DELPHI DIGITAL

Elastic Supply Protocols

Thematic Insights

January 2020

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Preface

The proliferation and success of stablecoins should come as no surprise. They generally provide the same key benefits that make cryptocurrencies useful, without their main drawback - price volatility. That final point is particularly important for mainstream adoption because stablecoins feel like a familiar payment method. Most people have spent their entire lives accustomed to products being quoted in, and purchased with, a non-volatile currency. For those not fortunate enough to have a non-volatile local currency, stablecoins represent an even greater paradigm shift for how they can conduct commerce.

What may come as a surprise, however, is the sheer variety of different stablecoin designs and the mechanisms they implement to maintain their price pegs. While transaction volume strongly skews towards collateral-backed stablecoins (i.e. USDT, DAI), their designs still leave a lot to be desired. The need for collateral, despite securing the value of the stablecoin, makes them capital inefficient and it can become a limiting factor for mainstream adoption. What do we mean by that latter point? Simply put, the demand for DAI does not increase the DAI supply. With this in mind, is it possible to create a non-collateralized stablecoin, in a decentralized way, that can scale to meet global demand? After all, the world's most popular currency, the US dollar, is backed by nothing more than a promise.

In this thematic, we'll explore a fringe category of stablecoins known as Elastic Supply Protocols (eg. Seigniorage Shares). Ideally, this design can produce a non-volatile digital currency that is either non-collateralized or partially-backed. How is this possible? Basically, the currency's supply algorithmically expands and contracts based on demand. As demand for the currency rises, increasing price, the supply automatically increases until the price reverts back to its peg. As demand for the currency falls, reducing price, the supply automatically contracts until, again, the price reverts back to its peg. At least, that's what is supposed to happen. This design has never worked at scale and reality is littered with examples where this approach has failed for one reason or another (i.e. Basis, Kowala, etc).

The purpose of this report will be to compare and contrast the mechanics behind Ampleforth, Terra and Celo. While these protocols are all targeting stability, there are significant differences between each of their respective designs. These differences range from the underlying stabilization mechanisms to the networks they exist on.

Elastic Supply Protocols:

Ampleforth

Terra

celo

Stablecoin & Protocol Comparison

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Fully Collateralized w/ Fiat

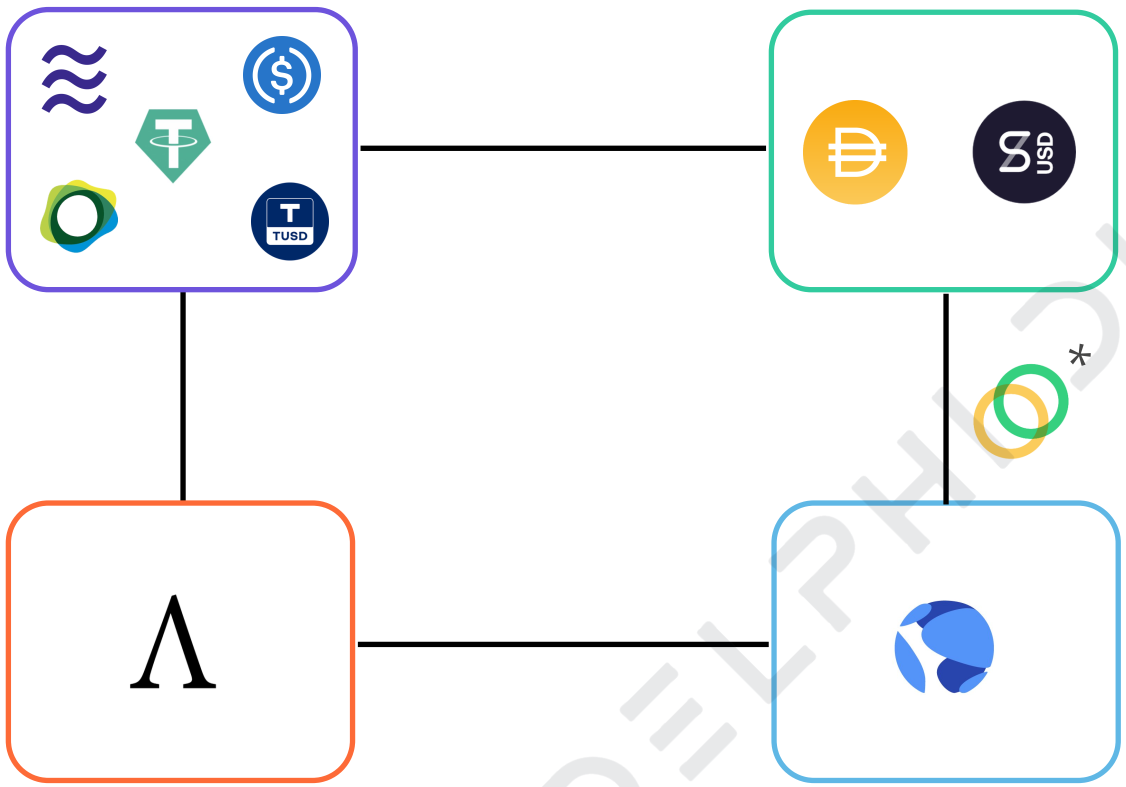
Strengths:
- Collateralized by stable assets
- Capital efficient (i.e. not overcollateralized)

Weaknesses:
- Not decentralized
- Demand doesn't necessarily increase supply

Over-Collateralized w/ Crypto

Strengths:
- Collateralized by assets
- Decentralized

Weaknesses:
- Not capital efficient (overcollateralized)
- Demand doesn't increase supply



Non-Collateralized & Rule-based Elasticity

Strengths:
- Demand increases supply
- Decentralized
- Very capital efficient

Weaknesses:
- No collateral securing value can make it difficult to maintain target price on downside moves

Partial Crypto Reserves & Rule-based Elasticity

Strengths:
- Demand increases supply
- Decentralized
- Value of secondary assets help support price peg
- Capital efficient

Weaknesses:
- Value of secondary assets may not fully secure value

Key

Terra	USDT
AMPL	USDC
Libra	PAX
Celo	TUSD
DAI	sUSD

**Based on the design of Celo's reserves it could be partially, fully or over-collateralized*

Ampleforth

- **Live on Mainnet:** Yes
- **Reference Peg:** USD
- **Oracle Type:** Whitelist/Chainlink
- **Secondary Asset:** No
- **Reserve:** Partial
- **Platform:** Ethereum

Terra

- **Live on Mainnet:** Yes
- **Reference Peg:** SDR, USD, KRW, etc.
- **Oracle Type:** Validators
- **Secondary Asset:** Yes, LUNA
- **Reserve:** No
- **Platform:** Terra is its own blockchain

Celo

- **Live on Mainnet:** No
- **Reference Peg:** USD and future fiat pairs
- **Oracle Type:** Validator + AMM
- **Secondary Asset:** Yes, Celo Gold
- **Reserve:** Yes, other crypto collateral
- **Platform:** Celo is its own blockchain based on an Ethereum fork

Ampleforth Mechanics

Figure 1

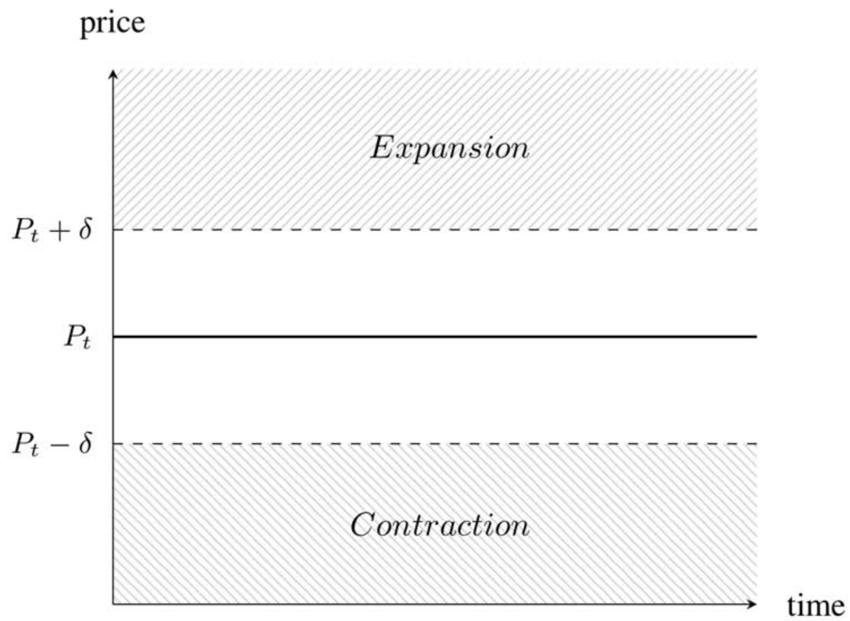
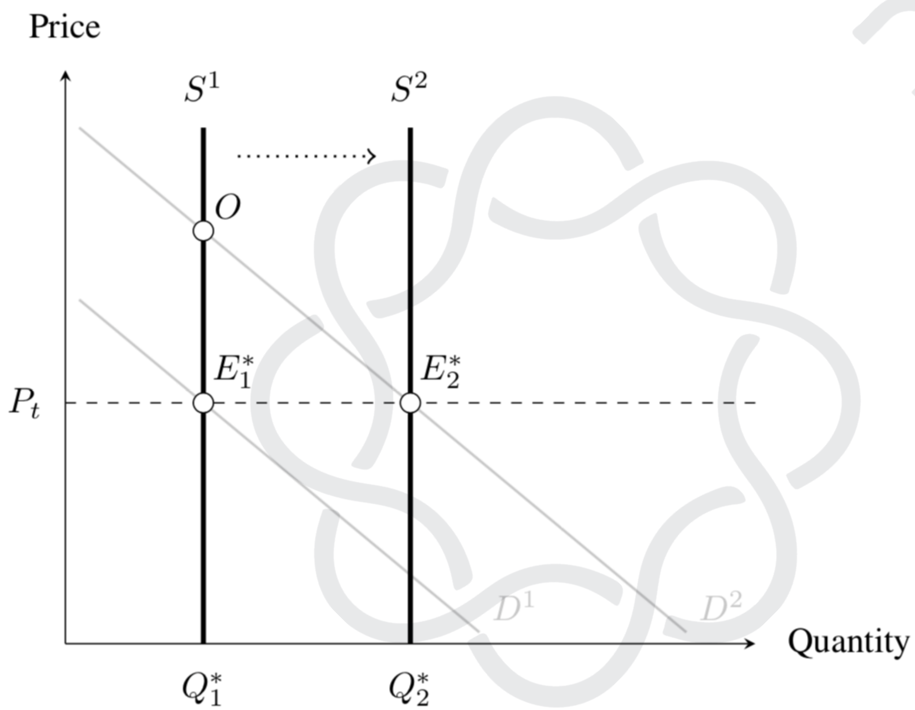


Figure 2



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Ampleforth is a self-described "synthetic commodity-money" whose whitepaper was released in May 2019. The protocol's token is referred to as an Ample (AMPL), which is an ERC-20 that algorithmically stabilizes towards an equilibrium price of $1. Right, so it's a stablecoin then? Not according to its development team who previously penned a piece titled "Why Aren't Amples a Stablecoin?". Regardless of whether or not it's historically been price stable, as we'll see on page 7, the goal is clearly to become just that. It's a stablecoin by intent if not by practice.

The protocol reacts to changes in AMPL's nominal exchange rate and reflects this price information in automatic changes to its supply. Put simply, the total supply of AMPL expands if the price of 1 AMPL > $1 and contracts if the price of 1 AMPL < $1. Figure 1 illustrates the two fundamental rules dictating the protocol. If the nominal exchange rate between Amples and Pt ($1) is > Pt + δ, the protocol proportionally expands supply to token holders. If the nominal exchange rate between Amples and Pt ($1) is < Pt + δ, the protocol proportionally contracts supply from token holders.

To smooth out changes, AMPL's supply expands/contracts over a predetermined amount of time, currently set at 10 days. For example, if an AMPL is worth $2, the holders' wallet balances will increase by 100% over 10 days. This gradual shift is illustrated in Figure 2. Using our current example, point O (the "Intermediate Phase") represents an AMPL price of $2 while point E1* represents the target price of $1. The steady decline in price back towards $1 (now represented by E2*) coincides with the supply doubling (Q1* to Q2*). If AMPL's price fell to $0.50, the inverse would happen.

Supply changes are determined using the 24h VWAP from market oracles. With an external price-feed dictating the core rebalancing mechanics, Ampleforth is reliant on the integrity of these oracles. The protocol uses a set of white-listed oracles and is currently integrating Chainlink to decentralize this process.

Ampleforth Mechanics

While the supply of AMPLs is elastic and algorithmically determined, it's important to understand that the system's design hinges upon the actions of market participants responding to changes. Ampleforth breaks these actors into two types: Slow and Fast. Slow Actors do not predictably trade on supply changes and have a low time-preference. Over the long-run, their net balance remains the same. Fast Actors, on the other hand, take advantage of the intermediate phase of the adjustment process by buying/selling AMPL, thus driving AMPL's price back to its target. It's the Fast Actors that ultimately stabilize the Ampleforth system.

For Slow Actors, supply and price changes do not impact their initial net balance or %-share of the total market cap. For example, at equilibrium t0 Alice owns 100 AMPL out of a 10,000 total supply of AMPL. At t0, 1 AMPL = $1 and she owns 1% of the market cap. At t1, 1 AMPLE = $1.5, and so the protocol begins expanding AMPL supply. At t2, the market moves back towards equilibrium and 1 AMPL = $1. However, Alice now owns 150 AMPL worth $1, rather than 100 AMPL worth $1.5 at t1. Alice still only owns 1% of the network, 150/15,000.

For Fast Actors, their initial net balance can + or - depending on if they accurately time when supply changes impact price changes. Using the same example above at t0, Bob owns 100 AMPL at $1 (1% of market cap). At t1, Bob owns 100 AMPL at $1.5. During supply expansion, Bob owns 150 AMPL at $1.5. In this intermediate stage, Bob has time to sell his AMPL at a higher price than the price target ($1.5 > $1). Here, Bob can sell 50 AMPL at $1.50 for $75, and plan to rebuy 75 AMPL at $1, earning a profit on the difference. This would increase his net balance to 175 AMPL, relative to the balance of 150 AMPL he would end up with if he did not sell.

In most elastic supply designs, the protocol relies on seignorage or reserve assets to contract supply (buy the stable coin with other assets). Ampleforth, in comparison, completely removes this process. The rebase function immediately multiplies/divides existing tokens by some value dependent on the price divergence. This multiplication and division happen over 10 days. With this design, Ampleforth relies on one key assumption - traders/holders using inflation as a signal to sell, and deflation as a signal to buy. This relationship, in practice, may not accurately account for more complex irrational actors. The protocol is designed to converge towards a $1 peg, but this does not necessarily defend the value of 1 AMPL : 1 USD. The only defense of the price target is the presence of sufficient incremental buyers at sub $1 prices. This is especially uncertain when a downward spiral can convince traders and holders to lose fundamental belief in the mechanics of the protocol. At maturation, a short-selling market can exacerbate this effect. Ideally, there would need to be a large uncoordinated pool of "Fast Actors" that mitigate sell pressure and who believe the price will revert back to the peg within a certain time-frame.

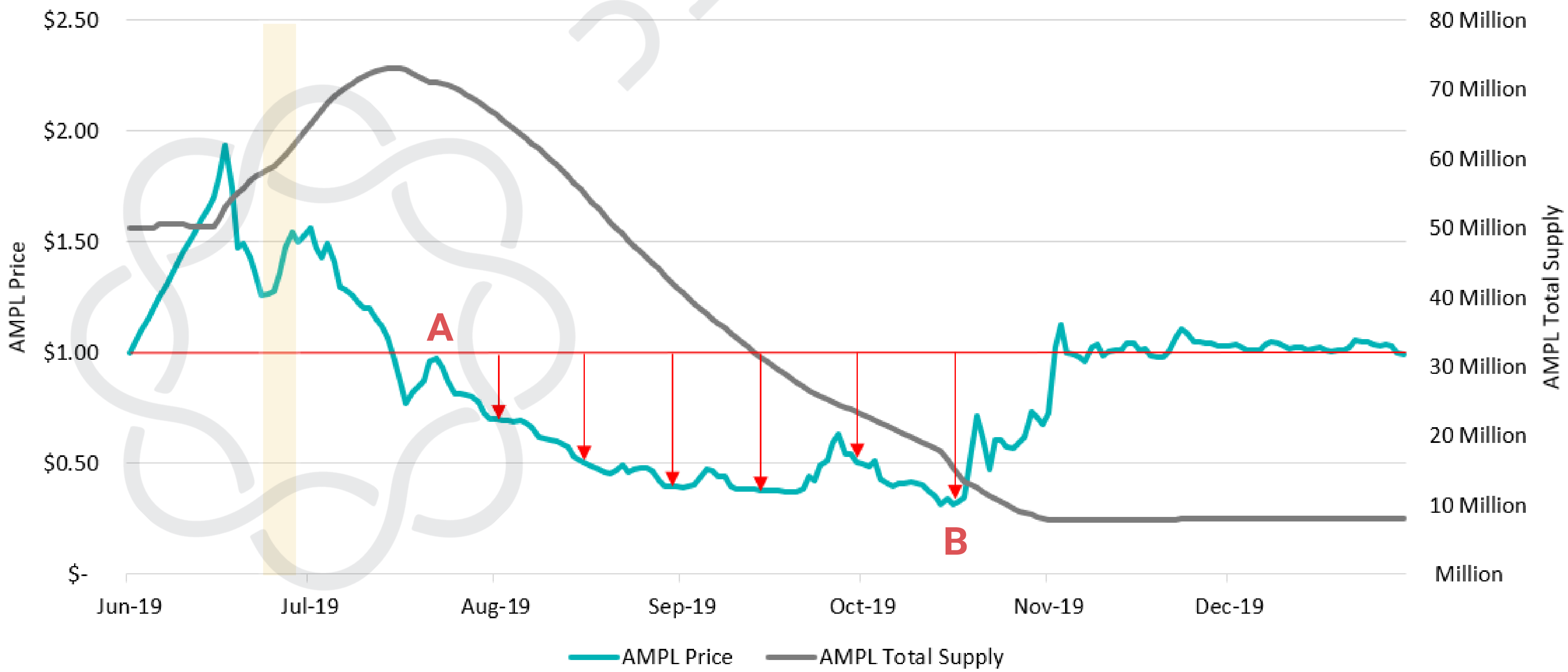
Ampleforth

AMPL Volatility & Supply

Evidenced in the graph below, AMPL has experienced prolonged periods trading above, below and at its target price. This volatility can be expected given its nascency. The period where AMPL traded below its peg (depicted by the red arrows) coincided with a continued contraction of the total supply (as expected), only flat-lining at ~8 million AMPL once the $1 price target was reached in November. Another factor that may have played an important role was the team's decision to change the length of the rebase reaction lag from 30 days to 10 days on October 30th, 2019, allowing for faster supply adjustments.

Simply understanding, let alone effectively trading, the AMPL mechanism is difficult. For Fast Actors trying to take advantage of profitable opportunities, timing is both imperative and difficult to assess. Let's use the time period highlighted by the yellow box as an example. An actor sells 100 AMPL at $1.26 for $126, with the expectation of later buying 126 AMPLE at $1. By doing this, he expects to increase his holdings by 26%. However, the price continued to increase rather than decrease. As a result, the actor missed out on additional profits and also gets penalized by dilution. In this situation, they can profit on a $-basis but still lose by owning a smaller % of the market cap than they started with.

Now let's examine what happens when the AMPL price is < $1. Psychologically, this is tough for Slow Actors to stomach. For example at point A, AMPL sat around $1 with a total supply of around 71M. A holder might own 710,000 AMPL (1% of the network) worth $710,000 at point A. At point B, the holder still owns 1% of the network - 154,000 AMPL at $0.32 - but their position is now only worth $49,280. A 68% price decline resulted in a net balance depreciation of 93%. From point A to B, this mechanic induced capitulation resulting in further downward sell pressure. Fast Actors witnessing this lack of price responsiveness see no profit opportunity and therefore do not support the system with necessary buy pressure. What AMPL needs to remain stable is a sizable pool of Slow Actors that do not capitulate and who, in turn, enable Fast Actors to take profits on small deviations from the price target.



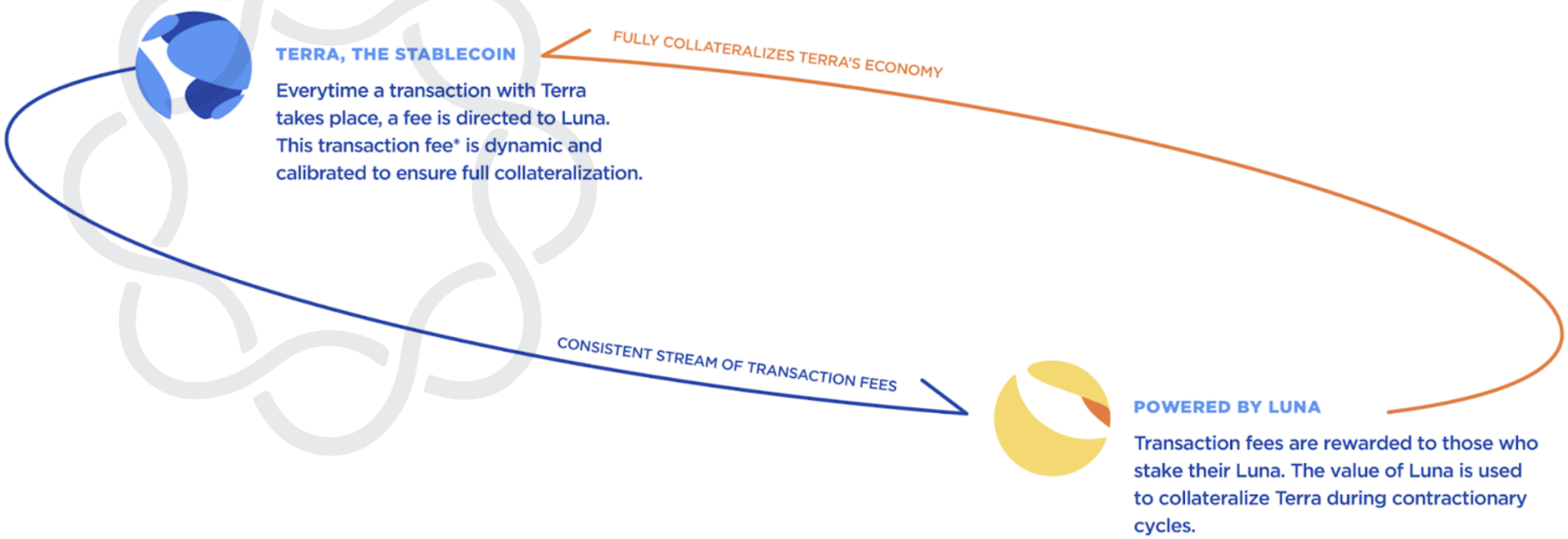
Terra Mechanics

Terra's stability mechanics differ from Ampleforth in a few key ways. To start, Terra has multiple tokens pegged to different fiat currencies/baskets 1 TerraKRW: 1KRW, 1 TerraUSD: 1USD, 1TerraSDR: 1SDR, etc. Given their focus on e-commerce payments, this makes sense in order to target different markets. Unlike Ampleforth, Terra utilizes a secondary token, Luna, and a set of stakers (Terra calls them miners) as the core stability provisioners of the protocol. Luna acts as both the PoS token and the "reserve asset" that absorbs Terra's price volatility. While mechanically different than Ampleforth, Terra also relies on an algorithmic elastic supply that changes following a nominal exchange rate. When Terra's price is greater than the price target, the protocol expands supply and vice versa.

So how do the mechanics differ? The protocol operates more closely to a classic seigniorage model. Users can always swap Terra for Luna at the target exchange rate. When Terra KRW price < 1 KRW, users can swap 1 Terra KRW for 1 KRW worth of Luna and profit from the difference. With this hardcoded relationship, Terra price volatility shifts to Luna supply volatility. In a seigniorage model, the protocol earns "profit" by minting and selling its stablecoin increasing the supply until price equilibrates down to the target. When the stablecoin trades below the price, the protocol (unlike Ampleforth) can not un-issue supply. Therefore, the protocol uses its seignorage (minting profits) to buy back its stablecoin. A clear issue with this model reveals itself when accumulated seigniorage < necessary seignorage to reduce the supply. To combat this, protocols (like Basis) issue seigniorage shares - entitlements to future seignorage. In this model, the stability floor predicates on future supply growth rewarding seignorage shareholders via future seignorage. This design has some criticisms.

With this in mind let's look at the nuances of Terra's seignorage model. When Terra price > 1 KRW, Terra earns seignorage by minting Terra for Luna. This earned Luna is both burned and allocated towards a treasury to fund fiscal stimulus. With that said, the 1 billion burn floor caps the value of this burn. So if the protocol doesn't stockpile Luna seignorage, how does it afford contraction costs? The protocol simply mints more Luna to swap with Terra. Therefore, in the short term, stakers absorb Terra supply contraction costs through "staking power" dilution (staking/mining power is equivalent to Luna supply). Luna supply dilutes (sold for Terra) and thus stakers own less total % of the network. A potential second-order effect of this comes from periods of sustained Terra price < 1 KRW, resulting in heavy dilution of Luna supply. This Luna supply immediately hits the open market inducing heavy sell-pressure. Existing stakers now are doubly punished - price and dilution. Concerns, also, over PoS security and oracle security now come into question (both are dependent on Luna).

The stability of Terra predicates on the long-term value of operating a Terra validator. To ensure this value and mitigate the issue mentioned above, the protocol compensates stakers through counter-cyclical validator rewards. In other words, reward variance is reduced through rewarding stakers more when Terra demand decreases and less when Terra demand increases. Staking rewards are made up of two components: a dynamic transaction fee and seigniorage (Luna burn). Fees and burn increase as demand decreases, and decrease as demand increases. Luna, ultimately, adapts this seignorage model to align incentives and stability to transaction activity, rather than simply future seignorage (the relationship between the two is somewhat related).



Source

Terra Mechanics

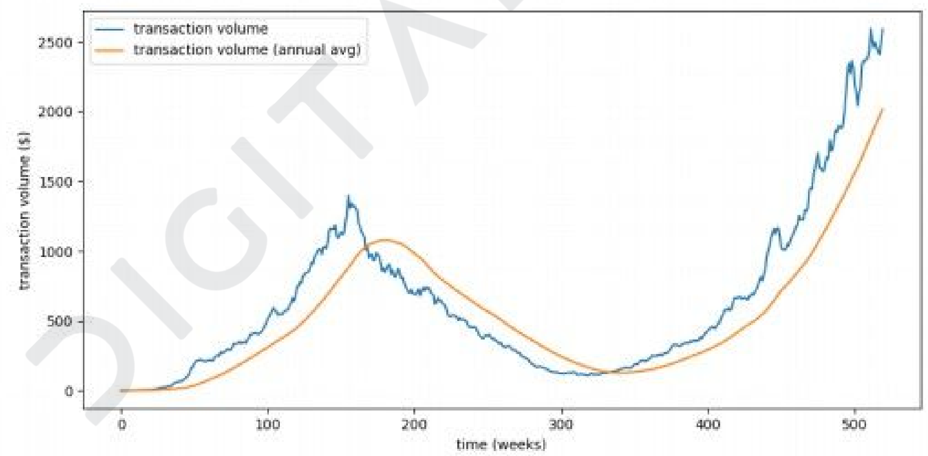
Diving deeper into the staking economics, the profit/loss function for a Luna staker is: P(t) = TotalRewards(t)/LunaSupply(t) - UnitStakingCost(t). The goal is to keep P(t) stable through various market conditions, ensuring predictable economics. This, in return, should bolster staking demand and reduce staker churn. The first term of the function represents the unit staking rewards and is a function of aggregate transaction fees and the number of staked Luna. The unit mining cost is 1 Luna.

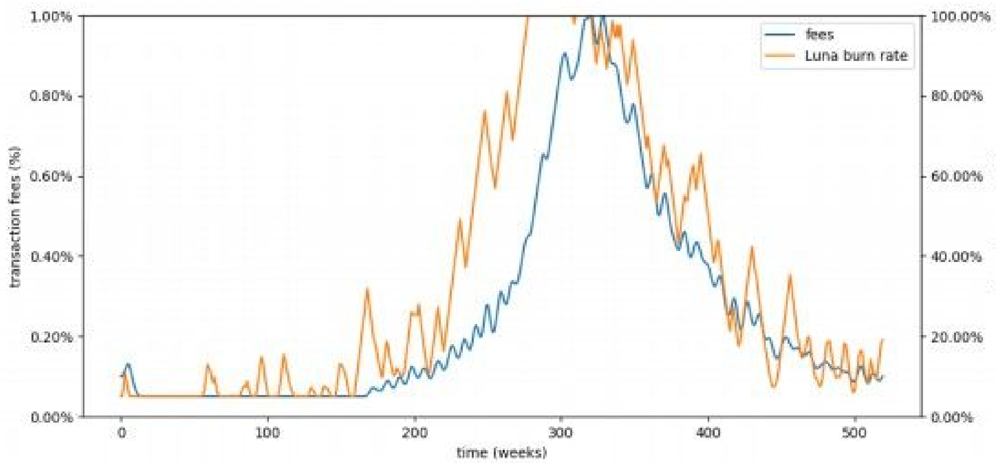
In addition to the counter-cyclical fee and burn design, the Terra protocol introduces "stability levers" as an additional precaution to mitigate volatility. These levers are the rate of Luna burn (what portion of seigniorage does the protocol buyback and burn) and fee growth rate (how do fees change in response to changing unit miner rewards). The graphs to the right are simulations run by the Terra team illustrating how the protocol adjusts its stability levers in response to changing economic conditions.

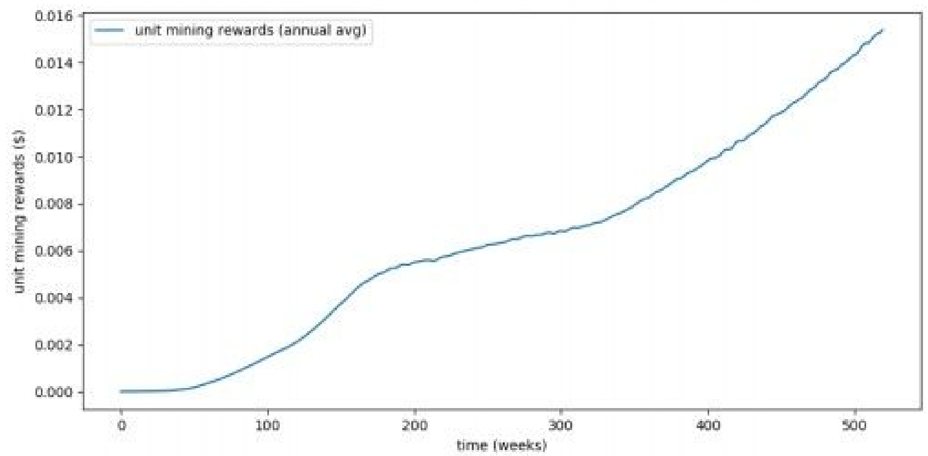
The stability and security of Terra hinge upon staking rewards, as stakers both absorb Terra price volatility, but also participate in PoS consensus. As a result, the core dependent of staking rewards, transaction volume (effects both fees and demand), is the foundation of a successful Terra protocol. As seen by the simulations to the right, the unit staking rewards in the bottom graph, while still volatile, respond stably to a 93% transaction volume retrace. With that said, this brings into question if an increase in fee% (graph 2) could induce a further reduction in transaction volume demand.

Funded through Terra expansion, Terra also incorporates a "fiscal policy" via its community treasury. Without going into too much detail, stakers vote on how to allocate funding for dApps. Stakers weight an application's economic activity and efficiency of capital when deciding on who to allocate capital towards.

Terra's elastic-supply, like Ampleforth, depends on exogenous price information, and thus, relies on price oracles. Rather than whitelisted oracles, it is the stakers that submit votes for the accurate exchange rate. The votes are tallied every n blocks, and the weighted medians are taken as the true value. Stakers who voted within 1 standard deviation of the median are rewarded, and those who did not are punished.







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Terra Price and Fundamentals

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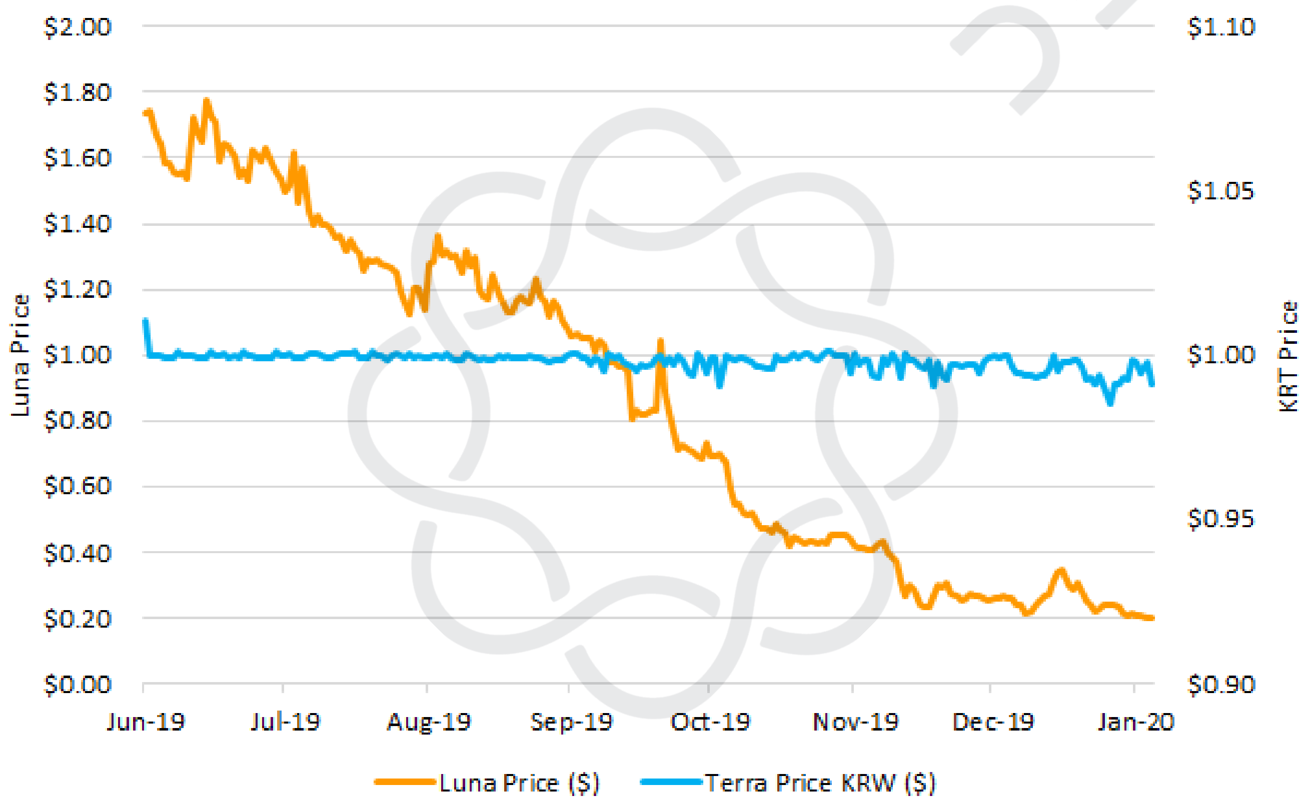
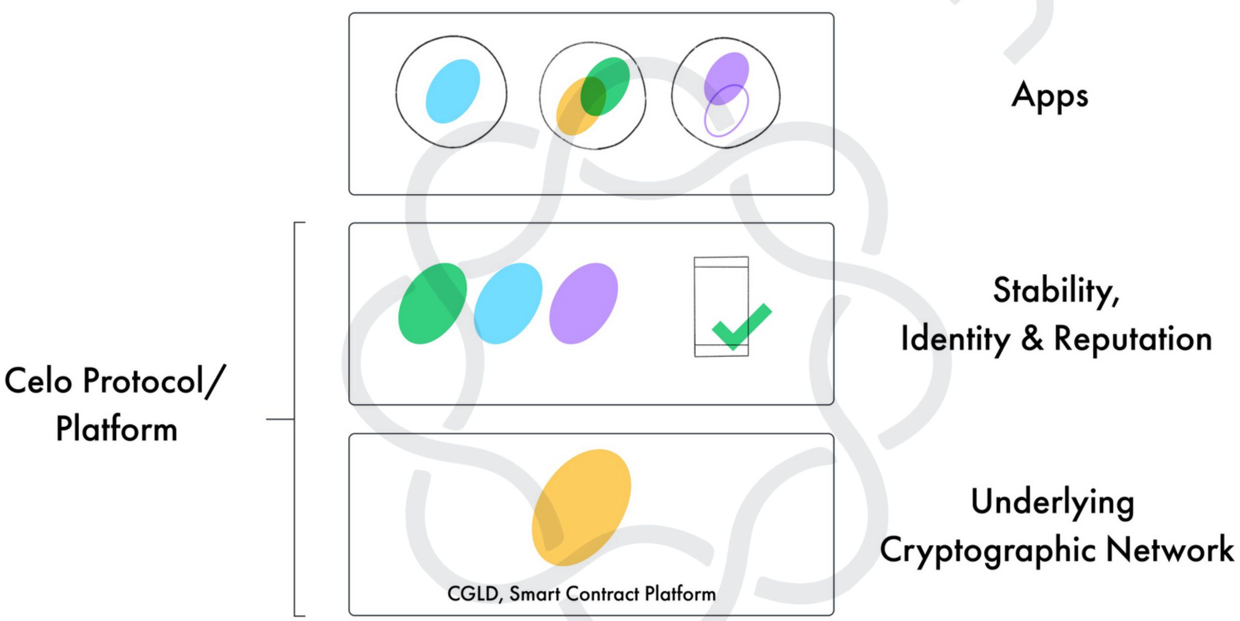
Apart from oracle attacks, Terra has exhibited stability since its launch. This (clearly) has not translated to positive price action for its sister token, Luna. Terra's fundamentals (transaction volume and accounts), on the other hand, have seen strong growth, with total accounts surpassing the 1M mark. To pinpoint the reason for Luna's price decoupling from its fundamentals is difficult. Negative price action can be attributed to a multitude of factors, from market irrationality, a portion of validators unbonding Luna and selling their holdings, to simply early private investors taking profits. The staking ratio of Terra currently sits at around 22% as of writing, and the annualized staking yield sits slightly above 12%. Further analysis is needed to ascertain the % of yield subsidized by Luna issuance.

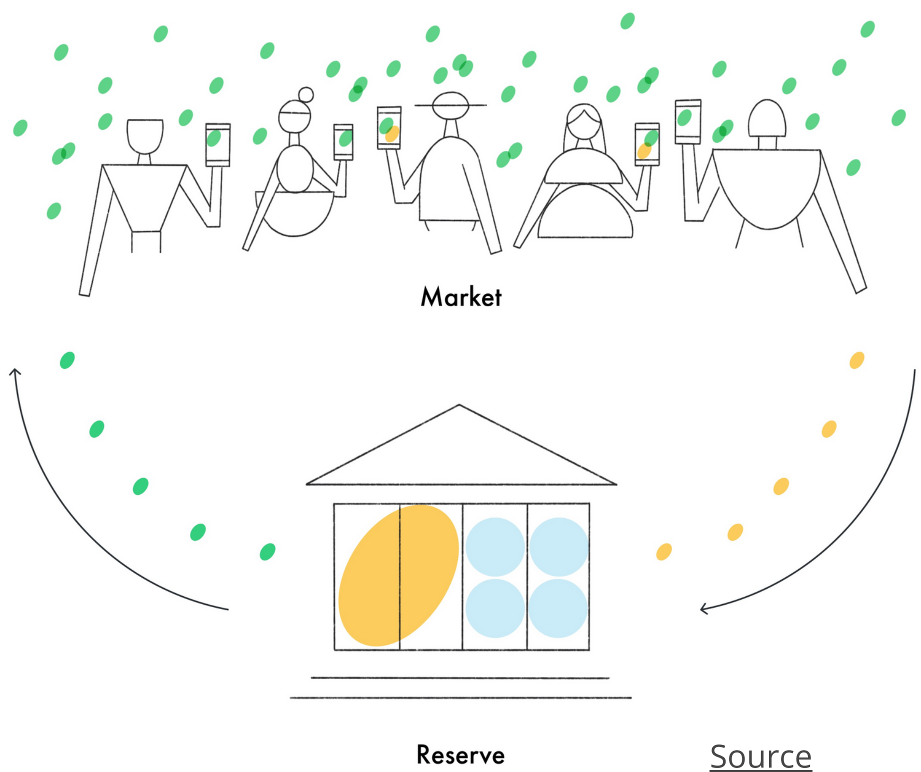


Celo Mechanics

The last protocol dissected in this thematic is Celo - a self-described decentralized payments system in which users transact with Celo Dollars, stablecoins pegged to a local fiat currency or a basket of goods. Similar to Terra, Celo utilizes a dual-asset system: Celo Dollars, the elastic-supply stablecoin, and Celo Gold, a free-floating fixed supply asset. Unlike Terra, Celo incorporates a reserve in addition to a secondary token (Celo Gold) to absorb the price volatility of Celo Dollars. Celo's stabilization mechanic, as a whole functions similarly to Terra: when the nominal exchange rate of Celo Dollars diverges from the price peg, the protocol expands/contracts the supply of Celo Dollars by selling/buying Celo Dollars in exchange for Celo Gold.

In times of expansion, when demand for Celo Dollars > supply of Celo Dollars, the protocol mints Celo Dollars and sells them in exchange for Celo Gold. The newly acquired Celo Gold is deposited into the reserve and diversified at the discretion of the stakeholders managing the reserve (sold for other crypto assets). In times of contraction, the protocol buys back and burns Celo Dollars using reserve assets. This process is continued until the price of Celo Dollars reverts back to the peg. This mechanic is exactly how Terra-Luna is swapped - and again, an oracle is needed to propagate the accurate nominal exchange rate. Celo plans to use stake-weight voting, with an on-chain constant-product market-maker model (Uniswap model) as the necessary price feed.





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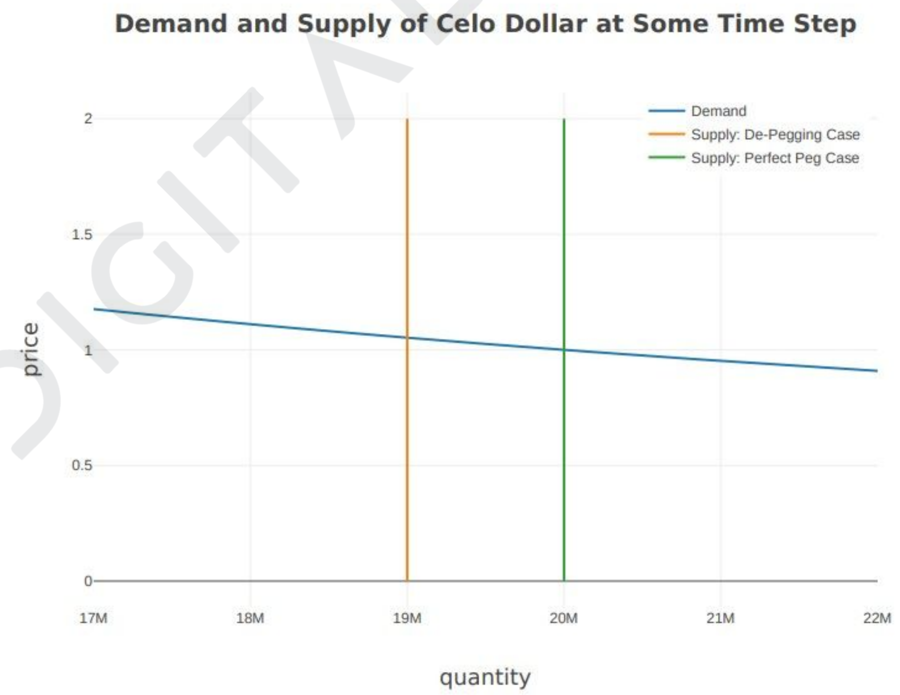
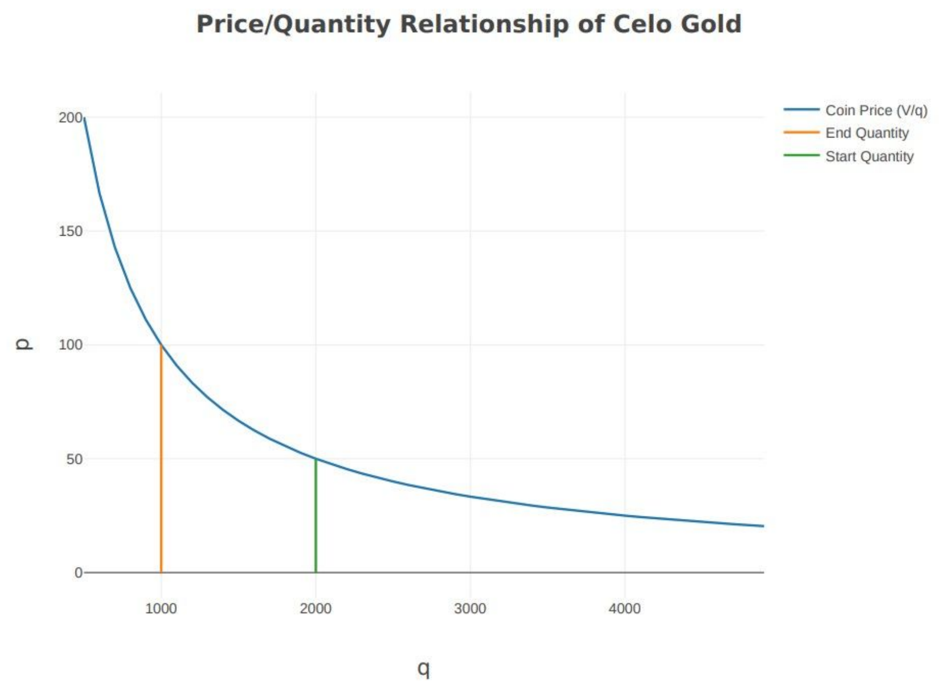
Celo Mechanics

Celo's stability mechanic revolves around the health of its reserve. Therefore, it is important to understand how this reserve works and how it reacts to adverse market conditions. Initially bootstrapped by a private sale of Celo Gold and a fixed amount of unsold Celo Gold, the reserve periodically rebalances to target a predetermined ratio of Celo Gold and non-Celo Gold assets.

As with Terra, the inherent risk of these elastic-supply protocols emerges from a contraction of demand for the stablecoin. To mitigate this risk, Terra institutes a dynamic fee and burn as a buffer. Celo, on the other hand, relies on its reserve. Looking at examples of sovereigns using foreign currency reserves to institute a stable peg, we know some real-world risks to this model. There are two main system breaking scenarios. First, if the contraction in demand for Celo dollars is greater than the total value of the reserve, the protocol will not have enough assets to sell to meet the necessary supply contraction; and second, the crypto market liquidity is not sufficient to sell off said assets in a given period.

Ultimately, the above issues directly arise from significant reserve asset depreciation, resulting in an undercollateralized system. Per the stability paper, the Celo team understands these risk factors and have conducted pricing simulations of Celo Gold and non-Celo Gold assets. The Celo protocol dynamically adjusts block reward and fee distribution to absorb the negative effects of reserve volatility. When the reserve ratio dips below a certain threshold, block rewards distribute Celo Gold in greater proportion into the reserve. This mechanic couples with a dynamic fee levied on every Celo Gold transaction that funnels into the reserve. The total fee charge adjusts following the reserve ratio - the inverse relationship results in greater reserve inflows during low collateralization. Celo Gold, like Luna, acts as both the PoS token for validation/governance, as well as the reserve asset of the Celo protocol. The safety of the system is predicated on the value of Celo Gold, as validators are the ones securing the network (manage the exogenous assets) by bonding Celo Gold. The external reserve assets should never be greater than the bonded assets at stake to ensure economic disincentives for misbehavior.





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