# Can Stablecoins Be Stable?*

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**Abstract**

This paper provides a general model of stablecoins, cryptocurrencies pegged to a traditional currency. We characterize the optimal design of a stablecoin protocol that generates seigniorage fees from issuance. We use this framework to assess the ability of various protocol designs to maintain the peg. Our model rationalizes algorithmic backing of stablecoins, but highlights its greater fragility relative to collateralization. Immutable smart contracts improve stability because the issuer suffers from a commitment problem. Even under full collateralization, promises to repurchase stablecoins when demand drops are not credible. Alternatively, the protocol can restore commitment by decentralizing issuance, which highlights a new benefit of DeFi protocols.

**Keywords:** Decentralized Finance, Cryptocurrencies, Currency Peg, Coase Conjecture

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# 1 Introduction

A stablecoin is a cryptocurrency designed to maintain a peg with an official currency. On the back of rising demand for alternative means of payment, the combined market value of all stablecoins grew from $3 billion in 2019 to $310 billion in 2025 (CoinMarketCap, 2025). To maintain the peg, stablecoin issuers rely on traditional approaches, such as backing with reserves (e.g., USDT, USDC), as well as recent innovations facilitated by blockchain technology: smart contracts, "algorithmic" backing (e.g., Terra-Luna), or decentralized issuance (e.g., DAI). The $40 billion crash of Terra in 2022 and recent regulatory initiatives suggest an evolution toward a "narrow" stablecoin model, with full backing by safe traditional assets.[1] Whether these developments will make stablecoins stable and the role of stablecoin innovations for stability remain open questions.[2]

We propose a model of stablecoin design to evaluate the stability of various protocols in practice. In this model, a monopolistic stablecoin issuer caters to a demand for stable, money-like assets. The issuer aims to maximize seigniorage revenue while maintaining the peg of the stablecoin with a unit of account. Our analysis yields three main insights. First, the model rationalizes algorithmic backing mechanisms, where stablecoins (e.g., Terra) can be exchanged for equity-like tokens (e.g., Luna). These equity tokens back stablecoins as claims on future seigniorage revenues generated by the protocol. While algorithmic backing is cost-effective, it proves inherently more fragile compared to tangible collateral backing. Second, full collateralization with safe assets alone does not eliminate peg deviations. Indeed, the issuer suffers from a commitment problem, whereby it overissues stablecoins and reneges on the promise to maintain the peg. Programming immutable issuance rules through smart contracts can address this problem. We show that decentralized issuance, combined with full collateralization, provides an alternative solution to this problem that does not sacrifice operational flexibility. Below, we detail our modeling approach and results, highlighting their practical implications.

In our model, a monopolist issuer faces a time-varying demand for stablecoins, which depends on the stablecoin protocol's ability to maintain the peg. A sufficient statistic for this demand is the marginal utility flow of users from holding stablecoins. This liquidity benefit, akin to a convenience yield, varies with an exogenous demand shock

[1] Recent legal and regulatory initiatives in this direction include the Genius Act by U.S. Congress (2025) or the Bank of England's consultation on regulating systemic stablecoins: https://www.bankofengland.co.uk/news/2025/november/boe-launches-consultation-on-regulating-systemic-stablecoins?

[2] These questions also connect stablecoin development to the evolution of banking and intermediation: even fully reserved "narrow" stablecoins may face fast run dynamics since redemption and secondary-market trading operate at high frequency and stablecoin issuers do not benefit from deposit insurance or lender-of-last-resort backstops (Cong, 2025).

and with the total stock of stablecoins to capture network effects (Cong, Li, and Wang, 2020; Li and Mann, 2025; Hinzen, John, and Saleh, 2022) or demand satiation. This liquidity premium proxies for various benefits users can enjoy in practice; for instance, they may use stablecoins as a means of payment on the blockchain, a safe and tax-efficient "parking space" for crypto volatility, or as digital dollars in emerging markets.[3] To reflect a preference for stable money-like assets, we assume that users enjoy these liquidity benefits only if the stablecoin price is pegged to the unit of account. Thus, in our model, the stablecoin issuer must maintain the peg to generate seigniorage revenues.

The issuer chooses the optimal protocol design to maximize seigniorage revenues from issuing stablecoins. We view these design choices as analogous to central banks' monetary policy choices. First, similar to CB reserves, the issuer chooses the fraction of the par value of stablecoins backed by a safe asset, called the collateralization ratio. By varying this ratio, our model covers many stablecoin designs, from unbacked (algorithmic) stablecoins like Terra to fully-backed stablecoins like USDT and USDC. Similar to private banknotes of the 19th century (Donaldson and Piacentino, 2022), stablecoins trade in a secondary market. Competitive market participants price the stablecoin according to their expectations about future protocol policies. Faced with users' demand, the issuer dynamically manages supply through the issuance or repurchase of stablecoins in this market. Thanks to these open-market operations, the monopolistic issuer influences the stablecoin price and determines the conversion rate for users. To finance the repurchase of stablecoins, the protocol can issue equity-like tokens at zero cost, which represent claims to future seigniorage revenue. Finally, like a central bank that pays interest on reserves, the issuer can pay interest on stablecoin holdings.[4]

As a starting point, we examine a stablecoin issuer that fully commits to its policy choices. This benchmark allows us to evaluate the benefits of immutable smart contracts as instruments for programming contingent monetary policies in advance. We focus specifically on the monetary equilibrium of our model, in which the issuer earns seigniorage revenues.[5] In this monetary equilibrium, the stablecoin peg remains resilient to minor demand fluctuations. When demand rises, the issuer mints additional stablecoins, while when demand declines, it finances repurchases by liquidating collateral and issuing

[3]See European Central Bank (2021); Federal Deposit Insurance Corporation and Office of the Comptroller of the Currency (2021).

[4]As we elaborate later, our main findings remain qualitatively unchanged even if the stablecoin issuer cannot directly pay interest. However, we also discuss practical ways stablecoin holders may indirectly receive interest.

[5]Even under commitment, a nonmonetary equilibrium exists for partially collateralized stablecoins, where the stablecoin price matches the collateralization ratio and yields no seigniorage revenue. This classical nonmonetary equilibrium emerges because there is no anchor linking the stablecoin to the unit of account, given that liquidity benefits in our model hinge upon the endogenous valuation of stablecoins.

equity-like tokens. These equity tokens represent claims on the protocol's intangible assets—future seigniorage revenue. For uncollateralized stablecoins, these operations closely mirror the adjustment mechanisms utilized by the Terra-Luna algorithmic protocol in practice. Through those operations, the issuer optimally controls the supply of stablecoins to maximize seigniorage revenue while simultaneously adjusting the interest rate to maintain the peg under moderate demand fluctuations. This approach effectively implements a profit-maximizing variant of the Friedman (1960) rule.

Our second key finding is that partially collateralized stablecoins are vulnerable to large, abrupt declines in demand. Such demand shocks diminish the present value of seigniorage revenue, thereby reducing the potential proceeds from issuing new equity precisely when these funds are needed to repurchase stablecoins. As a result, the stablecoin loses its peg, and equity token values collapse to zero. This prediction explains the collapse dynamics observed in the 2022 Terra-Luna algorithmic protocol, where the Luna equity tokens crashed as the Terra stablecoin lost its peg.[6] In other words, while smart contracts enable automatic and costless equity issuance, they cannot avoid the consequences of limited liability.

Building on these results, we study the issuer's optimal collateralization strategy. Backing stablecoins with tangible collateral enhances their stability relative to "algorithmic" backing with intangible future seigniorage revenues. In our model, however, collateralization is costly because it requires immobilizing safe assets, generating a trade-off between stability and profitability. As a result, issuers typically opt against full collateralization unless the collateral holding costs are minimal. Furthermore, if substantial adverse demand shocks are perceived as rare enough events, issuers will choose to forgo collateral altogether. This finding sheds light on the initial popularity of algorithmic stablecoins, fueled by optimistic expectations of consistent demand growth.

In the second part of our paper, we relax the assumption that all policies can be programmed in advance via immutable smart contracts. In practice, not every piece of information can be incorporated into smart contracts, and stablecoin issuers retain discretion over many governance decisions.[7] In our model, when given discretion over the issuance-repurchase policy, the issuer benefits ex-post from decreasing the stablecoin price

[6] In response to the depegging event, the protocol issued increasing amounts of Luna equity tokens to repurchase (burn) Terra stablecoins. We provide a detailed descriptive analysis of the May 2022 crisis for the five largest stablecoin protocols in Online Appendix A.

[7] In our model, the smart contract requires the exogenous demand shock as an input. In cryptocurrency jargon, such information qualifies as "off-chain" because it is not generated by the blockchain on which the stablecoin protocol runs. Incorporating off-chain information via "oracles" comes with implementation costs and vulnerabilities relative to on-chain information. See Czsun (2023) for details. In addition, most stablecoins do retain control over many of their policies through voting procedures. A notable example of a fully immutable protocol is Liquidity (LUSD).

below the peg when it repurchases stablecoins. Depegging dilutes legacy stablecoins and ultimately lowers the ex ante value of the protocol. However, ex post, the equity holders consider this cost sunk, as they already captured issuance proceeds from previously-issued stablecoins. This time-consistency problem implies that the stablecoin issuer fails to earn any seigniorage revenues when it lacks commitment power, like the durable good monopolist in Coase (1972).

In the last part of the analysis, we explore solutions to the commitment problem. First, we show that full collateralization alone does not restore commitment for the stablecoin protocol. This finding contrasts with the results of Demarzo (2019) who show that collateral neutralizes the leverage ratchet effect that affects firms' debt policies (DeMarzo and He, 2021). This difference arises because dilution of stablecoin users in our model operates via the liquidity benefit that depends on the total stablecoin stock, rather than via the possibility of a default that depends on debt riskiness. Hence, our model predicts that stablecoin fragility does not disappear with full backing.

Finally, we show that decentralization of issuance provides a solution to the issuer's time-consistency problem. This analysis is motivated by protocols such as DAI, in which any user can issue stablecoins by locking the required collateral in a vault. The protocol's equity holders set a seigniorage fee charged to vault owners, which is proportional to their outstanding stablecoin balance. Combined with full collateralization, decentralized issuance ties the hands of the stablecoin issuer and restores commitment, thanks to two features. First, competitive vault owners arbitrage away price deviations from the peg. Second, equity holders earn a rental-based income on the total stock of stablecoins from seigniorage fees rather than an issuance-based income from selling new stablecoins, as in the leasing solution to the Coase (1972) problem. We show that, under discretion, the protocol sets fees charged to vault owners and interest rates paid to users that implement the commitment solution with full collateralization. Ultimately, the privately optimal stablecoin design in our model combines elements from fully backed centralized stablecoins (USDT, USDC) and decentralized schemes (e.g., DAI).

Overall, our model highlights two key innovations that enhance stablecoin stability. First, immutable smart contracts allow stablecoin issuers to reliably implement optimal monetary policies. Second, when such commitment isn't feasible through smart contracts alone, decentralized issuance combined with full collateralization achieves similar optimal outcomes. Our analysis shows that centralized issuers tend to prefer partial collateralization or purely algorithmic stablecoins when large demand shocks seem unlikely, explaining the initial popularity of protocols like Terra. Additionally, we emphasize that full collateralization alone does not guarantee stability due to the issuer's commitment issues.

Thus, stablecoins may remain fragile despite regulations advocating complete backing with traditional money-like assets (U.S. Congress, 2025). The preference of issuers for partial collateralization also indicates the necessity of careful reserve monitoring. Lastly, while we focus specifically on stablecoin design, our insights are broadly relevant for any financial intermediary with market power that issues money-like liabilities.

**Related literature.** Our paper contributes to an emerging literature on cryptocurrencies and Decentralized Finance (DeFi). A few papers have studied the pricing of non-stable crypto assets such as Bitcoin or Ethereum. Biais, Bisière, Bouvard, Casamatta, and Menkveld (2023) finds that such assets are prone to crashes caused by sunspot shocks. Cong, Li, and Wang (2020) shows that transaction values create a feedback loop between user adoption and crypto prices. Our paper focuses instead on stablecoins—cryptos pegged to another currency—and on the issuer's ability to defend the peg.

Several works have studied stablecoin protocols and their pegging mechanisms empirically (Berentsen and Schär, 2019; Bullmann, Klemm, and Pinna, 2019; Eichengreen, 2019; ECB, 2019; Arner, Auer, and Frost, 2020; G30, 2020; Ho, Darbha, Gorelkina, and Garcia, 2022). Gorton, Ross, and Ross (2022) estimate the convenience yield on stablecoins and argue that further technological advances and reputation formation are required to make stablecoins money-like. Liu et al. (2023) provide a forensic analysis of the Terra-Luna crash and attribute it to growing concerns about sustainability rather than manipulation. Uhlig (2022) proposes a model of exchange dynamics specific to Terra-Luna. Our model rationalizes algorithmic backing, used by the Terra-Luna protocol, and highlights its fragility. Furthermore, our framework encompasses several other stablecoin designs that rely on collateralization or decentralization of issuance.

Closely related to our work, Li and Mayer (2022) propose a dynamic model of stablecoin in which the issuer devalues after a negative shock to their reserves to avoid costly liquidation. In their model, equity issuance costs are critical to fragility, while we emphasize instead demand shocks and commitment problems. Jermann and Xiang (2022) also focus on commitment issues attached to cryptocurrency issuance, but they do not study stablecoins. Most importantly, these two contributions do not analyze the decentralization of issuance. Relative to Lyons and Viswanath-Natraj (2023), who highlight the role of arbitrage by vault owners when issuance is decentralized, we also study optimal monetary policy for stablecoin issuers. While we emphasize the connection between stablecoin issuers and central banks, other works focus instead on the link with banks subject to runs (e.g., Bertsch, 2023) or ETFs (Ma, Zeng, and Zhang, 2025). Relatedly, Routledge and Zetlin-Jones (2021) advocate suspension of convertibility as a solution to cryptocurrency runs. While these works focus on the ability of stablecoin protocols to maintain the peg, we further analyze the issuer's commitment problems and study decentralized issuance.[8]

The time consistency problem we analyze affects monetary issuance beyond stablecoins. Early works in monetary economics (Calvo, 1978; Kydland and Prescott, 1977; Persson, Persson, and Svensson, 1987) show that a central bank has incentives to engineer surprise inflation to dilute the legacy stock of money, which represents nominal liabilities of the government. The commitment problem of the stablecoin issuer in our model can be traced back to the Coase's (1972) conjecture that a durable good monopolist competes against its future self and does not capture any markup. Admati, DeMarzo, Hellwig, and Pfleiderer (2018) show that similar dynamics emerge for a firm choosing its financial policy without commitment to future debt issuance, which they call the leverage ratchet effect. Methodologically, the supply target policies we consider for the stablecoin issuer resemble the target leverage policies in Malenko and Tsoy (2025). This paper shows that endogenous punishment by debtholders can discipline the firm and mitigate the leverage ratchet effect. Motivated by our setting, we present a different approach to solving the commitment problem based on decentralization of issuance. Furthermore, in our model, full collateralization alone does not solve the stablecoin issuer's commitment problem, while it neutralizes the leverage ratchet effect for firms (Stulz and Johnson, 1985; Rampini and Viswanathan, 2013; Demarzo, 2019).

Finally, our paper relates to a series of recent works that have studied how blockchain-based innovations can solve traditional economic problems. Still related to the Coase conjecture, Goldstein, Gupta, and Sverchkov (2024) show that issuing utility tokens dilutes the market power of a monopolist issuer by transforming a flow of services into a durable good. Brzustowski, Georgiadis-Harris, and Szentes (2023) show that "smart" contracts whereby a mediator imperfectly transmits information to the durable good seller can solve Coase's problem. Unlike this paper, we do not view smart contracts as communication devices, given our focus on cryptocurrencies. In the model developed by Cong, Li, and Wang (2022), blockchain technology mitigates underinvestment by addressing a time-consistency problem, and Cong and He (2019) study how decentralization through smart contracts affects consensus and competition.

[8] A recent literature on Central Bank Digital Currencies (CBDCs) has emerged (e.g., Brunnermeier, James, and Landau, 2021; Benigno, Schilling, and Uhlig, 2022; Fernandez-Villaverde, Sanches, Schilling, and Uhlig, 2021; Ahnert, Hoffmann, and Monnet, 2025; Chiu, Davoodalhosseini, Jiang, and Zhu, 2023; Niepelt, 2024). As electronic money issued by central banks, CBDCs can be considered public stablecoins, while our model studies private stablecoins issued by profit-maximizing institutions. Furthermore, to the best of our knowledge, decentralizing issuance to solve the issuer's commitment problem has not been proposed in the context of CBDCs.

## 2 Stablecoins as a New Technology

Stablecoin issuers promise to maintain a peg between their stablecoin and some traditional currency. The rapid growth of the stablecoin market and a few crashes during the 2022 crypto winter have raised regulators' concerns about stablecoin designs and their viability as stable (crypto)currencies.[9]

Maintaining a peg is a traditional monetary problem: Some central banks defend a currency peg, private banks must ensure convertibility of deposits, and money market funds must avoid "breaking the buck." However, stablecoin issuers can rely on several innovations facilitated by the blockchain technology to achieve stability. Our theoretical analysis focuses on three key innovations to assess their advantages and vulnerabilities: algorithmic backing, smart contracts, and decentralized issuance. Below, we describe these innovations and their role for the most important stablecoins in practice. Online Appendix A provides more institutional details about the main stablecoins and an account of their performance during the 2022 crypto winter.

**Reserves vs. Algorithmic Backing** Many stablecoin protocols, including the largest (USDT, USDC), back stablecoin issuance with reserves in the form of traditional financial assets (e.g., government bonds) or other cryptocurrencies (e.g., ETH). These stablecoin reserves play a role similar to that of central bank reserves to back currency issuance. Other stablecoin protocols (most notably Terra) have proposed "algorithmic adjustments" to maintain the peg. These algorithmic protocols rely on two crypto assets: the stablecoin itself and an equity token, which can be viewed as a claim on future protocol revenues. Algorithmic stablecoin holders can typically exchange one stablecoin for $1 worth of equity tokens. Conversely, a stablecoin can be created by "burning" $1 worth of equity tokens. One objective of our model is to provide a theoretical foundation for algorithmic backing and explain the crash dynamics of Terra in 2022. Relatedly, our model can shed light on the optimal degree of collateralization of stablecoin protocols.

**Smart Contracts** As we will show, stablecoin platforms face the same fundamental time-consistency problem as similar financial institutions: monetary issuers have an ex-post incentive to issue (or debase) currency, which jeopardizes long-term stability.[10]

[9]See President's Working Group on Financial Markets et al. (2021); Committee on Payments and Market Infrastructures and Board of the International Organization of Securities Commissions (2022); Financial Stability Board (2023).

[10]These insights trace back at least to Demosthenes (1935), with a modern formulation provided by Smith and Warner (1979). This logic also relates closely to the Coase (1972) conjecture concerning durable-goods monopolists.

Unlike traditional monetary institutions—which rely primarily on legal frameworks or institutional credibility to preserve parity with a unit of account—stablecoin issuers can encode monetary rules directly into transparent smart contracts. In our benchmark analysis, we thus consider a stablecoin issuer that can program all rules in advance via an *immutable* smart contract. Although such stablecoin contracts exist (e.g., Liquity's LUSD), immutability also creates practical challenges. First, it makes it difficult for issuers to correct technical or structural programmatic errors ex post. Second, blockchain-based smart contracts cannot control operations related to off-chain assets, which major issuers (USDC, USDT) use as collateral. Thus, we also analyze stablecoin issuance without commitment to show how other stablecoin design features contribute to stability.

**Decentralization of Issuance** Blockchain technology allows stablecoin protocols to decentralize the issuance of stablecoins (e.g., DAI from MakerDAO). Any user in the Ethereum ecosystem can issue ("mint") DAI by locking eligible crypto-assets as collateral inside a vault. Conversely, a user who has issued DAI can redeem it against vault collateral by "burning" a DAI and paying a fee. This decentralized scheme contrasts with the centralized issuance model adopted by the main issuers (USDT, USDC). To date, there exists no systematic analysis of the relative merits of decentralized issuance of stablecoins.

# 3 General Environment

This section lays out our model of stablecoins. Section 3.1 describes stablecoin demand from users who derive money-in-the-utility benefits from holding stablecoins. Sections 3.2 and 3.3 present the policies of the stablecoin issuer and its optimization problem, respectively. We discuss the mapping between our model and stablecoin designs in practice in Section 3.4.

## 3.1 Stablecoin Demand

Time is continuous with $t \in [0, \infty)$. Let $(\Omega, \mathcal{F}, \mathbb{P})$ be a probability space that satisfies the usual conditions. There is a monopolistic stablecoin issuer and a unit mass of homogeneous users. All agents consume a numeraire good—the unit of account—and discount the future at a rate of $r$. A stablecoin is an infinite-maturity asset issued by the stablecoin protocol, in supply $C_t$. At date $t$, it pays an interest rate $\delta_t$ in stablecoins.[11]

[11] For the sake of generality, we assume that the issuer can pay interest on its stablecoins. In Section 4.2, we discuss how issuers can pay interest indirectly in practice, despite regulatory constraints. In Remark 1, we argue that our results are qualitatively similar when the stablecoin cannot pay interest.

Stablecoin users enjoy direct utility from holding stablecoins and can trade those at price $p_t$. A user with $c_t$ stablecoins chooses his path of consumption $\{x_s\}_{s\geq t}$ of the numeraire good and stablecoin holdings $\{c_s\}_{s\geq t}$ to solve

$$\max_{\{x_s,c_s\}_{s\geq t}} \mathbb{E}_t\left[\int_t^\infty e^{-r(s-t)}\left\{x_s + u(A_s, p_s c_s)\right\}ds\right], \tag{1}$$

$$\text{subject to} \quad dx_s + p_s dc_s = de_s + \delta_s p_s c_s ds, \tag{2}$$

where $u(A_s, p_s c_s)$ is users' utility for real balances of stablecoins, $p_s c_s$. This money-in-the-utility specification captures, in reduced form, the use of stablecoins as a store of value or as a means of payment. Variable $A_s$ is an exogenous demand shifter for which we provide dynamics below. In budget constraint (2), $de_s$ represents a user's endowment flow of the numeraire good at date $s$. Users receive $\delta_s$ stablecoins as interest payment for each stablecoin held, which corresponds to the second term on the right-hand side of (2).

We derive the stablecoin demand equation by solving users' problem (1). User optimization over consumption and stablecoin holdings implies the following Euler equation:

$$rp_t = \delta_t p_t + p_t u_c(A_t, p_t c_t) + \mathbb{E}_t\left[\frac{dp_t}{dt}\right]. \tag{3}$$

Users require a return $r$, equal to their discount rate, to hold stablecoins. The right-hand side of (3) features all three sources of return from holding stablecoins: interest payment $\delta_t$, marginal utility for real balances $u_c(A_t, p_t c_t)$, and expected price appreciation of the asset, $\mathbb{E}_t\left[\frac{dp_t}{dt}\right]$. The entire unit mass of homogeneous users chooses the same holdings, $c_t$, equal to the total supply $C_t$ by market clearing. By setting $c_t = C_t$ in equation (3), we obtain the dynamic demand equation for stablecoins:

$$rp_t = \delta p_t + p_t u_c(A_t, p_t C_t) + \mathbb{E}_t\left[\frac{dp_t}{dt}\right]. \tag{4}$$

We refer to (4) as the dynamic demand equation for stablecoins because it maps the (real) stablecoin supply $p_t C_t$ to the stablecoin price dynamics.

Equation (4) highlights users' liquidity benefit $\ell_t := u_c(A_t, p_t C_t)$ as a sufficient statistic for stablecoin demand. This liquidity benefit is akin to a convenience yield, which captures indirect returns from holding an asset.[12] From this point onward, we treat the liquidity

[12] We rely on an ad hoc demand for stablecoins via money-in-the-utility function for simplicity, but a similar liquidity benefit emerges from microfounded theories of money demand. For instance, the new monetarist model of Choi and Rocheteau (2020) yields a similar dynamic demand equation as equation (4). In their version—without interest payment or demand shock—the liquidity benefit is given by $\ell_t = \alpha(v'(p_t C_t) - 1)$ when the bargaining power is given to sellers. In this formulation, the parameter $\alpha$

benefit as a primitive and impose the following assumptions:

**Assumption 1.** *The liquidity benefit for stablecoins $\ell(A, pC)$ is*

*(i) continuously differentiable in both arguments;*

*(ii) homogeneous of degree* $0$*;*

*(iii) such that $\ell(A, x)x$ has a unique interior maximum with* $\max_x \ell(A, x)x > 0$*;*

*(iv) equal to* $0$ *if* $p \neq 1$*.*

Properties (i) to (iii) are technical assumptions introduced to simplify the analysis. Property (i) holds if the money-in-the-utility function, $u$, is differentiable. Property (ii) helps reduce the dimensionality of the problem, as the liquidity benefit ultimately depends on the ratio, $a = A/C$, of stablecoin demand to supply. Thus, we define $\ell(a) \equiv \ell(A/C, 1) = \ell(A, C)$. As we will show, Property (iii) implies that the issuer's problem is well-behaved. To satisfy this property, the liquidity benefit $\ell(A, pC)$ must decrease at a faster rate than the real stablecoin supply, $pC$, when $pC$ is large.[13]

Finally, Property (iv) in Assumption 1 corresponds to users' preference for stability (e.g., when using the coin as a means of payment). For simplicity, we capture this feature by assuming that the liquidity benefit vanishes if the current price deviates from a reference peg price. This feature implies that the issuer fails to capture any seigniorage revenues if the stablecoin loses the peg. The peg is set to one without loss of generality to reflect market practice.[14].

Stablecoin demand is subject to exogenous shocks through the demand index $A_t$, which follows the law of motion:

$$dA_t = \mu A_t dt + \sigma A_t dZ_t + A_{t^-}(S_t - 1)dN_t, \tag{5}$$

where $dZ_t$ is the increment of a standard Brownian motion and $dN_t$ is a Poisson process with constant intensity $\lambda > 0$ adapted to $\mathcal{F}$. The size of a downward jump, $-\ln(S)$,

measures the frequency of decentralized meetings when coins are used, and $v$ corresponds to the utility of buyers from consuming decentralized goods.

[13] That the liquidity benefit $\ell(A, pC)$ should be decreasing with the real stablecoin supply, $pC$, follows naturally from its interpretation as a marginal utility. Taking $\ell_t$ as a primitive, instead, we do not require that the liquidity benefit decreases with $pC$ everywhere. For low values of $pC$, network effects in stablecoin adoption could increase the marginal utility for stablecoins as the supply increases.

[14] Without this "extreme-peg" assumption, a stablecoin could have value, even though there is no active management of the supply of stablecoins to stabilize its price (as for standard cryptocurrencies). In Remark 3, we discuss the other extreme case in which users do not value stability. See Li and Mayer (2022) for a related model with a smooth preference for stable means of payment.

is exponentially distributed with parameter $\xi > 0$ and the expected jump size is $\mathbb{E}[S - 1] = -1/(\xi + 1)$. The expected growth rate of stablecoin demand is thus given by $\mu - \lambda/(\xi + 1) < r$. The Poisson process generates large negative shocks to stablecoin demand. We denote $A_{t^-}$ (resp. $A_t$) for the value of the demand shock just before (after) the jump. We will use similar notations for policy variables chosen by the issuer.[15] For instance, changes in stablecoin demand could be driven by fluctuations of volatile cryptocurrencies, such as Bitcoin, because investors use stablecoin as a store of value in the crypto world. In this interpretation, $A_t$ would describe the exogenous price process for these non-stablecoin cryptocurrencies.[16]

## 3.2 Protocol Policies

In this section, we describe the issuer policies. In practice, stablecoin protocols either directly control the issuance of stablecoins (e.g., USDT, USDC) or decentralize the issuance process (e.g., DAI). For clarity, we first describe a centralized protocol and defer the analysis of a decentralized issuance protocol to Section 5.

A centralized protocol chooses the stablecoin supply $C_t$ and the interest rate $\delta_t$ paid to users. Moreover, the protocol may collateralize the issuance of stablecoins. The collateral asset is safe, with rate of return $\mu^k < r$.[17] The difference $r - \mu^k$ can be interpreted as a convenience yield on the safe asset that is lost when the protocol encumbers that asset as collateral. This assumption generates a collateral holding cost for the protocol.[18] Finally, the protocol can enter liquidation, which distributes the collateral to stablecoin holders.

**Definition 1 (Centralized Protocol Policies).** *The issuer chooses a collateral ratio $\varphi \in [0, 1]$ such that $\varphi$ worth of collateral backs each stablecoin; a sequence of stablecoin issuance and repurchase $\{d\mathcal{G}_t\}_{t\geq 0}$; interest rates $\{\delta_t\}_{t\geq 0}$ paid in stablecoins; and a stochastic liquidation time $\tau$, at which the protocol shuts down and distributes collateral to stablecoin holders uniformly.*

The issuer controls supply via new issuance to increase the stock of stablecoins or repurchases to retire them. Hence, the process $\{d\mathcal{G}_t\}_{t\geq 0}$ can take both positive and

[15] For a variable $X$, $X_{t^-}$ denotes the left limit $X_{t^-} = \lim_{h\to 0} X_{t-h}$.

[16] Alternatively, a shift in $A$ could also capture any variation in stablecoin demand related to its acceptability as a means of payment, tax treatment, regulation, or publicity events affecting adoption.

[17] Our assumption of a safe collateral asset comes with some loss of generality because some stablecoin protocols are often backed by risky cryptoassets. In this case, the collateral price would likely be correlated with the demand process $A_t$. It is intuitive, however, that such a correlation would reduce the usefulness of collateral as a hedge against demand fluctuations.

[18] Because it pays a return $\mu^k$ strictly lower than their discount rate, users consider collateral to be a dominated asset. Hence, their optimization problem (1) is unaffected by the availability of this asset.

negative values. The stablecoin interest policy, whereby every user receives $\delta_t \geq 0$ extra stablecoins per stablecoin owned, is similar to interest payment on reserves by a central bank. Interest payments thus also contribute to the supply of stablecoins. Overall, the law of motion for the stablecoin supply $C_t$ is:

$$dC_t = d\mathcal{G}_t + \delta_t C_t dt. \tag{6}$$

Both the active issuance $d\mathcal{G}_t$ and interest payments $\delta_t C_t dt$ contribute to supply changes.

The protocol's collateral plays a role similar to (central) banks' reserves. In line with stablecoin designs in practice, the protocol must maintain a constant ratio $\varphi$ between the value of its collateral holdings and the stock of stablecoins. This assumption simplifies our analysis because the stablecoin supply dynamics fully determine the protocol's collateral holdings. By varying the collateralized ratio $\varphi$, our model can speak to a wide range of stablecoin designs in practice. So-called "algorithmic stablecoins," like the Terra-Luna protocol, do not rely on collateral ($\varphi = 0$), whereas the leading issuers (USDT, USDC) fully collateralize stablecoins ($\varphi = 1$), similar to narrow banks. Between these two extremes, the stablecoin FRAX initially relied on partial collateralization ($\varphi \in (0, 1)$).[19]

## 3.3 The Centralized Protocol Problem

We solve for the policy sequence that maximizes the protocol's date-0 value under full commitment. In this case, the issuer can commit to future policies even if they are no longer optimal at the time of implementation. In practice, commitment power can be achieved via smart contracts, a central technological proposition of stablecoins that allows protocols to program rules in advance. For completeness, however, we also analyze the case without commitment in Section 5.

**Problem 1 (Full Commitment Problem).** *Under full commitment, the stablecoin protocol maximizes the date-*0 *value of its equity:*

$$E_0 := \max_{\varphi,\tau,\{\delta_t, d\mathcal{G}_t\}_{t\geq 0}} \mathbb{E}_0 \left[ \int_0^\tau e^{-rt} \big( p_t d\mathcal{G}_t + \varphi \mu^k C_t dt - \varphi dC_t \big) \middle| A_0, C_{0\text{-}} = 0 \right], \tag{7}$$

[19]In practice, some stablecoins are collateralized by risky cryptocurrencies. While collateral is safe in our model, risky collateral can be considered as partial collateralization. However, our model cannot speak to the optimal degree of overcollateralization for protocols that rely on crypto collateral.

*subject to the law of motion (6), stablecoin pricing equation (4) with $p_\tau = \varphi$, and*

$$\forall t, \qquad \lim_{T\to\infty} \mathbb{E}_t[e^{-rT} p_T C_T] = 0, \tag{NPG}$$

$$\forall t, \qquad E_t := \mathbb{E}_t\left[\int_t^\tau e^{-r(s-t)}\left(p_s d\mathcal{G}_s + \varphi\mu^k C_s ds - \varphi dC_s\right)\middle| A_t, C_{t^-}\right] \geq 0, \tag{LL}$$

*the No-Ponzi-Game condition and limited liability constraint, respectively.*

The stablecoin issuer maximizes the present value of its profit flow. The flow benefits include the issuance gains $p_t d\mathcal{G}_t$ evaluated at the post-issuance price and the return on collateral $\mu^k \varphi C_t dt$. The issuer incurs costs from collateral purchase, equal to, $\varphi dC_t$, as any stablecoin supply change $dC_t$ implies a change in collateral holdings, equal to $\varphi dC_t$ to maintain a constant collateralization ratio $\varphi$.

As a monopolist, the issuer internalizes its price impact when issuing stablecoins. Formally, this implies that it treats the demand equation (4) as an optimization constraint. At the liquidation date $\tau$, each stablecoin holder receives $\varphi$ worth of collateral, which pins down the liquidation price, $p_\tau = \varphi$. Condition (NPG) follows from the transversality condition in users' optimization problem.[20] This constraint rules out bubbles in which the stablecoin (real) supply would grow at the discount rate of $r$. It implies that the stablecoin has value only if it provides liquidity benefits to users.

Finally, the protocol issuer is subject to limited liability, which implies that its equity value, $E_t$, must remain positive. This implies that the issuer can finance negative cash flows—for instance, to repurchase stablecoins ($d\mathcal{G}_t < 0$), but no cash injection can exceed the present value of future expected profits. In our model, the protocol obtains such financing by the (frictionless) issuance of new equity.

**Equilibrium Selection** In our model, there exists an equilibrium in which the stablecoin price is equal to the collateralization ratio $\varphi$. The protocol has no value in this equilibrium, unless $\varphi = 1$, because it captures liquidity benefits only when the price is pegged to one. For an uncollateralized stablecoin ($\varphi = 0$), this outcome corresponds to the nonmonetary equilibrium in models of fiat money, in which money has no value (see e.g., Williamson and Wright 2011). The nonmonetary equilibrium exists for uncollateralized stablecoins because the stablecoin then lacks an anchor with the unit of account. In

[20] This condition states that a stablecoin holding plan is admissible if, for all $t$,

$$\lim_{T\to\infty} e^{-r(T-t)}\mathbb{E}_t[p_T c_T] = 0,$$

where $c_t$ is a (representative) user's holdings of stablecoins at date $t$. Condition (NPG) thus follows from the above equation and market clearing, $C_t = c_t$.

what follows, we abstract from this well-known multiplicity and instead investigate the existence of an alternative equilibrium in which the stablecoin protocol has a positive value.

## 3.4 Mapping to Stablecoins in Practice

**Trading vs. Redemption** In our model, as in practice, users convert stablecoins into the numeraire by trading in the secondary market. Some stablecoins (e.g., USDC, USDT) also offer direct redemption through their issuers. Although our model does not feature explicit redemption rights, the issuer implicitly sets a redemption rate by controlling the stablecoin price via open-market operations. In practice, even when stablecoin issuers advertise 1-for-1 convertibility with traditional currencies, redemption typically involves discretionary fees and is limited to select, large customers (see Ma, Zeng, and Zhang 2025). Thus, retail traders convert stablecoins primarily by trading in secondary markets, consistent with our modeling assumptions. Section 4.5 further discusses how our results can be interpreted within a redemption-based framework for stablecoins.

**Interest Rates** In our model, the issuer can pay interest to stablecoin users, analogous to a central bank's interest on reserves. In practice, stablecoin issuers typically do not pay interest to their users *directly*, reportedly due to regulatory concerns. Yet, various sponsored mechanisms exist to remunerate stablecoin holders indirectly. For instance, Terra paid an interest rate of approximately 20% via the Anchor protocol before its collapse; similarly, the Dai Savings Rate has fluctuated between 1% and 8%. Additionally, third-party schemes also exist: the Coinbase exchange rewards users depositing USDC on its platform by sharing a portion of the yield that Circle, the issuer of USDC, earns on its reserves. Taken together, this evidence indicates that stablecoin holders can effectively receive interest payments. Nevertheless, our main results remain unchanged if we impose $\delta = 0$ in our model (see Remark 1).

**Equity Tokens** The protocol finances stablecoin repurchases using its collateral and newly issued equity. In the model, equity issuance is assumed to be costless in the sense that it involves no direct issuance or intermediation costs. While equity issuance is typically costly for traditional firms, stablecoin protocols can mint blockchain-based equity—often referred to as "governance" tokens—through automated, on-chain mechanisms at negligible operational cost. This capacity has played a central role in the design of uncollateralized (algorithmic) stablecoins. For example, the Terra protocol relied on the issuance of its governance token, LUNA, as part of the mechanism intended to support the TerraUSD peg.

**Stablecoin Competition** Our model features a single stablecoin protocol. In practice, multiple stablecoin protocols compete to satisfy users' demand for alternative payment instruments. Thus, the liquidity benefit in our model can be interpreted as investors' residual demand for a specific stablecoin, given the supply from other issuers. Crucially for our analysis, the stablecoin protocol must possess some market power, which in practice could arise from platform effects, as described by Cong, Li, and Wang (2022).

# 4 Full Commitment

In this section, we characterize optimal policies under commitment. In practice, the issuer could achieve such commitment with complete and immutable smart contracts. This stringent benchmark provides minimal conditions for a stablecoin protocol to have value and to maintain parity. Since limited liability plays an important role in this analysis, we first consider a benchmark with unlimited liability in Section 4.1. Then, in Section 4.2, we reintroduce the limited liability constraint to analyze Problem 1 in full.

## 4.1 Unlimited Liability Benchmark

In this analysis, we ignore constraint (LL) from Problem 1, that is, the protocol's equity value may become negative. This means that the protocol's equity holders can meet any outflow, even if it exceeds the expected continuation value from the protocol. This unlimited liability benchmark is not meant to be realistic, but it provides an insightful characterization of the protocol's problem of maximizing profit and maintaining stability.[21]

When the protocol is not bound by limited liability, it never liquidates, that is, $\tau = \infty$. To characterize the other protocol policies, rewrite the date-0 equity value of the protocol

[21] Unlimited liability would require equity holders to use a large source of pledgeable income generated outside the protocol to finance repurchases. In a traditional monetarist context, unconditional backing of the central bank by the fiscal authority can be considered a form of unlimited liability for the central bank (Reis, 2015).

in (7) as follows:[22]

$$E_0 = \mathbb{E}\left[\int_0^{\infty} e^{-rt}\Big(\ell(A_t, C_t)C_t\mathbb{1}\{p_t = 1\} - (r - \mu^k)\varphi C_t\Big)dt \,\middle|\, A_0, C_{0^-} = 0\right], \tag{8}$$

Equation (8) expresses the issuer's equity value at date 0 as the expected present value of its profit flow. The first component of this flow is the seigniorage revenue, which is equal to the stablecoin supply, $C_t$, multiplied by investors' flow demand for stablecoins, $\ell(A_t, C_t)$. To obtain the profit flow, the collateral flow costs $(r - \mu^k)\varphi$ must be subtracted from the seigniorage revenues. Such cost is positive by assumption, because the return of the collateral asset, $\mu^k$, is lower than the discount rate, $r$.

As equation (8) shows, the issuer enjoys seigniorage revenues at date $t$ only if the stablecoin is pegged ($p_t = 1$), as otherwise users enjoy no liquidity benefit by assumption. The protocol then sets the stablecoin supply and the interest rate to achieve two objectives: maximize seigniorage revenues and maintain the peg. The interest rate $\delta_t$ affects the protocol's objective function (8), only via its contribution to the peg. To maintain the peg, the protocol thus sets the interest rate according to the following rule:

$$\forall\, t \geq 0, \quad r = \delta_t + \ell(A_t, C_t). \tag{9}$$

Under this rule, equation (4) shows that the peg $p_t = 1$ holds at any date $t$. Next, given that the peg holds at every date $t > 0$, the protocol's choice of a stablecoin supply sequence $\{C_t\}_{t\geq 0}$ to maximize (8) boils down to a static optimization problem. This observation follows from the absence of supply adjustment costs. Given that the peg holds, the optimal supply can be characterized as follows.

**Definition 2.** *Given collateralization ratio $\varphi$ and demand shock $A_t$, the stablecoin supply that maximizes the issuer's profit flow at date $t$ in (8), given that the peg holds, is*

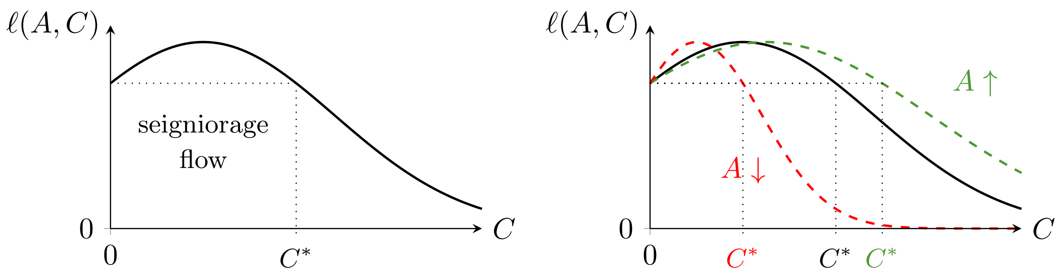
$$C^{\star}(A, \varphi) \equiv \arg\max_C \left\{\ell(A, C)C - \varphi(r - \mu^k)C\right\}. \tag{10}$$

*We define $a^{\star}(\varphi) \equiv A_t/C^{\star}(A_t, \varphi)$ as the constant "demand ratio" at this optimal supply.*

The interest rate rule in (9) together with the supply rule in Definition 2 characterize the optimal policies for a protocol with unlimited liability.

**Proposition 1 (Commitment with Unlimited Liability).** *A protocol with collateralization ratio $\varphi \in (0, 1)$ sets supply $C_t = C^{\star}(A_t, \varphi)$ and pays an interest rate $\delta^{\star} = r - \ell(a^{\star}(\varphi))$ to peg the stablecoin price to 1, for all $t \geq 0$.*

[22] Detailed computations to obtain (8) from (7) are reported in the proof of Proposition 1.




**(a)** Monopolist Profit Maximization **(b)** Adjustments Following Demand Shocks

**Figure 1:** Demand for Stablecoins and Issuer Profit Maximization. This figure displays examples of liquidity benefits along with the associated maximized stablecoin supply $C^*$ for $\varphi = 0$. The functional form for the liquidity benefit is given by $\ell(a) = \exp(a/2(1 - a/2))$.

Given a collateralization ratio $\varphi$, the protocol sets the date-$t$ supply $C_t$ to $C^\star(A_t, \varphi)$, as this maximizes the profit flow from seigniorage net of collateral costs. As Figure 1 shows, the issuer behaves as a static monopolist facing a demand curve $\ell(A, C)$, given by users' liquidity benefit. Our specification of the liquidity benefit implies that the protocol maintains a constant ratio, $a^\star(\varphi)$ between demand and supply. To implement this ratio, the protocol issues (buys back) stablecoins when demand $A_t$ increases (decreases), as illustrated by Panel (b) of Figure 1. Under unlimited liability, observe that equity holders can commit to finance any repurchase, even if the protocol holds no collateral. Hence, such a protocol would optimally choose to hold no collateral ($\varphi^* = 0$), because doing so is costly. As we will show later, this cost advantage of uncollateralized stablecoins can rationalize the appeal of algorithmic protocols, even when we reintroduce limited liability.

Under unlimited liability, the protocol maintains the peg $p_t = 1$ at all dates by paying an interest rate $\delta^\star$ that exactly compensates users for their opportunity cost, $r$, net of the liquidity benefit, $\ell(a^\star(\varphi))$ from holding stablecoins. This liquidity benefit, which is a source of seigniorage revenues for the protocol, explains why it can pay a rate, $\delta^*$ below the market rate on its liabilities. Intuitively, the larger the investors' liquidity benefit, $\ell(a^\star(\varphi))$, the lower the financial compensation $\delta^*$ required by stablecoin users.

**Remark 1.** *Some stablecoins (e.g., USDT, USDC) do not pay interest directly, a constraint that our model can accommodate. In this case, equation (9) shows that, to maintain the peg, the protocol must set supply $C_t$ to satisfy $r = \ell(A_t, C_t)$ at any date $t$. Such a protocol enjoys seigniorage revenues, although these would be larger if it could freely choose the interest rate $\delta_t$, as in the benchmark version of our model.*

**Remark 2.** *As shown in the proof of Proposition 1, the platform's total value at date* 0 *with unlimited liability is given by the net present value of seigniorage flows, that is,*

$$E_0^\star = \frac{\ell(a^*(0))}{r - \mu + \frac{\lambda}{\xi+1}} \frac{A_0}{a^\star(0)}, \tag{11}$$

*where the discount rate is adjusted for the growth rate of stablecoin demand $\mu - \lambda/(\xi+1)$.*

**Remark 3.** *Proposition 1 still holds without Property iv from Assumption 1, which states that users enjoy liquidity benefits only when the peg holds. However, when users have preferences only over the real value of stablecoins, richer price dynamics are compatible with an optimum. Then, the protocol maximizes seigniorage revenues with any policy such that $p_t C_t = C^\star(A_t, \varphi)$. The stablecoin pricing equation (9) becomes*

$$r = \delta_t + \ell(A, C^\star(A, \varphi)) + \pi_t, \tag{12}$$

*with $\pi_t$ the deflation rate—the growth rate of the stablecoin price. Users' preferences for stable means of payment pin down the implementation of this general rule with $\pi_t = 0$. Without such preferences, equation (12) shows that deflation and interest payments are substitutable tools for the protocol to achieve its objective. This observation echoes results about the dual implementation of the Friedman rule in monetary economics.*

## 4.2 Target Policies under Limited Liability

We now consider Problem 1 in full, including limited liability constraint (LL). The protocol must now be able to finance stablecoin repurchases either with collateral or by issuing equity. Formally, the protocol's equity value, $E_t$ must remain positive at all times.

First, we derive the equity value at any date $t$ and show that the unlimited-liability policy violates (LL) unless the protocol is fully collateralized. Following the same steps as when we derived equation (8). We obtain

$$E_t = \mathbb{E}\left[\int_t^\tau e^{-r(s-t)}\Big(\ell(A_s, C_s)C_s \mathbb{1}\{p_s = 1\} + (\mu^k - r)\varphi C_s\Big)ds \middle| A_t\right] - p_t C_{t^-} + \varphi C_{t^-}. \tag{13}$$

The first component of (13) is the present discounted value of seigniorage revenues net of collateral costs. It represents the protocol's total value at date $t$, similar to equation (8) for the date-0 equity value. At date $t$, once in operation, the protocol has $C_{t^-}$ stablecoins outstanding. The term $p_t C_{t^-}$, that enters negatively in the protocol's equity value, represents the market value of the protocol's stablecoin "debt". Finally, the term $\varphi C_{t^-}$ is the value of the corresponding collateral. Figure 2 provides a balance-

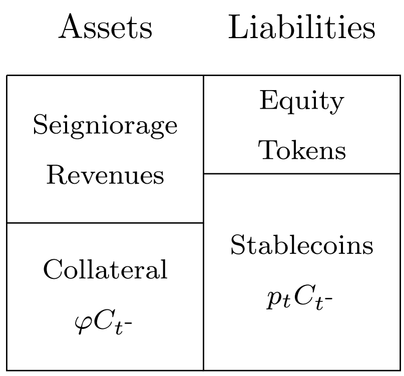



**Figure 2:** Balance Sheet of a Stablecoin Protocol

sheet representation of equation (13), highlighting that both tangible collateral and the (intangible) future revenues from seigniorage back the protocol's outstanding stablecoins.

Next, we show that the unlimited liability policy from Proposition 1 may lead to a negative equity value. Under the policy in Proposition 1, we show in the proof of Proposition 1 that the equity value in (13) becomes

$$E_t = \frac{\ell(a^\star(\varphi)) - (r - \mu^k)\varphi}{r - \mu + \frac{\lambda}{\xi+1}} \frac{A_t}{a^\star(\varphi)} - (p_t - \varphi)C_{t^-}. \tag{14}$$

The first term of $E_t$ in (14) scales with demand $A_t$. Hence, unless the protocol is fully collateralized ($\varphi = 1$), for any outstanding stock of stablecoins $C_{t^-}$ there exists a low enough demand shock $A_t$ such that a positive equity value, $E_t > 0$, and the peg $p_t = 1$ cannot be sustained jointly. Intuitively, the present value of seigniorage revenues, which scales with $A_t$, falls when demand drops significantly. In this case, the combined value of the collateral, $\varphi C_{t^-}$ and of future seigniorage revenues no longer backs stablecoins at par.

**Lemma 1.** *The unlimited-liability policy from Proposition 1 can be implemented under constraint* (LL) *if and only if the stablecoin is fully collateralized ($\varphi^* = 1$). A fully-collateralized protocol is profitable if and only if $\ell(a^\star(1)) \geq r - \mu^k$.*

The first result follows from the discussion above. Fully collateralized protocols rely only on collateral to finance repurchases. Hence, equity holders do not need to raise equity against future seigniorage revenues. The second part of Lemma 1 follows from inspection of equation (14). A fully collateralized stablecoin protocol generates profits if the liquidity benefit it captures from users, $\ell(a^\star(1))$, exceeds the collateral holding cost $r - \mu^k$, which can be interpreted as the collateral's own convenience yield. Fully backing stablecoins with collateral generates profits only if the former command a larger convenience yield.

In the rest of this section, we analyze optimal policies and price dynamics for partially collateralized and unbacked stablecoins ($\varphi < 1$). Problem 1 proves difficult to tackle generally, because optimal policies are not time-consistent.[23] To make progress, we restrict the protocol to use a class of policies defined below. Most notably, these policies depend on time only via the state variable $a_t \equiv A_t/C_{t\text{-}}$, called the demand ratio—the ratio of the current demand $A_t$ to the outstanding stock of stablecoins $C_{t\text{-}}$ at date $t$.

**Definition 3.** *A target Markov policy (TMP) is given by collateralization ratio $\varphi$; liquidation threshold $\underline{a}$; peg threshold $\bar{a}$; target ratio $a^\star$; interest rate policy $\delta_t = \delta(a_t)$; and issuance policy*

$$d\mathcal{G}_t = \begin{cases} g(a_t)C_{t\text{-}}dt & \textit{if} \ \ \underline{a} \leq a_t < \overline{a}, \\ (a_t/a^\star - 1)\, C_{t\text{-}} & \textit{if} \ \ a_t \geq \overline{a}, \end{cases} . \tag{15}$$

*with $\underline{a} < \overline{a} < a^\star$. The issuance policy is smooth over $[\underline{a}, \overline{a}]$ (i.e., of order $dt$). The policy supports a continuous stablecoin price function $p_t = p(a_t)$ with*

$$p(a) = \begin{cases} \varphi & \textit{if} \ \ a \leq \underline{a}, \\ p(a) & \textit{if} \ \ a \in [\underline{a}, \overline{a}], \\ 1 & \textit{if} \ \ a \geq \overline{a} \end{cases} . \tag{16}$$

The Markov label for TMPs refers to the fact that policies depend only on two state variables: current demand shock $A_t$ and outstanding stock of stablecoins $C_{t\text{-}}$. Furthermore, once the issuance policy in (15) is normalized by the outstanding stablecoin stock $C_{t\text{-}}$, it depends only on the demand ratio $a_t$. Focusing on TMPs only provides a partial solution to Problem 1, but it greatly increases tractability and still allows us to highlight the main effect of limited liability on protocol stability.

A TMP is characterized by three regions for the demand ratio $a$: a liquidation region $[0, \underline{a}]$, a smooth-issuance region $[\underline{a}, \overline{a}]$, and a peg region $[\overline{a}, \infty]$. The TMP is also characterized by the stablecoin price it implements. While this is an equilibrium object, the monopolistic protocol ultimately controls the price via its policy choices. In the peg region, the protocol implements a target demand ratio $a^\star$. While the protocol can always enforce such a target under unlimited liability, it must abandon the target following a large

[23] This implies that optimal policies do not solve a standard recursive program with $A_t$ and $C_{t\text{-}}$ as state variables. Marcet and Marimon (2019) develop a method to analyze programs similar to Problem 1 with forward-looking constraints. They show that recursive methods can still be used if one enriches the state space. However, such methods make any analytical characterization difficult, so we sacrifice generality for tractability. Note that the problem with unlimited liability in Section 4.1 is also time inconsistent, but the absence of constraint (LL) greatly simplifies its analysis (see Proposition 1).

negative demand shock under constraint (LL).[24] In a TMP, two outcomes are possible depending on the size of this shock. When $a \in [\underline{a}, \overline{a}]$, the issuer depegs the stablecoin and switches to a smooth-issuance policy. If the shock is so large that the demand ratio $a$ falls below threshold $\underline{a}$, the protocol liquidates. Upon liquidation, it distributes collateral to stablecoin holders, which explains why the stablecoin price is equal to $\varphi$ in this region.

In the remainder of this section, we analyze the optimal TMP for a partially-collateralized stablecoin ($\varphi < 1$). This analysis has two main steps. First, we characterize the protocol's equilibrium equity value, $E(A, C_{\text{-}})$ and price function, $p()$, as well as the issuance policy, $g()$ and interest rate policy, $\delta()$. The second step consists in optimizing over the TMP parameters $\{\underline{a}, \overline{a}, a^\star\}$ to maximize the date-0 value of the protocol.

**Equity Value, Price, and Policies** Our first result under limited liability describes the equity value and the price function, and the optimal policies in a TMP. To state this result, we guess that the protocol's equity value inherits from the TMP the homogeneity with respect to the outstanding stock of stablecoins, $C_{\text{-}}$. Thus, let $e(a) \equiv E(a, 1)$ be the equity value per stablecoin outstanding such that $E(A, C_{\text{-}}) = e(a)C_{\text{-}}$.

**Lemma 2.** *In an optimal TMP, the interest rate in the peg region is*

$$\delta^\star = r - \ell(a^\star) + \lambda \left(1 - \mathbb{E}[p(Sa^\star)]\right). \tag{17}$$

*In the smooth-issuance region $[\underline{a}, \overline{a}]$, the issuer pays no interest ($\delta(a) = 0$) and buys back stablecoins at rate*

$$g(a) = -\frac{\mu^k \varphi}{p(a) - \varphi}, \tag{18}$$

*the protocol's equity value is zero, $e(a) = 0$, and the price function solves*

$$0 = -(r + \lambda)p(a) + (\mu - g(a))ap'(a) + \frac{\sigma^2}{2}a^2 p''(a) + \lambda\mathbb{E}[p(Sa)], \tag{19}$$

*with boundary conditions $p(\underline{a}) = \varphi$ and $p(\overline{a}) = 1$.*

Similar to equation (9) with unlimited liability, equation (17) determines the interest rate payment necessary to maintain the stablecoin price at 1 in the peg region. This comparison shows that, for a given value of the target ratio $a^\star$, the stablecoin pays an extra interest rate, $\lambda \left(1 - \mathbb{E}[p(Sa^\star)]\right)$, to compensate users for the expected price devaluation. Indeed, any negative demand shock driving the demand ratio below $\overline{a}$ induces a loss of

[24] The optimal policy under unlimited liability from Proposition 1 is a TMP with $\underline{a} = \overline{a} = 0$. The notation $a^\star$ refers to a generic target for a TMP, while $a^\star(\varphi)$ refers to the mapping introduced in Definition 2, which is the target demand ratio for the unlimited liability policy.

the peg. Intuitively, this interest rate premium is proportional to the probability $\lambda$ of a negative jump in demand. High interest rates thus reflect in part the likelihood of a price crash. This finding can rationalize the observation that the Terra-Luna protocol paid very high interest rates, close to 20%, before its collapse.

Now, consider the protocol's policies in the smooth-issuance region $[\underline{a}, \overline{a}]$. The protocol's value rests on its ability to capture investors' liquidity benefits as seigniorage. In this region, the stablecoin trades below the peg, that is, $p(a) < 1$, and users enjoy no such benefit. The protocol thus sets policies to minimize the time spent in the region $[\underline{a}, \overline{a}]$ and decreases the supply of coins at the fastest feasible rate. Thus, it pays no interest rate, and uses all its returns from collateral holdings, $\mu^k \varphi$ to buy back stablecoins. Equation (18) defines the maximum repurchase rate compatible with limited liability. Indeed, each stablecoin repurchased requires resources equal to $p_t - \varphi$ as a fraction $\varphi$ is financed with collateral.

Lemma 2 also characterizes the equity value function and the price function in the smooth-issuance region $[\underline{a}, \overline{a}]$. The protocol's equity value falls to zero when the stablecoin loses the peg. As explained above, this follows from the incentives of the protocol to reestablish the peg as quickly as possible. In this region, the protocol's equity holders are indifferent between shutting down and continuing to operate. Staying in operation, however, maintains a positive price for the stablecoin. Equity holders capture this benefit ex ante via a lower interest payment $\delta^\star$ in the peg region. Our model thus predicts that the protocol's equity value falls to zero when the stablecoin depegs. This prediction is consistent with the crash of the equity tokens of NuBits and Terra, two algorithmic stablecoins that lost their peg in 2018 and 2022, respectively (see Online Appendix A for details).

Finally, the HJB equation (19) describes the stablecoin price dynamics in the smooth issuance region. Observe that the stablecoin repurchase rate $-g(a)$ affects the price dynamics via the law of motion of the state variable $a$. As a result, an analytical solution for the stablecoin price exists only in the uncollateralized case ($\varphi = 0$), which we study in Section 4.3. For the partially-collateralized case, $\varphi \in (0, 1)$, we provide a numerical analysis in Section 4.4.

## 4.3 Uncollateralized Stablecoins

In this section, we focus on the uncollateralized case ($\varphi = 0$). It corresponds, for instance, to the design of Terra-Luna, the notorious algorithmic stablecoin that crashed in May 2022. Theoretically, this case proves easier to solve, because the equilibrium price function in the smooth-issuance region admits an analytical characterization. When $\varphi = 0$, there is no feedback between the stablecoin repurchase rate and the stablecoin price (Lemma 2). In the next result, we describe this solution and characterize the liquidation threshold.

**Lemma 3.** *An uncollateralized stablecoin never needs to liquidate: $\underline{a} = 0$. In the smooth-issuance region $[0, \overline{a}]$, the equilibrium stablecoin price is*

$$p(a) = \left(\frac{a}{\overline{a}}\right)^{-\gamma} \tag{20}$$

*where $\gamma < -1$ is the unique negative root of the following characteristic equation:*

$$r + \lambda = -\mu\gamma + \frac{\sigma^2}{2}(1+\gamma)\gamma + \frac{\lambda\xi}{\xi - \gamma}. \tag{21}$$

Lemma 3 contains two key insights. First, an uncollateralized protocol never programs a liquidation ($\underline{a} = 0$). Liquidation can only increase the protocol's date-0 value via an ex-post transfer of collateral to stablecoin users. Hence, without collateral, the protocol optimally continues to operate, even for very low demand ratios $a$. Second, and related to the first point, the stablecoin price remains strictly positive when the peg is lost, although investors enjoy no liquidity benefit. The stablecoin value rests on the possibility that demand ratio $a_t$ eventually reaches the peg threshold $\overline{a}$ following positive demand shocks. The speed of this process depends on the value of the root $\gamma$.

To characterize the optimal TMP, we first express the protocol's objective function as a function of the target demand ratio $a^\star$. By definition, the total protocol value at $t = 0$ is equal to the equity value after issuance plus the value of stablecoins issued (at par):

$$E_0 = E(A_0, 0) = E(A_0, C^\star(A_0)) + C^\star(A_0) = A_0 \frac{e(a^\star) + 1}{a^\star}, \tag{22}$$

with $e(a^\star)$ the (endogenous) equity value at the target demand ratio. Next, we show in the Appendix that the equity value at the target demand ratio satisfies the following equation

$$(r + \lambda - \mu)e(a^\star) = \mu - \delta(a^\star) + \lambda\mathbb{E}[e(Sa^\star)]. \tag{23}$$

Absent negative jumps in demand, the protocol issues stablecoins at the growth rate of demand $\mu$ and pays interest $\delta(a^\star)$ to stablecoin users. The expected equity value following a negative jump in demand, $\mathbb{E}[e(Sa^\star)]$, can be expressed as a function of $e(a^\star)$. Indeed, in the smooth-issuance region, we showed that $e(a) = 0$ for $a \leq \overline{a}$ (Lemma 2), while, in the peg region,

$$\forall a \geq \overline{a}, \quad e(a) = e(a^\star)\frac{a}{a^\star} + \left(\frac{a}{a^\star} - 1\right). \tag{24}$$

by definition of the issuance policy for $a \geq \overline{a}$. Combining Lemma 3 and the observations above, we obtain the following characterization of the optimal TMP.

**Proposition 2 (Optimal Uncollateralized Stablecoin).** *The optimal TMP for an uncollateralized stablecoin is such that* $\underline{a} = 0$ *(Lemma 2). The optimal lower bound* $\overline{a} > 0$ *for the peg region and target ratio* $a^\star$ *solve*

$$\frac{e(a^\star)+1}{a^\star} = \max_{\overline{a},a^\star} \left\{ \frac{\ell(a^\star)/a^\star}{r + \frac{\lambda}{\xi+1} - \mu + \left(\frac{\lambda\xi}{\xi+1} - \frac{\lambda\xi}{\xi-\gamma}\right)\left(\frac{a^\star}{\overline{a}}\right)^{-(\xi+1)}} \right\} \tag{25}$$

$$\textit{subject to} \qquad e(\overline{a}) = \left[e(a^\star)+1\right]\frac{\overline{a}}{a^\star} - 1 = 0. \tag{26}$$

The first key result from Lemma 3 is that the smooth-issuance region is nonempty ($\overline{a} > 0$). This means that an uncollateralized stablecoin will lose its peg after a large enough negative demand shock. Even if it can fully commit to all policies, the protocol cannot escape limited liability. After a large negative demand shock, the issuer cannot issue enough equity to repurchase stablecoins at par. As a result, the peg is then lost. This result echoes findings in monetary economics by Del Negro and Sims (2015) and Reis (2015), who show that an insolvent central bank without fiscal support cannot control inflation.

The protocol's optimization problem, in equation (25), then amounts to the optimal choice of the lower bound of the peg region, $\overline{a}$, and the target demand ratio $a^\star$. Limited liability constraint (LL) for all $a$ is equivalent to constraint (26), which states that $e(\overline{a}) = 0$, because $e(a) = 0$ for all $a \leq \overline{a}$ and $e(a)$ is linear and increasing for $a \in [\overline{a}, \infty)$. Similar to equation (11) with unlimited liability, equation (25) shows that the protocol's date-0 value is the present discounted value of seigniorage revenues. As a key difference, however, the effective discount rate is higher under limited liability to account for the risk that the protocol loses the peg.

A direct corollary of Proposition 2 is that the optimal target demand ratio with limited liability, denoted $a^\star_{ll}(0)$, is higher than the target with unlimited liability, $a^\star(0)$: Reducing stablecoin issuance from $C^\star(A)$ to $C^\star_{ll}(A) < C^\star(A)$ protects the protocol against large negative demand shocks. Next, we show in Corollary 1 that an uncollateralized stablecoin protocol is not always profitable, even though the cost of minting stablecoins is zero.

**Corollary 1.** *An uncollateralized stablecoin protocol can be profitable only if*

$$\max_a \ell(a) \geq r - \mu + \frac{\lambda}{\xi+1}. \tag{27}$$

Corollary 1 shows that an uncollateralized protocol can emerge only if it faces sufficient growth in demand. Equation (27) provides a sufficient condition for existence.[25] It implies that the growth rate of stablecoin demand, $\mu - \lambda/(\xi + 1)$ must exceed the interest paid by the protocol, $\delta^\star \geq r - \ell(a^\star)$ in equation (17). The difference between the growth rate of demand and the interest rate is the net issuance rate of stablecoins, since the issuer must repurchase the stablecoins created as interest to maintain the target demand ratio. Equity tokens have value only if this net issuance rate is positive.

### 4.4 Numerical Analysis of Partially-Collateralized Stablecoins

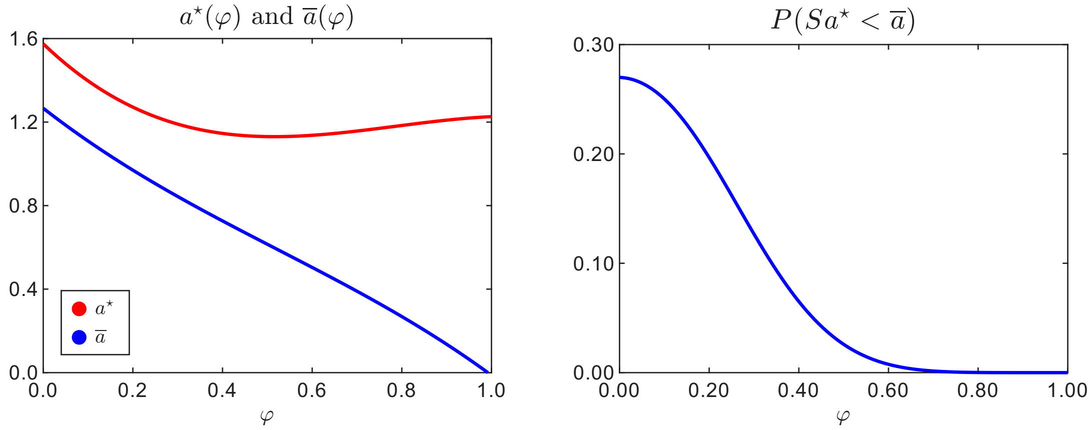
To shed light on the optimal TMP for partially-collateralized stablecoins, we rely on a numerical analysis. First, we solve for the equilibrium equity value and stablecoin price for given TMP parameters, $\{\underline{a}, \overline{a}, a^\star, \varphi\}$. Next, we maximize the date-0 (equity) value of the protocol over these parameters to obtain the optimal TMP. The functional form for the liquidity benefit, $\ell(a)$ and the parameter values are indicated below the figures.

**Impact of Collateralization** First, we perform a comparative statics exercise with respect to the collateralization ratio $\varphi$, treated as a parameter. First, panel (a) of Figure 3 shows that the collateralization ratio has an ambiguous effect on the conservatism of the issuance policy, as measured by the target ratio $a^\star(\varphi)$, which is U-shaped in $\varphi$. This result reflects the tension between two opposite forces on the supply policy. A higher collateralization ratio improves the protocol stability, which encourages more issuance per unit of demand. This explains why $a^\star(\varphi) \equiv A/C^\star(A, \varphi)$ initially decreases as $\varphi$ increases. However, for higher values of $\varphi$, the collateral holding cost starts to dominate, which disincentivizes stablecoin issuance, thereby increasing $a^\star(\varphi)$ as $\varphi$ increases. Ceteris paribus, the conservatism of the issuance policy determines the protocol stability. However, Panel (a) of Figure 3 also shows that the optimal lower bound of the peg region, $\overline{a}(\varphi)$, decreases with $\varphi$. For a given $a^\star$, this implies that the peg holds for larger negative demand shocks, as $\varphi$ increases. Overall, Panel (b) of Figure 3 confirms the intuition that the protocol becomes more stable as the collateralization ratio increases, because the probability that the stablecoin loses the peg decreases with $\varphi$.[26]

**Optimal Collateralization** Second, we characterize the optimal collateralization ratio chosen by the protocol. In particular, we perform a comparative statics exercise with

[25] We report sufficient condition (27) here, because it is intuitive. In the proof of Corollary 1, we also provide the necessary and sufficient condition for existence.

[26] This result follows directly from the fact that the difference $a^*(\varphi) - \overline{a}(\varphi)$ increases with $\varphi$. Hence, as $\varphi$ increases, a larger negative demand shock is needed for the stablecoin to lose the peg.




**(a)** Target and Peg Region

**(b)** Probability of Depegging

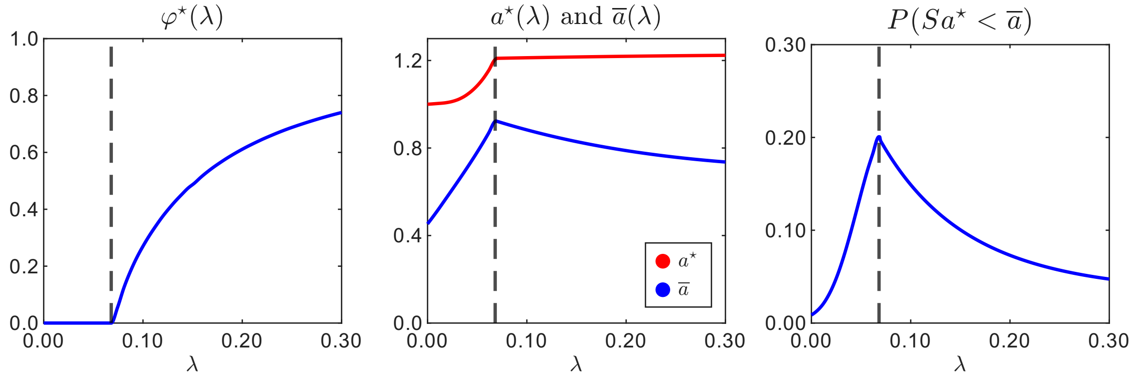
**Figure 3:** Optimal TMP as a function of $\varphi$, the collateralization ratio. The set of parameters is given by $r = 0.06$, $\mu = 0.05$, $\sigma = 0.1$, $\xi = 6$, and $\lambda = 0.1$. The functional form for the liquidity benefit is $\ell(a) = r \exp(-1/a)$.

respect to $\lambda$, the probability of a negative jump in demand. Panel (a) of Figure 4 shows the optimal collateralization ratio, $\varphi(\lambda)$. Intuitively, the protocol increases $\varphi$ when large negative demand shocks become more frequent (higher $\lambda$). Interestingly, Figure 4 also shows that the issuer chooses pure algorithmic backing, that is, $\varphi(\lambda) = 0$, when $\lambda$ is small enough. The issuer trades off collateral holding costs with stability. When large negative demand shocks are rare (low value of $\lambda$), the first effect dominates, and the issuer does not back stablecoin issuance with collateral. Panel (b) of Figure 4 shows the optimal target ratio, $a^\star(\lambda)$ and the optimal lower bound of the peg region, $\overline{a}(\lambda)$, similar to Panel (a) of Figure 3. In the region where the issuer does not collateralize issuance, it instead reduces supply per unit of demand (higher $a^\star(\lambda)$). However, the lower bound of the peg region, $\overline{a}(\varphi)$ increases at a faster pace, which implies that depegging risk increases with $\lambda$, as shown by Panel (c) of Figure 4. For higher values of $\lambda$, when the protocol uses collateralization, depegging risk decreases, in line with the results reported in Figure 3.

## 4.5 Tradable vs. Redeemable Stablecoins

We conclude this section by providing an interpretation of the results from our supply-based model of stablecoins within the alternative framework where users directly redeem stablecoins with the issuer. In a redemption-based model, the issuer would satisfy users' requests to convert stablecoins in the unit of account at an advertised conversion rate. This conversion rate corresponds to the secondary market price in our model, which the monopolistic issuer controls via open-market operations.

With this analogy, our results suggest that, in a redemption-based model, the issuer




**(a)** Collateralization Ratio **(b)** Target and Peg Region **(c)** Probability of Depegging

**Figure 4:** Optimal TMP as a function of $\lambda$, the (Poisson) arrival rate of negative jumps in demand. The set of parameters is given by $r = 0.06$, $\mu = 0.05$, $\sigma = 0.1$ and $\xi = 6$. The functional form for the liquidity benefit is $\ell(a) = r\exp(-1/a)$.

would set a soft conversion rate, reflecting the imbalance between outstanding stablecoins and users' demand. To see this, consider demand ratio $a$ in the peg region $[\overline{a}, \infty)$ of a TMP. In the redemption-based model, the protocol would offer conversion at a rate of $e_t = 1$. Given such a rate, users would redeem or buy new stablecoins until the stablecoin stock adjusts to $C^\star(A)$. Now, consider a state $a \leq \overline{a}$ for which the stablecoin trades below the peg in the model. The protocol could achieve the same outcome in the redemption-based model by lowering its conversion rate from 1 to $e = p^\star(a)$, where $p^\star(a) < 1$ denotes the equilibrium price of our model at this demand ratio. Overall, the discussion suggests that the equilibrium of our supply-based model of stablecoins can be implemented as an equilibrium of a redemption-based model, thanks to a soft conversion rate. In practice, with USDT and USDC, users must pay variable redemption fees, so the effective redemption rate is not necessarily one for one.

Relative to a redemption-based model, however, our model necessarily misses the strategic complementarity at play in runs.[27] Still, our model also highlights the greater fragility of partially-collateralized stablecoins. More importantly, in the next section, we identify a new source of stablecoin fragility generated by the issuer's commitment problem. Unlike run-based fragility, we will show that this commitment problem arises even when stablecoins are fully backed. In our framework, the commitment problem arises if the issuer retains discretion over the supply policy. A similar problem arises in a redemption-based model if the issuer retains the ability to adjust redemption fees, as is the case in practice. Consistent with the view that issuers retain significant discretion

[27]See Routledge and Zetlin-Jones (2021) for an analysis of runs and of the benefits of suspension of convertibility in a model of a pegged cryptocurrency. Suspension of convertibility plays no role in our model, because we assume that collateral is fully liquid.

over these policies, Section 426 of the GENIUS Act by U.S. Congress (2025) requires stablecoin issuers to publicly disclose redemption and conversion procedures in plain language, including any associated fees and the terms and timing for redemption requests.

# 5 Commitment Problem and Decentralized Issuance

So far, we assumed that the issuer could fully commit to its future policies. In practice, many stablecoin protocols retain discretion over governance decisions, including the repurchase and issuance of stablecoins. In this section, we show that the policies derived in Section 4 are not time-consistent for the protocol's issuer, that is, discretion is costly. Then, we show that decentralized issuance, a feature of stablecoin protocols like DAI, solves this commitment problem.

## 5.1 The Time-Consistency Problem

At date $t = 0$, equity holders choose the policy sequence that maximizes the total protocol value. At any future date $t > 0$, however, they would like to maximize its equity value

$$E_t = \mathbb{E}_t \left[ \int_t^\tau e^{-r(s-t)} \Big( \ell(A_s, C_s) C_s \mathbb{1}\{p_s = 1\} - (r - \mu^k) \varphi C_s \Big) ds \right] + \varphi C_{t^-} - p_t C_{t^-}, \quad (28)$$

which no longer coincides with the total protocol value, once stablecoins have been issued ($C_{t^-} > 0$). In fact, equation (28) shows that the equity value is equal to the total protocol value, net of the market value of outstanding stablecoins, $p_t C_{t^-}$. This wedge implies that equity holders may not find the commitment policy optimal ex post. As we show below, equity holders can benefit from a temporary peg loss, at the expense of stablecoin holders.

We show that equity holders would not implement the commitment policy if they could reoptimize at some date $t > 0$. For this argument, we consider a fully collateralized stablecoin ($\varphi = 1$) for expositional simplicity and to highlight that collateral does not solve the commitment problem. Suppose that, at date $t > 0$, the protocol's equity holders can alter the issuance process as follows:

$$C_\tau = \begin{cases} \widetilde{C}_t & \text{if} \quad \tau = t, \\ C^\star(A_\tau) & \text{if} \quad \tau = t + \Delta t, t + 2\Delta t, ... \end{cases} \quad (29)$$

Equity holders choose supply $\widetilde{C}_t$ instead of $C^\star(A_t)$ at date $t$ and subsequently revert to the commitment policy. We evaluate the benefit of such "one-step deviation" under the interest rate of the commitment policy: $\delta_\tau = \delta^\star$ for all dates $\tau \geq t$.[28]

The fact that the issuer implements the commitment policy from date $t + \Delta t$ implies that $p_\tau = 1$ from date $\tau = t + \Delta t$. At date $t$, however, the price falls to

$$\widetilde{p}_t = 1 - (r - \delta^\star)\Delta t = 1 - \ell(a^\star)\Delta t, \tag{30}$$

as users no longer enjoy the liquidity benefit at date $t$ when $\widetilde{C}_t \neq C^\star(A_t)$.

As we show in the Appendix, the re-optimized policy dominates the commitment policy if and only if

$$\ell(a^\star)C^\star(A_{t-\Delta t}) \geq \left[\ell(a^\star) - (r - \mu^k)\right]C^\star(A_t) - \left[0 - (r - \mu^k)\right]\widetilde{C}_t. \tag{31}$$

The right-hand side is the loss in the issuer's seigniorage flow, net of collateral costs, from the deviation. This term is positive because this flow is maximized at $C^\star(A_t)$ for demand $A_t$, by definition. The left-hand side captures the benefit from the deviation. The price drop from 1 to $\tilde{p}_t$ caused by this deviation dilutes the outstanding stock of stablecoins, $C^\star(A_{t-\Delta t})$, which benefits the equity holders. This benefit arises because the issuer has a short position in the pre-existing stock $C_{t-}$. By inducing $\tilde{p}_t < 1$ over some time interval, it can repurchase outstanding stablecoins at the depegged price before the peg is restored. Under $\phi = 1$, repurchasing one coin frees one unit of collateral, while it costs only $\tilde{p}_t$, for a net gain $1 - \tilde{p}_t \simeq \ell(a^*)\Delta t$ per coin—this is the dilution term captured on the left-hand side of (30). Equation (31) shows that the deviation is beneficial when demand drops sufficiently ($A_t \ll A_{t-\Delta t}$), as the benefit from diluting outstanding stablecoins then outweighs the loss in seigniorage flows.

Stablecoin equity holders face the same commitment problem as the monopolist in Coase (1972), who sells durable assets. The issuance price of stablecoins today depends on the issuer's implicit promise to maintain the peg in the future. After stablecoins have been issued, however, equity holders may prefer to renege on this promise, because the benefit from commitment is sunk. Recently, Admati et al. (2018) and DeMarzo and He (2021) showed that equity holders have similar incentives to dilute existing corporate debt once it is issued. In their models, however, new debt dilutes past debt via an increase in the probability of bankruptcy. This implies that full collateralization restores commitment. Instead, in our model, dilution operates via the liquidity benefit for stablecoins, and the

[28] In this exercise, the issuer re-optimizes once and for all at date $t$, which implies that the new policy is credible. We assume that investors price the stablecoin from date $t$ considering only current and future policy choices. That is, in the spirit of Markov perfection, dispersed stablecoin investors cannot punish the equity holders for deviating from the original policy.

commitment problem remains for any level of collateralization.[29]

The stablecoin issuance policies derived in Section 4 require commitment—for instance, via smart contracts. Lack of such commitment weakens the issuer's ability to credibly maintain the peg and extract seigniorage revenues. We can show that this commitment problem is so severe that the protocol cannot generate any seigniorage under time-consistent policies. In the interest of space, and since these results are already established in the aforementioned papers, we relegate the formal details of this analysis to the Online Appendix.[30] Instead, in the main text, we show how decentralized issuance, a design specific to some stablecoins, such as DAI, can solve the issuer's commitment problem.

## 5.2 Decentralized Issuance

So far, our analysis has focused on centralized protocols where one issuer supplies stablecoins to the market. In this section, we consider instead *decentralized* protocols—with DAI as a leading example. Decentralized protocols delegate the issuance of stablecoins to any users holding eligible collateral. We show that delegation of issuance solves the commitment problem that plagues centralized issuance.

In a decentralized protocol, any user can issue stablecoins against collateral locked in a "vault." Vault owners can unlock their collateral by repurchasing and "burning" stablecoins.[31] At any date $t > 0$, the protocol's equity holders steer supply, which they no longer control directly, by charging a seigniorage fee, $s_t$, to vault owners, paid in stablecoins. Our objective is to show that the commitment problem faced by a centralized issuer does not apply with delegated issuance. Thus, we give the issuer discretion to choose its seigniorage fee and the interest paid to stablecoin holders, $\delta_t$, sequentially. The collateralization ratio $\varphi \in [0, 1]$ is the only parameter of the protocol that equity holders cannot alter ex post.[32]

[29] Note that under full commitment, the stablecoin is unstable if and only if there are large negative jumps to demand. However, the commitment problem arises even if demand shocks are only Brownian.

[30] Specifically, we characterize optimal policies in a Markov Perfect Equilibrium. Markov perfection requires that the protocol policies and the stablecoin price can depend only on the current demand shock, $A_t$ and the current stock of stablecoins, $C_{t^-}$. This standard equilibrium concept rules out punishments by investors when equity holders deviate from a pre-announced policy. Hence, the temptation remains for equity holders to dilute outstanding stablecoins, as discussed above.

[31] Differently from our model, risky cryptoassets (such as ETH) are eligible as collateral to issue DAI. Observe, however, that the MakerDAO's Peg Stabilization Mechanism allows users to swap DAI for other stablecoins, such as USDC. To the extent that these other stablecoins are safe, MakerDAO effectively relies on safe collateral to maintain the peg between DAI and the dollar.

[32] Note that commitment to the collateralization ratio does not bias the comparison with the centralized issuance case. Indeed, our analysis in Online Appendix C shows that a centralized issuer cannot earn any seigniorage revenue if it can commit only to the collateralization ratio.

### 5.2.1 Vault Owners

Any agent can open a vault and issue stablecoins. A vault is indexed by $i$ with $C^i_{t\text{-}}$ the amount of stablecoins outstanding for vault $i$ at date $t$. Every period, a vault owner chooses to default or to keep the vault open. In the latter case, the vault owner chooses new issuance $d\mathcal{G}^i_t$ subject to collateralization ratio $\varphi$, its expectation about the protocol's policies, and the price process for stablecoins. Denoting $\tau^i$ the default time for vault owner $i$ and $\tau$ the liquidation time of the protocol, the vault owner's problem writes

$$V^i_t(C^i_{t\text{-}}) = \max_{\tau^i, d\mathcal{G}^i_t} \mathbb{E}_t \left[ \int_t^{\tau^i \wedge \tau} e^{-r(s-t)} \left( p_s d\mathcal{G}^i_s + \varphi \mu^k C^i_s ds - \varphi dC^i_s \right) \right], \tag{32}$$

$$\text{subject to} \qquad dC^i_s = s_s C^i_s ds + d\mathcal{G}^i_s. \tag{33}$$

The vault owner's optimization problem (32) resembles that of a centralized issuer, given by equation 7, except that it pays a seigniorage fee $s_t$ to the protocol, rather than an interest $\delta_t$ to stablecoin holders. Equation (33) is the law of motion for the stablecoins issued by vault $i$. Total supply is still denoted $C_t = \int_i C^i_t \mathrm{d}i$. As a key difference with a centralized issuer, competitive vault owners take the stablecoin $p_t$ as given.

Next, we derive equilibrium restrictions that follow from vault owners' optimization. Unlike with a centralized issuer, free entry of vault owners and competition drive the gains from issuance to 0. Given that atomistic vault owners do not enjoy seigniorage, a vault is worth the collateral held net of the value of outstanding stablecoins:

$$V^i_t(C^i_{t\text{-}}) = (\varphi - p_t) C^i_{t\text{-}}. \tag{34}$$

Now, we may state the equilibrium implications of vault owners' optimal behavior.

**Proposition 3.** *In any equilibrium with positive and finite stablecoin supply $C_t$ at date $t$, the stablecoin price cannot exceed the collateralization ratio, that is,*

$$p_t \leq \varphi, \tag{35}$$

*and the stablecoin price and the vault fee satisfy*

$$r(\varphi - p_t) = \varphi \mu^k - s_t p_t - \mathbb{E}_t \left[ \frac{dp_t}{dt} \right]. \tag{36}$$

The first result follows from an arbitrage argument for vault owners. If the stablecoin price $p_t$ exceeded the collateralization ratio $\varphi$, vault owners could achieve an infinite profit from issuing stablecoins at price $p_t$ and defaulting the next instant. Equation (36) is the dynamic supply equation that follows from vault owners optimizing supply. It equates the opportunity cost from owning a vault, $r(\varphi - p_t)$ to the vault's sources of income. A vault owner enjoys the return on collateral $\varphi\mu^k$ and pays the seigniorage fee $s_t$ in stablecoins. The last term reflects the loss in value of a vault when the stablecoin appreciates because, as an issuer, a vault owner holds a short position in stablecoins.

Dynamic supply equation (36) is the counterpart for vault owners of dynamic demand equation (4) for stablecoin holders. The protocol's equity holders influence demand (supply) via their interest rate (seigniorage fee) policy. Next, we characterize these policies for a profit-maximizing decentralized protocol.

### 5.2.2 Decentralized Protocol Policies

Our first result is that a decentralized protocol must be fully collateralized.

**Corollary 2.** *The protocol can generate seigniorage revenues in equilibrium only if $\varphi \geq 1$.*

Corollary 2 follows directly from the no-arbitrage relationship (35) in Proposition 3 and Assumption 1 that users enjoy liquidity benefits only if the stablecoin is pegged. If $\varphi < 1$, the stablecoin price satisfies $p_t < 1$ by Proposition 3, and the protocol's equity holders earn no seigniorage revenue. Thus, the protocol can generate profit only if $\varphi = 1$.

Next, we characterize the remaining policies of a fully collateralized decentralized protocol. At every date $t$, the equity holders set the interest rate $\delta_t$ paid to users and the seigniorage fee $s_t$ it charges to vault owners, to whom issuance is delegated.

**Problem 2 (Decentralized Protocol Problem Without Commitment).** *A decentralized protocol chooses its interest rate $\{\delta_t\}_{t\geq 0}$ and its seigniorage fee $\{s_t\}_{t\geq 0}$ sequentially to maximize its equity value at every date $t$,*

$$E_t = \max_{\tau,\delta,s} \mathbb{E}_t \left[ \int_t^\tau e^{-r(s-t)} \big(s_s - \delta_s\big) p_s C_s ds \right], \tag{37}$$

*subject to stablecoin pricing equation (4), the no-Ponzi Game condition (NPG), and the vault owner's arbitrage conditions (35) and (36).*

Similar to the centralized case, the monopolistic protocol ultimately controls the stablecoin price $p$ and the supply $C$, via its choices of policy variables $\delta$ and $s$. The protocol's equity holders treat the dynamic demand and supply equations, (4) and (36) as optimization constraints. However, decentralized issuance changes the equity holders' incentives in a fundamental way. As can be seen from (37), the protocol's profit flow is now proportional to the stablecoin stock $C_t$, rather than to the issuance $d\mathcal{G}_t$. That is, the protocol's model changes from an issuance-based revenue flow (centralized) to a rental-based revenue flow (decentralized). As our next result shows, this change in the revenue model neutralizes the commitment problem under decentralized issuance.

**Proposition 4 (Decentralized Protocol Equilibrium).** *A fully-collateralized decentralized protocol implements the optimal outcome of Proposition 1 even without commitment. The equilibrium stock of stablecoins thus satisfies*

$$C_t = \arg\max_{C} \left\{ \ell(A_t, C)C + (\mu^k - r)C \right\} \equiv C^\star(A_t, 1). \tag{38}$$

*To implement $C^\star(A_t, 1)$, the protocol sets a vault fee schedule of the form*

$$s(a) - \delta(a) = \begin{cases} \ell(a) + (\mu^k - r)/p(a) + \varepsilon & \text{if} \quad C_t > C^\star(A_t, 1), \\ \ell(a^\star(1)) + \mu^k - r & \text{if} \quad C_t = C^\star(A_t, 1), \\ \ell(a) + (\mu^k - r)/p(a) - \varepsilon & \text{if} \quad C_t < C^\star(A_t, 1), \end{cases} \tag{39}$$

*where $\varepsilon$ is strictly positive. The equilibrium interest rate is $\delta^\star = r - \ell(a^\star(1))$.*

The key result from Proposition 4 is that, under full collateralization, the optimal policy is time-consistent for a decentralized protocol. That is, unlike in the centralized case, equity holders do not need commitment power to maximize the seigniorage revenues from issuing stablecoins. As mentioned above, the equity holders of a decentralized protocol earn a rental income on the total stock of stablecoins, rather than an issuance profit from new stablecoins issued. This feature neutralizes incentives to dilute past stablecoins, which generates the commitment problem in the centralized case. Hence, our model predicts that decentralized issuance dominates other designs if commitment cannot be achieved via other means (e.g., smart contracts).

By definition, the time-consistent policies chosen by the protocol's equity holders coincide with the optimal full-commitment policy derived in Section 4. That is, the protocol implements the stablecoin stock $C^\star(A_t, 1)$ that maximizes the liquidity benefit flow net of collateral costs, given by (38). Unlike in the centralized case, however, the protocol's equity holders do not control supply directly. The second part of Proposition 4 shows how the protocol steers issuance by vault owners via the seigniorage fee schedule, given by equation (39). Equity holders set the fee schedule on and off equilibrium to guarantee that decentralized supply by vault owners achieves the protocol's target. To get some intuition, suppose that the stablecoin supply falls below the target set by the protocol—that is, $C_t < C^\star(A_t, 1)$. Vault owners then face a lower seigniorage fee than in equilibrium, which stimulates issuance until $C_t$ reaches $C^\star(A_t, 1)$. When $C_t = C^\star(A_t, 1)$, the equilibrium fee schedule makes vault owners indifferent about issuance.

There exists an analogy between Proposition 4 and the rental solution of the durable-good monopolist problem analyzed by Coase (1972) and Bulow (1982). A seller of a durable good who lacks commitment fails to internalize the effect of a decline in the price of previously sold goods caused by future issuance. Renting helps because the full stock of goods is repriced every period. Similarly, in our model, decentralized issuance and its rental-based revenue model neutralize the protocol's equity holders incentives to dilute previously issued stablecoins. However, a decentralized protocol is not a pure stablecoin rental market, as vault owners and users can still trade the stablecoin. Such a market is essential in our model because users' liquidity benefit from holding stablecoins depends on the price, unlike for a non-monetary durable good.

# 6 Conclusion

This paper proposes a model to study the merits and vulnerabilities of various stablecoin designs. Our analysis rationalizes algorithmic backing, but it shows that partially collateralized protocols are always vulnerable to large demand shocks. The optimal collateralization level trades off resilience to these shocks against collateral holding costs. Furthermore, we show that optimal policies are not time-consistent: the issuer tends to devalue stablecoins by deviating from the peg, even under full collateralization. Decentralized issuance, combined with full collateralization, a design similar to DAI, can restore commitment and ensure stability. To focus on the novel technological dimensions of stablecoins, we assume a reduced-form liquidity benefit for stablecoins and consider the problem of a single stablecoin issuer using riskless and fully liquid collateral. These assumptions imply that our framework does not capture all relevant aspects of stablecoins, such as liquidation and run risks that emerge when stablecoins hold illiquid and risky collateral. We leave the analysis of these microfoundations and extensions to future research.

## References


Admati, Anat R, DeMarzo, Peter M, Hellwig, Martin F, and Pfleiderer, Paul. The leverage ratchet effect. *The Journal of Finance*, 73(1):145–198, 2018.

Ahnert, Toni, Hoffmann, Peter, and Monnet, Cyril. Payments and privacy in the digital economy. *Journal of Financial Economics*, 169, 2025.

Arner, Douglas W, Auer, Raphael, and Frost, Jon. Stablecoins: risks, potential and regulation. *Financial Stability Review. Nº 39 (Autumm 2020), p. 95-123*, 2020.

Benigno, Pierpaolo, Schilling, Linda M., and Uhlig, Harald. Cryptocurrencies, currency competition, and the impossible trinity. *Journal of International Economics*, 136: 103601, 2022. ISSN 0022-1996. NBER International Seminar on Macroeconomics 2021.

Berentsen, Aleksander and Schär, Fabian. Stablecoins: The quest for a low-volatility cryptocurrency. *Fatas A., Economics of Fintech and Digital Currencies*, pages 65–71, 2019.

Bertsch, Christoph. Stablecoins: Adoption and fragility. *Sveriges Riksbank Working Paper Series*, (423), May 2023.

Biais, Bruno, Bisière, Christophe, Bouvard, Matthieu, Casamatta, Catherine, and Menkveld, Albert J. Equilibrium bitcoin pricing. *Journal of Finance*, 78(2):967–1014, April 2023.

Brunnermeier, Markus, James, Harold, and Landau, Jean-Pierre. The digitalization of money. BIS Working Papers 941, Bank for International Settlements, May 2021.

Brzustowski, Thomas, Georgiadis-Harris, Alkis, and Szentes, Balázs. Smart contracts and the coase conjecture. *American Economic Review*, 113(5):1334–1359, 2023.

Bullmann, Dirk, Klemm, Jonas, and Pinna, Andrea. In search for stability in crypto-assets: are stablecoins the solution? ECB Occasional Paper 230, European Central Bank, August 2019.

Bulow, Jeremy I. Durable-goods monopolists. *Journal of Political Economy*, 90(2):314–332, 1982.

Calvo, Guillermo A. Optimal seigniorage from money creation: An analysis in terms of the optimum balance of payments deficit problem. *Journal of Monetary Economics*, 4 (3):503–517, 1978.

Chiu, Jonathan, Davoodalhosseini, Seyed Mohammadreza, Jiang, Janet, and Zhu, Yu.

Bank market power and central bank digital currency: Theory and quantitative assessment. *Journal of Political Economy*, 131(5):1213–1248, 2023.

Choi, Michael and Rocheteau, Guillaume. New Monetarism in Continuous Time: Methods and Applications. *The Economic Journal*, 131(634):658–696, 07 2020.

Coase, R. H. Durability and monopoly. *The Journal of Law & Economics*, 15(1):143–149, 1972.

CoinMarketCap. https://coinmarketcap.com/view/stablecoin/, 2025. [Online; accessed 17-December-2025].

Committee on Payments and Market Infrastructures and Board of the International Organization of Securities Commissions. Application of the principles for financial market infrastructures to stablecoin arrangements. Technical report, Bank for International Settlements, July 2022. URL https://www.bis.org/cpmi/publ/d198.pdf.

Cong, Lin William. Stablecoins and banking: Deposit dynamics, financial stability, and regulatory design. SSRN Working Paper, Dec. 2025. URL https://ssrn.com/abstract=6163266. White paper dated December 7, 2025 (Appendix added January 30, 2026).

Cong, Lin William and He, Zhiguo. Blockchain disruption and smart contracts. *The Review of Financial Studies*, 32(5):1754–1797, May 2019.

Cong, Lin William, Li, Ye, and Wang, Neng. Tokenomics: Dynamic Adoption and Valuation. *The Review of Financial Studies*, 08 2020. ISSN 0893-9454.

Cong, Lin William, Li, Ye, and Wang, Neng. Token-based platform finance. *Journal of Financial Economics*, 144(3):972–991, 2022.

Czsun, Sam. Taking undercollateralized loans for fun and for profit. Website, 2023. [Online].

Del Negro, Marco and Sims, Christopher A. When does a central bank's balance sheet require fiscal support? *Journal of Monetary Economics*, 73:1–19, 2015. ISSN 0304-3932. Carnegie-Rochester-NYU Conference Series on Public Policy "Monetary Policy: An Unprecedented Predicament" held at the Tepper School of Business, Carnegie Mellon University, November 14-15, 2014.

Demarzo, Peter M. Presidential address: Collateral and commitment. *The Journal of Finance*, 74(4):1587–1619, 2019.

DeMarzo, Peter M and He, Zhiguo. Leverage dynamics without commitment. *The Journal of Finance*, 76(3):1195–1250, 2021.

Demosthenes. *Orations, Volume III: Orations 21–26*. Number 299 in Loeb Classical Library. Harvard University Press, Cambridge, MA, 1935.

Donaldson, Jason Roderick and Piacentino, Giorgia. Money runs. *Journal of Monetary Economics*, 126(C):35–57, 2022.

ECB. Stablecoins – no coins, but are they stable? IN FOCUS 3, European Central Bank, November 2019.

Eichengreen, Barry. From commodity to fiat and now to crypto: What does history tell us? Working Paper 25426, National Bureau of Economic Research, January 2019.

European Central Bank. Financial stability review. November 2021.

Federal Deposit Insurance Corporation and Office of the Comptroller of the Currency. Report on stablecoins. November 2021.

Fernandez-Villaverde, Jesus, Sanches, Daniel, Schilling, Linda, and Uhlig, Harald. Central Bank Digital Currency: Central Banking For All? *Review of Economic Dynamics*, 41: 225–242, July 2021.

Financial Stability Board. High-level recommendations for the regulation, supervision and oversight of global stablecoin arrangements. Technical report, Financial Stability Board, July 2023. URL https://www.fsb.org/2023/07/high-level-recommendations-for-the-regulation-supervision-and-oversight-of-global-stablecoin-arrangements/.

Friedman, Milton. *A Program for Monetary Stability.* Fordham University Press, New York, 1960.

G30. Digital currencies and stablecoins. Risks, opportunities, and challenges ahead. Technical report, Group of Thirty, July 2020.

Goldstein, Itay, Gupta, Deeksha, and Sverchkov, Ruslan. Utility tokens as a commitment to competition. *Journal of Finance*, 79(6):4197–4246, 2024.

Gorton, Gary B., Ross, Chase P., and Ross, Sharon Y. Making Money. NBER Working Papers 29710, National Bureau of Economic Research, Inc, Jan. 2022.

Hinzen, Franz J., John, Kose, and Saleh, Fahad. Bitcoin's limited adoption problem. *Journal of Financial Economics*, 144(2):347–369, 2022. ISSN 0304-405X.

Ho, Annetta, Darbha, Sriram, Gorelkina, Yuliya, and Garcia, Alejandro. The relative benefits and risks of stablecoins as a means of payment: A case study perspective. Discussion Papers 2022-21, Bank of Canada, 2022.

Jermann, Urban and Xiang, Haotian. Tokenomics: Optimal monetary and fee policies. Technical report, Working Paper, 2022.

Kydland, Finn E. and Prescott, Edward C. Rules rather than discretion: The inconsistency of optimal plans. *Journal of Political Economy*, 85(3):473–492, 1977.

Li, Jiasun and Mann, William. Digital tokens and platform building. *Review of Financial Studies*, 2025. Forthcoming.

Li, Ye and Mayer, Simon. Money creation in decentralized finance: A dynamic model of stablecoin and crypto shadow banking. 2022.

Liu, Jiageng, Makarov, Igor, and Schoar, Antoinette. Anatomy of a run: The terra luna crash. *NBER Working Paper Series*, (31160), 2023.

Lyons, Richard K. and Viswanath-Natraj, Ganesh. What keeps stablecoins stable? *Journal of International Money and Finance*, 131:102777, 2023.

Ma, Yiming, Zeng, Yao, and Zhang, Anthony Lee. Stablecoin runs and the centralization of arbitrage. *Review of Financial Studies*, 2025. Forthcoming.

Malenko, Andrey and Tsoy, Anton. Optimal time-consistent debt policies. *Review of Financial Studies*, 2025. Forthcoming.

Marcet, Albert and Marimon, Ramon. Recursive contracts. *Econometrica*, 87(5):1589–1631, 2019.

Niepelt, Dirk. Money and banking with reserves and CBDC. *Journal of Finance*, 79(4): 2505–2552, 2024.

Persson, M., Persson, T., and Svensson, L.E.O. Time consistency of fiscal and monetary policy. *Econometrica*, 55:1419, 1987.

President's Working Group on Financial Markets, Federal Deposit Insurance Corporation, and Office of the Comptroller of the Currency. Report on stablecoins. Technical report, U.S. Department of the Treasury, Nov. 2021. URL https://home.treasury.gov/system/files/136/StableCoinReport_Nov1_508.pdf.

Rampini, Adriano and Viswanathan, S. Collateral and capital structure. *Journal of Financial Economics*, 109(2):466–492, 2013.

Reis, Ricardo. Comment on: "When Does a Central Bank's Balance Sheet Require Fiscal Support?" by Marco Del Negro and Christopher A. Sims. *Journal of Monetary Economics*, 73:20–25, 2015. ISSN 0304-3932. Carnegie-Rochester-NYU Conference Series on Public Policy "Monetary Policy: An Unprecedented Predicament" held at the Tepper School of Business, Carnegie Mellon University, November 14–15, 2014.

Routledge, Bryan and Zetlin-Jones, Ariel. Currency stability using blockchain technology. *Journal of Economic Dynamics and Control*, page 104155, 2021. ISSN 0165-1889.

Smith, Clifford W. and Warner, Jerold B. On financial contracting: An analysis of bond covenants. *Journal of Financial Economics*, 7(2):117–161, 1979.

Stulz, René and Johnson, Herb. An analysis of secured debt. *Journal of Financial Economics*, 14(4):501–521, 1985.

Uhlig, Harald. A Luna-tic Stablecoin Crash. NBER Working Papers 30256, National Bureau of Economic Research, Inc, July 2022.

U.S. Congress. Guiding and Establishing National Innovation for U.S. Stablecoins Act (GENIUS Act), S.1582, 119th Cong. (2025). https://www.congress.gov/bill/119th-congress/senate-bill/1582/text, 2025. Accessed: 2025-12-16.

Williamson, Stephen and Wright, Randall. New monetarist economics: Models. In Friedman, Benjamin and Woodford, Michael, editors, *Handbook of Monetary Economics*, volume 3A. Elsevier, 2011.

# Appendices

## A Proofs

### A.1 Proof of Proposition 1

Substituting for $d\mathcal{G}_t = dC_t - \delta_t C_t dt$, the objective function can be written as

$$E_0 = \max_{\varphi, \{\delta_t, d\mathcal{G}_t\}_{t\geq 0}} \mathbb{E}_0 \left[ \int_0^\infty e^{-rt} \Big( p_t dC_t - \delta_t p_t C_t dt + \mu^k \varphi C_t dt - \varphi dC_t \Big) \right]. \tag{A.40}$$

Integrating the terms in $dC_t$ by parts, we obtain

$$\begin{aligned} E_0 &= \max_{\varphi, \{\delta_t, d\mathcal{G}_t\}_{t\geq 0}} \mathbb{E}_0 \left[ \left[ (p_t - \varphi) C_t e^{-rt} \right]_0^\infty - \int_0^\infty e^{-rt} C_t \left( dp_t - r(p_t - \varphi)dt + \delta_t p_t dt - \mu^k \varphi \right) \right] \\ &= \max_{\varphi, \{\delta_t, d\mathcal{G}_t\}_{t\geq 0}} \mathbb{E}_0 \left[ \int_0^\infty e^{-rt} \Big( \ell(A_t, C_t) \mathbb{1}\{p_t = 1\} + (\mu^k - r)\varphi \Big) C_t dt \right]. \end{aligned} \tag{A.41}$$

To obtain the second line, we guess and verify that $\lim_{t\to\infty} \mathbb{E}_0[(p_t - \varphi)C_t e^{-rt}] = 0$. We use pricing equation (4) to substitute for $dp_t - (r - \delta_t)p_t dt$ within the expectation.

Equation (A.41) shows that setting $\varphi = 0$ is optimal. Next, $\delta_t$ is only determined to the extent that it maintains the price peg, and we can rewrite equation (A.41) as

$$E_0 = \max_{\{\delta_t, d\mathcal{G}_t\}_{t\geq 0}} \mathbb{E}_0 \left[ \int_0^\infty e^{-rt} \ell(A_t, C_t) C_t \mathbb{1}\{p_t = 1\} dt \right]. \tag{A.42}$$

Assuming that such interest rate policy can be chosen, the protocol's problem is static, and the optimal issuance rule is such that $C_t$ maximizes $\ell(A_t, C_t)C_t$. By Property iii in Assumption 1, this maximizer exists, is unique, and is given by (10). The fact that $C^\star(A, 0) = A/a^\star(0)$ is linear in $A$ follows from Property ii in Assumption 1. Moreover, our conjecture $\lim_{t\to\infty} \mathbb{E}_0[(p_t - \varphi)C_t e^{-rt}] = 0$ and the fact that the objective function is bounded follows from the fact that $A_t$ grows at a rate inferior to $r$. Finally, the interest rate policy must be such that $p_t = 1$ for all $t$, which holds with $\delta(a^\star(0)) = r - \ell(a^\star(0))$.

The optimal issuance-repurchase policy $\{d\mathcal{G}_t\}_{t\geq 0}$ features a jump from 0 to $C^*(A_0, 0)$ at date 0 and is such that $d\mathcal{G}_t + \delta_t C_t dt = dA_t$ for $t > 0$. This concludes the proof.

Now, we derive the expression for the date-0 equity value, equation (11), thanks to Proposition 1. For future reference, we compute the equity value $E_t$ at any date, and for all values of $\varphi \in [0, 1]$ under the optimal full-commitment policy. Starting from equation

(A.41), we have

$$\begin{aligned}E_t &= -(p_t-\varphi)C_{t\text{-}} + \mathbb{E}_0\left[\int_t^\infty e^{-r(s-t)}\Big(\ell(A_s,C_s)\mathbb{1}\{p_s=1\}+(\mu^k-r)\varphi\Big)C_s ds\right],\\ &= -(p_t-\varphi)C_{t\text{-}} + \frac{\ell(a^\star(\varphi))+(\mu^k-r)\varphi}{a^\star(\varphi)}\mathbb{E}_t\left[\int_t^\infty e^{-r(s-t)}A_s dt\right]. \end{aligned} \tag{A.43}$$

Remember that $C_{t\text{-}}$ is the left limit of the supply process $C_s$ at $s=t$. To obtain the second line, we substituted for the optimal supply policy, $C_s = C^\star(A_s,\varphi) = A_s/a^\star(\varphi)$. Using then equation (5) that describes the law of motion for $A_t$, we obtain

$$E_t = -(p_t-\varphi)C_{t\text{-}} + \frac{\ell(a^\star(\varphi))+\mu^k-r}{a^\star(\varphi)\left(r-\mu+\frac{\lambda}{\xi+1}\right)}A_t. \tag{A.44}$$

Setting $t=0$ and $C_{0\text{-}}=0$, we obtain equation (11).

## A.2 Proof of Lemma 1

The fact that the optimal full-commitment policy violates limited liability (LL) if and only if $\varphi<1$ obtains directly from equation (14).

For the second part of Lemma 1, set $p_t=\varphi=1$ in equation (14). The equity value is positive if and only if the numerator of the first term is positive, that is, if and only if $\ell(a^\star(1)) \geq r-\mu^k$. This concludes the proof.

## A.3 Proof of Lemma 2

The proof proceeds in three steps. First, we derive the value of the interest rate $\delta^\star$ paid by the protocol at the target ratio $a^\star$ in order to maintain the peg. Next, we show that $e(a)=0$ in the smooth-issuance region and derive the relevant policies in that region. Finally, we derive the HJB equation (19) for the price function.

**Step 1: Interest Rate $\delta^\star$** Let us derive the dynamic equation for the price at the target. Given that the price at the target ratio is 1, we obtain

$$1 = \big(\delta^\star+\ell(a^\star)\big)dt + (1-rdt)(1-\lambda dt)\mathbb{E}[p(a^\star+da)] + (1-rdt)\lambda dt\mathbb{E}[p(Sa^\star)]. \tag{A.45}$$

The third (last) term in equation (A.45) corresponds to smooth changes (jumps) in demand $A_t$. After a smooth change in demand, the peg still holds given that the protocol maintains the target, that is, $p(a^\star+da)=1$ in this case. After a jump, however, the price may fall below 1 if $Sa^\star \leq \overline{a}$. Plugging $p(a^\star+da)=1$ into equation (A.45), we obtain equation (17).

**Step 2: Equity Value and Policies in $[\underline{a},\overline{a}]$** The main step is to show that $e(a)=0$ is optimal for all $a \leq [\underline{a},\overline{a}]$. Note that $e(a)=0$ for $a\leq\underline{a}$ holds by definition of a TMP.

We then derive the optimal issuance policy in the smooth region.

To show that $e(a) = 0$, for all $a \leq [\underline{a}, \overline{a}]$, consider the total protocol value at date $t$, denoted $F_t$. The total protocol value includes both the equity value, $E_t$ and the net value of stablecoins outstanding, $(p_t - \varphi)C_{t^-}$. At date 0, equity value and total protocol value are equal, so the protocol's equityholders objective is to maximize the date-0 total protocol value.

Consider a demand ratio $a = A/C > \overline{a}$. In this, case $F$ only depends on $A$—not on the outstanding stock of stablecoins $C$—and we denote $\bar{F}(A)$ to avoid confusion. Let $\tau_S$ denote the first (stochastic) time when a shock $S \leq \underline{a}/a^\star$ hits. We have

$$\begin{aligned}\bar{F}(A_0) = E_{\tau_S}\bigg[\int_0^{\tau_S} & e^{-rt}\Big(\ell(A_t, C^\star(A_t))C^\star(A_t) + \varphi(\mu^k - r)C^\star(A_t)\Big)dt \\ & + e^{-r\tau_S}\mathbb{E}\left[F\left(SA_{\tau_S}, C^*(A_{\tau_S})\right)\Big| Sa^* \leq \overline{a}\right]\bigg]. \end{aligned} \tag{A.46}$$

Given values for $(a^\star, \overline{a})$, maximizing value $\bar{F}(A_0)$ consists in maximizing the second term of the above equation. We thus explicit the dynamic equation for $F(A,C)$ in the region where $a = A/C \in [\underline{a}, \overline{a}]$. For a given $a \in [\underline{a}, \overline{a}]$, denote $\tau^+(a)$ the first stochastic time when $a_t = \overline{a}$ and $\tau^-(a)$ the first stochastic time when $a_t = \underline{a}$. Let $\tau(a_0) = \min\{\tau^+(a_0), \tau^-(a_0)\}$. We have

$$\begin{aligned}F(A_0, C_0) = \mathbb{E}_{\tau(a_0)}\Bigg[\int_0^{\tau(a_0)} & e^{-rt}(\mu^k - r)\varphi C_t dt \\ + \quad & e^{-r\tau(a_0)}\Big(\mathbb{1}\{\tau(a_0) = \tau^+(a_0)\}\bar{F}(A_{\tau(a_0)}) + \mathbb{1}\{\tau(a_0) = \tau^-(a_0)\}\varphi C_{\tau(a_0)}\Big)\Bigg],\end{aligned} \tag{A.47}$$

where the law of motion for $C_t$ is given by (6). The dividend flow for the total protocol is negative in the region $[\underline{a}, \overline{a}]$. Hence, maximizing $F(A,C)$ in region $[\underline{a}, \overline{a}]$ and thus $\bar{F}(A)$ amounts to minimizing the expected time $\tau^+(a)$ from any given point $a$. Given the policies in $[\underline{a}, \overline{a}]$ in (15), we have

$$\mathbb{E}\left[\frac{da_t}{a_t}\right] = \left(\mu - \frac{\lambda}{\xi + 1}\right)dt - (\delta_t + G_t/C_t)dt. \tag{A.48}$$

Hence the protocol seeks to minimize $\delta_t$ and $G_t$ subject to the constraint that equity value $E(A,C)$ remains positive for $A/C \in [\underline{a}, \overline{a}]$.

Next, we derive the recursive equation for the equity value in order to pin down the minimum value of $g$ and $\delta$ such that limited liability holds in region $[\underline{a}, \overline{a}]$. In doing so, we guess and verify that it holds for $[\overline{a}, \infty)$. Adapting Equation (7), we have

$$\begin{aligned}E(A,C) =& p(A,C)G(A,C)dt + \mu^k\varphi C dt - \varphi dC \\ & + (1 - rdt)(1 - \lambda dt)\mathbb{E}[E(A + dA, C + dC)] + (1 - rdt)\lambda dt\mathbb{E}[E(SA, C)].\end{aligned} \tag{A.49}$$

Using Ito's Lemma for the term $E(A+dA, C+dC)$ above and keeping only terms of order $dt$, we obtain the following HJB:

$$(r+\lambda)E(A,C) = (p(A,C)-\varphi)G(A,C) + (\mu^k - \delta(A,C))\varphi C + \mu A E_A(A,C) + \frac{\sigma^2}{2}A^2 E_{AA}(A,C) \\ + (\delta(A,C)C + G(A,C))E_C(A,C) + \lambda \mathbb{E}[E(SA,C)]. \tag{A.50}$$

Using the normalized equity value, $e(a) = E(A,C)/C$, we obtain $E_A(A,C) = e'(a)$, $E_{AA}(A,C) = e''(a)$, $E_C(A,C) = e(a) - ae'(a)$. Introducing the normalized issuance rate, $g(a) \equiv G(A,C)/C$, we get

$$(r+\lambda)e(a) = (p(a)-\varphi)g(a) + \mu a e'(a) + \frac{\sigma^2}{2}a^2 e''(a) + (\delta(a)+g(a))(e(a)-ae'(a)) \\ + (\mu^k - \delta(a))\varphi + \lambda E[e(Sa)]. \tag{A.51}$$

It follows from the equation above that the minimum value of $g(a)$ such that $e(a) \geq 0$ for all $a \in [\underline{a}, \overline{a}]$ is given by

$$g(a) = -\frac{\mu^k - \delta(a)}{p(a)-\varphi}\varphi. \tag{A.52}$$

Given policy $g(a)$ above and $e(a) = e'(a) = 0$, the impact of $\delta(a)$ is offset in HJB equation (A.51) and we can set $\delta(a)$ to its minimum at 0 for $a \in [\underline{a}, \overline{a}]$.

**Step 3: HJB equation for price in $[\underline{a}, \overline{a}]$** The price equation can be written as

$$p(A,C) = (1-rdt)(1-\lambda dt)\mathbb{E}[p(A+dA, C+dC)] + (1-rdt)\lambda dt \mathbb{E}[p(SA,C)]. \tag{A.53}$$

When $a \in [\underline{a}, \overline{a}]$, stablecoin owners enjoy no cash flow because the protocol optimally sets $\delta(a) = 0$ and liquidity benefits are equal to 0 since $p(a) < 1$. Using $dC = g(a)Cdt$, the first term on the right-hand side can be expanded using Ito's Lemma:

$$\mathbb{E}[p(A+dA, C+dC)] = p(A,C) + p_A(A,C)\mu A dt + \frac{\sigma^2}{2}A^2 p_{AA}(A,C)dt + p_C(A,C)g(a)Cdt \\ = p(a) + (\mu - g(a))ap'(a)dt + \frac{\sigma^2}{2}a^2 p''(a)dt. \tag{A.54}$$

To obtain the second line, we use the homogeneity of degree 0 of the price function, that is, $p(A/C) \equiv p(A,C)$, to replace $p_A(A,C) = p'(a)/C$, $p_{AA}(A,C) = p''(a)/C^2$ and $p_C(A,C) = -p'(a)A/C^2$. Substituting (A.54) into (A.53) and keeping only terms of order $dt$, we obtain equation (19). This concludes the proof.

## A.4 Proof of Lemma 3

We solve for the price function that satisfies HJB equation (19). Doing so, we prove that for $\varphi = 0$. For this result, we first need to express the protocol's objective function, given by equation (22).

**Step 1: Objective Function** We derive the HJB for the equity value at demand ratio $e(a^\star)$. The recursive equation is given by

$$\begin{aligned} E(a^\star C_-, C_-) =& (1 - rdt)(1 - \lambda dt)\mathbb{E}\left[ E(a^\star C_- + dA, C_- + dC) \middle| dN_t = 0\right] \\ &+ (1 - rdt)\lambda dt \mathbb{E}\left[ E(Sa^\star C_-, C_-) \middle| dN_t = 1\right], \end{aligned} \tag{A.55}$$

where the term on the first line corresponds to the case in which the adjustment in demand $A_t$ is smooth ($dN_t = 0$), while the second term corresponds to the case in which demand jumps ($dN_t = 1$). To express the term corresponding to Brownian shocks, use equation (24) and $dC = \delta(a^\star)Cdt$ to obtain the following relationship by Ito's Lemma:

$$\mathbb{E}\left[ E(a^\star C_- + dA, C_- + dC) \middle| dN_t = 0\right] = E(a^\star C_-, C_-) + \mu\big[e(a^\star) + 1\big]C^\star(A)dt - \delta^\star C^\star(A)dt. \tag{A.56}$$

Keeping only terms of order at least $dt$ and dividing by $C^\star(A)$ in equation (A.55), we obtain

$$e(a^\star) = e(a^\star) + \big(-(r + \lambda)e(a^\star) + \mu\big[e(a^\star) + p(a^\star)\big] - \delta^\star + \lambda\mathbb{E}[e(Sa^\star)]\big)\, dt, \tag{A.57}$$

which simplifies to equation (23) after setting $p(a^\star) = 1$.

Now, we must compute $e(Sa^\star)$. From Lemma 2, $e(a) = 0$ for $a \le \bar{a}$. For $a \ge \bar{a}$, we have

$$E(A, C_-) = E(A, C^\star(A)) + (1 - \varphi)(C^\star(A) - C_-). \tag{A.58}$$

Hence, the normalize equity value $e(a) = E(A, C_-)/C_-$ satisfies equation (24). We thus obtain

$$\begin{aligned} \mathbb{E}[e(Sa^\star)] &= \int_0^{ln(a^\star/\bar{a})} e(e^{-s}a^\star)\xi e^{-\xi s} ds && \text{(A.59)} \\ &= \int_0^{ln(a^\star/\bar{a})} \Big[(e(a^\star) + 1 - \varphi)e^{-s} - 1 + \varphi\Big]\xi e^{-\xi s} ds && \text{(A.60)} \\ &= \frac{\xi}{\xi+1}\left(1 - \left(\frac{a^\star}{\bar{a}}\right)^{-(\xi+1)}\right)(e(a^\star) + 1 - \varphi) - \left(1 - \left(\frac{a^\star}{\bar{a}}\right)^{-\xi}\right)(1 - \varphi). && \text{(A.61)} \end{aligned}$$

Plugging this equation in (A.57), we get

$$\begin{aligned} &\left(r + \frac{\lambda}{\xi+1} - \mu + \frac{\lambda\xi}{\xi+1}\left(\frac{a^\star}{\bar{a}}\right)^{-(\xi+1)}\right) e(a^\star) \\ &= \left(\mu^k - \mu + \frac{\lambda}{\xi+1} - \lambda\left(\frac{a^\star}{\bar{a}}\right)^{-\xi} + \frac{\lambda\xi}{\xi+1}\left(\frac{a^\star}{\bar{a}}\right)^{-(\xi+1)}\right)\varphi \\ &\quad + \left(\mu - \delta^\star - \frac{\lambda}{\xi+1} - \frac{\lambda\xi}{\xi+1}\left(\frac{a^\star}{\bar{a}}\right)^{-(\xi+1)} + \lambda\left(\frac{a^\star}{\bar{a}}\right)^{-\xi}\right)p(a^\star). \end{aligned} \tag{A.62}$$

After some manipulations, we can rewrite the protocol's objective function as

$$\frac{e(a^\star)+1-\varphi}{a^\star}=\frac{(\mu^k-r)\varphi+r-\delta^\star+\lambda(1-\varphi)\left(\frac{a^\star}{\overline{a}}\right)^{-\xi}}{r-\mu+\frac{\lambda}{\xi+1}+\frac{\lambda\xi}{\xi+1}\left(\frac{a^\star}{\overline{a}}\right)^{-(\xi+1)}}. \tag{A.63}$$

Observe that the objective function depends on $\underline{a}$ only via $\delta^*$, which is itself given by equation (17) in Lemma 2.

**Step 2: Stablecoin Price Function** Next, we characterize the stablecoin price function that solves (19) for $\varphi = 0$. Our general guess for the price function is

$$\forall\, a \in [\underline{a}, \overline{a}], \quad p(a) = \sum_{k=1}^{3} b_k a^{-\gamma_k}, \tag{A.64}$$

where $\{\gamma_k\}_{k=1,2,3}$ are the roots of characteristic equation (21). Our objective is to show that only the root $\gamma < -1$ is valid and that $\underline{a} = 0$. These results rely on a number of intermediate lemma, proven below.

**Lemma 4.** *The guess given by* (A.64) *is an admissible solution for* (19) *if the boundary conditions and the consistency condition hold, respectively,*

$$\sum_{k=1}^{3} b_k \underline{a}^{-\gamma_k} = 0, \qquad \sum_{k=1}^{3} b_k \overline{a}^{-\gamma_k} = 1, \tag{A.65}$$

$$\sum_{k=1}^{3} b_k \frac{\xi}{\xi-\gamma_k} \underline{a}^{-\gamma_k} = 0 \tag{A.66}$$

*Proof.* The boundary conditions given by equation (A.65) follow simply by continuity of $p$ at $\underline{a}$ and $\overline{a}$. Next, the guess is an admissible solution of (19) if the term $\mathbb{E}\left[p\left(Sb_k a^{-\gamma_k}\right)\right]$ is a sum of power functions in $a$ with exponents $-\gamma_k$. Using the guess, we have for $a \in [\underline{a}, \overline{a}]$,

$$
\begin{aligned}
\mathbb{E}[p(Sa)] &= \int_0^{\infty} p(e^{-s}a)\xi e^{-\xi s} ds && \text{(A.67)}\\
&= \int_0^{\ln\left(\frac{a}{\underline{a}}\right)} p(e^{-s}a)\xi e^{-\xi s} ds + \int_{\ln\left(\frac{a}{\underline{a}}\right)}^{\infty} p(e^{-s}a)\xi e^{-\xi s} ds && \text{(A.68)}\\
&= \sum_{k=1}^{3} b_k \int_0^{\ln\left(\frac{a}{\underline{a}}\right)} e^{\gamma_k s} a^{-\gamma_k} \xi e^{-\xi s} ds + \sum_{k=1}^{3} b_k \int_{\ln\left(\frac{a}{\underline{a}}\right)}^{\infty} e^{\gamma_k s} a^{-\gamma_k} \xi e^{-\xi s} ds && \text{(A.69)}\\
&= \sum_{k=1}^{3} b_k \int_0^{\ln\left(\frac{a}{\underline{a}}\right)} e^{\gamma_k s} a^{-\gamma_k} \xi e^{-\xi s} ds + \left(\frac{a}{\underline{a}}\right)^{-\xi} \sum_{k=1}^{3} b_k \int_0^{\infty} e^{\gamma_k s} \underline{a}^{-\gamma_k} \xi e^{-\xi s} ds && \text{(A.70)}\\
&= \sum_{k=1}^{3} b_k \int_0^{\ln\left(\frac{a}{\underline{a}}\right)} e^{\gamma_k s} a^{-\gamma_k} \xi e^{-\xi s} ds + \left(\frac{a}{\underline{a}}\right)^{-\xi} \mathbb{E}[p(S\underline{a})] && \text{(A.71)}\\
&= \sum_{k=1}^{3} b_k a^{-\gamma_k} \frac{\xi}{\xi - \gamma_k} \left[e^{-(\xi-\gamma_k)s}\right]_0^{\ln\left(\frac{a}{\underline{a}}\right)} && \text{(A.72)}\\
&= \sum_{k=1}^{3} b_k a^{-\gamma_k} \frac{\xi}{\xi - \gamma_k} - \sum_{k=1}^{3} b_k a^{-\gamma_k} \frac{\xi}{\xi - \gamma_k} \left(\frac{a}{\underline{a}}\right)^{-(\xi-\gamma_k)} && \text{(A.73)}\\
&= \sum_{k=1}^{3} b_k a^{-\gamma_k} \frac{\xi}{\xi - \gamma_k} - \left(\frac{a}{\underline{a}}\right)^{-\xi} \sum_{k=1}^{3} b_k \frac{\xi}{\xi - \gamma_k} \underline{a}^{-\gamma_k} && \text{(A.74)}
\end{aligned}
$$

Hence, the desired property holds if and only if the second term is equal to zero, which is equivalent to condition (A.66). This concludes the proof. □

When (A.66) holds, the guess, given by (A.64) is an admissible solution if the power exponents $\{\gamma_k\}_{k=1,2,3}$ solve the characteristic equation (21). Using Budan-Fourier theorem, we can show that the three roots are such that $\gamma_1 < 0 < \gamma_2 < \xi < \gamma_3$. The conditions in Lemma 4 yield a linear system for the coefficients $\{b_k\}_{k=1,2,3}$. We can write this system in matrix form as

$$
\begin{pmatrix} A_1 & A_2 & A_3 \\ B_1 & B_2 & B_3 \\ w_1 B_1 & w_2 B_2 & w_3 B_3 \end{pmatrix} \begin{pmatrix} b_1 \\ b_2 \\ b_3 \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \tag{A.75}
$$

where $A_k = \overline{a}^{-\gamma_k}$, $B_k = \underline{a}^{-\gamma_k}$, and $w_k = \xi/(\xi - \gamma_k)$. The solution is given by

$$
\begin{aligned}
b_1 &= \frac{B_3 B_2 (w_3 - w_2)}{D}, && \text{(A.76)}\\
b_2 &= \frac{B_1 B_3 (w_1 - w_3)}{D}, && \text{(A.77)}\\
b_3 &= \frac{B_2 B_1 (w_2 - w_1)}{D}, && \text{(A.78)}
\end{aligned}
$$

where $D = A_1 B_3 B_2 (w_3 - w_2) + A_2 B_1 B_3 (w_1 - w_3) + A_3 B_2 B_1 (w_2 - w_1)$.

To show that $\underline{a} = 0$, we prove that the objective function, given by (A.63) is decreasing in $\underline{a}$. This is equivalent to showing that $\mathbb{E}[p(Sa^\star)]$ is decreasing in $\underline{a}$ for any $\overline{a}$ and $a^\star$, which we show next. We use expression (A.64) to obtain

$$\begin{aligned}
\mathbb{E}[p(Sa^\star)] &= \int_0^\infty p(e^{-s}a^\star)\xi e^{-\xi s} ds \\
&= \int_0^{\ln\left(\frac{a^\star}{\overline{a}}\right)} \xi e^{-\xi s} ds + \sum_{k=1}^3 b_k \int_{\ln\left(\frac{a^\star}{\overline{a}}\right)}^{\ln\left(\frac{a^\star}{\underline{a}}\right)} e^{\gamma_k s} \left(a^\star\right)^{-\gamma_k} \xi e^{-\xi s} ds \\
&= \int_0^{\ln\left(\frac{a^\star}{\overline{a}}\right)} \xi e^{-\xi s} ds + \sum_{k=1}^3 b_k \left(a^\star\right)^{-\gamma_k} \frac{\xi}{\xi - \gamma_k} \left[-e^{-(\xi-\gamma_k)s}\right]_{\ln\left(\frac{a^\star}{\overline{a}}\right)}^{\ln\left(\frac{a^\star}{\underline{a}}\right)} \\
&= \int_0^{\ln\left(\frac{a^\star}{\overline{a}}\right)} \xi e^{-\xi s} ds + \sum_{k=1}^3 b_k \left(a^\star\right)^{-\gamma_k} w_k \left[\left(\frac{a^\star}{\overline{a}}\right)^{-(\xi-\gamma_k)} - \left(\frac{a^\star}{\underline{a}}\right)^{-(\xi-\gamma_k)}\right] \\
&= \int_0^{\ln\left(\frac{a^\star}{\overline{a}}\right)} \xi e^{-\xi s} ds + \left(\frac{a^\star}{\overline{a}}\right)^{-\xi} \sum_{k=1}^3 b_k w_k \overline{a}^{-\gamma_k} - \underbrace{\left(\frac{a^\star}{\overline{a}}\right)^{-\xi} \sum_{k=1}^3 b_k w_k \underline{a}^{-\gamma_k}}_{=0 \text{ by (A.66)}}
\end{aligned}$$

Given that the first term above is not a function of $\underline{a}$, the monotonicity of $\mathbb{E}[p(Sa^\star)]$ with respect to $\underline{a}$ is the same as that of

$$J(\underline{a}) := \sum_{k=1}^3 b_k(\underline{a}) w_k \overline{a}^{-\gamma_k} \tag{A.79}$$

We show that $\underline{a} = 0$ by proving our next result. Before stating that result, observe that a direct corollary is that the only the negative root of (21) is admissible, as otherwise $p(.)$ diverges as $a$ converges to 0. The next result thus concludes the proof of Lemma 3.

**Lemma 5.** *The function $J$ is strictly decreasing with $\underline{a}$. Hence $\underline{a} = 0$ is optimal.*

*Proof.* For all $\underline{a} \in (\underline{a}, \overline{a}]$, we have

$$J'(\underline{a}) = \sum_k w_k \overline{a}^{-\gamma_k} \frac{\partial b_k}{\partial \underline{a}} \tag{A.80}$$

and for $k \in \{1, 2, 3\}$,

$$\frac{\partial b_k}{\partial \underline{a}} = -\frac{\sum_{l \neq k} \gamma_l}{\underline{a}} b_1 - \frac{b_k}{D} \frac{\partial D}{\partial \underline{a}} \tag{A.81}$$

$$\frac{\partial D}{\partial \underline{a}} = \frac{D}{\underline{a}} - \sum_{i=1}^3 A_i b_i \sum_{j \neq i} \gamma_j \tag{A.82}$$

Hence,

$$\frac{\partial b_k}{\partial \underline{a}} = \left[\sum_{i=1}^{3} A_i b_i \sum_{j\neq i} \gamma_j - \sum_{l\neq k} \gamma_l\right] \frac{b_k}{\underline{a}} \tag{A.83}$$

Next, compute

$$\begin{aligned}
\underline{a}J'(\underline{a}) &= \sum_{k=1}^{3} w_k A_k b_k \left[\sum_{i=1}^{3} A_i b_i \sum_{j\neq i} \gamma_j - \sum_{l\neq k} \gamma_l\right] && \text{(A.84)}\\
&= \sum_{k=1}^{3} w_k A_k b_k \left[\sum_{i=1}^{3} A_i b_i \sum_{j\neq i} \gamma_j\right] - \sum_{k=1}^{3} w_k A_k b_k \sum_{l\neq k} \gamma_l && \text{(A.85)}\\
&= \sum_{k=1}^{3} w_k A_k b_k \left[\sum_{i} \gamma_i - \sum_{i} \gamma_i A_i b_i\right] - \sum_{k=1}^{3} \gamma_k \sum_{i} w_i A_i b_i + \sum_{k=1}^{3} \gamma_k w_k A_k b_k && \text{(A.86)}\\
&= -\sum_{k=1}^{3} w_k A_k b_k \sum_{i} \gamma_i A_i b_i + \sum_{k=1}^{3} \gamma_k w_k A_k b_k && \text{(A.87)}\\
&= -\sum_{k=1}^{3} \sum_{i\neq k} w_i A_i b_i \gamma_j A_j b_j + \sum_{k=1}^{3} \gamma_k w_k A_k b_k (1 - A_k b_k) && \text{(A.88)}\\
&= -\sum_{k=1}^{3} \sum_{i\neq k} w_k A_k b_k \gamma_i A_i b_i + \sum_{k=1}^{3} \sum_{i\neq k} \gamma_k w_k A_k b_k A_i b_i && \text{(A.89)}\\
&= \sum_{k=1}^{3} \sum_{i\neq k} (\gamma_k - \gamma_i) w_k A_k b_k A_i b_i && \text{(A.90)}\\
&= \sum_{1\leq k<i\leq 3} (\gamma_k - \gamma_i)(w_k - w_i) A_k b_k A_i b_i && \text{(A.91)}
\end{aligned}$$

To obtain the second equality, we used $\sum_k A_k b_k = 1$ from boundary condition (A.65). We use again this equality to obtain (A.89)from (A.88). Rewriting equation (A.91), we get

$$\begin{aligned}
\underline{a}J'(\underline{a}) = A_1 A_2 (\gamma_1 - \gamma_2)(w_1 - w_2) b_1 b_2 + A_1 A_3 (\gamma_1 - \gamma_3)(w_1 - w_3) b_1 b_3 \\
+ A_2 A_3 (\gamma_2 - \gamma_3)(w_2 - w_3) b_2 b_3
\end{aligned} \tag{A.92}$$

Multiplying both sides of this equality by $D^2$, we obtain

$$
\begin{aligned}
D^2 \underline{a} \frac{\partial J(a;\underline{a})}{\partial \underline{a}} &= A_1A_2(\gamma_1-\gamma_2)(w_1-w_2)B_3B_2(w_3-w_2)B_1B_3(w_1-w_3) \\
&\quad + A_1A_3(\gamma_1-\gamma_3)(w_1-w_3)B_3B_2(w_3-w_2)B_2B_1(w_2-w_1) \\
&\quad + A_2A_3(\gamma_2-\gamma_3)(w_2-w_3)B_1B_3(w_1-w_3)B_2B_1(w_2-w_1) \qquad \text{(A.93)} \\
&= B_1A_1B_2A_2B_3A_3\left((\gamma_1-\gamma_2)\frac{B_3}{A_3}+(\gamma_3-\gamma_1)\frac{B_2}{A_2}+(\gamma_2-\gamma_3)\frac{B_1}{A_1}\right) \\
&\quad \times (w_2-w_1)(w_2-w_3)(w_1-w_3) \qquad \text{(A.94)}
\end{aligned}
$$

Let $f(\gamma) := (\underline{a}/\overline{a})^\gamma$. Since $A_k, B_k > 0$, $w_2-w_1>0$, $w_1-w_3>0$, $w_2-w_3>0$, the sign of $J'(\underline{a})$ is the same as the sign of the term in round parentheses, given by

$$
\begin{aligned}
H &:= (\gamma_1-\gamma_2)f(\gamma_3)+(\gamma_3-\gamma_1)f(\gamma_2)+(\gamma_2-\gamma_3)f(\gamma_1), \qquad \text{(A.95)} \\
&= (\gamma_3-\gamma_1)\left(f(\gamma_2)-f(\gamma_1)-\frac{f(\gamma_3)-f(\gamma_1))}{\gamma_3-\gamma_1}(\gamma_2-\gamma_1)\right), \qquad \text{(A.96)}
\end{aligned}
$$

The function $f(\gamma)$ is strictly convex, because $(\underline{a}/\overline{a}) \in (0,1)$. Hence, $H<0$ for $(\underline{a}/\overline{a}) \in (0,1)$. This proves that $J'(\underline{a})<0$ and thus that the optimal value of $\underline{a}$ is zero. □

## A.5 Proof of Proposition 2

First, rewrite equation (A.63) in the case $\varphi=0$ to obtain Rewriting equation (A.63) for $\varphi=0$, we obtain

$$
\frac{e(a^\star)+1}{a^\star} = \frac{r-\delta^\star+\lambda\left(\frac{a^\star}{\overline{a}}\right)^{-\xi}}{r+\frac{\lambda}{\xi+1}-\mu+\frac{\lambda\xi}{\xi+1}\left(\frac{a^\star}{\overline{a}}\right)^{-(\xi+1)}}. \qquad \text{(A.97)}
$$

To obtain the objective as a function of TMP parameters, let us replace the interest rate for the peg, thanks to equation (17). We have

$$
\begin{aligned}
\delta^\star &= r-\ell(a^\star)+\lambda\left(1-\mathbb{E}[p(a^\star S)]\right), \\
&= r-\ell(a^\star)+\lambda-\lambda\left[\int_0^{\ln(a^\star/\overline{a})}\xi e^{-\xi s}ds+\int_{\ln(a^\star/\overline{a})}^{\infty}\left(\frac{a^\star}{\overline{a}}\right)^{-\gamma}e^{s\gamma}\xi e^{-\xi s}ds\right], \\
&= r-\ell(a^\star)+\lambda-\lambda\left[1-\left(\frac{a^\star}{\overline{a}}\right)^{-\xi}\right]-\lambda\frac{\xi}{\xi-\gamma}\left(\frac{a^\star}{\overline{a}}\right)^{-\xi}. \qquad \text{(A.98)}
\end{aligned}
$$

To obtain the second line, we used equation (20) to substitute for $p(a^*S)$. Substituting for $\delta^\star$ into (A.97), we obtain

$$
e(a^\star)+1 = \frac{\ell(a^\star)+\frac{\lambda\xi}{\xi-\gamma}\left(\frac{a^\star}{\overline{a}}\right)^{-\xi}}{r+\frac{\lambda}{\xi+1}-\mu+\frac{\lambda\xi}{\xi+1}\left(\frac{a^\star}{\overline{a}}\right)^{-(\xi+1)}}. \qquad \text{(A.99)}
$$

Simple computations show that this equation is equivalent to (25) if the liability constraint (26) holds. From Lemma 2, we have $e(a) = 0$ for all $a \in [0, \overline{a}]$ and, from equation (24), $e(a)$ strictly increases with $a$ for $a \in [\overline{a}, \infty)$. Hence, limited liability holds for all $a$ if $e(\overline{a}) = 0$. Using equation (A.58) with $\varphi = 0$ and $p(a^\star) = 1$, condition $e(\overline{a}) = 0$ is equivalent to equation (26). This concludes the proof.

## A.6 Proof of Corollary 1

Proposition 2 shows that an equilibrium with positive equity value exists if there exist $(\overline{a}, a^\star)$ with $\overline{a} \leq a^\star$ such that condition (26) holds. Using equation (25) to substitute for $e(a^\star) + 1$, this condition holds if there exists $a^\star$ and $x \in [0, 1]$ such that

$$\ell(a^\star)x - u - v(\gamma)x^{\xi+1} \geq 0, \quad \text{with} \quad u \equiv r + \frac{\lambda}{\xi + 1} - \mu, \quad v(\gamma) \equiv \frac{\lambda\xi}{\xi + 1} - \frac{\lambda\xi}{\xi - \gamma}. \tag{A.100}$$

To derive implications from this condition, define $H : x \mapsto \frac{x}{u+v(\gamma)x^{\xi+1}}$ and let $x_{max}$ be the value of $x$ where $H$ attains its global maximum on $[0, 1]$. We have

$$H'(x) \propto u - v(\gamma)\xi x^{\xi+1}, \tag{A.101}$$

which is strictly decreasing with $x$ because $v(\gamma) > 0$ since $\gamma < -1$ (Lemma 3). Two cases are then possible. Either $H'(1) = u - \xi v(\gamma) \geq 0$ and $x_{max} = 1$ or $H'(1) < 0$ and $x_{max} = \left(\frac{u}{v(\gamma)\xi}\right)^{\frac{1}{\xi+1}}$ so that overall $x_{max} = \min\left\{1, \frac{u}{v(\gamma)\xi}\right\}^{\frac{1}{\xi+1}}$ and, for a given $a^\star$, a necessary and sufficient condition for the desired equilibrium to exist is

$$\ell(a^\star) \geq \frac{u + v(\gamma)x_{max}^{\xi+1}}{x_{max}} = \frac{u + v(\gamma)\min\left\{1, \frac{u}{v(\gamma)\xi}\right\}}{\min\left\{1, \frac{u}{v(\gamma)\xi}\right\}^{\frac{1}{\xi+1}}}. \tag{A.102}$$

A necessary condition for (A.102) to hold is $\ell(a^\star) \geq u$, which is equivalent to (27). This concludes the proof.

## A.7 Derivation of Equation (31)

As we consider a one-step deviation, the protocol's equityholders reverts back to the commitment policy from date $t + \Delta t$ and $p_\tau = 1$ for all $\tau \geq t + \Delta t$. As a result, we can write the equityholders' continuation value as a function of the next-period shock and the stock of stablecoins chosen at date $t$:

$$E_{t+\Delta t}(A_{t+\Delta t}, C_t) = f(A_{t+\Delta t}) - (1 + \delta_t\Delta t)C_t + \varphi(1 + \mu^k\Delta t)C_t \tag{A.103}$$

Now, we may evaluate the equityholders' gain when deviating from $C(A_t^\star)$ to $\tilde{C}_t$ at date

$t$. If the equityholders implement the commitment policy, they get

$$\begin{aligned} E_t &= -(1+\delta^\star\Delta t)C_{t-\Delta t} + \varphi(1+\mu^k\Delta t)C_{t-\Delta t} + (1-\varphi)C^\star(A_t) \\ &\quad + (1-r\Delta t)\mathbb{E}\left[E_{t+\Delta t}(A_{t+\Delta t}, C^\star(A_t))\right] \qquad \text{(A.104)} \\ &= -(1+\delta^\star\Delta t)C_{t-\Delta t} + \varphi(1+\mu^k\Delta t)C_{t-\Delta t} + (1-\varphi)C^\star(A_t) \\ &\quad + (1-r\Delta t)\mathbb{E}\left[f(A_{t+\Delta t}) - (1+\delta_t\Delta t)C^\star(A_t) + \varphi(1+\mu^k\Delta t)C^\star(A_t)\right] \qquad \text{(A.105)} \end{aligned}$$

If the protocol chooses $\tilde{C}_t$ instead, it gets

$$\begin{aligned} \tilde{E}_t &= -\tilde{p}_t(1+\delta^\star\Delta t)C_{t-\Delta t} + \varphi(1+\mu^k\Delta t)C_{t-\Delta t} + (\tilde{p}_t-\varphi)\tilde{C}_t \\ &\quad + (1-r\Delta t)\mathbb{E}\left[E_{t+\Delta t}(A_{t+\Delta t}, \tilde{C}_t)\right] \qquad \text{(A.106)} \\ &= -(1-\ell(a^\star)\Delta t)(1+\delta^\star\Delta t)C_{t-\Delta t} + \varphi(1+\mu^k\Delta t)C_{t-\Delta t} + (1-\ell(a^\star)\Delta t-\varphi)\tilde{C}_t \\ &\quad + (1-r\Delta t)\mathbb{E}\left[f(A_{t+\Delta t}) - (1+\delta_t\Delta t)\tilde{C}_t + \varphi(1+\mu^k\Delta t)\tilde{C}_t\right] \qquad \text{(A.107)} \\ &= E_t + \ell(a^\star)C_{t-\Delta t}\Delta t + (1-\ell(a^\star)\Delta t-\varphi)\tilde{C}_t - (1-\varphi)C^\star(A_t) \\ &\quad + (1-r\Delta t)\left[-(1+\delta_t\Delta t)\tilde{C}_t + \varphi(1+\mu^k\Delta t)\tilde{C}_t + (1+\delta^\star\Delta t)C^\star(A_t) - \varphi(1+\mu^k\Delta t)C^\star(A_t)\right] \\ &\qquad \text{(A.108)} \end{aligned}$$

where $\tilde{p}_t$ is the price when the equityholders deviate, given by equation (30). Equityholders benefit from the deviation if and only if $\tilde{E}_t \geq E_t$. Keeping only terms of order $\Delta t$ or above, this condition becomes

$$\begin{aligned} 0 \leq \ell(a^\star)C_{t-\Delta t} &+ \left[1-\ell(a^\star)\Delta t - \varphi - (1-\varphi) + \delta_t\Delta t + \varphi\mu^k\Delta t + r\Delta t(1-\varphi)\right]\tilde{C}_t \\ &+ \left[-(1-\varphi) + (1-\varphi) + \delta^\star\Delta t - \varphi\mu^k\Delta t - r(1-\varphi)\Delta t\right]C^\star(A_t) \qquad \text{(A.109)} \end{aligned}$$

From equation (30), we have

$$\tilde{p}_t = 1 - \ell(a^\star)\Delta t = 1 - (r-\delta_t)\Delta t$$

and, by definition, $\ell(a^\star) = r - \delta_t$. Substituting in (A.109), we obtain

$$0 \leq \ell(a^\star)C_{t-\Delta t} - \varphi(r-\mu^k)\tilde{C}_t - \left[\ell(a^\star) - \varphi(r-\mu^k)\right]C^\star(A_t) \qquad \text{(A.110)}$$

which, given that $C_{t-\Delta t} = C^\star(A_{t-\Delta t})$ is equivalent to condition (31). This concludes the proof.

## A.8 Proof of Proposition 3

The first part of Proposition 3 follows from the argument in the text. If $p_t > \varphi$, a vault owner can get an infinite profit by issuing stablecoins backed by collateral, which is incompatible with $p_t$ being an equilibrium price.

To obtain the second part of Proposition 3, we derive the dynamic equation for a vault value. From equation (34), the vault value at date $t$ per coin outstanding is $\varphi - p_t$. As mentioned in the main text, the vault value is independent of the amount issued, so we can derive it as if the vault owner issued zero stablecoins. We thus have

$$\varphi - p_t = -s_t p_t dt + \varphi \mu^k dt + (1 - rdt)\mathbb{E}_t[(\varphi - p_{t+dt})]. \tag{A.111}$$

In equation (A.111), the first (second) term corresponds to the collateral cost generated by the protocol's fee policy (the return on collateral). Expanding the term of equation (A.111) inside the expectation, we have

$$\varphi - p_t = -s_t p_t dt + \varphi \mu^k dt + (1 - rdt)\mathbb{E}_t \left[ \varphi - p_t - dt \frac{dp_t}{dt} \right]. \tag{A.112}$$

Observe that the term $\mathbb{E}_t[dp_t]$ must be of order $dt$ in equilibrium, otherwise the price would violate no arbitrage. Then, keeping only terms of order $dt$ in (A.112) and rearranging, we obtain equation (36). This concludes the proof.

## A.9 Proof of Proposition 4

The HJB equation for the price is

$$p_t = \ell_t \mathbb{1}\{p_t = 1\}dt + \delta_t \mathbb{1}\{p_t = 1\}dt + (1 - rdt)\mathbb{E}\left[p_{t+dt}\right]. \tag{A.113}$$

Keeping only terms of order dt, we obtain

$$rp_t = \ell_t \mathbb{1}\{p_t = 1\} + \delta_t \mathbb{1}\{p_t = 1\} + \mathbb{E}_t \left[ \frac{dp_t}{dt} \right] p_t. \tag{A.114}$$

Combining equations (36) for $\varphi = 1$ and (A.114), we get

$$(s_t - \delta_t)p_t = \ell_t \mathbb{1}\{p_t = 1\} + \mu^k - r. \tag{A.115}$$

The maximization problem is then given by

$$E_t = \max_{\tau,s,\delta} \mathbb{E}_t \left[ \int_0^\tau e^{-r(s-t)} \Big( \ell_s \mathbb{1}\{p_t = 1\} + \mu^k - r \Big) C_s ds \right] \tag{A.116}$$

subject to $\varphi - p_t \geq 0$. Hence, the protocol's equityholders choose the policy that maximizes the present discounted value of seigniorage revenues net of collateral costs. This means that the protocol seeks to implement the same policy as in the full-commitment outcome of Proposition 1. In particular, it seeks to implement supply rule (38) and interest rate rule $\delta^* = r - \ell(a^\star(1))$.

We are left to show how the protocol can implement the desired policy when it does not directly control issuance. From arbitrage condition (36), their supply function is a step function given by

$$d\mathcal{G}^i = \begin{cases} +\infty & \text{if} \quad s_t p_t < \mu^k - r + rp_t - \mathbb{E}_t\left[\frac{dp_t}{dt}\right], \\ -C^i_{t\text{-}} & \text{if} \quad s_t p_t > \mu^k - r + rp_t - \mathbb{E}_t\left[\frac{dp_t}{dt}\right], \end{cases} \tag{A.117}$$

and it is indeterminate if $s_t = (\mu^k - r)/p_t + r - \mathbb{E}_t[dp_t/dt]$. To satisfy equation (36) and implement the price peg at the target $a^\star(1)$, we must have $s^\star = \mu^k$. To implement $C^\star(A, 1)$, the protocol uses a fee schedule contingent on the amount of stablecoins, whereby vault owners are induced to issue (buy back) stablecoins if $C > C^\star(A, 1)$ ($C < C^\star(A, 1)$). Such a schedule is given by (39). In this case, the only equilibrium supply is $C_t = C^\star(A, 1)$. In particular, we have $s^\star - \delta^\star = \ell(a^\star(1)) + \mu^k - r$. This last equation combined with $s^\star = \mu^k$ implies that $\delta^\star = r - \ell(a^\star(1))$. This concludes the proof.