Radical Responsibility

A Foreword to the SPOT Paper

In light of recent events, we feel it is appropriate to externalize our views on radically responsible protocol design before jumping into a detailed outline of SPOT, our forthcoming inflation-resistant store of value. Following the collapse of Terra, Vitalik Buterin posed two questions to be asked of automated stablecoins in May 2022[1]:

1. "Can the stablecoin, even in theory, safely wind down to zero users?"
2. "What happens if you try to peg the stablecoin to an index that goes up 20% per year?"

The first question, we interpret as a proxy for a broader important question: *Is the system's design responsible?* If an automatic system cannot wind down safely to zero users then it is likely a ticking time bomb that assumes bailout capital will intervene to avoid calamity. Such bailouts are not a luxury afforded to issuers of independent money.

The second question, we interpret as a proxy for another broader important question: *Does the asset need to exist?* Let's imagine a system, pegged to CPI, that begins fully collateralized by US dollars. Let's also imagine the dollar is experiencing price-inflation at a rate of 20% per year. Over time, such a system either becomes less and less collateralized or its token price tracks the purchasing power of the US dollar, invalidating its reason for existing.

Radically Responsible Protocol Design

The global and permissionless nature of blockchain technologies calls for truly complete economic designs. Radically responsible protocol design is not an appeal to meet the standards of traditional finance, but rather an appeal to profoundly surpass the design standards of traditional finance.

It is too often the case that today's DeFi developers build and deploy with the impression that moving fast and breaking things is a good practice. Given the scale of assets committed, the interconnectedness of these financial systems, and the general lack of intellectual discretion displayed by market participants, we consider this mentality to be highly irresponsible.

To embrace the path of moving fast and breaking things, is to invite catastrophe and after-the-fact regulation in an ever repeating cycle when the real opportunity presented here is to create greater financial stability through greater transparency.

As responsible stewards of decentralized finance:

- **We cannot obfuscate risk**. Risk must be presented as transparently as possible, such that it can be priced.

[1] Vitalik Buterin. "Two thought experiments to evaluate automated stablecoins." May 25, 2022. Available at https://vitalik.ca/general/2022/05/25/stable.html

- **We cannot assume that bailouts are forthcoming**. Every market scenario, including potential unwinding, must be handled gracefully *a priori*.

Achieving this requires that we think more like mathematicians and less like scientists. We should either be happy living with a protocol's complete space of outcomes (at least in theory) or we should return to the drawing board and continue working before deploying to the public.

Applying these standards to SPOT, yes, SPOT can gracefully wind down to zero users without bailouts. More broadly, for every conceivable market scenario, there exists an equilibrium price for SPOT that reflects the value and risk of its collateral precisely because risk is transparent. Lastly, SPOT can gracefully resume even after winding down.

Radically Simple Purpose

What makes our purpose simple is the fact that 1) vulnerability to inflation is a monetary problem that predates the advent of blockchain technology, 2) price-inflation remains a meaningful problem today, and 3) there's reason to believe that independent issuers of on-chain money can produce assets that compete to offer better refuge from inflation.

Just a Basket of Assets

Without getting into the full details, we can ground these principles and demonstrate their key benefits by discussing the SPOT system's design at a high level.

The SPOT token is simply a redeemable claim on a basket of on-chain collateral.

- **Example A:** Let's imagine Alice holds 10 SPOT tokens and there are 1000 SPOT tokens in total circulation. Alice owns 1% of SPOT's circulating supply and she can redeem her 10 SPOT tokens for 1% of the collateral set at any time.

The price of SPOT is left up to the market and will ultimately reflect the value of what the token is redeemable for in a collateral set. If the value of the collateral set goes up, the price of SPOT will likely go up, if the value of the collateral set goes down the price of SPOT will likely go down.

In the event that there are multiple asset types in the collateral set, SPOT tokens redeem proportionally:

- **Example B**: Let's again imagine Alice holds 10 SPOT tokens and there are 1000 SPOT tokens in total circulation. This time, however, let's imagine the collateral set comprises two classes of assets A and B. When Alice redeems her 1% of SPOT tokens, they are released proportionally. This means Alice receives 1% of the A tokens in the collateral set and 1% of the B tokens in the collateral set.

Since all assets are distributed proportionally upon redemption, the ratio of tokens comprising the collateral set remains equivalent before and after any given redemption. Looking strictly at the effect of withdrawals, this means the value of SPOT remains the same even as withdrawals unwind to an empty set.

There are no pegs, feedback loops, or liquidation markets used in the system's design. However, due to unique properties of how the system's collateral is prepared and rotated, the redeemable value of 1 SPOT token will tend towards 1 CPI adjusted dollar.

The SPOT whitepaper 1) details how collateral is prepared and rotated, 2) explains why this results in the value of SPOT claims tending towards 1 CPI-adjusted dollar, and 3) outlines a system of incentives for rotating fresh tranches in and mature tranches out.

There are several simple and remarkable components detailed in the paper that we expect to see used throughout the space and we encourage you to give it a close read.

In the end, however, the fact remains that SPOT is simply a freely redeemable claim on a basket of on-chain collateral. Catastrophic outcomes commonly associated with stablecoins like "peg-breaks', "bank-runs", "cascading liquidations," and "liquidity crunches," simply do not apply—much as they simply do not apply to Uniswap-V2 LP tokens.

SPOT — An Inflation Resistant Store of Value

Evan Kuo, Brandon Iles, Nithin Krishna, Manny Rincon-Cruz

October 2022

Abstract

Permissionless, peer-to-peer, cryptocurrencies have been successfully developed, but these are too volatile to be used non-speculatively. Alternatively, Treasury-backed stablecoins and central bank digital currencies can work as dollar substitutes, but they do not solve the current problem of inflation, a perennial weakness of all post-1970 fiat currencies. This paper presents a path beyond speculative tokens and dollar substitutes. We describe and outline a unique contribution that combines AMPL (an inflation-tracking unit of account) with Buttonwood Tranche (a protocol for resegmenting volatility into collateralized tranches) to produce SPOT—an inflation-resistant store of value.

1 Background

Since its launch in 2009, Bitcoin has proved to be a resilient, censorship-resistant asset, but it falls short of delivering on the promise of a peer-to-peer digital-cash.[1] So much so, that the industry has christened Bitcoin "digital gold." But like real gold, Bitcoin experiences unit-price volatility and deflation, which undermines its use as a unit of account and store of value.[2] And in the past decade, thousands of permissionless floating-price tokens have followed Bitcoin's suit.

Thus far, developers have attempted to address the shortcomings of Bitcoin and other floating-price tokens with privately-issued stablecoins—tokens which attempt to maintain a "stable" peg with a sovereign currency like the dollar. Centralized stablecoins, like Circle's USD Coin (USDC) and Tether's USDT are merely claims against assets held by Circle's and Tether's custodian companies. Yet decentralized stablecoins like MakerDAO's DAI, have ironically resorted to including tokens like USDC in order to reduce exposure to the volatility of their underlying collateral.

Mainstream economists, on the other hand, have championed CBDCs (such as China's e-yuan) over privately-issued stablecoins. Their conclusion is that in a fiat-dominated system, only the state can provide information-insensitive and run-proof money, leaving no room at all for privately-issued cryptocurrencies.[3]

However, there are two issues with CBDCs, and dollar substitutes more generally. What matters to a citizen is not that a "ten-dollar bill should be accepted as being worth ten dollars, not a penny less." What matters is that a ten-dollar bill can purchase more or less the same basket of goods today as it does tomorrow. Measured against its purchasing power, state-issued money remains always and everywhere sensitive to information about monetary policy.

Given that fiat currencies like the US dollar are already widely available—and vulnerable to inflation by discretionary policymaking—skeptics are correct to question whether any differentiated, non-speculative, utility has been created by these on-chain dollar-substitutes. A *reliable*, *decentralized*, *inflation-resistant*, refuge from volatility has yet to be produced.

Aside from stablecoins and CBDCs, we believe there is a third solution available to Satoshi's puzzle of digital cash. Thus, this paper outlines SPOT—a permissionless, peer-to-peer, inflation-resistant store of value which is non-runnable.

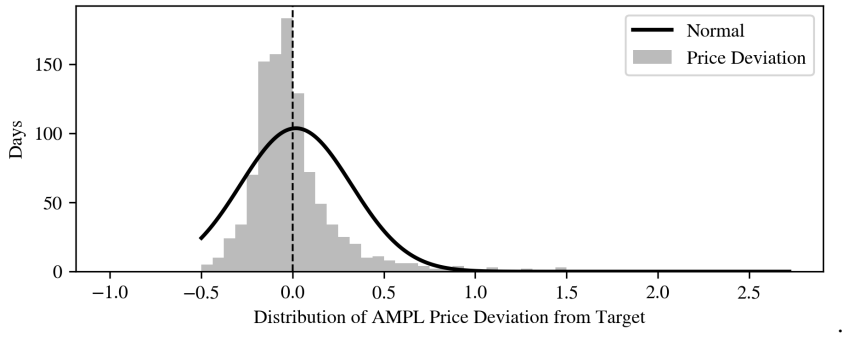
The first part of this solution is Ampleforth, a protocol that transfers its volatility of demand from price per AMPL token to the quantity of AMPL tokens held in user wallets. Launched in 2019, AMPL targets the CPI adjusted dollar and has effectively done so through extreme market conditions.[4]

[1] Satoshi Nakamoto. "Bitcoin: A Peer-to-Peer Electronic Cash System." paper available at: https://bitcoin.org/bitcoin.pdf. whitepaper

[2] In the inflationary 1970s, gold rose in price by 463% before declining 61% after Paul Volcker raised rates. Bitcoin's price moves are even more dizzying, surging 1,380% from its lows in March 2020 before declining 71% this year.

[3] Gorton, Gary B. and Zhang, Jeffery, Taming Wildcat Stablecoins (September 30, 2021). University of Chicago Law Review, Vol. 90, Forthcoming, Available at SSRN: https://ssrn.com/abstract=3888752

[4] Ampleforth Network Durability Report: https://docs.ampleforth.org/reports/ampleforth-network-durability



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But holders of AMPL still experience high float volatility, similar in measure to the price volatility that characterizes all non-collateralized digital assets. For this reason, AMPL can be used as a decentralized unit of account, but not as a refuge from volatility. Which leaves us asking—*can we insulate users from AMPL's supply volatility altogether?* If a variation or derivative of AMPL could be created that somehow shares AMPL's price volatility, but not its supply volatility, such an asset could be used as an inflation-resistant store of value.

The second part of this solution combines AMPL with Buttonwood Tranche, a protocol for separating the supply volatility of unit-of-account tokens, like AMPL, into junior, equity-like tranches and senior, debt-like tranches.

Noting that senior tranches would be significantly less volatile than underlying AMPL, the Buttonwood Stable white paper was first to suggest using senior tranches to collateralize a stablecoin, but it did not specify how such a system would be built, how it would avoid runs, nor how it would avoid degradation in times of low demand.[5]

Elaborating on that idea and going further still, the SPOT protocol abstracts AMPL's supply changes from its holders by issuing a token that is a claim on a perpetually rotating collateral set of senior tranches. It has rules that create incentives for users to autonomously renew the tranches within the contract while also making SPOT run-resistant. Furthermore, because of its novel collateralized design, SPOT does not experience disruptive feedback loops and abrupt changes in value. For that reason, it has the potential to serve as a decentralized safe-asset collateral alternative to USDC or as a form of peer-to-peer digital cash.

SPOT is a unique solution that weaves between the rock and hard place of speculative assets and dollar substitutes. Where AMPL is an inflation-tracking unit of account, SPOT is an inflation-resistant store of value.

In Section 2 we provide an overview of Ampleforth and Buttonwood Tranche, the two protocols comprising SPOT, and explore the properties of the AMPL tranches that serve as collateral for SPOT. In Section 3 we present the SPOT protocol. We outline its three main public functions—mint, redeem, and rollover—and explore the financial properties of its notes. In Section 4 we explain how the minting, redemption, and rollover rules in SPOT make it run-resistant, and in Section 5 we

[5]Manny Rincon-Cruz. "ButtonStable– A Blueprint for a Money-Like Note." March 11, 2021. Available at https:// stable.button.finance/whitepaper

explore the scenarios under which the price of SPOT tokens can deviate from that of a single AMPL token.

2 Overview

SPOT combines two protocols, Ampleforth and Buttonwood Tranche.

- **AMPL**: is the underlying collateral asset used in the SPOT system. AMPL's key distinction is that its price targets the CPI adjusted dollar and can thus be used as a durable, inflation-resistant, unit-of-account.
- **Tranche**: Is a protocol for separating the supply volatility of unit-of-account tokens, like AMPL, into two or more tranches. .

AMPL is a price-stable but supply-volatile cryptocurrency. Rather than price increasing and decreasing with demand, the quantity of tokens in user wallets increases and decreases with demand.

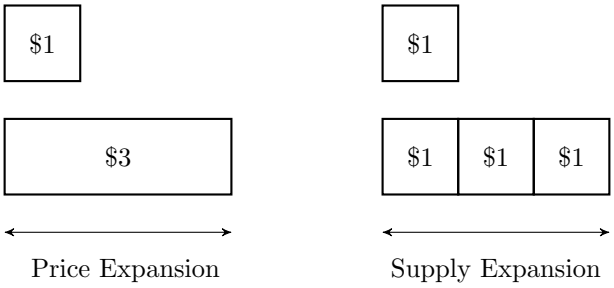

Figure 1: Price vs Supply (Volatility)

In Figure 2 we show the difference between price expansion and supply expansion. On the left, as demand increases the price of a token increases correspondingly. On the right, as demand increases, the quantity of units increases but the price per unit remains constant. In practice, the automatic process of adjusting supply in response to demand takes time to find equilibria, but the long-run result is a price-stable but supply-volatile cryptocurrency.

Tranche allows users to separate the supply volatility of unit-of-account tokens like AMPL into separate tranches.

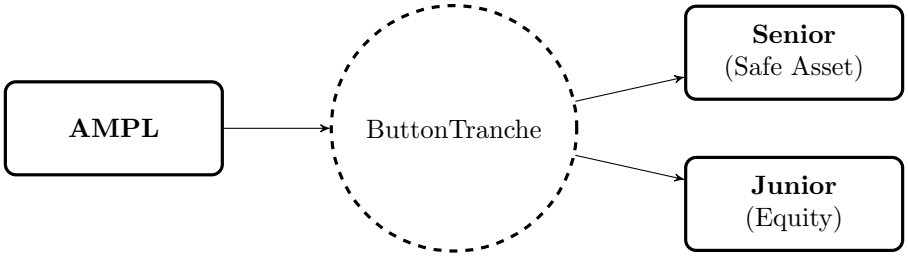

Figure 2: Senior and Junior Tranching

Each tranche is an ERC-20 token that is redeemable for AMPL at a predetermined maturity date. The Tranche protocol accepts as its inputs:

- **Maturity Date**: A future date and time at which tranches mature and become redeemable for collateral.
- **Tranche Ratios**: An ordered list of values, adding to 1, determining the distribution and seniority with which supply changes propagate to various tranches.

When AMPL is deposited into Tranche, two or more tranches are created. We can illustrate this process with just two tranches, a senior tranche and a junior tranche, where junior tranches are more exposed to AMPL's underlying supply expansion or contractions than the senior tranches.

When the underlying AMPL collateral's supply expands beyond the amount initially deposited, the excess AMPL accrues only to the junior tranche. In Figure 3, the junior tranche benefits from the underlying expansion, while the senior tranche is unaffected.

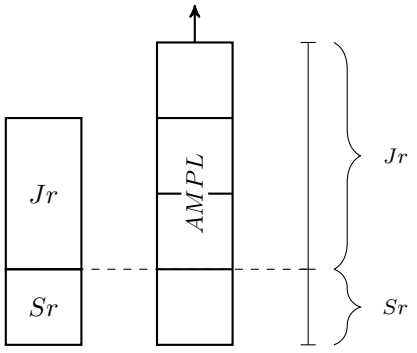

Figure 3: Tranche Under Supply Expansion

When the underlying AMPL collateral's supply contracts beneath the amount initially deposited, the supply reduction affects junior tranches first before senior tranches are affected. In Figure 4, the underlying supply contraction propagates only to the junior tranches.

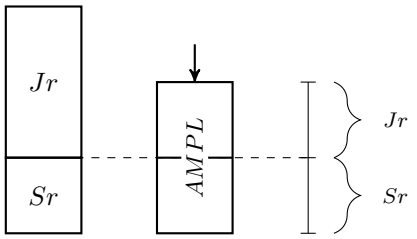

Figure 4: Tranche Under Supply Contraction

We can thus deduce the following:

- **Senior Tranches**: Behave like "safer assets" that can be used as collateral because they are insulated from, but not immune to, AMPL's supply volatility.
- **Junior Tranches**: Behave like "equity" because they are first in line to absorb AMPL's supply expansions or contractions, which are in turn produced by increases or decreases in AMPL's overall network demand.
- **Conservation of Collateral**: The total sum of AMPL tokens for which senior and junior tranches can be redeemed will always equal the number of AMPL that would have remained if the AMPL collateral were simply held over the same time period.

3 The SPOT Protocol

SPOT is a fungible ERC-20 token and claim on a perpetually rotating set of senior AMPL tranches. Because these tranches are backed by AMPL, which is an inflation-tracking unit-of-account, this makes SPOT an inflation-resistant store of value.

In this section we cover the basic mechanics of the SPOT system before exploring its possible financial behavior.

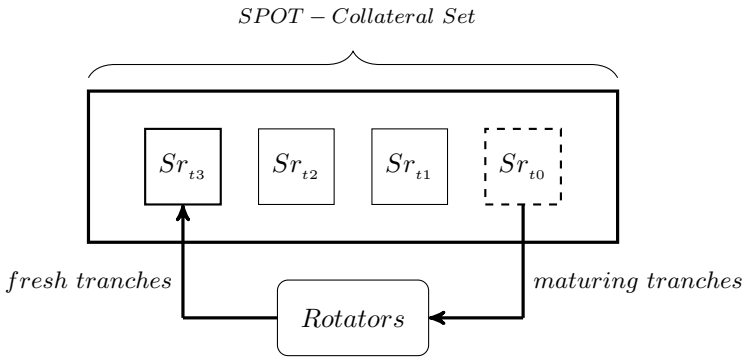

Figure 5: SPOT collateralized note

Senior tranches are less volatile than their underlying collateral and could be used as a store of value, but they are not fungible across vintages. This is because different vintages mature at different times and might have endured different market conditions, which affects their level of underlying collateralization. Moreover, tranches have maturity dates at which point they expire.

SPOT is a contract that produces notes collateralized by a perpetually rotating set of AMPL senior tranches. It has rules that create incentives for users to autonomously renew the tranches within the contract while also ensuring SPOT is run-resistant. At its core, the SPOT system has three public user operations. Users can:

- **Mint**: By depositing tranche tokens in exchange for SPOT.
- **Redeem**: By exchanging SPOT for tranche tokens.
- **Rollover**: By depositing new tranche tokens and withdrawing old tranche tokens.

In addition to the above functions, SPOT also implements innovative mechanisms which are crucial to the idea of a tranche-backed money-like note. We describe the four most important of these ideas in more detail below:

1. Active Minting Bond
2. Collateral Set
3. Proportional Redemption
4. Rolling over Maturing Tranches and/or the Holding Pen

3.1 Active Minting Bond

At any given time SPOT can only be minted by depositing tranche tokens from a single "active minting bond." The Minting Bond is refreshed periodically at a configured frequency.

Minters pay a percentage-based minting fee.

3.2 Collateral Set

SPOT is backed by a set of senior AMPL tranches as collateral. If a tranche token inside SPOT matures and is not rolled out in a timely fashion, the underlying AMPL are automatically redeemed and placed into a special data structure called the holding pen.

Thus, the collateral set consists of immature tranches and sometimes raw AMPL in the holding pen.

The holding pen both 1) holds raw AMPL and 2) stores a number $\_matureTrancheBalance$ that records the number of tranches that have been redeemed and whose AMPL collateral is still in the holding pen. $\_matureTrancheBalance$ increases every time mature tranches are redeemed for AMPL, and decreases every time users rollover AMPL out of the holding pen.

For more details see the technical appendix.

3.3 Proportional Redemption

SPOT redemptions are proportionally withdrawn from its entire collateral set. In other words, if a user redeems 1% of the total SPOT supply, they will receive both 1% of each tranche vintage in SPOT and 1% of the AMPL in SPOT's holding pen.

Users pay a percentage-based redemption fee.

3.4 Rollover

Rolling over is the process of withdrawing stale collateral from SPOT and replacing it with tranches minted from the new minting bond.

SPOT stores a value called $\_minTrancheMaturitySec$, which is the minimum amount of time to maturity a tranche must have left before it is no longer considered "fresh." Once a tranche ages past this limit, it is considered stale and available to be rolled over.

When rolling over stale tranches, a user will deposit N tranche tokens from the active minting bond and choose which stale collateral they want to receive in return. The system determines, based on equal value[6], how many of the stale collateral to return to the user.

The holding pen is rolled out the same way as stale tranches, except AMPL is returned instead of tranche tokens. When the user is due T "tranches," they receive $(T/\_matureTrancheBalance) * holdingPenBalance$ in AMPL. In other words, we can think of $\_matureTrancheBalance$ as "virtual tranches" that represent proportional claims on the AMPL in the holding pen.

Users that rollover receive a percentage-based reward.

For details on rollover scenarios and incentives (including rolling over tranches that are impaired) see appendix A.

3.5 SPOT's Financial Behavior

From a certain perspective, senior tranches are tokens freely redeemable for claims on "future AMPL," and these claims are heavily insulated from AMPL's supply volatility. And since the price of AMPL always reverts to the 2019 CPI adjusted dollar, 100 SPOT are more or less a claim on 100 AMPL tranches, which are a claim on 100 future AMPL, each worth 100 CPI adjusted dollars. For this reason, we expect SPOT's **value** will loosely track AMPL's price target when it is collateralized by fresh tranches.

However, while SPOT's **value** is roughly that of a CPI-adjusted dollar, its **price** is still subject to a variety of market behaviors and macroeconomic forces which is a combination of many complex factors. Refer to the appendix for a discussion on possible differences between SPOT's value and price in the market.

[6] A straightforward method of valuing an incoming or outgoing tranche is to simply count the number of Unit of Account (AMPL) tokens backing them

4 Runnability

A mainstream criticism of privately issued cryptocurrencies backed by collateral is that they are prone to runs. In this section we describe how SPOT equips a novel, blockchain-enabled solution to the perennial problems of runs–Proportional Redemption.

4.1 Free Redemption vs Collateral Choice

Douglas Diamond's and Philip Dybvig's seminal "Bank Runs, Deposit Insurance, and Liquidity," articulated a game theoretic model for bank runs.[7] The basic insight is that runs do not occur because a bank or institution is insolvent. Runs can be "self-fulfilling prophecies."

A customer might think the bank has made too many loans—even highly profitable loans—and might therefore not be able to redeem his deposits for cash on demand. When a bank cannot redeem deposits it declares bankruptcy, leaving the customer stuck as the bank collects on loans. This customer thus redeems his deposits for cash, just to be safe. This only makes it more likely that another customer reaches the same conclusion and also redeems his deposits. Thus, a wave of customers will seek to redeem their deposits at the same time, triggering the bankruptcy they all feared.

Generalizing from the intricacies of traditional banks, we find two key features to consider with respect to runnability—free redemption and collateral choice.

- **Collateral choice**: allows users to choose which type of collateral they would like to redeem for, in a multi-collateral system.
- **Free redemption**: allows users to redeem as much collateral as they see fit on demand with no restrictions.

Broadly speaking, a note contract is runnable if it allows both of these features simultaneously. To make a note contract like SPOT non-runnable, a choice between these two must be made.

- **Collateral choice**: If a contract allows collateral choice on redemption, note-holders will choose the collateral they perceive to be the most valuable. As long as notes can be freely redeemed on-demand, the entire contract will be drained of collateral, beginning from the most valuable and ending with the least valuable, distributed on a first-come first-served basis. Restricting redemption would be required to halt these runs.
- **Free redemption**: A user is provided free redemption on-demand but the note contract decides which collateral is returned. The contract must ensure there's no reason for users to redeem their notes in a race ahead of others, while ensuring that the note-collateral relationship is meaningful.

4.2 Proportional Redemption

SPOT chooses free redemption over collateral choice to avoid runnability.

SPOT is collateralized by senior AMPL tranches, but these tranches are of different vintages. It is

[7] Douglas Diamond and Philip Dybvig. "Bank runs, deposit insurance, and liquidity". Journal of Political Economy. 1983: 401–419

possible that users can think of these as more or less valuable, depending on their maturity dates and varying collateralization ratios, which reflect the unique market conditions each vintage has experienced.

A solution to the collateral choice problem which is uniquely implementable in a blockchain environment is proportional redemption.

Proportional redemption means that every user redeeming a note will receive the same distribution of collateral assets. This is the equivalent of a bank depositor not receiving just cash on redemption, but a combination of cash and a slice of the bank's loan portfolio. Since every user receives a proportional slice of every asset in the collateral set, there is no benefit to being first and no opportunity to receive more valuable assets. Thus there is no incentive to form a run.

5 Degradation Scenarios

SPOT functions smoothly in all scenarios, and a reduction in the demand for SPOT or AMPL produces a gradual transition rather than a rapid phase change or "breaking" behavior.

In May 2022, Vitalik Buterin posed two thought experiments to any would-be money-like token.[8] One of those thought experiments asked if a stablecoin can safely wind-down to zero users. Since SPOT represents a share ownership over a collateral set and there is no restriction in redemption, SPOT can safely wind down to zero users in an orderly fashion. For every market scenario affecting SPOT and AMPL there exists a stable equilibrium between the value of the system's collateral and the price of SPOT.

The SPOT system can exist **only** in three possible collateral states:

- **Fresh**: Collateralized entirely by immature tranches
- **Mixed**: Collateralized by a mix of AMPL in the holding pen and immature tranches
- **Mature**: Collateralized entirely by AMPL in the holding pen

In a fully Fresh state, SPOT's value is roughly that of a CPI adjusted 2019 dollar. As explained above, its price might deviate above or below depending on the demand for and supply of inflation protection.

In a fully Mature state, SPOT's value is equivalent to the value of the AMPL in SPOT's holding pen. In this state, holding SPOT is equivalent to holding a non-dilutive percentage of the AMPL network.

A Mixed state represents a point on the continuum between Fresh and Mature states. At any point in this continuum the system can be moved directionally away from the Mature state and towards the Fresh state by rolling over.

However, at no point does SPOT enter reflexive death spirals, trigger a run, or require bailouts.

[8] Vitalik Buterin. "Two thought experiments to evaluate automated stablecoins." May 25, 2022. Available at https://vitalik.ca/general/2022/05/25/stable.html

This is because at redemption there is no feedback loop responding to market prices. SPOT uses no external data feed and no oracle. SPOT is simply a one-directional claim on its underlying collateral.

Below we discuss three degradation scenarios which move SPOT from Fresh to Mature.

5.1 Rollovers Halting

The process of rolling over, described above, keeps the system fresh by replacing old tranches that are near maturity with new tranches that are far from maturity.

Although a percentage-based fee reward is paid to users who rollover, there may come times when users are unwilling or unable to deposit new tranches in exchange for tranches within the $minMaturityThreshold$ or assets in the holding pen. This puts the system in the Mixed state, where the collateral set contains a combination of active senior tranches and raw AMPL in the *holding pen*.

If rollovers cease for an extended stretch of time, an increasing fraction of the collateral set will mature and be collected in the holding pen as raw AMPL. Eventually, the system would enter a Mature state where all collateral has been claimed as raw AMPL in the holding pen.

For every point in this continuum of non-rollover states, there exists an equilibrium price of SPOT that reflects the value of its collateral.

5.2 Downward Pressure on AMPL

In the event of excessive downward pressure on AMPL price or prolonged supply contraction, we expect the price of SPOT to similarly correct downwards. Recall that there is always an equilibrium price that reflects the market value of collateral that SPOT is redeemable for, and the system is freely redeemable. Users could:

- **Sell SPOT**: until the collateral set is in equilibrium with SPOT's market cap
- **Mint + Sell SPOT**: this both recapitalizes SPOT, bringing up its collateral value, while decreasing SPOT's price, rapidly bringing both into equilibrium. *Note that users would either have to already be holding AMPL to mint or buy AMPL to mint, which would doubly move prices towards an equilibrium.*

In short, **SPOT can be overpriced but it cannot be undercollateralized.** This is one of the key benefits of avoiding hard pegs, i.e. redemption functions which take as an input the stablecoin's exchange rate. Using the the stablecoin's price as an input in its redemption function creates feedback loops:

- When DAI became undercollateralized (March 2020), markets were incentivized to purchase DAI from circulation in order to liquidate borrowers, driving up the price of DAI and making it increasingly difficult to remove enough DAI from circulation and restore health. Ultimately the collapse required a bailout, MKR holder dilution, and the inclusion of centralized USDC collateral to return function.
- When Terra LUNA suffered a price collapse, the corresponding downward price deviation on UST (the stablecoin issued against LUNA) triggered hyperinflation. The price decline, rather

than bringing the asset's price back into equilibrium with its collateral, became an intractably growing liability over time.

5.3 Downward Pressure on SPOT

In the event of a major SPOT sell-off, the price of SPOT would move downward in the market. If SPOT's price fell below the value of its collateral, there would be an incentive to purchase SPOT and redeem it for collateral until the price of SPOT is inline with the value of the collateral. *Note that unlike price deviations in a hard-peg system with feedback loops, this state does not become a growing liability over time and does not in any way influence the supply of AMPL.*

6 Conclusion

Throughout our efforts, we've sought foremost to utilize this technology to solve problems that otherwise couldn't be solved. Accepting that vulnerability to inflation is the central weakness of discretionary fiat currencies, it is our view that the opportunity presented before developers of independently-issued monies is precisely one of providing refuge from demand-driven global money-printing cycles.

However unlike state-issued monies, independently-issued monies cannot force adoption and they cannot be assured bailout opportunities. The SPOT protocol shows we can push beyond speculative assets and dollar-substitutes to produce an inflation-resistant store of value. More importantly, it shows this can be done in a peer-to-peer fashion responsibly.

SPOT's design reflects our belief that risk ought to be presented transparently so that it can always be priced. Moreover, it reflects our opinion that fundamental monetary building blocks should avoid using liquidation markets and requiring buyers of last resort to intervene in times of low demand.

Lastly SPOT's design reflects our belief that markets are unpredictable, and for this reason long-lived systems should avoid feedback loops, lest that impair their ability to gracefully weather a maximum range of market scenarios.

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Appendices

A Discussion of System Incentives

In this section we'll expand on some of the incentives that uphold the SPOT system, but first it's worth noting that minting, redeeming, and rolling over, are power user methods. We expect most holders of SPOT and AMPL will simply be buying and selling the assets on the open market.

A.1 Minting Incentives

Minting is the process of depositing senior AMPL tranches in exchange for SPOT. There are two main minting incentives:

- Borrowing Against Collateral
- Arbitrage

A.1.1 Borrowing Against Collateral

Minting allows users to borrow against existing collateral while maintaining their AMPL position. This is similar to taking out a loan against a piece of land in the form of a mortgage.

- Imagine Alice has a long-term position in AMPL, but she also has near-term cash flow needs. Alice can tranche her AMPL into junior and senior tranches. Then she can mint SPOT with her senior tranches while holding onto her junior tranches. Now she can spend or invest her SPOT while maintaining most of her equity position in AMPL.

A.1.2 Arbitrage

If SPOT is trading at higher than the market value of its collateral, users can mint SPOT to capture the difference.

A.2 Redeeming Incentives

Redemption is the process of exchanging SPOT for proportional slices of its collateral set. There are two main redemption incentives:

- Liquidity
- Arbitrage

A.2.1 Liquidity

Typically if a user wants to exit their SPOT position they would simply sell it on the market, but SPOT is always freely redeemable for its collateral. If a user believes they can exit their position with less slippage by first converting to the underlying, this option is always available to them.

A.2.2 Arbitrage

If users believe SPOT is trading at less than the market value of its collateral, they can redeem SPOT to capture the difference.

A.3 Rollover Incentives

Rolling over is the process of withdrawing senior AMPL tranches that are nearing maturity and depositing an equal value of AMPL tranches from the active deposit bond. Timely rollovers ensure that the system is maximally insulated from supply changes. A percentage reward is paid to users who rollover, based on the SPOT denominated amount of collateral being rolled out. There are two sources for the rollover incentives:

- Fee Buffer
- New Emissions

A.3.1 General Reward Example

Imagine Alice rolls out R fully collateralized tranches representing 1% of the collateral set value, and rolls in R fresh tranches. If the SPOT supply is 1M, the SPOT denominated value Alice rolls over is 1% of 1M = 10,000 SPOT. If the rollover_reward is 2%, Alice will receive 200 SPOT as reward for her work.

A.3.2 Emission Reward Example

Imagine the same Alice rollover example as above. Alice is owed 200 SPOT, but there are only 100 SPOT remaining in the fee buffer. Alice will receive those 100 SPOT plus 100 freshly minted SPOT.

This emission has the effect of diluting SPOT holders, but only by a rule-bound, constant, rate. We regard a fixed k% emissions system to be perfectly acceptable, but we will launch with rewards and emissions set to 0%. This can be later enabled through governance.

A.3.3 Rolling Undercollateralized Tranches

A rollover action consists of an equal value of tranches entering and leaving the system, which implies there is a valuation function applied to tranches. To value a tranche in the rollover scenario, the system looks at the Collateral Debt Ratio of the tranche–essentially how many AMPL are behind each Tranche.

- Imagine Alice rolls out R half-collateralized tranches representing 1% of the collateral set value. Alice would then roll in $R/2$ fresh tranches, because each incoming Tranche holds twice the underlying AMPL as each outgoing tranche. The remaining fee computation is the same as above. Rolling out 1% of the collateral at a total supply of 1M and a reward fee of 2% would yield Alice a 200 SPOT reward.

The tranche valuation function can be further refined over time through governance. See the section below, SPOT Debasement, for further discussion on this scenario.

B SPOT Debasement

We touched on the rollover incentives above and in this section we'll discuss how these incentives impact the value of the SPOT token over time. For a treatment on how this affects SPOT as a refuge from inflation please see appendix C.

The SPOT token can be diluted by:

- Fee Buffer Rewards
- Undercollateralized Rollovers

B.1 Emission Rewards Debasement

Rollover rewards are paid for out of the fee buffer and by emission rewards. Only emission rewards contribute to SPOT debasement and the maximum rate of SPOT debasement by emission is determined by two configuration parameters:

- Rollover Reward
- Bond Length

Let's say bonds mature n times per year and we want to cap the rate of SPOT debasement by emission rewards to k% annually. To accomplish this, we would configure rollover reward r, using the following equation:

- $k = (1 + r)^n$
- $r = k^{(1/n)} - 1$

The rollover reward and bond length parameters can be configured by governance.

Alternatively an auction contract can be used to allow market participants to bid on rollover rewards. Instead of a fixed rate of debasement, the auction model minimizes debasement by allowing rewards to be determined by the market. This eliminates all guess-work from determining what incentive is necessary for securing perennially fresh collateral and minimizes governance.

B.2 Undercollateralized Rollover Debasement

The second way SPOT can experience debasement is by the rolling over of undercollateralized tranches (see appendix A).

When a stale tranche is undercollateralized, users rolling over withdraw more senior tranches than they deposit, diluting each SPOT holder's claim on the collateral set.

The system can minimize (and in most cases entirely avoid) this type of debasement by configuring tranche ratios and bond lengths such that the likelihood of tranches becoming undercollateralized by the time of maturity is negligible. Consider the following example:

Let's imagine the active bond issuer is configured with (.20, .80) (senior, junior) tranche ratios. This means AMPL supply would have to contract by $> 80\%$ before senior tranches are impacted. At present, the maximum rate of AMPL contraction is 7.77% per day if the price per AMPL is \$0. Thus, an entirely debasement-proof bond duration can be computed as follows:

- $0.2 = (1 - .10)^{\ bond\_length}$
- $log(0.2) = bond\_length * log(0.923)$
- $bond\_length = log(0.2)/log(0.923)$

In practice the likelihood of AMPL price falling to \$0 is infinitesimal, the above just illustrates an extremely conservative configuration.

C Refuge From Inflation

We refer to SPOT as a refuge from inflation throughout the paper and in this section we'll expand on it briefly.

Central banking authorities like the Federal Reserve have what is commonly referred to as a dual mandate "so as to promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates." This means their prerogative extends to caring for the broader economic health of the state. However, periods of monetary loosening to spur demand and create jobs often require subsequent tightening to curb inflation and restore stable prices.

One of the challenges presented by this difficult, but important, balancing act, is predicting the amount of time it takes to bring inflation back in line. For this reason price-inflation can run away for indefinite periods of time.

Correspondingly, the clearest opportunity presented to a monetary system that is disconnected from any single state, is the opportunity to limit its prerogative to that of maintaining relatively stable prices.

SPOT can go for long periods of time without experiencing debasement. But in the event that it does, SPOT debasement is rule-bound, predictable, and solely in service of bearing the cost of rotations. In this sense SPOT is disconnected from global money printing cycles and can function as a refuge from central bank inflation—much as Friedmann's k-percent rule proposed that the money supply should be increased by the central bank by a constant percentage rate every year, irrespective of business cycles.

Lastly, any SPOT user can choose to insulate themselves from debasement altogether by participating in rollovers. This stands in contrast to the Cantillon effect faced by fiat monetary expansion, whereby participants who are "close to the money" i.e. big companies, banks, etc. have greater insulation from price-inflation than those who are not.

D Alternative Collateral Considerations

We came to the SPOT solution by reasoning naturally in a design-space that assumes there exists a base collateral asset with unit-of-account functionality. But what are the benefits of using AMPL vs a typical floating-price token as collateral?

D.1 Fully-minimized Oracle Risk

A remarkable quality of the SPOT design is that it does not introduce any oracle into the system. This is because AMPL's unit-of-account functionality makes it perfectly suited for the creation of fully-backed on-chain derivatives. Tranches are safe, simple, transparent, modular, data-structures—not the inscrutable rube-goldberg machines we've grown accustomed to seeing.

Oracles carry with them market and centralization risks, minimizing exposure to them increases system stability and resilience. Both ButtonTranche and SPOT inherit the safety of AMPL's unit-of-account functionality without making any calls to the outside.

The Ampleforth protocol does read from an oracle, but in a measured and compartmentalized way. Ampleforth never consumes live market prices as input–it only uses 24hr VWAP. This makes it resilient against short term market based attacks. It only requires one oracle read per day, and is resilient against Denial of Service attempts. A small number of missing oracle reports has no long term effects on the health of the AMPL ecosystem.

D.2 Deterministic Supply Policy

The nature of AMPL's smooth supply changes provide another layer of stability. Since the supply of AMPL is determined by the rebase curve, the supply change is bounded per day. In turn, this means the collateralization ratio of senior tranches changes in a bounded amount per day as well.

D.3 Collateral Asset Stability & Interaction Effects

There are two factors contributing to AMPL's stability as a collateral asset in the long run.

- AMPL supply reacts to demand counter-cyclically
- SPOT stabilizes AMPL and vice-versa

In the long term, AMPL's feedback of 24hr VWAP price into supply increases the stability of AMPL itself. Perhaps more interestingly, the existence of SPOT may actually stabilize AMPL and therefore stabilize SPOT in a virtuous cycle. Because AMPL price is mean-reverting and SPOT is redeemable for future AMPL with almost no exposure to supply rebases, it becomes straightforward for market makers buy SPOT when it's trading at under the AMPL price target and sell SPOT when it's trading over the AMPL price target. This counter-cyclical demand for SPOT translates into counter-cyclical demand for AMPL, stabilizing the collateral.

E Multicollateral Considerations

With respect to a multi-collateral implementation, our recommendation would be to combine multiple SPOT-like perpetuals that utilize different underlying collateral (like ETH, BTC and AMPL) into a single multi-collateral system.

F Discussion on SPOT's Value and Price in the Market

At the individual level, the most important factor will be the inflation expectations held by buyers and sellers of SPOT. Assuming an equilibrium with no net increases or decreases in the demand for AMPL, CPI increases will raise AMPL's price target. At steady state, then, inflation causes AMPL's supply to contract until AMPL's price reaches a new, higher equilibrium. These contractions are absorbed by holders of junior tranches.

A minter and/or seller of SPOT thus would not sell SPOT for its CPI-dollar value **today**. He will charge a premium on that value that matches his expectations for inflation **tomorrow**. SPOT is, in effect, protection against inflation. Thus, ceteris paribus, trades will occur primarily between optimistic sellers and pessimistic buyers. For example, if a seller believes inflation will be 8%, he might charge a 10% premium on SPOT's value. A buyer that believes inflation will be 12% will in turn willingly pay that premium.

Behavior is harder to analyze at the macroeconomic level because, like all assets, AMPL will be influenced both by inflation and interest rates.

A general monetary inflation, such as occurred during after the COVID-19 pandemic lockdowns in 2020, will inflate asset prices. This will create dollar inflows into AMPL, driving up its price and creating a supply expansion much as occurred in 2020 and 2021. In such a scenario, minters might sell SPOT at a discount to its value. They will prefer to capture the upside of AMPL's supply expansion, and so will sell SPOT in order to buy more AMPL and mint more AMPL junior tranches. Buyers of SPOT will be happy because their wealth will be insulated from the general increase in the price level in addition to the discount given to them by sellers.

A sharp cost-push inflation does not have such effects, as this produces demand destruction. In such a scenario, both the price of AMPL and SPOT might fall as all asset classes readjust to a lower, likely recessionary, equilibrium.

A combination of high inflation and high rates, such as happened in 1970s and 1980s, tends to drive prices down for almost all assets except for real estate, which benefits from tax code idiosyncrasies. Even then, household wealth experienced a 25% drop during this era.[9] It is difficult to extrapolate too closely from this historical episode, given that household wealth and savings were affected both by demographic changes and different expectations between generations.

The composition of inflation and its magnitude relative to interest rates will also affect the AMPL supply, and thus how sellers and buyers price SPOT. For example, interest rates higher than inflation

[9]Monica Piazzesi, Matteo Leombroni, Ciaran Rogers and Martin Schneider. "Inflation and the Price of Real Assets." January 2020. Under revision for Review of Economic Studies. Available at http://www.stanford.edu/ piazzesi/inflationAP.pdf

might make it more attractive to hold government debt than SPOT. Net buyers of SPOT might thus become net sellers, as they opt to buy Treasury bills. This will drive down the price of SPOT until its gross real return matches the yield on new government debt.

In short, while the value of SPOT is relatively straightforward to think about, the way in which buyers and sellers will price is very far from simple.