_0)+\beta p_2)\right) \\ &\quad -\frac{-\theta^*(\theta^*-p_2)r}{(p_1\theta^*-p_2r)^2}\left(p_1-\frac{r-Ap_1}{(1-A)r}\theta^*\right) \\ &\quad +\int_0^{\frac{(\theta^*-p_2)r}{p_1\theta^*-p_2r}}(1-\alpha(N)\tau_2)dA+\int_{\frac{(\theta^*-p_2)r}{p_1\theta^*-p_2r}}^{r/p_1}\left(1+\frac{A}{(1-A)r}\theta^*\right)dA > 0,\ if\ \tau_2 \leq \tau_1/\beta.\end{aligned}$$

and:

$$\begin{aligned}-\frac{dI_1}{d\tau_2}=\frac{dI_1}{dp_2} &= -\frac{rp_1\theta^*}{(p_1\theta^*-p_2r)^2}\left(p_1(1-\tau_2\alpha(N))-((1-\beta)(1-\tau_0)+\beta p_2)\right)+\frac{rp_1\theta^*}{(p_1\theta^*-p_2r)^2}(p_1-p_2) \\ &\quad -\int_0^{\frac{(\theta^*-p_2)r}{p_1\theta^*-p_2r}}(\beta-p_1\alpha(N))dA \\ &= \frac{rp_1\theta^*}{(p_1\theta^*-p_2r)^2}(1-\tau_0)\tau_2(1-\beta+\tau_2\alpha(N))-\int_0^{\frac{(\theta^*-p_2)r}{p_1\theta^*-p_2r}}(\beta-p_1\alpha(N))dA > 0\ if\ \beta > p_1\alpha(N)\ and\ \tau_2 \to 0.\end{aligned}$$

By application of the implicit function theorem the results in Proposition 3 follow. This completes the proof.

A.2.3 Proof of Proposition 4

A.2.4 Proof of Proposition 5

The first result is a mere extension of the second to last result in Proposition 3. The second result follows from:

$$\frac{dI_2(\theta^*)}{dm_{k+1}} = \frac{b_k-b_{k+1}}{\Sigma_{g=j}^k m_g} < 0, \forall k \in \{j, G-1\}.$$

A.3 Alternative payoffs