Ampleforth - An Ideal Money

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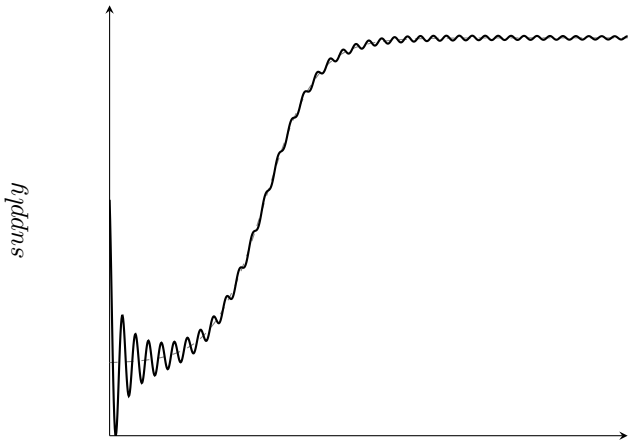
Abstract

Today's stablecoins are focused on filling the gaps left by Tether, but bringing fiat to the blockchain does not mean we have created better money. Tomorrow's stablecoins, will focus on filling the gaps left by Bitcoin.

Ampleforth is a decentralized store of value protocol that is volatile in price and supply at launch, but is strictly better than Bitcoin at steady state because it converges on a stable unit of account. Like Bitcoin, Ampleforth is decentralized, enforces a strict supply policy, and is resistant to the devaluing effects of inflation. However unlike Bitcoin, the currency is capable of evolving from a store of value, to a unit of account, to a medium of exchange over time.

In this paper we 1) introduce a framework for evaluating the quality of money, 2) apply this framework to Bitcoin and stablecoin approaches today, and 3) describe the Ampleforth protocol for creating an Ideal Money.



$Ampleforth\ supply\ (\ time\ )$

1 Introduction

In the past year, the cryptocurrency community has produced many stablecoin projects. This newfound appreciation for price stability, in a market that thrives on volatility, has been fueled by the fear of Tether collapsing as a medium of exchange token on cryptocurrency exchanges.

However, the idea that a price stable currency could be considered the "Holy Grail" of money predates the "Tether problem." It refers to a solution to the "Bitcoin problem," and we should be careful not to confuse the two contexts. Tether, being entirely fiat collateralized, is not a better money than fiat. And more importantly, any stablecoin capable of immediately replacing Tether is also not a meaningfully better money than fiat.

So then what *actually is* a better money than fiat, than gold, than Tether, than Bitcoin? Before describing our solution, we'll provide a concrete framework for benchmarking monies against an Ideal Money, and analyze a variety of approaches. In this paper we:

1. Introduce a framework for evaluating the quality of money
2. Apply this framework to Bitcoin and other approaches today
3. Describe the Ampleforth protocol for creating an Ideal Money

Lastly, before beginning we'd like to thank Noah Jessop, Sam Lessin, Paul Veradittakit, and Joey Krug—for reading everything we've ever thrown their way, and pushing us to continue evolving our thoughts and context. This is an unprecedented time, one in which the world is willing to create and adopt new monies. And we believe that it is important to introduce monies that have the potential to advance society.

2 A Framework for Ideal Money

The mathematician and economist John Nash, famous for his Nobel winning work on non-cooperative game theory, first conceived Ideal Money in the early 60's. At the time he became unsettled by the fact that certain currencies, as part of the International Monetary Fund (IMF), had agreed to fix exchange rates with one another. Nash's concern was that a fixed exchange ratio between currencies would encourage hyperinflation—and his reasoning went something like this:

Let's say Alice and Bob agree to a fixed exchange rate: 1 Alice Coin =1 Bob Coin.
Let's also say that: 1 Bob Coin = 1 Gold Nugget.

Since Alice can always exchange her coins for Bob coins 1:1 and then redeem them for gold, she stands to benefit from inflating her currency as aggressively as possible, trading her coins for Bob coins, and then for gold—all before Bob catches on.

Nash, thinking this wasn't a healthy game, immediately sought to trade his US dollars for Swiss Francs, which could be redeemed for gold, but were not subject to the fixed exchange rates designated by the IMF. He considered the Swiss Franc to be "better money" because it was more likely to hold its value against

gold, but went on to imagine what an "ideal money" might look like. Eventually, he would spend the last 20 years of his career promoting the idea that an Ideal Money is one free from the conflict of interests that arise when country's currency is used as a global reserve currency.

2.1 Ideal Money - Traditional Definition

> *Ideal Money is a solution to the conflict between near-term domestic interests and long-term international interests that occurs when using a country's currency to stabilize a global economy.*

Until recently, circulating new and independent currencies has been very difficult, and even Nash could not have foreseen the proliferation of distributed ledger technology, or the effect it has had on lifting geopolitical constraints.

Today, it's trivial to create and circulate government-independent cryptocurrencies. In fact, we now have thousands of new currencies like Bitcoin and Ethereum—many of which were created in just the last two years—and any of which could theoretically be adopted as global reserve currencies.

So if we allow ourselves to drop the previously difficult challenges associated with geopolitical conflict from the original definition, we're left with a simplified definition.

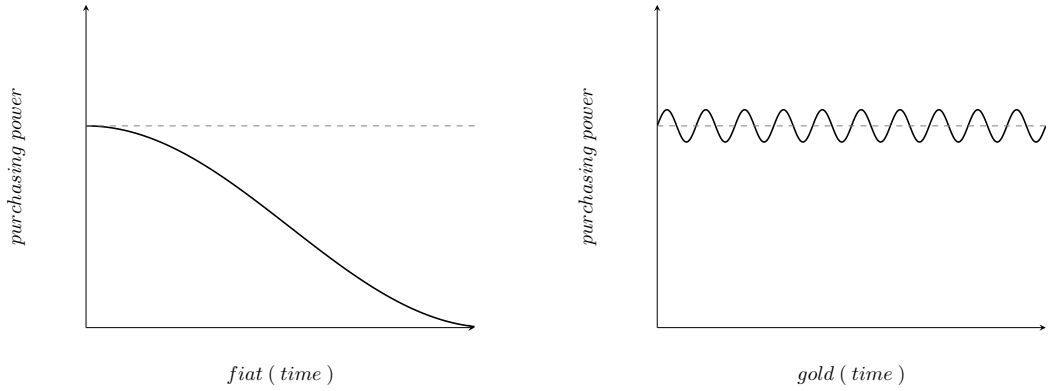
2.2 Ideal Money - Contemporary Definition

> *Ideal Money is a solution to the conflict between near and long-term interests when creating a stable digital currency.*

This new definition is certainly simpler than the first, but it's still vague. In the digital currency arena, many economic theories previously reserved for philosophical debate can be empirically tested. But in order to seize this opportunity, we need to articulate statements that can be evaluated. So the question is: "Can we describe Ideal Money concretely?" Let's start with the three functions of money, commonly known as:

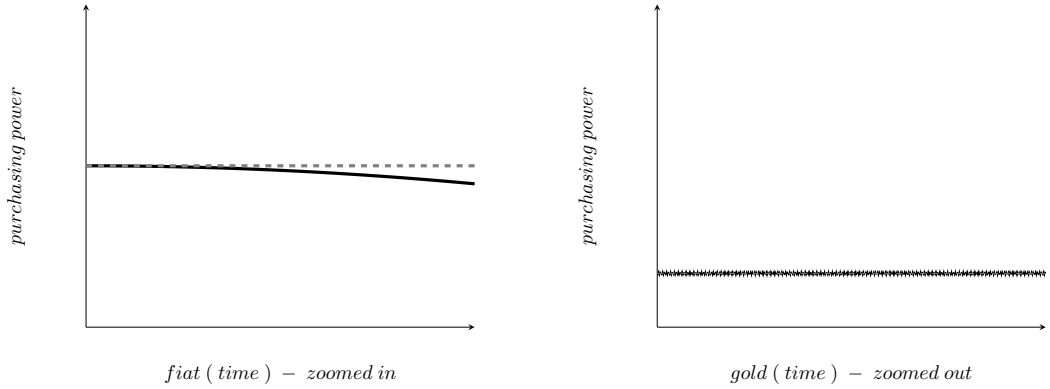
1. A Unit of Account
2. A Store of Value
3. A Medium of Exchange

Fiat money already fulfills these three functions, and yet Nash would not have considered any fiat to be ideal. What's missing from these functions is simply the dimension of time. Recall that Nash traded his dollars for Swiss Francs because he believed they were more likely redeemable for gold. This is sensible because unlike fiat, gold maintains its purchasing power over long periods of time.

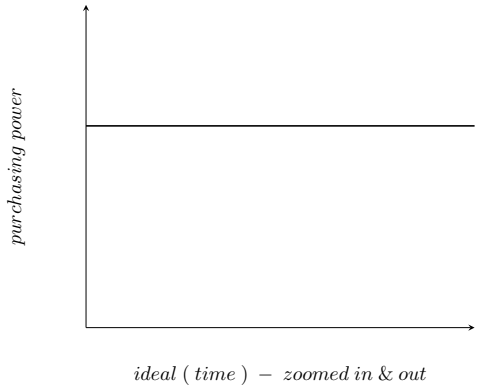


However, gold cannot easily adjust its supply in response to demand. And for this reason, gold is near-term volatile, and can only function as a long-term store of value.

On the other hand, fiat money can adjust its supply to create near-term stability. But the very mechanism that creates near-term stability also dilutes the value of fiat long-term, and for this reason fiat cannot be used as a long-term store of value or unit of account.



An Ideal Money would demonstrate stable purchasing power in both near and long time scopes, resembling **fiat zoomed in** and **gold zoomed out**.



Having now identified time as a dimension that matters, there are some newly introduced dependencies we need to address. Examples of this include the following:

1. To function as a near-term unit of account, a money needs to store near-term value
2. To function as a long-term unit of account, a money needs to store long-term value
3. No long-term considerations are necessary for functioning as a medium of exchange.

Some of these qualities appear to be in conflict with how we think about the functions of money, and this may cause some confusion. But luckily, an even simpler definition of Ideal Money can offer clarity.

2.3 Ideal Money - Concrete Definition

Ideal Money is a digital currency capable of storing both near-term and long-term value.

In essence, a digital currency that is algorithmically bound to store both near and long-term value can serve as Ideal Money in all three functions, across all time scopes.

Now we're finally ready to unpack our concrete definition of Ideal Money into a simple framework, for the purpose of benchmarking the quality of any money against Ideal Money.

2.4 Ideal Money - A Quality Framework

The following framework for Ideal Money consists of seven qualities; and the monies that have all seven qualities are considered Ideal Money. Generally, the higher the score, the better the money.

We've already talked about the three functions of money in near and long scopes. In addition, we have also added "Globally Scalable" and "Government Independent" to the list below to ensure that the full scope of Ideal Money is captured. It's worth noting that by "Globally Scalable," we mean economic scalability,

rather than system scalability. As a counter-example, a currency that needs to lock up all the existing world assets of another currency in order to scale would not qualify.

Ideal Money	Near-Term	Long-Term
Unit of Account	1	1
Store of Value	1	1
Medium of Exchange	1	
Globally Scalable	1	
Government Independent	1	

Table 1: Ideal Money Quality Framework - 7.0 is the maximum score

The case could be made that the qualities 1) long-term store of value, 2) long-term unit of account, and 3) government independence—are distinct from modern day fiat—and this distinctiveness is a quality itself.

We could have placed a heavier weight on these distinctive qualities because currencies like Bitcoin can be held in addition to fiat, bringing up the average quality of money—whereas holding multiple fiat currencies that only maintain near-term value would have a smaller cumulative effect on the average.

However, only a currency with all seven qualities can function as Ideal Money—so we've given equal weight to all qualities, and simply encourage readers keep the current context of the ecosystem in mind.

3 Bitcoin & Tether

Below we begin by looking at Bitcoin and Tether through the lens of Ideal Money. We've selected these two because both are overtly money and have commonly understood use cases that are analogous to gold and fiat.

3.1 Bitcoin

Ideal Money Score: 5.0 / 7.0

Bitcoin is a better money than fiat in the sense that it is government independent and has a predetermined supply. This allows Bitcoin to behave as a global long-term store of value, like a digital gold. But at steady state, the fixed supply cannot react to changes in demand. And as a result, Bitcoin will not be suitable for use as a near-term store of value or unit of account.

Bitcoin	Near-Term	Long-Term
Unit of Account	0	1
Store of Value	0	1
Medium of Exchange	1	
Globally Scalable	1	
Government Independent	1	

Table 2: Ideal Money Quality Framework - Bitcoin (5.0 / 7.0)

3.2 Tether

Ideal Money Score: 3.0 / 7.0

Tether, being entirely fiat collateralized is very equivalent to fiat. It can function as a near-term unit of account, store of value, and medium of exchange—but offers no long-term utility. The currency is heavily centralized and entirely unscalable.

Tether	Near-Term	Long-Term
Unit of Account	1	0
Store of Value	1	0
Medium of Exchange	1	
Globally Scalable	0	
Government Independent	0	

Table 3: Ideal Money Quality Framework - Tether (3.0 / 7.0)

4 Our Protocol

Now that we've defined an Ideal Money framework and applied it to some known currencies, we're ready to describe our protocol before benchmarking it below. At a high level, our protocol seeks to move volatility from unit price to unit count. Consider the following examples:

> **Floating Price Model**
> *Imagine you purchased 1 BTC at* $1*, and now have 1 BTC worth* $10000*.*
>
> **Ampleforth Model**
> *Now imagine an alternate universe, in which you again purchased 1 BTC at* $1*, but this time you have 10000 BTC each worth* $1*.*

This difference may appear subtle, but the second model is strictly better than the first because it preserves the unit of account function of money. To achieve this, the protocol expands and contracts supply according to a price-target in one of two ways:

1. When the price exchange rate between Amples and dollars is > 1, the protocol responds by inflating directly to coin holders, placing pressure on speculators to sell.

2. When the price exchange rate between Amples and dollars is < 1, the protocol responds by deflating directly from coin holders, placing pressure on speculators to buy.

By expanding to, and contracting from coin holders directly, the Ampleforth protocol avoids the devaluing effects of inflation observed in fiat currencies, while re-engaging the supply mechanism that allows fiat currencies to preserve near-term stability.

Much like Bitcoin's algorithmically enforced promise of a predetermined supply policy, the Ampleforth protocol operates on the algorithmically enforced promise of an elastic supply policy.

5 How it Converges

The Ampleforth protocol establishes a set of initial conditions and incentives for the network, but it's actually the actors that create stability.

> The Quantity Theory of Money states that a price difference of $X\%$ can be offset by a supply change of $X\%$.

We make use of this to algorithmically set supply targets—which is important because the promise of elastic supply needs to be strictly enforced. But changing supply does not mean that traders will correspondingly adjust their bids. In practice, traders will respond to supply changes based on how quickly or slowly they think others will respond. And while it may be tempting to think our key assumption is that the Quantity Theory of Money will hold, this is not the case. In truth, our key assumption is that traders will eventually seek to buy low and sell high.

> Let's say the token is trading at $\$1.5$ to $\$1$. The Ampleforth protocol offsets this by inflating as though it is increasing supply by 50% over the course of a 30 day period. Merely increasing supply will not affect the price, because traders need to take the new information into consideration and willingly modify their bids for price changes to be reflected.
>
> If users continue to hold, the Ampleforth protocol continues increasing supply, retargeting supply offsets according to a 30 day period again each day. Eventually the sell pressure becomes undeniable, triggering sales, and causing the price to decrease.
>
> If the price falls below $\$1$, the Ampleforth protocol begins contracting supply, making the token increasingly scarce. At some point, a much larger percentage of the market cap can be purchased for a comparably low price and the buy pressure compels traders to buy, continuing the cycle.

Eventually, traders become habituated to inflation as a signal to sell and deflation as a signal to buy. And as competition increases, the feedback loop hastens. This feedback loop follows a simple logic that asks

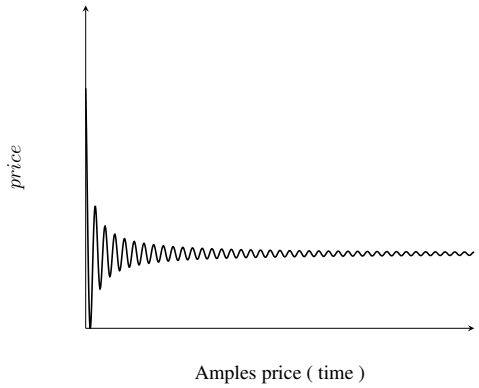
market makers the following question upon expansion:

> **Expansion Question**: "Given that Amples are inflating, what is the likelihood of sell pressure occurring in $\{1, 2, 3, \ldots n\}$ days?"

And the following question upon contraction:

> **Contraction Question**: "Given that Amples are deflating, what is the likelihood of buy pressure occurring in $\{1, 2, 3, \ldots n\}$ days?"

Over time, market pressures cause n to decrease. At equilibrium, traders will benefit from responding to price as a first-order signal even in advance of supply changes, causing the system to converge on stability much faster than any supply policy can.



This game theoretic view of convergence implies that the currency will evolve in phases.

Phase I - Store of Value

The token is volatile in both price and supply at launch. Elastic supply is fully functional and the asset is entirely non-dilutive.
$n > 1$

Phase II - Unit of Account

Once traders have habituated to inflation being a signal to sell and deflation a signal to buy, the token will enter a state where it's stable in price but volatile in supply.
$n < 1$

Phase III - Medium of Exchange

At this point, traders respond to price as a signal to buy / sell, in advance of inflation / deflation. Eventually, the supply variation will converge on a rate of sector level expansion.

$n = 0$

6 How it Compares

In this section we apply the Ideal Money framework to the Ampleforth protocol, but before benchmarking, we'd like to highlight some of the additional benefits of this approach.

6.1 More Functional than Bitcoin

Above we alluded to some of the benefits of government independent money. The separation of monetary policy from government grants optionality to governments, individuals, and institutions alike. The Bitcoin protocol, being inflation resistant, anonymous, and decentralized, has made huge strides in this direction. But Bitcoin's functionality is severely limited by its price volatility. As a standard for deferred payment, Bitcoin cannot be used to denominate the debt or credit instruments that much of our financial infrastructure is built on. For example, if a country wanted to borrow $10 billion to be paid back in equal installments over the course of 10 years, such a contract could never be denominated in Bitcoin, but it eventually could in Amples.

6.2 More Fair than Fiat

When central banks inflate their currency, they do not expand new supply to existing holders. Effectively, the purchasing power of each person's account balance is devalued, and the new money is held and distributed at the discretion of a central authority. In the case of Ampleforth, inflation and deflation occur entirely in response to demand and propagate to all coin holders. This is not a criticism of how central banks act; rather it is an opportunity that could never have been possible without innovations in distributed ledger technology like Ethereum.

6.3 Benchmarking Ampleforth

We have yet to talk about Ampleforth in the context of scalability, near-term value storage, and government independence, so before we tally up the score we'll address these three topics:

On Scalability

Like Bitcoin, Ampleforth is a non-collateralized game-theoretic money. Scaling Ampleforth does not require locking up exogenous assets. This qualifies the currency as globally scalable.

On Government Independence

Ampleforth begins price-targeted to the USD, which introduces a connection to existing fiat monetary policy. Initially, the relative growth rates of Amples have the potential to vastly outpace any rates of fiat inflation. But at steady state, fiat inflation would eventually drag the purchasing power of the coin down.

Luckily, one of the great benefits of a non-collateralized coin is that the price target can easily be switched to a CPI that represents purchasing power against a basket of commonly consumed goods. By compari-

son, a collateralized coin like Tether would have to reinvest its reserves into higher yield assets than fiat to target a CPI, further reducing transparency and requiring trust.

On Storing Near Term Value

"If Ampleforth simply trades unit price volatility for unit count volatility, how can it ever store near-term value?" To answer this question, we need to first discuss why fiat is a good near-term store of value.

Fiat's near-term stability emerges from price and wage stickiness that occurs naturally in any economy. When people denominate goods and services using a particular currency, there is always a delay between the moment new money is introduced to the system and the moment prices and wages reflect that difference. In addition to a delay, there's also an observable resistance to changes in price among currencies that are used for denomination.[1] For example, wages are more flexible upwards than downwards, and there is a real cost to repricing menus and renegotiating supply chains.

Today, many people hold Bitcoin for idealistic and speculative reasons and are thus compelled to settle payments with it; but its volatile price prevents denomination of goods and services from taking hold. Ample are aligned with early adopters the same way Bitcoin is, but can easily be used for denomination. This leads to price and wage stickiness just as it does with fiat.

If Bitcoin gained adoption as a unit of account, it could temporarily be used to store near-term value the way gold was used in the past. However this effect would be short-lived because its fixed supply cannot respond to changes in demand. In periods of increased demand, the currency would repeat the history of scarce metals leading to currency price increases, hoarding, and deflationary spirals.

6.4 Ampleforth

Ideal Money Score: **7.0 / 7.0**

Ampleforth uses an elastic supply policy that responds to demand, allowing it to function as a unit of account and corresponding a near-term store of value. Additionally, the policy inflates and deflates symmetrically to coin holders, allowing it to store long-term value. The currency is game-theoretic and non-collateralized, making Ampleforth globally scalable—and its price-target can be adjusted to any purchasing power index, making it government-independent.

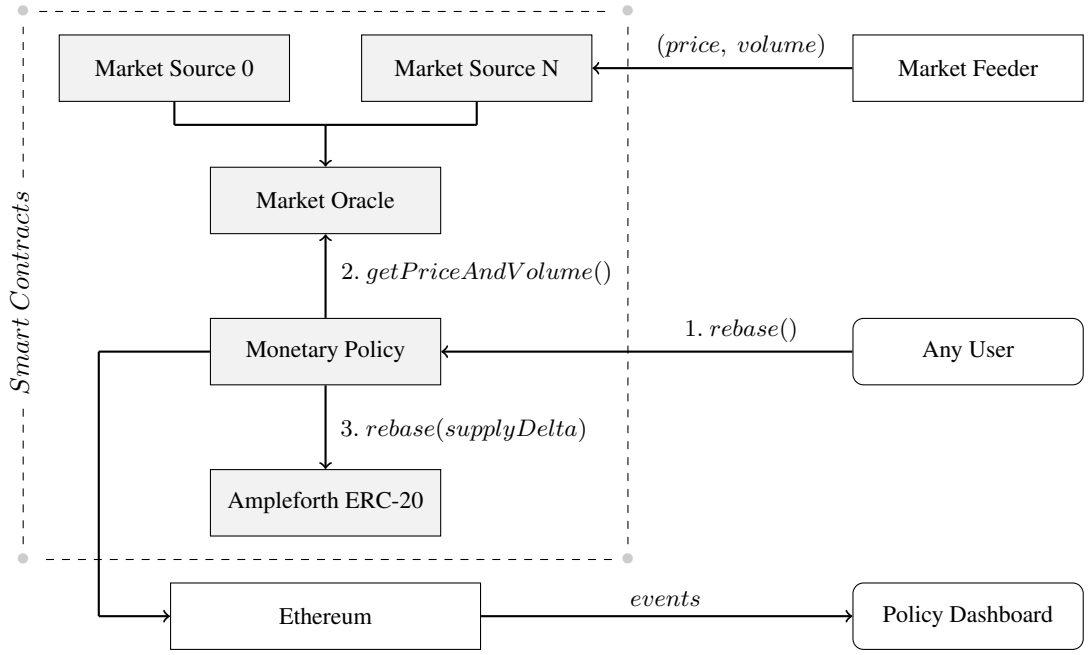
Ampleforth	Near-Term	Long-Term
Unit of Account	1	1
Store of Value	1	1
Medium of Exchange	1	
Globally Scalable	1	
Government Independent	1	

[1] 'Michael L. Mussa, "Exchange Rates In Theory And In Reality", *Essays In International Finance - Department of Economics of Princeton University No. 179*, December 1990

Table 4: Ideal Money Quality Framework - Ampleforth (7.0 / 7.0)

7 Software Architecture

Here we present an overview of the Ampleforth architecture and its touch-points with the external world. At its core, the system consists of three smart contracts: 1) the Ampleforth ERC-20 Contract 2) the Market Oracle Contract, and 3) the Monetary Policy Contract.



7.1 Ampleforth ERC-20 Contract

The Ampleforth token implements the standard ERC-20 interface. It has one additional function called `rebase(uint256 epoch, int256 supplyDelta)` and overwrites a number of public interfaces. This method instructs the token contract to add to, or subtract from, the total supply of tokens, and is only callable by the Monetary Policy Contract. All supply adjustments are symmetric across expansion and contraction such that:

If `supplyDelta` is positive, the new tokens are distributed to existing holders pro-quota. If `supplyDelta` is negative, tokens are removed from existing holders pro-quota.

To execute this process efficiently, we avoid generating a transaction for each wallet. Instead, Ampleforth balances are internally represented by a hidden internal denomination. All external interfaces to the system reference the external denomination, while all internal operations reference the hidden internal denomination.

The conversion rate between the hidden internal denomination and the external denomination is controlled by an exchange rate that equals `hiddenSupply/uFragmentSupply`. This rate, sometimes referred to as the `splitRatio`, is represented rationally as the quotient of two numbers in the codebase.

For good reason, Solidity does not support floating point numbers. Rounding is a tricky business in accounting software and this puts pressure on developers to take great care when thinking about numerical stability. In practice, we follow a stricter version of the EU's guidelines on rounding numbers during currency conversion[2]. We guarantee the following:

> If address A transfers X Ample to address B, A's resulting external balance will be decreased by precisely X Ample, and B's external balance will be precisely increased by X Ample.

In other words, any transaction or approval will always be precise with respect to both sides of the transaction. However, we do not guarantee that the sum of all balances always equals the result of calling `totalSupply()`. This is consistent with widely adopted currency conversion systems, and the trade-off is unavoidable because for any conversion function f that has non-zero rounding error, $f(x_0) + f(x_1) + ... + f(x_n)$ is not always equal to $f(x_0 + x_1 + ... x_n)$.

7.2 Market Oracle Contract

The Market Oracle Contract provides data from the outside world to be used by the Monetary Policy Contract. Specifically, it returns the Ampleforth Price and Trade Volume. At launch, the oracle will have a trusted whitelist of sources and the price is calculated as a volume weighted average from the sources.

1. Each market source will only accept values from their creators.
2. The market source feeders will provide new price and volume info at least every 6 hours, or if the price deviates by greater than `priceThreshold`.
3. If enough time passes before new data is sent to the source, it is considered expired and not used in the Market Oracle Contract's aggregation logic.

See the Governance section for how this will evolve over time as the network grows.

7.3 Monetary Policy Contract

The Monetary Policy Contract has a single external function, also called `rebase()`, this not to be confused with the rebase method in the Ampleforth ERC-20 Contract.

This `rebase()` method is publicly callable by anyone, but will only execute at most once every 24 hours. Opening this method up, helps to remove us as a necessary central party in the system's execution. If we

[2] "The Introduction of the Euro and the Rounding of Currency Amounts (1999)" is a good starting reference for practices related to currency conversions. We follow a stricter version of these rules in our implementation. `http://ec.europa.eu/economy_finance/publications/pages/publication1224_en.pdf`

fail to call `rebase()` for any reason, others are free to make that call in our place.

The `rebase()` method first queries the Market Oracle to get the current price. If the price is within `priceThreshold` of the target price, no monetary policy change is applied. Otherwise, the absolute `supplyDelta` is equal to `(price-target)*totalSupply/target`. For example, if Amples are trading for $1.15, the absolute `totalSupply` increase will be 15%.

Next, it applies a "rebase reaction lag" to dampen the supply change. At launch, the reaction lag will be 30 days. Finally, the Ampleforth ERC-20 token is instructed to adjust its supply by the dampened value. Continuing with the example above, the dampened increase would be (15% / 30 days) = 0.5% per day.

8 Simulations & Hyperparameters

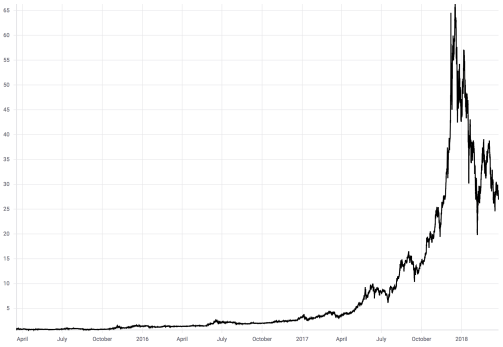
Previously we talked about how convergence happens and how little we rely on the Quantity Theory of Money. Nonetheless, simulating convergence as though the Quantity Theory holds can ground hyper-parameters like the `rebaseReactionLag`.

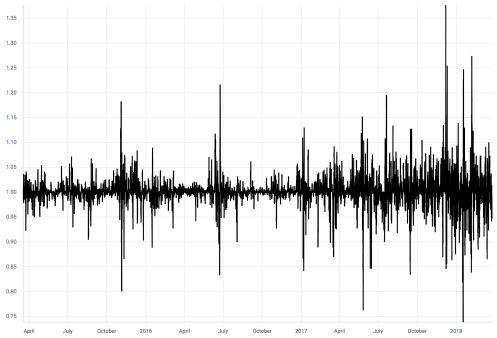
We have initialized this hyper-parameter value to 30 days. Effectively, this means we inflate or deflate as though `supplyDelta` will be distributed over the course of the next 30 days. Of course, the `supplyDelta` is recomputed each day, so we never fully release any specific instance of `supplyDelta`—but the net effect is a graded increase in either sell-pressure or buy-pressure.

Looking at rebase simulations over Bitcoin's price volatility distribution allows us to glimpse what the world would look like if traders responded to supply changes in a perfectly rational way and nothing else. These are neither the equilibrium conditions of the system, nor the initial conditions of the system.

8.1 Bitcoin Volatility vs 1:1 Rebasing

Below is a chart of Bitcoin's price distribution (left) compared to complete supply rebasing daily (right). In other words, this compares the current BTC distribution to what the system would look like if we assumed the Quantity Theory of Money held, and distributed the entire `supplyDelta` once per day.





8.2 1:30 Rebasing vs 1:120 Rebasing

Below is a chart of 1/30 supply rebasing (left) compared to 1/120 supply rebasing daily (right). In other words, this compares what the system would look like if we assumed the Quantity Theory of Money held, and distributed the one 30th of `supplyDelta` vs one 120th of the `supplyDelta` once per day.

8.3 High Frequency Rebasing

It may be tempting to think that the faster we rebase, the more stable the currency will be, but this is not true. Recall that for any price changes to be reflected, traders need to process the supply change and modify their bids accordingly. Rebasing too quickly introduces unnecessary supply changes and dilutes the inflation and deflation indicators.

In practice, traders will respond to supply changes based on how quickly or slowly they think other traders will respond. The promise of a continued inflation cycle and the belief that someone else will sell at the maxima is what ultimately drives traders to sell. Similarly the promise of a continued deflation cycle, and the belief that someone else will buy at the minima is what ultimately drives traders to buy.

As a result, the effect of simple arbitrage will stabilize price much more quickly and accurately than rebasing can. In the meantime, we've opted to initialize the system with 1/30 rebasing as a healthy middle

ground.

9 Conclusion

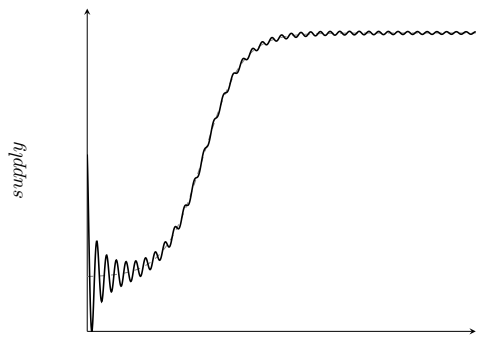
In 1976 the economist and Nobel Laureate Friedrich Hayek published an important and now incredibly relevant paper titled "The Denationalization of Money" In it, he proposes two things:

1. Open up the free trade of money.
2. Allow the issuance of independent monies.

Opening up the free trade of money lifts the floor of monetary quality by placing pressure on weak currencies to be more responsible with their issuance and regulation of supply. If citizens of hyperinflationary states like Venezuela and Argentina can simply purchase US dollars, there is little excuse left for their respective governments to execute poor monetary policy.

Issuing independent monies lifts the ceiling of monetary quality by placing pressure on leading currencies to be more responsible with their issuance and regulation of supply. Lacking military and government mandates, independent monies can only exist if they are better at regulating supply than existing alternatives. Independent monies like Bitcoin expose inefficiencies in existing systems, pressuring governments to execute better monetary policy.

The Ampleforth protocol is a return to the original mission of cryptocurrencies. And we feel that if Bitcoin, or a token like it, was following a path that could lead it from store of value to unit of account to medium of exchange, those who embraced this original mission would be pleased.



$\mu fragments\ supply\ (\ time\ )$

Appendices

A Governance

The final state of governance for Ampleforth will completely remove any single entity, including us, from the critical paths of the system. The goal is for Ampleforth to become a truly decentralized and enduring organization governed entirely by its community of users.

Nonetheless, we believe that launching with full governance out the gate introduces unnecessary risks that do not serve to prove or disprove the core hypotheses of the protocol. Moreover, no high profile project has yet to succeed in fully decentralizing governance, and this will be an ongoing area of inquiry for the ecosystem.

Instead, we will publish a separate stand-alone paper providing a governance roadmap—in collaboration with other projects that specialize in governance and the Ampleforth transition to community governance will occur in phases that shift control to token holders over time. This approach allows us to co-develop governance with the community in a manner aligned with the true needs of the network, rather than guessing.

There will be no separate governance token at launch. And to the extent possible, we will leverage staked voting and structures that do not require a separate token first. Before implementing on-chain voting, we will engage the community in a non-binding fashion to gather sentiment and ensure that we are reflecting its true needs. Given what we know at this time, the following is how we foresee the governance transition:

A.1 Phase I - Hyperparameters 1.0

The first phase will gate modifications to uFragments hyper-parameters like the rebase reaction lag and price threshold with on-chain voting. Each hyper-parameter will only be adjustable by a factor of paramDelta to limit sudden swings in behavior, and paramDelta itself will only be adjustable by a factor of paramDelta. While actual voting will take place on-chain, members of the Ampleforth core team will first gather information using tools like Carbon Vote to better understand community sentiment before on-chain voting takes place. Our voting system will likely operate similarly to OpenZeppelin's "Vouching" system using the native Ampleforth token.

A.2 Phase II - Hyperparameters 2.0

Next, adding to or subtracting from the MarketOracle's whitelist of sources will be executed by the voting mechanism.

A.3 Phase III - Veto Power

While phase 1 and 2 allow the community to modify the parameters within the existing logic, Phase 3 allows the community to weigh-in on proposed upgrades and changes to the original logic. This allows the team to make more fundamental changes to the system, with the community's approval.

A.4 Phase IV - Proposal Power

After implementing community veto power, we will move to allow anyone to propose contract code updates and carry out voting processes to determine whether proposals are accepted and deployed.

B Failure Cases

Below we talk about potential failure cases.

B.1 Peg Breaking

The first failure case that we want to address is that of peg-breaking. This is a common question for stablecoins that is less relevant for Ampleforth, but still worth discussing. In the case of tokens like Tether, a price deviation of 25% might be irrecoverable. This is because the promise of Tether is that one fiat dollar will be warehoused for every USDT token minted. As a result, a substantial price deviation would only occur if faith in that promise was severely shaken.

Ampleforth promises only that it will inflate when the price exchange rate is over one and deflate when the price exchange rate is under one. Price stability is a property that eventually emerges from this promise. Like Bitcoin, it begins as a volatile store of value token; and like Bitcoin Ampleforth can recover from almost any state. In this regard it is extremely fault tolerant.

B.2 Temporary Non-Convergence

Temporary non-convergence could happen for a few reasons: 1) People refuse to buy during contraction 2) People refuse to sell during inflation 3) People buy and sell frequently at random prices in random volumes.

If people refuse to buy under contraction, the currency supply can shrink to a very small amount, but will never get to zero. In this scenario, the currency can still recover and will indefinitely await the beginning of another cycle to potentially bootstrap convergence.

If people refuse to sell under expansion, this suggests that holders are willing to accrue an immense and increasing amount of wealth, but have absolutely no desire to ever redeem that wealth.

If people buy and sell at truly random prices, in truly random increments, without regard for fear, greed, or any other identifiable interest, at a substantial enough aggregate volume to dominate the behavior of the system, this could prevent the network from converging until larger players with coherent interests enter the system.

C What About Transactional Demand?

Gold has a multi-trillion dollar market cap and serves an important function in the global economy, despite not fielding much transactional demand. One of the beautiful things about Bitcoin is that it could potentially replace this function as a global store of value, without blockchains profoundly scaling. A compara-

ble coin to Bitcoin, that can also function as a stable unit of account, could play an even larger part in stabilizing the global economy as a global reserve currency, long before fielding heavy transactional demand. Ampleforth, like Bitcoin, could grow to fill this role without blockchains transformitively scaling.

Nonetheless, the presence of a price stable unit of account makes Ampleforth considerably easier to adopt for transactional use. Many people hold Bitcoin for speculative and idealistic reasons, and are compelled to settle payments or spend using it, but the unit price volatility makes it inconvenient to use in this case.

Menu and wage denomination are important factors in creating price stickiness, which plays a key role in the near term stability of fiat, and we believe this follows more naturally from a stable unit of account. Any added transactional demand contributes to near-term storage capabilities.

D Analysis of Other Monies

Below we analyze a number of monies using the Ideal Money framework. In the case of pre-launch protocols, we take the position of first assuming they work as described. Recall that our goal is to create an Ideal Money and have little interest in recreating fiat. Assuming protocols will work allows us to evaluate the quality of any experiment in money before investigating further. In other words, we take a "Let's say these work, have we created meaningfully better money?" approach.

D.1 Maker Dai

Ideal Money Score: 4.0 / 7.0

Maker is one of the oldest projects in the stablecoin space. We consider it to be the most successful non-fiat backed cryptocurrency to date and the project's contributions to the open source community have been extremely influential for us. However, its over-collateralized model is extremely expensive to scale, and requires locking up an unsustainable volume of crypto assets. Additionally, since it's collateralized it will be unable to move its peg off of a fiat price target. This removes any long term unit of account or store of value.

DAI	Near-Term	Long-Term
Unit of Account	1	0
Store of Value	1	0
Medium of Exchange	1	
Globally Scalable	0	
Government Independent	1	

Table 5: Ideal Money Quality Framework - DAI (4.0 / 7.0)

D.2 Basis

Ideal Money Score: 7.0 / 7.0

The Basis model is government independent, globally scalable, and would be resistant to the devaluing effects of inflation if it were to switch its peg off the USD to a CPI index or similar. All of these qualities gives Basis a high money score. We apply the framework with the assumption that the protocol is able to fulfill its intended purpose over the long term and have noted our concerns below:

Basis relies on the open market sale of bonds to contract supply, which we consider to be very risky in the long-run. While the public liquidity of government bonds has been helpful for sovereign states, governments like Argentina have to lobby incredibly hard to be repeatedly bailed out by bodies like the IMF under periods of low demand for bonds. It is difficult to imagine a public non-government backed bond market becoming responsibly decentralized.

Basis Shares have an unhealthy Nash equilibrium point. Upon expansion, Basis Shareholders are engaged in a war of attrition to hold and avoid selling into the market. The longer a shareholder waits to sell, the more dividends they receive, and because bonds bear all risk of contraction there's no immediate risk to this strategy.

Basis	Near-Term	Long-Term
Unit of Account	1	1
Store of Value	1	1
Medium of Exchange	1	
Globally Scalable	1	
Government Independent	1	

Table 6: Ideal Money Quality Framework - Basis (7.0 / 7.0)

D.3 Havven

Ideal Money Score: 4.5 / 7.0

Havven imposes fees on nUSD transactions which incentivize holders of HAV, hampering it as a medium of exchange. Additionally, the newly minted coins are sold on decentralized exchanges with the proceeds going to a fixed supply of HAV tokens, making nUSD unsuitable as a long-term store of value.

Havven	Near-Term	Long-Term
Unit of Account	1	0
Store of Value	1	0
Medium of Exchange	0.5	
Globally Scalable	1	
Government Independent	1	

Table 7: Ideal Money Quality Framework - Havven (4.5 / 7.0)

D.4 ETH

Ideal Money Score: 4.0 / 7.0

ETH has a constant rate of monetary inflation via the block mining process. However, ETH self-describes this as disinflationary because the monetary base of ETH is not constant. The inflation rate with respect to the monetary base shrinks over time and could even become deflationary similar to Bitcoin: `https://blog.ethereum.org/2014/04/10/the-issuance-model-in-ethereum/`.

ETH	Near-Term	Long-Term
Unit of Account	0	0.5
Store of Value	0	0.5
Medium of Exchange	1	
Globally Scalable	1	
Government Independent	1	

Table 8: Ideal Money Quality Framework - ETH (4.0 / 7.0)

D.5 Fiat

Ideal Money Score: 4.0 / 7.0

Fiat can function as a near-term unit of account, store of value, and medium of exchange—but offers no long-term utility. The currency is heavily centralized, but has already proven to be globally scalable.

Fiat	Near-Term	Long-Term
Unit of Account	1	0
Store of Value	1	0
Medium of Exchange	1	
Globally Scalable	1	
Government Independent	0	

Table 9: Ideal Money Quality Framework - Fiat (4.0 / 7.0)

D.6 Gold

Ideal Money Score: 5.0 / 7.0

Gold is naturally scarce, allowing it to store long-term value and has historically been used as a medium of exchange.

Gold	Near-Term	Long-Term
Unit of Account	0	1
Store of Value	0	1
Medium of Exchange	1	
Globally Scalable	1	
Government Independent	1	

Table 10: Ideal Money Quality Framework - Gold (5.0 / 7.0)

E Acknowledgements

In addition to the works and people cited below, we'd like to thank all of the stablecoin projects out there today for pushing the community forward.

Works

1. Satoshi Nakamoto, *"Bitcoin: A Peer-to-Peer Electronic Cash System"*
2. Vitalik Buterin, *"A Next-Generation Smart Contract and Decentralized Application Platform"*
3. Friedrich Hayek, *"Denationalization of Money"*
4. Ferdinando M. Ametrano, *"Hayek Money: The Cryptocurrency Price Stability Solution"*
5. Robert Sams, *"Seigniorage Shares"*

People

1. Aditya Sarawgi
2. Jessica Yen
3. Nithin Krishna
4. Noah Jessop
5. Paul Veradittakit
6. Joey Krug
7. Adam D'Augelli
8. Sam Lessin

"If I have seen further it is by standing on the shoulders of Giants." — Isaac Newton