Ethena USDe: An overview and risk analysis of the concept of "Internet bond"

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1 Part 1: Basics and yield mechanics.

1.1 Origin of the idea: Dust on crust blog post [10]

Stablecoins are designed to provide stability in the volatile crypto markets by being pegged to the dollar. The most popular (and also the only ones to not have failed) are backed by fiat currencies like the USD, and facilitate cheaper, easier and faster transactions that bypass the traditional banking system. This is particularly crucial given the systemic challenges faced by crypto markets, where crypto exchanges struggle to maintain banking relationships due to the competitive threat they pose to conventional financial institutions. Stablecoins enhance liquidity and ease transactions, suggesting a move towards a decentralized financial model that could function independently of traditional banks by possibly using cryptocurrencies like Bitcoin as backing.

The article by Arthur Hayes highlights a significant issue with the current state of stablecoins, which is the lack of participation by established banking institutions in their creation. An important point is mentionned, which is the following: If a major bank like JP Morgan were to launch its own stablecoins backed by G10 fiat currencies, it could potentially dominate the stablecoin market, overshadowing existing ones like USDT, USDC, and BUSD. JP Morgan's ability to manage deposits and integrate blockchain technology effectively, along with its status as a "Too Big to Fail" bank, means it could offer a more reliable and widely accepted stablecoin.

However, JP Morgan launching such a stablecoin could also have severe repercussions for the traditional banking system. Therefore, no bank with an account at the Federal Reserve is likely to launch a stablecoin unless mandated by the government.

The delta-neutral hedge, as used by the proposed NakaDollar (NUSD), is more appealing than traditional fiat-backed stablecoins because it eliminates reliance on centralized fiat reserves and banking systems. By using Bitcoin and inverse perpetual swaps, it maintains a stable USD value, ensuring liquidity and stability even in volatile markets. This approach avoids the regulatory and systemic risks of fiat-backed stablecoins, offering a more resilient and efficient solution for seamless crypto transactions.

1.2 Delta neutral hedging strategy: Achieving stability through linear and inverse perpetuals

In this section we extract information directly from the documentation of Ethena usde : [9]. In order to achieve the peg, the protocol (Ethena) takes advantage of some of the most liquid derivatives protocols **by shorting perpetuals as well as going long on the spot of the underlying asset**.

Let us grasp the intuition behind it : This can be clearly illustrated with inverse perpetuals that are intended to keep the same value in dollars when the trader enters the position and hence the price would be quoted in ETH. Let us recall the example presented again by Arthur Hayes and that serves as an inspiration:

An Ethereum inverse perpetual which is worth $1 of Ethereum paid out in Ethereum has the following payoff function:

- **1 USDe = $1 of ETH + Short 1 Ethereum / USD Inverse Perpetual**
  - To create 1 USDe, Ethena needs to delegate 1 ETH as margin with a derivatives exchange (via "Off-Exchange Settlement" solution) and short 1 ETHUSD perpetual.
- **Rapid ETH Price Decrease:**
  - Now the Ethereum price falls from $1 to $0.1.
  - The value of ETHUSD in ETH = $1 / $0.1 = 10 ETH
  - The PNL of ETHUSD Position = 10 ETH (current value) − 1 ETH (initial value) = +9 ETH
  - We have 1 ETH delegated as margin with the exchange.
  - Ethena's total equity balance with the exchange is 1 ETH (our initial margin) + 9 ETH (profit from the ETHUSD position), and the total balance is now 10 ETH.
  - The Ethereum price is now $0.1, but the system has 10 ETH, and therefore the USD value of the total portfolio is unchanged at $1, $0.1 * 10 ETH.
- **Rapid ETH Price Increase:**
  - Now the Ethereum price rises from $1 to $100.
  - The value of ETHUSD in ETH = $1 / $100 = 0.01 ETH
  - The PNL of ETHUSD Position = 0.01 ETH (current value) − 1 ETH (initial value) = -0.99 ETH
  - Ethena's total equity balance with the exchange is 1 ETH (initial margin) − 0.99 ETH (loss from ETHUSD position), and total balance is now 0.01 ETH.
  - The Ethereum price is now $100, but Ethena has 0.01 ETH, and therefore the USD value of the total portfolio is unchanged at $1, $100 * 0.01 ETH.

(this reasoning is also explained in the dust on crust document). We can see that the peg can indeed be achieved by holding the right amount of ETH and shorting the right amount of ETH inverse perpetuals. Note that Ethena does not only use inverse perpetuals, **it uses linear perpetuals as well futures (to catch the yield through basis spread, this point will be discussed later)** however inverse perpetuals serve as a perfect illustrative example.

There is an interesting consequence of this delta hedging strategy : it is also possible to generate yield from the stablecoin protocol.

1.3 Origin of the yield: liquid staking, funding rates and basis spread (Question 1)

After minting USDe the user can then stake it into the protocol, the yield generated by the protocol originates from two sources:

- **Staked asset consensus, execution layer rewards and MEV capture**

  In the context of Ethena's USDe, when the user want to stake usde in the protocol the collateral provided are staked. liquid staking offers substantial benefits by generating yields through APR rewards. Staked ETH can be obtained from protocols like Lido and traded in CEX and DEX protocols. These staked ETH create a yield, and as pointed out by Ethenas documentation, the expected inflationary rewards are more predictable at the Consensus layer but the Execution layer yield is more volatile due to its reliance on activity at the base layer. All these combined they generate the yield that the user benefits from.

- **Funding and basis spread earned from the delta hedging derivatives positions:** After recieving the coins the protocol enters a delta hedging strategy in the derivatives market with these coins in order to generate a yield. In derivatives market, particularly with perpetual swaps, the funding rate is a mechanism where a fee is transferred between contract holders to align the market price of the derivative with the underlying spot price. This fee flows from long to short position holders in a bullish market, and in the reverse direction during bearish conditions. Ethena shorts linear and inverse perpetuals. Concurrently, the basis spread, which is the discrepancy between the spot price and the futures price of an asset, presents another opportunity for Ethena to catch the yield. Ethena uses an algorithmic balancing strategy between perps and futures, they do not specify exactly the strategy (obviously) but we know that it leverages both kinds of derivatives. Note that the funding rates can also become negative for the short holders position and this will be explained later

The following figure illustrates the origin of the yield (Figure 1).

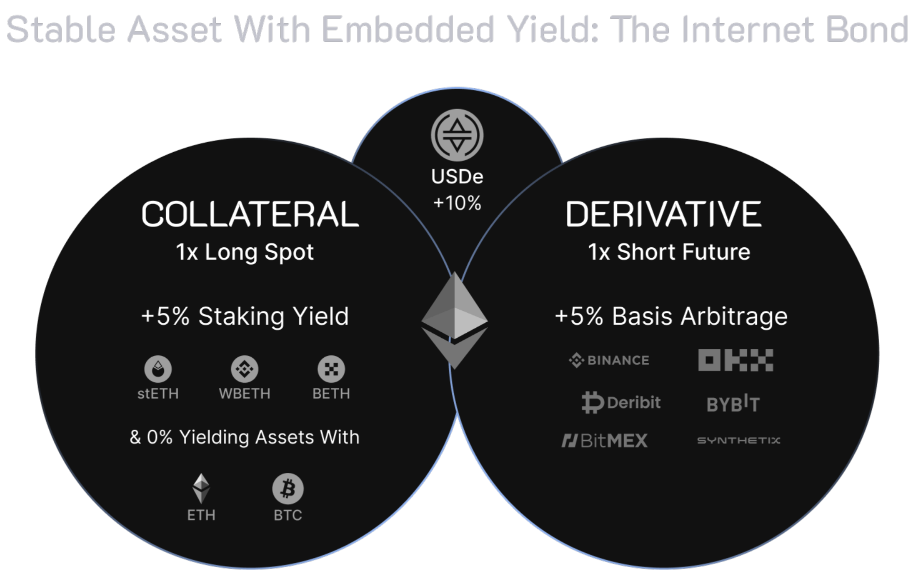

Figure 1: Origins of the yield

An illustration of the process of minting and redeeming from the user to the centralized exchanges (Figure 2):

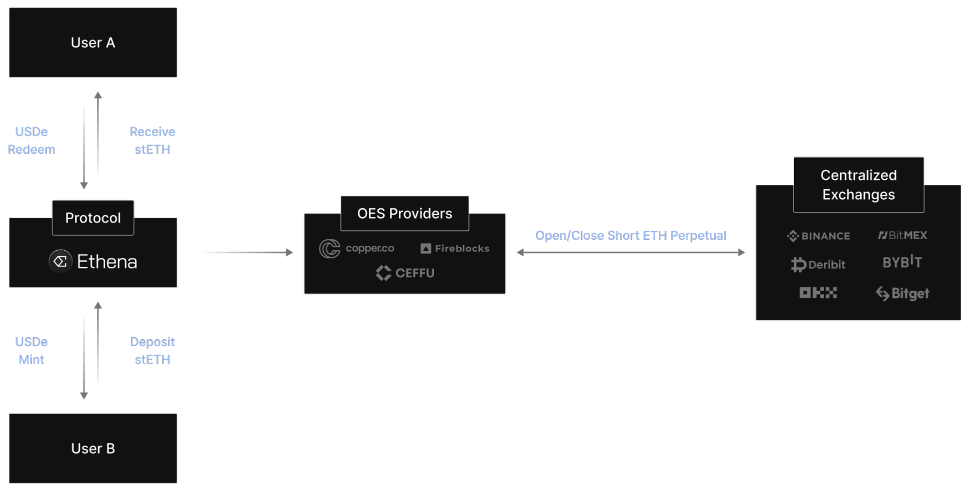

Figure 2: Ethena protocol: from the user to the centralized exchange

2 Part 2: A data analysis review (Question 2)

We now analyze how good could have done the internet bonds in the previous years by analyzing the components of the yield.

2.1 Staked yield: a post merge analysis

For the following section we chose to analyze lido stETH, we gather the data of the APY from DefiLamma as a csv file and plot it using python.

This graph tracks indeed the Annual Percentage Yield (APY) of Lido's staked Ethereum (stETH) from April 2022 to May 2024, a period that includes Ethereum's significant shift to a Proof of Stake (PoS) consensus mechanism, dubbed "The Merge." Prior to The Merge, the APY was consistently just above 4%. Following this pivotal update, the yield experienced marked volatility, with peaks surging to around 10%.. By 2024, the APY ranged from 3% to around 4.5% and is now close to 3%.

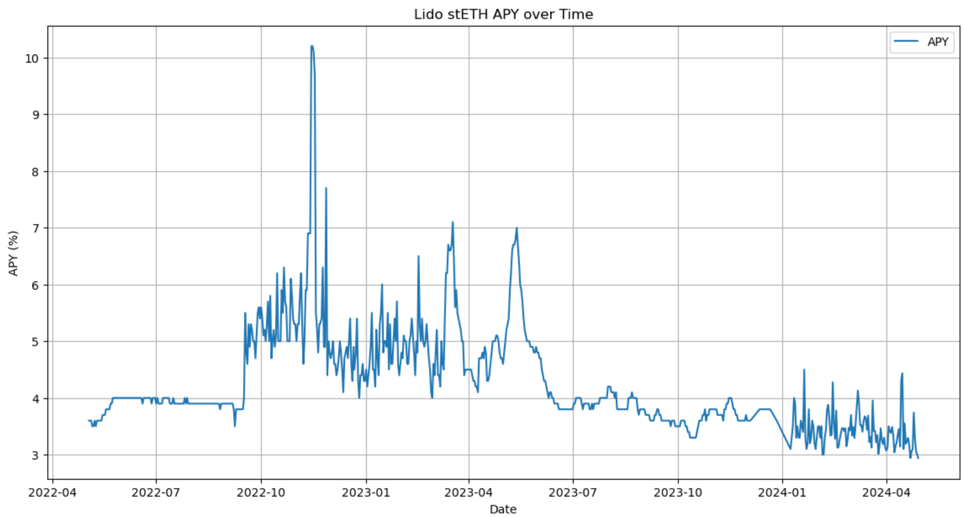

Figure 3: A table of the APR of stETH APY from DefiLamma : [5]

2.2 The funding rates mechanics: an analysis of the linear perpetuals funding rates and futures basis spread

2.2.1 Linear perpetuals :

In the following first part of our analysis we will analyse linear perpetuals of ETH/USD, we fetch data from coinalyze [1] (an analysis platform that fetches data directly from the biggest platfroms such as Binance, BitMex, Deribit...) by connecting to their API through GET requests. We base our analysis in the following way : We first fetch and plot the open OI (open interest) from 4 of the protocols Ethena uses, namely Binance, BitMex, Okex and Huobi, then for these platforms we plot the open funding rates and perform summary statistics on it in 2 different tables, one for Binance and Bitmex and the other table for Okex and Huobi. In order to have an idea about the rolling volatility we also plot the 30 days rolling voltility of the funding rates on Binance which has the highest liquidity and open interest among the studies protocols

An important parameter to analyze is the open interest which represents the total number of outstanding contracts that have not been settled. For perpetual contracts, which are a type of futures contract without an expiry date, open interest is the sum of all the contracts that are still open – not closed or filled – at any given time.

Analyzing open interest is useful because it provides insights into the market's liquidity and depth. It can also be indicative of market sentiment. A rising open interest suggests new money is coming into the market, reflecting increased trading activity and possibly a validation of the current price trend, be it bullish or bearish. Conversely, declining open interest signifies that the market is liquidating, which could indicate a reversal of the price trend.

Through figure 4/5/6/7 we can see that the open interest is largely dominated by Binance and that in all of the platforms it sees many fluctuations.

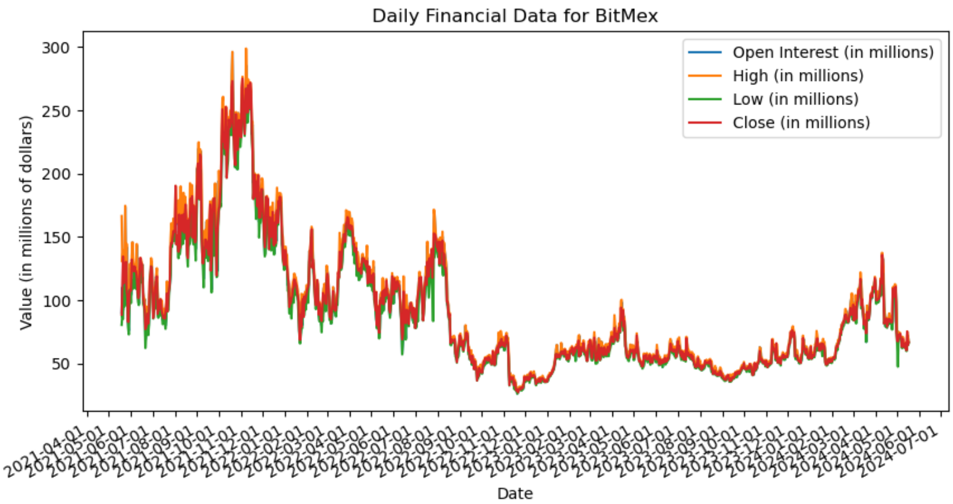

Figure 4: Open, high low and close open interest of ETH/USD linear perps on BitMex

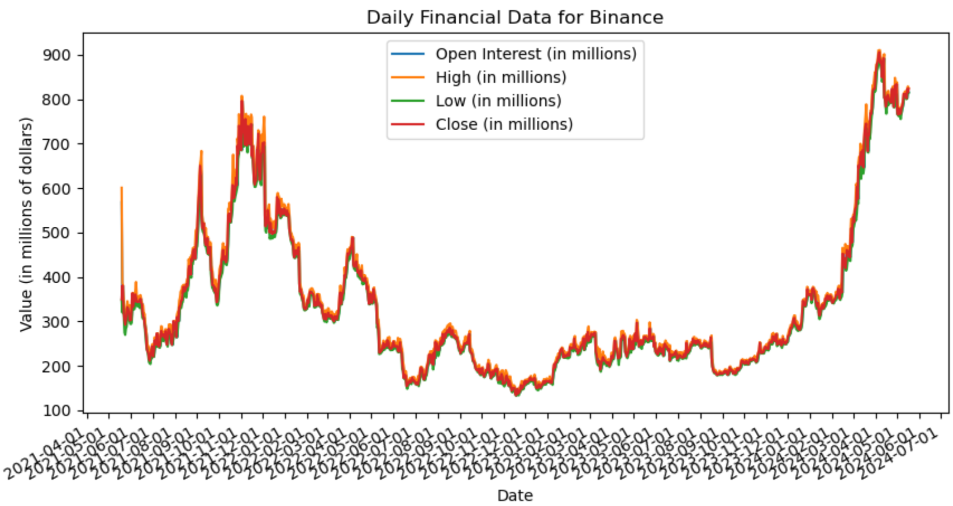

Figure 5: Open, high low and close open interest of ETH/USDT linear perps on Binance

Lets have a look now at the main components that generate the yield, namely the funding rates. BitMEX takes credit for introducing the perpetual swap market with a funding rate designed to keep the trading price close to the underlying asset's value. The funding rate has a dual nature—it reflects both the premium index, indicating the price gap between the perpetual contract and the actual asset, and an interest component that represents the cost of holding positions, much like borrowing one currency to purchase another.

To calculate the funding rate (F), BitMEX combines the premium index (P) with the interest rate (I), while ensuring the result remains within a set boundary:

F = P + clamp(I - P, 0.05%, -0.05%)

Diving deeper, the interest rate (I) is the net result of the daily fixed interest indices for the quote and base currencies, divided by the number of funding intervals per day. BitMEX usually breaks the day

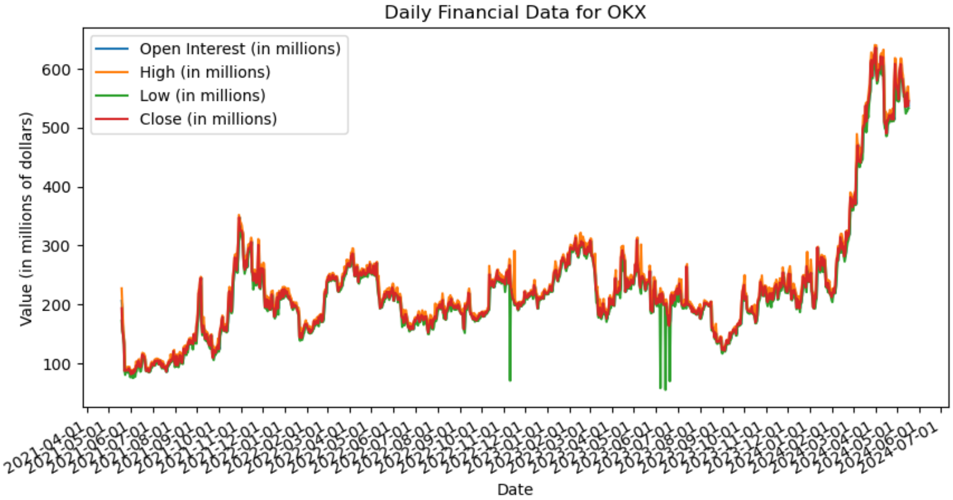

Figure 6: Open, high low and close open interest of ETH/USD linear perps on OKEX

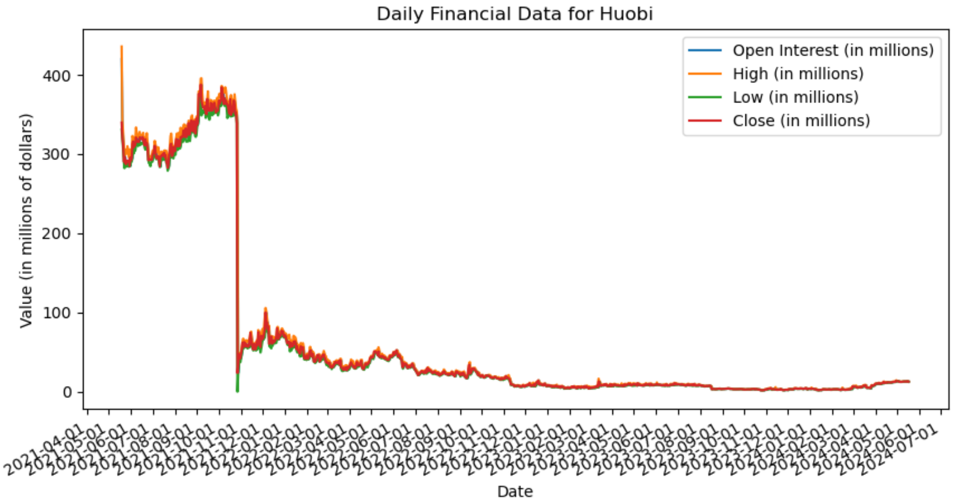

Figure 7: Open, high low and close open interest of ETH/USD linear perps on Huobi

into three 8-hour funding periods, thus the funding interval is three. The premium index (P) is slightly more complex, incorporating the impact bid and ask prices—which reflect a more realistic market depth than the best bid and ask prices—alongside the mark price and the index price, factoring in the fair basis which adjusts the index price to align with the funding rate over time.

The concept of "impact prices" comes into play to estimate a more accurate depth of market demand. It's not about the singular best bid or ask price but about the price if a substantial size of BTC was to be executed immediately in the order book. Similarly, the fair basis helps to integrate the memory of the recent funding rate into the current price, ensuring the price accounts for the latest market conditions.

When the mark price is nestled between the impact bid and ask prices, the premium index simplifies to just the fair basis. If the mark price is beneath the impact bid price, the premium index rises above the fair basis, indicating a tendency for the funding rate to increase. Conversely, if the mark price overshadows the impact ask price, the premium index dips below the fair basis, hinting at a potential decrease in the funding rate. These adjustments ensure that the perpetual swap price remains tethered to the underlying asset, balancing the market over time.

In figure 8,9,10,11 we plot the high low and close funding rates of the platforms for which we plotted the open interests, then we anayze how long they **consecutively stayed negative** as it is one of the mian dangers of the protocol that can drain the insurance fund. We also try to understand how volatile these funding rates are in every platforms as well as the max, min funding rates, the results are reported in the 2 different tables: Table 1 and Table 2

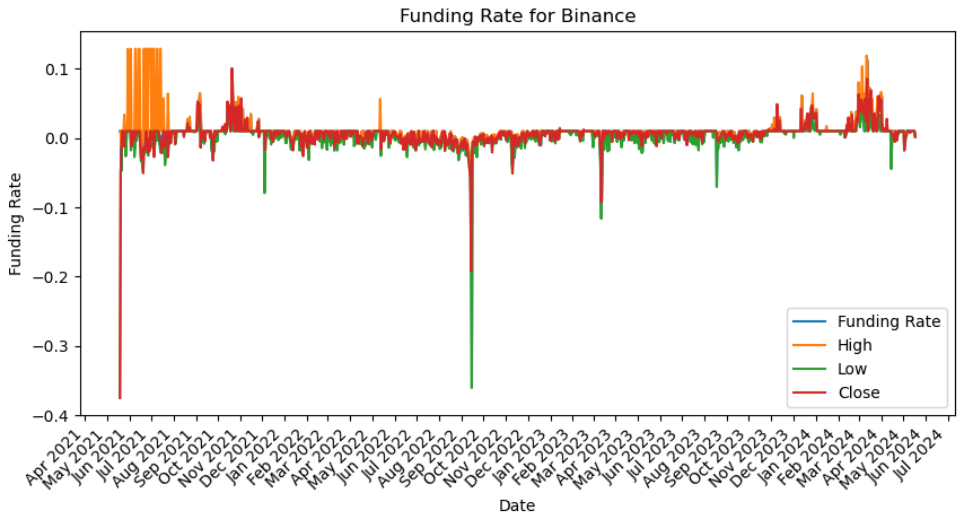

Figure 8: High, low, and close funding rates for Binance

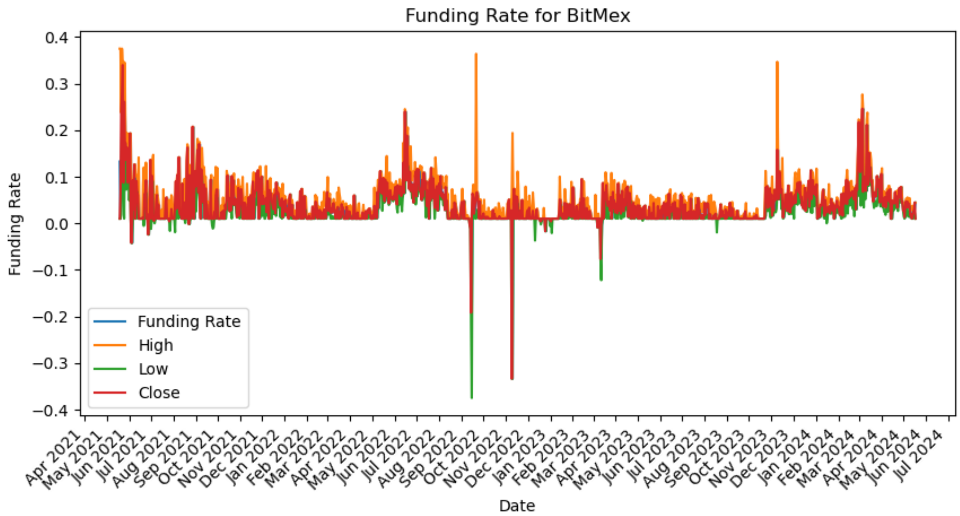

Figure 9: High, low, and close funding rates for BitMex

After analyzing the graphs we can see that the funding rates revert to the mean under various market conditions, however when the market turn bearish the investors tend to prefer more short positions, several market events can explain this trendy behaviour as we see that for all protocols the funding rates turned out negative deeply at around october 2022 which is a period after the Luna collapse and shortly before the big FTX collapse. However, in general these negative phases are generally short-lived as seen in the tables, and rates usually return to positive levels. Also, even during extended periods of negative rates, the average levels have generally remain above those seen in LST APRs and Ethena mainly gain yield from both sources so for the protocol to face problems the negative funding rate needs to overcome the stETH yield.

The graph shows the 30-day rolling volatility of funding rates for Binance from May 2021 to May 2024. Initially, from mid-2021 to early 2022, volatility is low, around 0.01, with brief spikes above 0.02, indicating relative stability. Mid-2022 sees a significant spike, with volatility peaking around 0.07, suggesting high uncertainty or major market events. Post-2022, volatility decreases but remains higher than earlier levels, showing a return to stability with some variability. In 2023 and early 2024, there

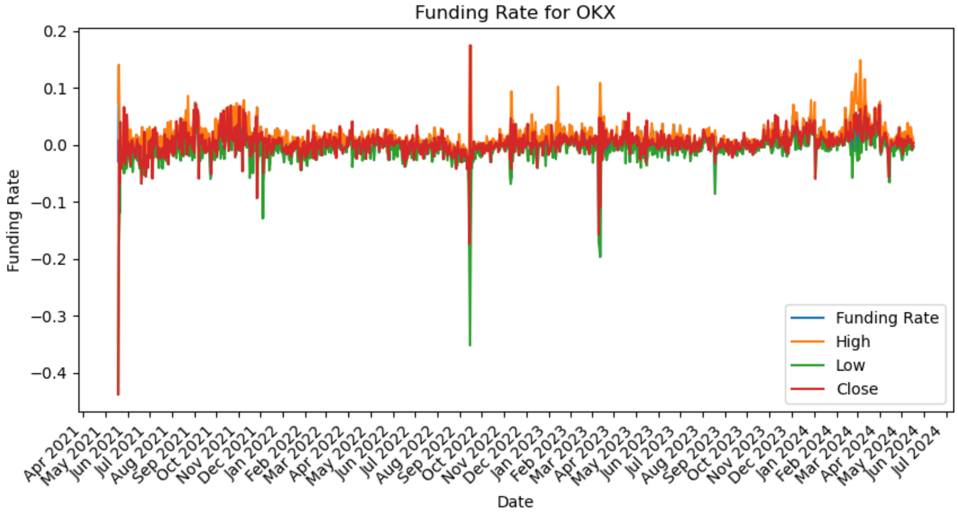

Figure 10: High, low, and close funding rates for OKEX

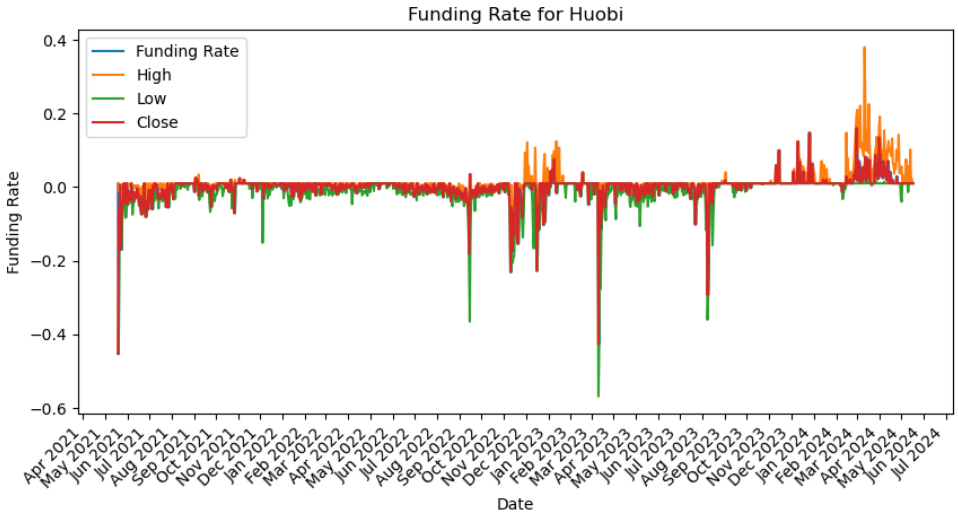

Figure 11: High, low, and close funding rates for Huobi

are smaller volatility peaks, indicating recurring periods of increased variability. Recently, in early to mid-2024, volatility declines, approaching the low levels of the initial period, suggesting a return to more stable conditions.

2.2.2 Future basis spread :

Ethena also takes advantage of the basis spread in futures derivatives market by earning a positive spread when shorting the future contract, however it also comes with its negative basis risks. Ethena do not provide its algorithmical procedure to balance between futures and perpetuals, however doing some exploratory analysis about future contracts might also give some insights about the overall sentiment of the market and might give insights also towards the robustness of Ethenas protocol.

Methodology :

We analyze in this section the future prices of Binance ETH quaterly (3 months) contracts through interacting with Coinalyze API (for more details about the interaction with the API please consult the jupyter notebook). We gather the open prices from Investing.com of Binance's Ethereum and compare it with the future prices in Binance again. We then analyze the average basis spread (taken here as the

Statistics	**BitMex**	**Binance**
Max Funding Rate	0.1297	0.0854
Min Funding Rate	-0.3326	-0.3019
Average Funding Rate	0.0072	0.0079
Standard Deviation	0.0226	0.0155
Median Funding Rate	0.01	0.01
25th Percentile	0.0072	0.0032
75th Percentile	0.01	0.01
Max Consecutive Days Negative Funding	8	8

Table 1: Summary Statistics for BitMex and Binance

Statistics	**OKX**	**Huobi**
Max Funding Rate	0.1745	0.1606
Min Funding Rate	-0.1966	-0.4530
Average Funding Rate	0.0028	-0.00006
Standard Deviation	0.0215	0.0352
Median Funding Rate	0.0018	0.01
25th Percentile	-0.0075	-0.0051
75th Percentile	0.0116	0.01
Max Consecutive Days Negative Funding	23	21

Table 2: Summary Statistics for OKEX and Huobi

difference between the open future price and the open spot price of ETH), the standard deviation of the spread as well as some temporal measures to assess the overall trend and evolution of the spread (rollvol/rollavg...).

We can summarize our findings in the following table:

Statistic	**Value**
Average Basis Spread	20.6992511141552512
Volatility of Basis Spread	108.26914492235301
Maximum Basis Spread	997.88999999999999
Minimum Basis Spread	-545.86000000000001
Maximum Consecutive Days of Negative Basis Spread	7

Table 3: Basis Spread Statistics

The graph in figure 14 displays the 30-day rolling average and 30-day rolling volatility of the basis spread from May 2021 to May 2024. The blue line represents the rolling average, indicating the overall trend of the basis spread over time. Initially, from mid-2021 to early 2022, the rolling average fluctuates significantly, with a notable peak around early 2022, suggesting substantial changes in the basis spread during this period. The orange line shows the 30-day rolling volatility, which measures the variability of the basis spread. There is high volatility around mid-2021, peaking above 250, indicating considerable market uncertainty. Following this, both the average and volatility decrease, showing a period of stabilization with occasional spikes. In 2023, the average basis spread rises again, accompanied by increased volatility, reflecting renewed market activity. By early 2024, both metrics surge before sharply declining, indicating a period of heightened market fluctuations followed by stabilization. This graph captures the fluctuating nature of the basis spread, marked by periods of both stability and significant variability.

2.3 Consequences of the De-peg

The de-pegging of stETH from ETH between May and September 2022 was a multifaceted event marked by market liquidity pressures and broader crypto market instability. The initial catalyst was the drastic de-pegging of TerraUSD (UST), an algorithmic stablecoin, in May 2022, which instigated widespread

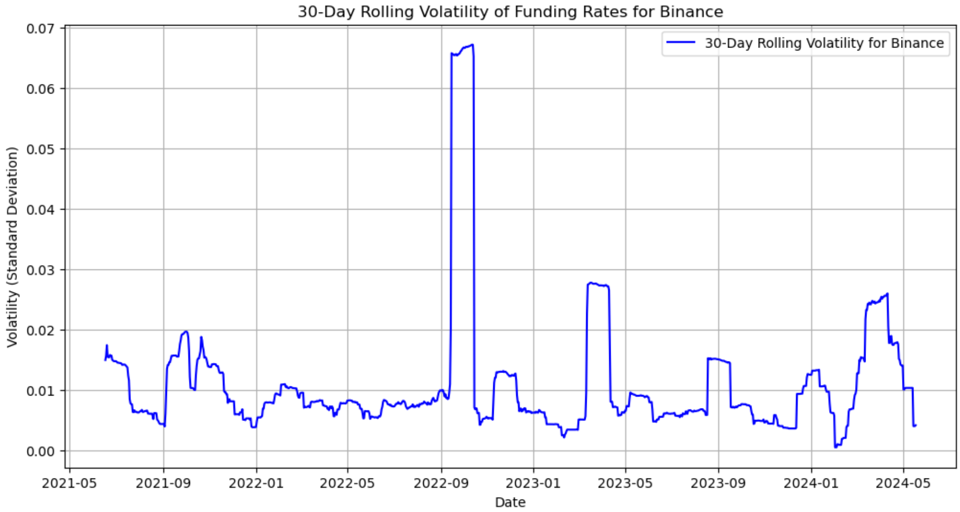

Figure 12: 30 day rolling volatility of funding rates on binance

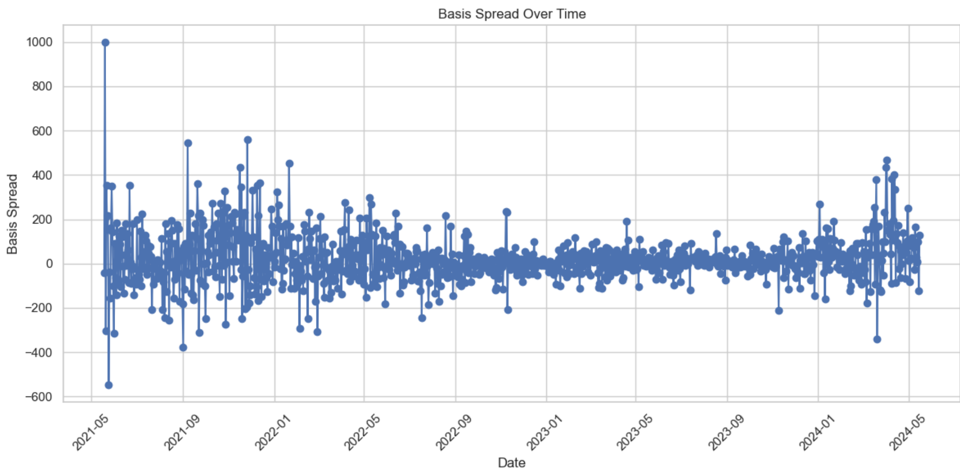

Figure 13: Futures ETH basis spread computed from 2021 by taking the difference of the future prices and the spot prices

panic across crypto assets and platforms linked through investment strategies and liquidity pools. This panic led to significant unwinding of stETH positions, with holders converting their stETH into ETH amidst fears of similar de-pegging incidents. Large-scale withdrawals from liquidity pools exacerbated this trend, intensifying the selling pressure on stETH.

Further compounding the issue, major market players such as Three Arrows Capital and Celsius engaged in substantial transactions that removed critical liquidity from the main stETH/ETH pools. This loss of liquidity was a direct contributor to stETH trading at a discount to ETH, putting additional strain on their peg. On-chain data from this period also showed a net sale of over 169,000 stETH primarily through decentralized exchanges (DEXs), which further depleted liquidity and disturbed the stETH/ETH ratio from its previously stable 1:1 alignment.

Many stETH holders used their staked Ethereum as collateral on the decentralized finance platform Aave to borrow other assets, leading to high leverage situations. As stETH prices fell relative to ETH, the collateral value decreased, which could trigger liquidations if the value fell below certain thresholds, amplifying the price drop in a cascading effect. This increased the risks for holders of leveraged positions, compelling them to sell stETH to cover potential margin calls and mitigate further losses, thereby adding to the selling pressure in a strained liquidity environment. This feedback loop of selling pressure and falling prices could exacerbate the de-pegging, setting off a classic "death spiral" in financial terms.

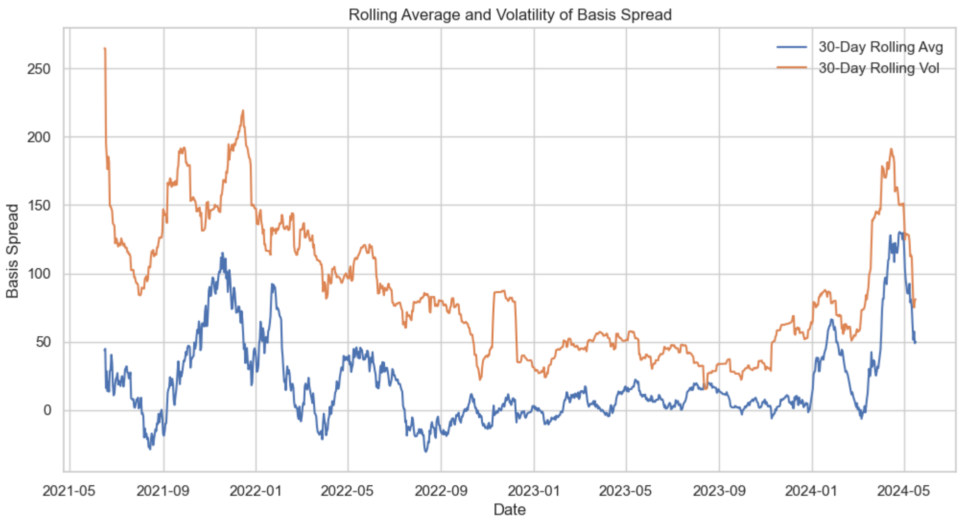

Figure 14: Rolling average and volatility for the futures basis spread over time since 2021

The following datas displaying the de-peg was taken from Coinmarketcap [4] as they directly provide an image to download.

Figure 15: An illustration of the De-peg and of the price if stETH/ETH since 2021 from coinmarketcap

Additionally, the implications of a de-pegging event such as the one experienced by stETH relative to ETH, which itself was partly catalyzed by broader market events, can severely impact market confidence. This shaken confidence might drive holders to trade pegged assets like USDe on decentralized exchanges (DEXes) such as Curve. In such scenarios, if many investors decide to sell their USDe, the increased selling pressure could lead to a lower price on Curve pools compared to its pegged value of 1:1 with USD. This price discrepancy creates significant arbitrage opportunities, as traders attempt to profit from price variations between different markets.

Such arbitrage efforts, while normal in financial markets, can exacerbate the issue by leading to increased volume and volatility, which, if not matched by corresponding liquidity, can strain the peg further. As observed with stETH in 2022, a similar dynamic could potentially trigger a de-pegging event for USDe if there is a substantial liquidity outflow. This scenario highlights the critical nature of liquidity in maintaining stable trading conditions and the peg of crypto-based synthetic assets to their underlying values.

Therefore, it's essential for entities like Ethena, managing USDe, to ensure robust mechanisms are in place to handle sudden shifts in market sentiment and liquidity, mitigating risks that could destabilize the asset's peg and investor confidence in the platform. This includes maintaining sufficient reserves, strategic liquidity provision, and possibly utilizing stabilization tools such as automatic market makers

Figure 16: Another illustration of the depeg with a graph displaying both prices in dollars from coinmarketcap again

(AMMs) or other financial instruments designed to cushion against large, sudden withdrawals and sales.

2.4 Is the crypto world healed from the LUNA trauma ? (Not graded question just remarks)

High Yields and alternative pegs, the golden path towards decentralization and general confidence. Well is it? Not really what everybody thinks in the crypto world, LUNA promised the same things but failed and the downfall of this multibillion dollars structure had drastic consequences on the market health. An interesting short article by Coindesk about the subject can be found here. Despite these comparisons, the USDe stablecoin, unlike Terra's UST, is not algorithmically backed but claims to be a synthetic stablecoin secured through a "cash-and-carry" trade strategy as explained before. which balances buying assets and shorting derivatives without direct market risk.

Since its public introduction, USDe has offered a striking 37% annualized yield for stakers at some time, boosting its total value locked from $178 million to $2.3 billion in two months. However, such high returns are typically indicative of high risks but the protocol's reliance on this trade strategy is considered safe and traditional by industry experts, although it carries risks related to market volatility and potential issues with the exchanges used for trades. Despite the risks, significant investments continue as seen with recent large withdrawals of Ethena's governance tokens.

The collapse of Terra caused ripples throughout the cryptocurrency sector, precipitating the downfall of numerous crypto enterprises and inflicting enduring damage across the industry landscape. The implosion was triggered when UST—a stablecoin based on algorithms—plunged into a destabilizing downward trend exacerbated by intense sell-offs and a drop in the value of its collateral currency, LUNA.

Guy Young, the founder of Ethena Labs, dismissed comparisons between the Ethena and Terra projects as superficial during an appearance on the Unchained podcast hosted by Laura Shin. "Comparing Ethena's operations with Luna is a shallow take," he stated. "The fundamental distinction lies in the backing of the stablecoin. Whereas UST's backing was the highly volatile LUNA token, Ethena's USD maintains full collateralization." He acknowledged that dependence on a bull market is a legitimate concern, noting that despite the turbulent market of 2022, staked ETH combined with other bases still yielded returns surpassing those of U.S. Treasuries. However, Young conceded that a bear market could likely lead to a contraction in USDe's supply, a scenario he finds acceptable as it reflects the natural ebb and flow of market forces. If the demand for leverage decreases alongside interest rates, Young is prepared to scale back, maintaining adaptability to the market's tides. Moreover, he did not dismiss the possibility of revising Ethena's approach to generating yield to align with the demands of a bear market when the situation calls for it.

3 Calculating the insurance fund resilience and toy model

Ethena's Approach to Mitigating Funding Risk

Ethena has developed a strategy to protect its users from the financial consequences of negative funding rates, referred to as "funding risk." To address this issue, they have established an emergency fund designed specifically to cover any deficits arising from these rates. The effectiveness of this approach hinges on two crucial parameters: the initial capital injected into the insurance fund and the annual percentage rate (APR) that is allocated to enhance the fund's robustness.

Modeling the Insurance Fund's Resilience

In order to evaluate the resilience of Ethena's insurance fund under adverse conditions, we constructed a toy model that simulates the impact of negative funding rates. The current balance of the insurance wallet, as reported by Etherscan, serves as the baseline for our stress test [12].

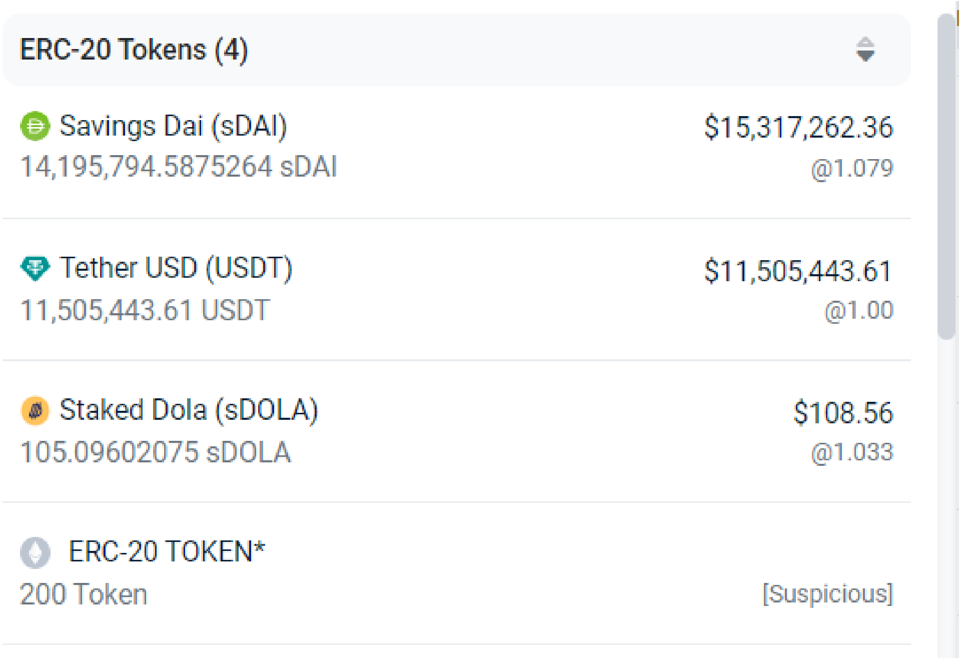

Figure 17: Value held in sUSD of the insurance fund

Thus we consider an insurance amount of 26 million dollars.

We will apply varying levels of stress tests with negative funding rates at 5%, 10%, 20%, and 30%. Additionally, we will analyze the fund's durability under various staked ethereum rates scenarios (2, 5, 10 %). This comparative analysis helps us understand how the insurance fund might perform in different market conditions.

Historical Context and Justification for Stress Test Levels

The rationale behind selecting a cap of -30% for our stress test is rooted in historical data. During the Ethereum merge, funding rates plummeted due to traders reducing their exposure to Ethereum [2] :

Records indicate that funding rates dropped to as low as -300% for brief periods, while the weighted average over a 30-day span reached -20% [8]. This historical precedent justifies the stress test thresholds and provides a relevant context for evaluating the potential longevity of the fund under similar extreme conditions .

Given the total value V of the staked assets and the insurance fund F, we examine how different negative funding rates and staked Ethereum interest rates affect the number of days the insurance fund can cover the losses. The calculations follow these steps:

1. **Funding Rates:** Define a range of negative funding rates r_f from -5% to -30% in increments of 1%.

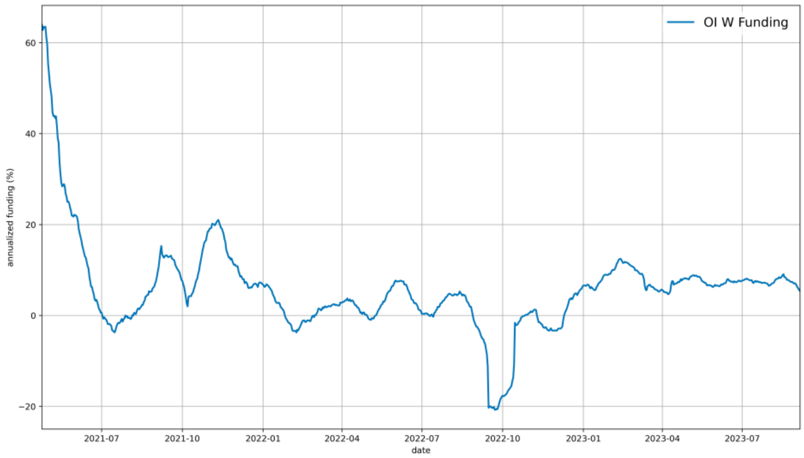

Figure 4: ETH Open Interest Weighted Perpetuals Funding Rates, 30-day Moving Average

Figure 18: Graph taken from the ethena insurance fund report

2. **Annual Losses:** Calculate the annual losses L_a as a product of the total value V and each funding rate r_f:
$$L_a = V \times r_f$$
3. **Net Annual Losses:** Adjust the annual losses by subtracting the gains from staked Ethereum at various interest rates r_i:
$$L_{net} = L_a - (V \times r_i)$$
4. **Daily Losses:** Convert the net annual losses into daily losses assuming 365 days per year:
$$L_d = \frac{L_{net}}{365}$$
5. **Days of Coverage:** Calculate the number of days D the insurance fund can cover these losses:
$$D = \frac{F}{|L_d|}$$

We implemented this in python (see insurance_fund_toy_model.py).

First off the impact of the ethereum interest rates in low stress situations greatly increase the insurance fund durability (which makes sense). However, in high stress cases, they have a limited impact.

When we consider that the weighted 30 days average of negative funding rates once dipped to -20% Figure 23 extracted from [8]), even in a very optimistic staked ethereum return of 10% scenario, the insurance fund is expected to last less than 20 days : the fund is not enough to weather this crisis. In the case of the 3AC and FTX crash, the short duration of negative funding rates means the insurance fund would have lasted until the market regained confidence and stabilised itself.

This shows that with current fund and TVL conditions, the insurance fund would have been able to cover one of the worst market crashes (FTX debacle) but there are limits to the tool - and in the very specific market conditions of the merge it would have failed (although this situation is purely fictional since it was impossible to stake ethereum before the merge).

4 Part 3: The benefits of arbitrageurs

4.1 Interaction with DEX/CEX

By fetching the data from Coingecko, we can see that as expected the volatility of USDe is way below the average volatility of altcoins, ethereum or bitcoin, due to its peg strategy (several debates have turned around if USDe can be considered as a stablecoin, the creator of Ethena decided to not call the product

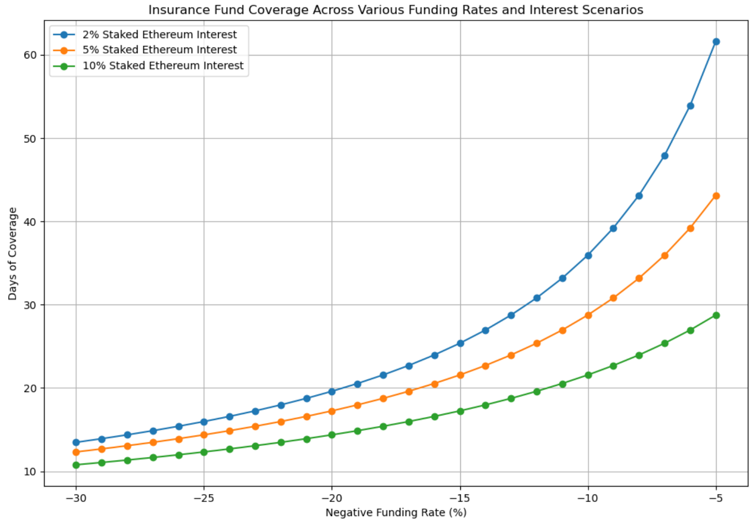

Figure 19: Days of insurance fund durability w.r.t negative funding rates and staked ETH interest

a stablecoin afterall), the price has mainly stuck to one dollar, however we can remark some deviating periods: from february 1 to february 15 2024, the coin was trading below 1 dollar, (an average of 0.996) showing arbitrage trading opportunities for 15 days straight.

The most common way to exploit arbitrage opportunities that arise from external markets (centralized ones as well as AMMs) is to take advantage of the mint and redeem contracts offered by Ethena. Prices diverge due to several reasons, they are especially more pronounced in Decentralized exchanges as the pools are fully regulated by smart contracts and hence by the demand and supply dynamics. The trading strategy has then 2 different sidesd whether the external market price of USDe is less than 1 dollar or more than 1 dollar.

If USDe is worth LESS in an external market than from Ethena directly, a user could buy 1x USDe at 0.95 from Curve using USDC, redeem 1x USDe at 1.00 from Ethena receiving ETH, then sell the received ETH for USDC on Curve. The user profits.

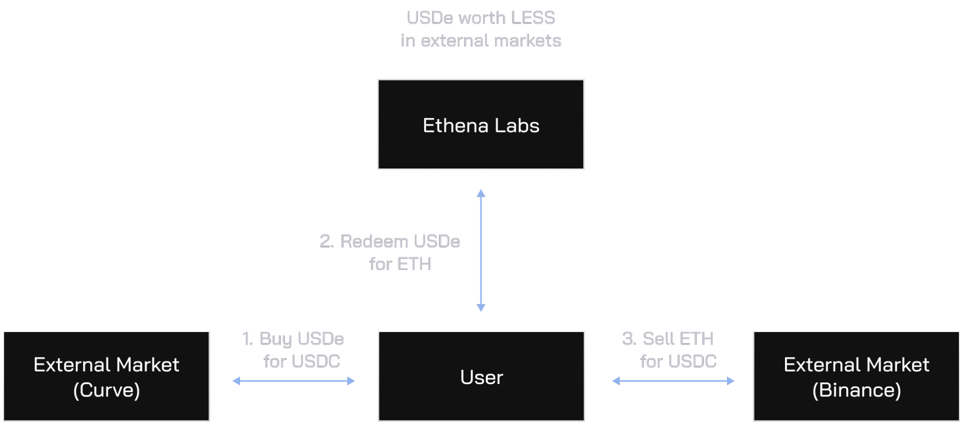

Figure 20: An illustration of the steps if the USDe is worth externally less than 1 dollar

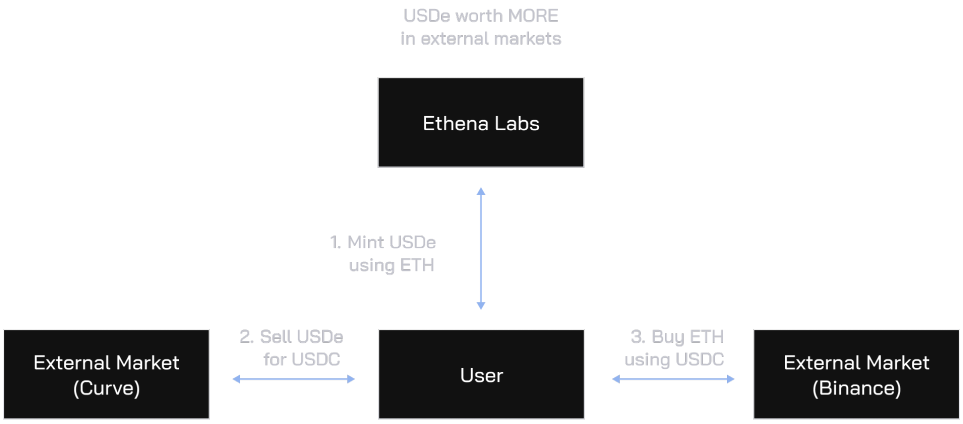

Figure 21: An illustration of the steps if the USDe is worth externally more than 1 dollar

Due to this arbitrage dynamics, the price tends to quickly revert to 1 dollar as it is the price at which the USDe can be minted at any time (no matter what happens externally as a result of trading activities, the protocols ensures the peg throught its delta neutral stategy) Hence **the arbitrageur has the choice to interact either with a decentralized platform or a centralized platform when the price deviates.**

4.2 Targeting lending protocols: Aave or Compound

The savvy arbitrageur could utilize lending platforms like Aave or Morpho to capitalize on discrepancies between the market price of USDe and its expected parity with the US dollar. For instance, should USDe trade below its peg on decentralized exchanges, an arbitrageur might borrow USDC from Aave or Morpho at prevailing market rates and then purchase undervalued USDe. This USDe could subsequently be redeemed at Ethena's fixed rate, converted to ETH, and sold for a profit. Conversely, if USDe is trading above the peg, the arbitrageur could lend USDC on Aave or Morpho, use the proceeds to mint USDe from Ethena, and sell it at a premium on exchanges. These arbitrage strategies not only generate profit for the arbitrageur but also exert a stabilizing influence on USDe's price by aligning it with its peg. Leveraging these platforms allows arbitrageurs to amplify their capital efficiency and benefit from the differential between borrowing costs and arbitrage gains, ultimately fostering a self-correcting mechanism that guides USDe back to its target value.

4.3 CEX/DEX

Another way to exploit arbitrage without having to go through Ethena's protocol would be to directly take advantage of the price differences between Decentralized exchanges and Centralized exchanges. However It is important to note that Ethena is still not listed in Binance for example hence it might be hard to exploit centralized exchanges in order to perform profitable arbitrage trades.

5 Bonus: implementing the trading strategy

In order to do this we first gather the data from Coingecko by downloading in a csv file the price of Ethena usde from its creation, we plot it in the following plot :

As discussed earlier, arbitrageurs can use several methods to exploit price differences. Some of them might be more expensive than others, some can be profitable while others are not. Let us delve deeply in this and give numerical proofs :

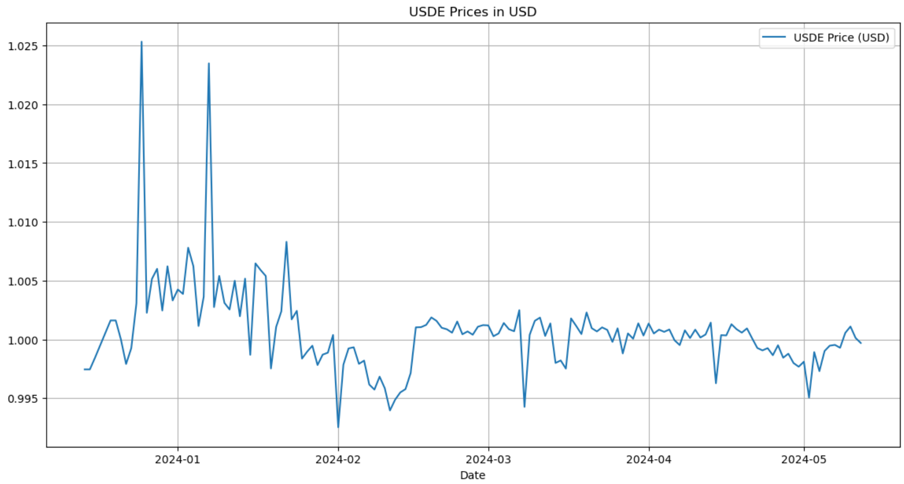

Figure 22: Price of Ethena Usde since day 1 [3]

5.0.1 Trading through Decentralized exchanges

Uniswap v3 :

Uniswap v3 is one of the leading decentralized exchanges in terms of TVL but also in terms of its concentrated liquidity that intends to minimize the impermanent loss for the liquidity provider but also the slippage for the trader. however when it comes to stable coins it is not really the best DEX around for arbitrageurs to catch arbitrage, an obvious reason for this is the fact that the trading fees in Uniswap v3 is 0.3% while stable coins are generally traded very closely to 1 dollar and catching a deviation more than 0.3% in the pool where the stable coin is traded is rare.

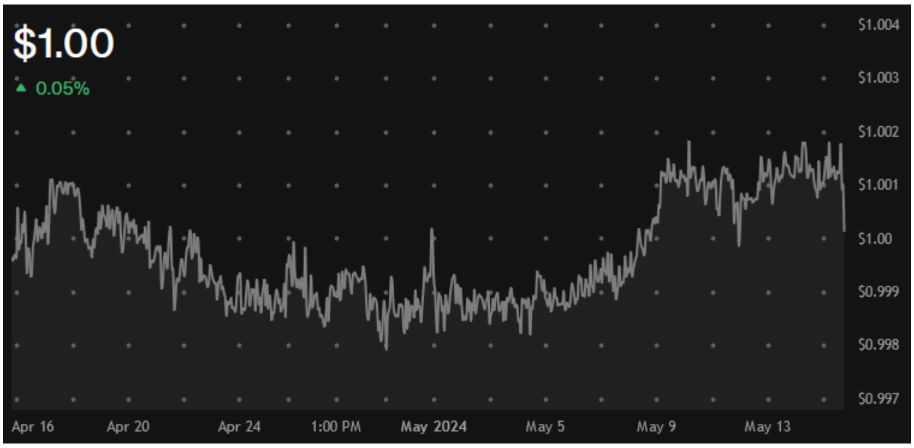

Figure 23: Price of Ethena usde at Uniswap snipped directly from the website of Uniswap [11]

Ethena Usde is listed in Uniswap v3 in different pools, the most liquid one is the USDE/USDT pool that has the following contract : 0x435664008F38B0650fBC1C9fc971D0A3Bc2f1e47 with around 12.6M in total value locked. However, the problem is that the query using GrapgQL API do not recognize the pool hence it is impossible to fetch the pool data only using API from graphQL.

However we still perform the following trading backtest strategy making some assumptions. We first fetch data from Coingecko about the prices of USDE/USD then we assume that the following price datas are the ones from a uniswap pool with trading fees of 0.01% then we assume we make one trade per day starting with a fairly low amount of money compared to the total value locked in the pool in order to avoid as much as possible the price impact. We start trading with 5000 dollars and the strategy is a simplified version of the mint and redeem on ethena + trade on DEX, which means if the price goes lower than 0.01 per cent we buy usde from uniswap and redeem it in ethena with a value of 1 dollar, and the opposite would be if the price is higher by more than 0.01 per cent then we mint usde from ethena then we sell it to the pool. Both results in arbitrage and after performing computations we find that this startegy made a profit of 12.7 per cent and that our balance is now 5638.17 dollars. (for more details about the implementation please check the jupyter notebook called Trade.sim).

Curve :

While Uniswap V3 is more tailored for a variety of asset pairs, including those with higher volatility, Curve is often considered a better platform for trading stablecoins due to its specialized design. Curve's StableSwap AMM is optimized to minimize slippage and offer low fees, which is ideal for stablecoins that don't fluctuate much in value. Uniswap V3's concentrated liquidity feature is innovative and versatile, but for stablecoins, Curve's approach ensures deep liquidity and minimal price impact. This makes Curve a preferred choice for traders looking to move large amounts of stablecoins without significant loss. A very well explained library about simulations of pool datas in curve is available in python, the following github : **https://github.com/curveresearch/curvesim** explains the implementatin steps and the code, however the library does not fetch data of the usde pools in Curve as they are newly created, which then makes it impossible to simulate the AMM through that library. Another approach to simulate the backtest trading strategy would be to simulate from scratch a simplified version of the AMM.

The trading process within a Curve AMM revolves around maintaining an invariant, D, which ensures the balance between two asset reserves, x_0 and x_1. The invariant is defined as $D = x_0 + x_1 - A \cdot \gamma^2 \cdot \frac{x_0 \cdot x_1}{D^2}$, where A is the amplification coefficient, and γ is an adjustment parameter. When a trade is executed, the reserves are adjusted while keeping this invariant constant. The details about the implementation cen be found in the official whitepapers of the protocol [7][6].

Initially, a trading fee is calculated. For an input amount Δx_i of asset i, the new reserve becomes $x'_i = x_i + \Delta x_i$. The invariant equation $D = x'_i + y_j - A \cdot \gamma^2 \cdot \frac{x'_i \cdot y_j}{D^2}$ is then solved numerically (typically via the Newton-Raphson method) to find the new reserve y_j for asset j. The output amount $\Delta y_j = x_j - y_j$ is adjusted by the trading fee, resulting in $\Delta y_j = \Delta y_j \times (1 - \text{fee})$.

Thus, the process involves calculating the new reserves after the input, solving the invariant to find the new reserve of the output asset, determining the output amount, and applying the fee to ensure minimal slippage and proper reward distribution to liquidity providers.

However simulating this is quite time consuming and I couldnt implement a specific AMM simulation for the USDE pool, however it would be an excellent approach ,when time permits, to test with it some trading strategies in order to be very close to the real parameter updates within Curve protocol.

6 sources

References

[1] Coinalyze. *Coinalyze: Cryptocurrency Market Analysis.* `https://coinalyze.net/`. Accessed: 2023-12-14 (cit. on p. 4).

[2] CoinDesk. "Merge-Focused Hedging Makes Ether Shorts Most Expensive in 16 Months". In: *CoinDesk* (Sept. 2022). Accessed: 2024-05-08. URL: `https://www.coindesk.com/markets/2022/09/14/merge-focused-hedging-makes-ether-shorts-most-expensive-in-16-months/` (cit. on p. 13).

[3] CoinGecko. *eThena USDE Historical Data.* `https://www.coingecko.com/en/coins/ethena-usde/historical_data?start=2023-05-18&end=2024-05-17`. Accessed: 2023-12-14 (cit. on p. 17).

[4] CoinMarketCap. *stETH to ETH Chart.* `https://coinmarketcap.com/currencies/steth/steth/eth/`. Accessed: 2023-12-14 (cit. on p. 11).

[5] DeFiLlama. *Yield Pool.* `https://defillama.com/yields/pool/747c1d2a-c668-4682-b9f9-296708a3dd90`. Accessed: 2023-12-14 (cit. on p. 4).

[6] Michael Egorov. *Automatic market-making with dynamic peg.* https://curve.fi/files/dynamicpeg-paper.pdf. Accessed: 2023-12-14. June 2021 (cit. on p. 18).

[7] Michael Egorov. *StableSwap - efficient mechanism for Stablecoin liquidity.* https://curve.fi/files/stableswap-paper.pdf. Accessed: 2023-12-14. Nov. 2019 (cit. on p. 18).

[8] Ethena Insurance Fund. *Ethena Insurance Fund Analysis: Resilience to Negative Funding Rates.* Accessed: 2023-05-08. 2023. URL: https://596495599-files.gitbook.io/~/files/v0/b/gitbook-x-prod.appspot.com/o/spaces%2FsBsPyff5ft3inFy9jyjt%2Fuploads%2F6QaFsqFXNHYka7KRgMPK%2FEthena%20Insurance%20Fund%20Analysis.pdf?alt=media&token=bce65681-8e24-4f04-99e2-089037af7c92 (cit. on pp. 13, 14).

[9] eThena Labs. *eThena Labs Documentation.* https://ethena-labs.gitbook.io/ethena-labs. Accessed: 2023-12-14 (cit. on p. 1).

[10] Arthur Hayes. *Dust on Crust.* 2024. URL: https://blog.bitmex.com/dust-on-crust/ (visited on 04/17/2024) (cit. on p. 1).

[11] Uniswap. *Uniswap Token Exploration: Ethereum Token.* https://app.uniswap.org/explore/tokens/ethereum/0x4c9edd5852cd905f086c759e8383e09bff1e68b3. Accessed: 2023-12-14 (cit. on p. 17).

[12] *Wallet Content of Ethena Labs Insurance Fund.* Etherscan. Accessed: 2024-05-08. May 2024. URL: https://etherscan.io/token/0x83F20F44975D03b1b09e64809B757c47f942BEeA?a=0x2b5ab59163a6e93b4486f6 (cit. on p. 13).