Lending and Borrowing

Anthony Lee Zhang

November 19, 2025

Lending and Borrowing in Tradfi

- Some agents have more money than they need to spend, willing to save
  - Firms, households, governments...
- Some agents want to spend now and pay back later
  - Firms, households, governments...
- **Fixed income** contracts – debt – is the simplest way to get funds from borrowers to savers
  - Mortgages, auto loans, bank deposits, margin loans, bonds, treasuries, commercial paper, repo...
- We'll talk mostly about **collateralized debt**, which is most of defi debt

Collateralized lending

Collateralized lending IRL:

- Houses $\Longrightarrow$ mortgages
- Cars $\Longrightarrow$ auto loans
- Stocks $\Longrightarrow$ margin loans
- Firms $\Longrightarrow$ equipment, real estate, etc. collateralized loans
- Bonds $\Longrightarrow$ repo loans

Collateralized Debt in Tradfi: the Borrower

- I want to buy a house for $400k, but don't have all the $$
- I tell a bank: "lend me $200k; I'll pay you back $250k; if I don't, you get the house"
- Key is, the bank only needs to believe that the house is worth over $250k
- Collateral provides safety to lenders, making them willing to lend me more

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- Collateral provides safety to lenders, making them willing to lend me more
- IRL, what happens if house price falls below $300k?
  - Not all collateralized debt has this issue! (Stock margin loans, repo...)
  - "Margin call"
  - No better/worse design: about the division of risk

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- $\Longrightarrow$ The synthesis of safety through overcollateralization creates a liquid, homogeneous market for capital!
  - "Money markets" funds go to bonds, mortgages, payroll...
- But, of course, the safety is not 100% "real"...

For more info, see Holmstrom Understanding the role of debt in the financial system

The Design Problem: Fixed Income in Decentralized Finance

- Core problem for fixed income in web3 settings: lack of persistent identity
- Any lending system based on reputation won't work!
- Solution: collateralized lending

Defi Collateralized Lending

- Collateralized lending requires:
  1. System for collateral custody
  2. System for evaluating collateral value and "margin calls"
- Defi good at 1., can have a "collateral pot" smart contract
- Defi less good at 2.!

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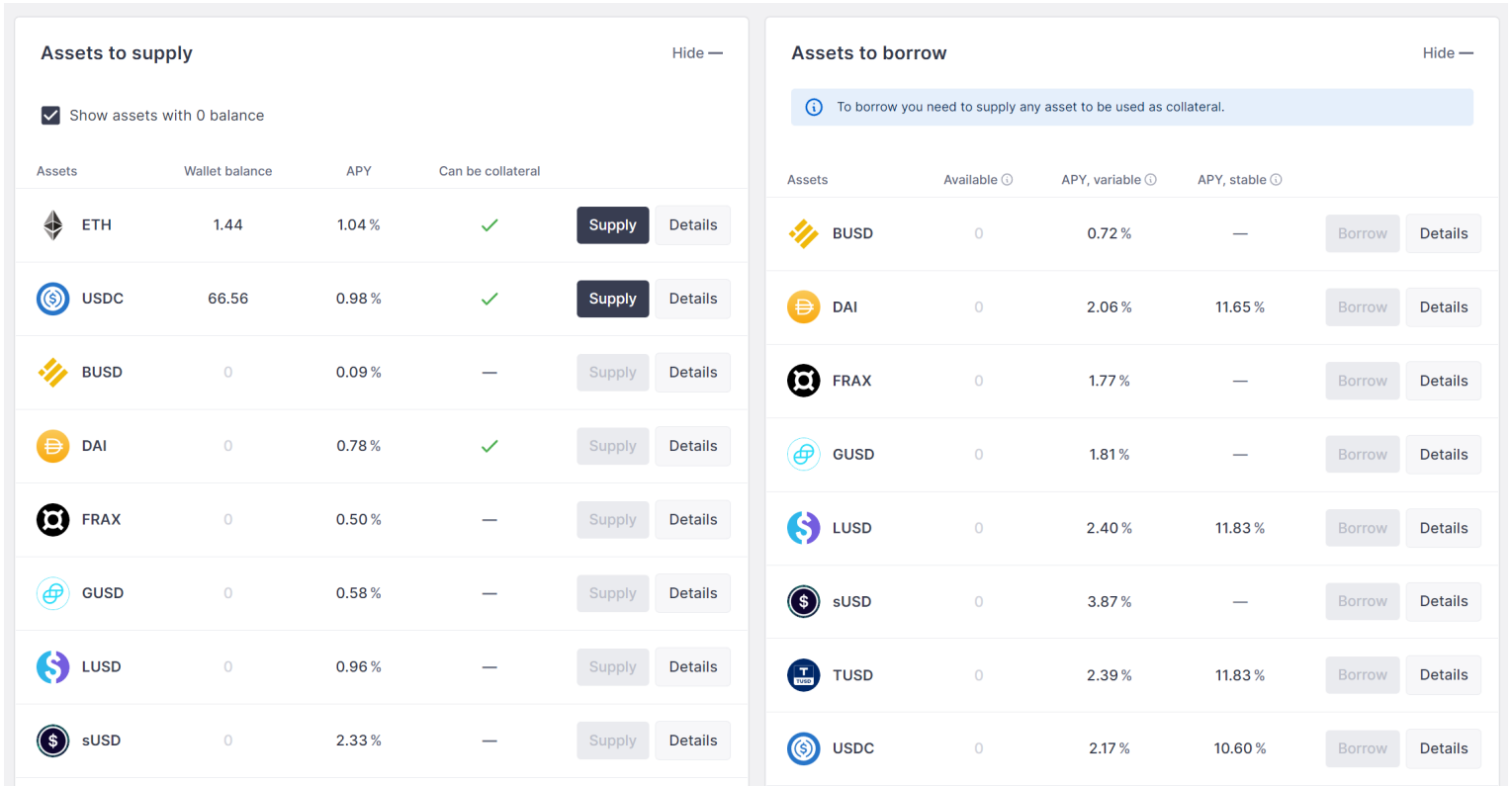
- Thus, system should never lose money

Aave Rates



Assets to supply Hide —

Show assets with 0 balance

Assets	Wallet balance	APY	Can be collateral		
ETH	1.44	1.04 %	✓	Supply	Details
USDC	66.56	0.98 %	✓	Supply	Details
BUSD	0	0.09 %	—	Supply	Details
DAI	0	0.78 %	✓	Supply	Details
FRAX	0	0.50 %	—	Supply	Details
GUSD	0	0.58 %	—	Supply	Details
LUSD	0	0.96 %	—	Supply	Details
sUSD	0	2.33 %	—	Supply	Details

Assets to borrow Hide —

To borrow you need to supply any asset to be used as collateral.

Assets	Available	APY, variable	APY, stable		
BUSD	0	0.72 %	—	Borrow	Details
DAI	0	2.06 %	11.65 %	Borrow	Details
FRAX	0	1.77 %	—	Borrow	Details
GUSD	0	1.81 %	—	Borrow	Details
LUSD	0	2.40 %	11.83 %	Borrow	Details
sUSD	0	3.87 %	—	Borrow	Details
TUSD	0	2.39 %	11.83 %	Borrow	Details
USDC	0	2.17 %	10.60 %	Borrow	Details

Who uses Aave?

Why would you lend to Aave?

- Have tokens, want returns
- Have tokens, want to borrow

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  - Leverage: hold $100 of assets with only $50 of cash
  - Mortgages, margin buying...
  - Borrow stablecoins against ETH

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  - Mortgages, margin buying...
  - Borrow stablecoins against ETH
- Want to short tokens
- Need tokens for some utility function
  - Borrow tokens to vote on governance proposals?

Why Aave?

Why use Aave, instead of tradfi?

- Tradfi institutions won't lend against crypto easily
- Capital market completeness: can borrow/lend across jurisdictions

Rate Setting on Aave

- Aave interest rates based on utilization:

$$U = \frac{Total\ Borrowed}{Total\ Lent}$$

- Interest rate is higher when U is higher
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- When few people want to borrow, what happens?
  - U decreases, decreasing lending, increasing borrowing
  - Pool equilibrates at a smaller size
- When some lenders need to withdraw, what happens?
  - U increases, so remaining lenders have incentive to stay in pool
  - New lenders higher incentive to join pool
  - Borrowers have incentives to scale down

See Aave website

Equilibrium in a DeFi Lending Market

Thomas J Rivera, Fahad Saleh, Quentin Vandeweyer

- Interest rate set as a function of utilization quantity
- But this cannot be efficient: unused funds should be lent somewhere else!
- Paper characterizes how the interest rate function could be redesigned to improve efficiency

What is defi?

All of defi is a big securitization machine, which turns a moderately risky asset (crypto) into a very risky asset (levered crypto) and a less risky asset (crypto-backed loans)

Aave vs Maker

- Suppose you have ETH and WBTC. Two choices:
  - Make 2 MakerDAO vaults, print DAI
  - Deposit both in Aave, borrow USDC against both
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- If rates are the same, which do you prefer?

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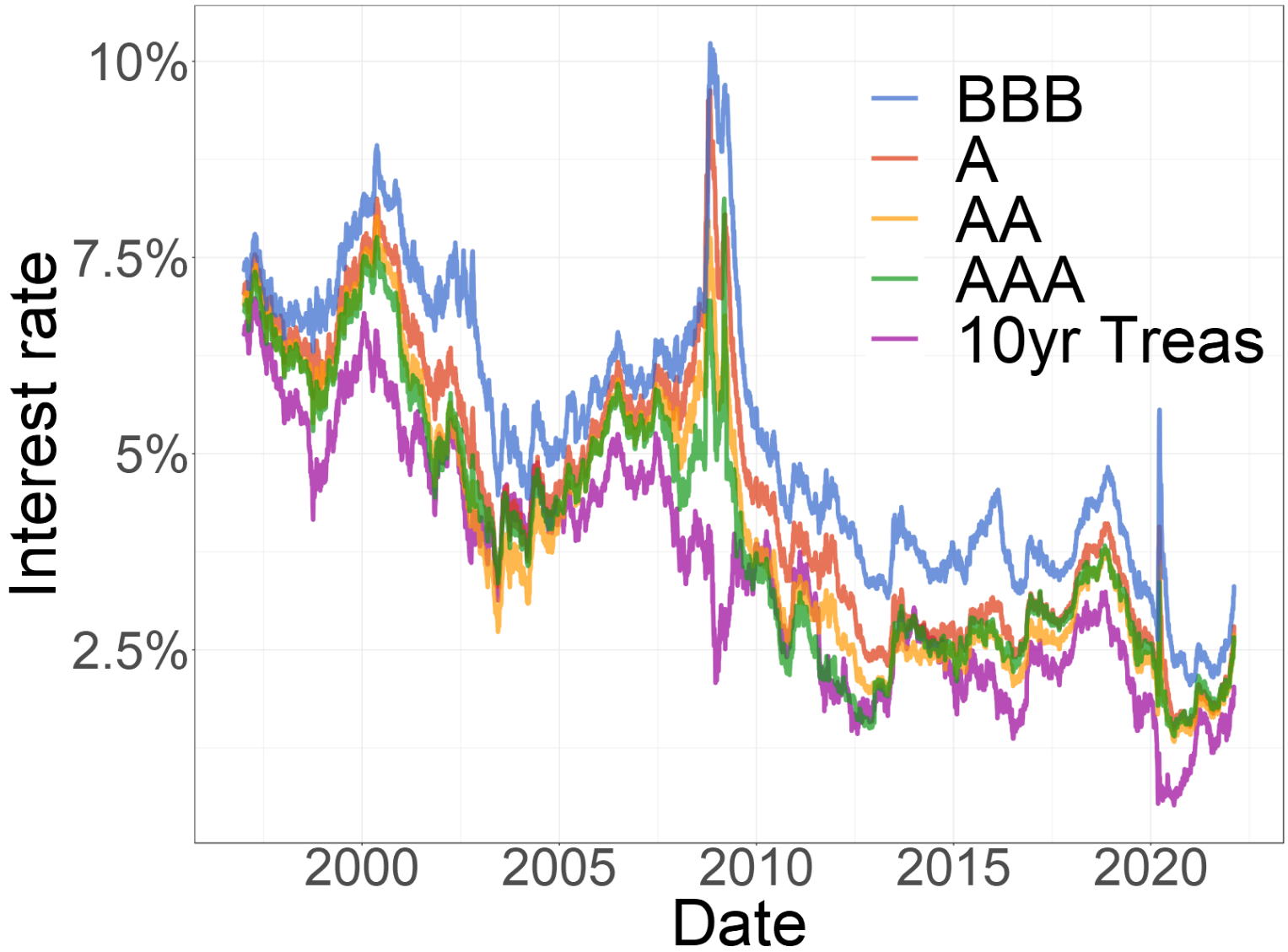
- Subtle differences!

The Defi Fixed Income Ecosystem

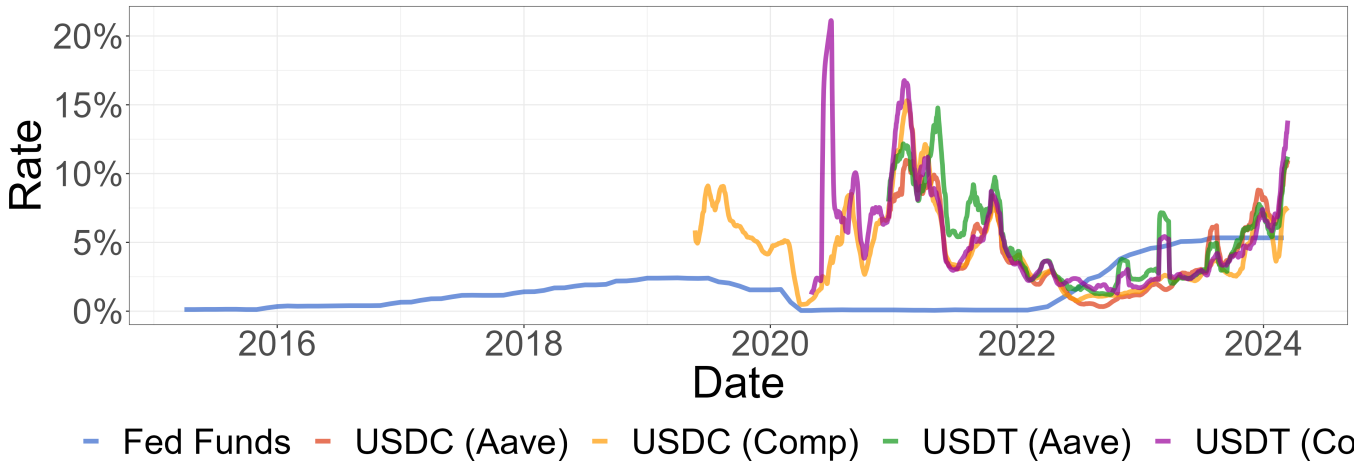
Borrowing/lending protocols imply there is now an ecosystem of fixed income strategies available in defi:

- Pure borrow/lend (Aave, Compound)
- Stablecoin market making (Curve, Convex)
- Clones/variants on other chains besides ETH
- Frontiers (later): uncollateralized lending, fixed rates...

Interest Rates in Traditional Finance



Interest Rates in Defi



- Until 2022, Aave rate higher (why?)
- After 2022, Aave rate lower (what does this mean?)
- Around 2024, Aave rates higher again (why?)

Liquidation

I borrow $400k against my $500k house

- Ideal case: I pay back $400k, live in my house
- Non-ideal: I can't make payments, bank sells my house and keeps $400k
- Safety of bank's mortgage debt depends on how well they can "liquidate collateral"
- How does a smart contract play the role of the bank in liquidating collateral?

Ideal Liquidation

- Suppose you borrow $100 USD against $150 of ETH
- ETH price drops to be worth $149, so your position must be liquidated
- "Ideal" procedure:
  - Protocol detects that ETH price dropped, your position is insolvent
  - Protocol sells ETH to pay down your debt
- Is this possible?

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Liquidation in Practice: Trigger

- Human initiates a "liquidation"
- Smart contract checks oracle price: if sufficiently low, liquidation begins
- Question: how to sell collateral?

Liquidation in Practice: Sale Mechanism

- Sell to AMM?
  - Large order, may move prices too much
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  - Fast!
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Liquidation in Practice: Sale Mechanism

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- Sell to humans? How?
- **Aave/Compound:** fixed price, below current oracle price, see risk parameters
  - Fast!
  - Pays liquidators a lot...
- **Maker**: collateral sold in descending auction
  - Slower, but may get better deal

Fire Sale Loops

- Suppose price of ETH drops
- People borrowing against ETH get liquidated, so ETH gets sold
- Selling pressure pushes down ETH prices...
- Leading to more liquidations...

Systemic Fragility

Systemic Fragility in Decentralized Markets

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University of Calgary

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UC Berkeley

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Preliminary
Comments Welcome

Abstract

We analyze a unique data set of collateral liquidations on two Decentralized Finance lending platforms – Compound and Aave. Such liquidations require arbitrageurs to repay the loan in return for the discounted collateral. Using Blockchain transaction data, we observe if arbitrageurs liquidate positions out of their own inventory or obtain "flash loans." To repay flash loans, arbitrageurs immediately sell the collateral asset. We document the high frequency price impact of such liquidity trades on nine different decentralized exchanges. Consistent with large block trades in equity markets there is a temporary and permanent price impact of collateral asset sales in DeFi. We document the effect of these trades on return distributions. Our work highlights the systemic fragility of decentralized markets.

Keywords: Decentralized Lending, Blockchain, Decentralized Finance, Systemic Risk

Source

Risks: Oracle Risk

- Unlike AMMs, collateralized lending systems require oracle inputs for prices
- Risk factor: if oracle gets manipulated, lending system is at risk!
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Risks: Oracle Risk

- Unlike AMMs, collateralized lending systems require oracle inputs for prices
- Risk factor: if oracle gets manipulated, lending system is at risk!
- How would you attack Aave through oracle manipulation?
  1. Deposit \$100 Xtoken as collateral
  2. Manipulate oracle, make Aave think \$100 Xtoken is worth \$100,000
  3. Borrow \$50,000 USDC against your Xtoken
  4. Default: you've just traded \$100 Xtoken for \$50,000 USDC!
- See here for other examples of oracle attacks
- Chainlink is the main oracle provider
  - Uses off-chain data! Ironic, as it's more "principled" to use on-chain data

Alleviating Oracle Risks?

Liquidation Bonds: While a loan's eligibility to be liquidated is determined formulaically by the contract, no actual liquidation will occur unless an external user triggers one. In order to trigger a liquidation this user must pledge a liquidation bond. A liquidation bond is effectively a bet, with a payoff curve similar to a short put option spread (effectively a bet that the bidders in the dutch auction will place bids below the Neutral Price of the loan, see 7.3.1 Determining the Neutral Price), on the outcome of a pay-as-bid dutch auction for the collateral. This mechanism encourages fair outcomes by imposing a penalty on spurious liquidations. While there is no endogenous incentive to spuriously liquidate a borrower in Ajna, this introduces an overt disincentive to liquidate loans that are well collateralized with respect to the market price of the collateral (as well as an incentive to liquidate loans that are comparatively undercollateralized).

Source: Ajna protocol

Risks: Operational Risk

- Lending code particularly tricky to get right, because your funds are locked in contract, and can be lent out
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- How does this differ from AMM trading?
- Many examples, such as CREAM finance, Compound

Flash Loans

- Unlike traditional finance, transactions in defi are atomic: either the whole tx finishes, or none of it does
- Enables a cool trick called flash loans
- You can borrow a very large amount of money, unsecured...
- ...as long as you pay it back in the same transaction!
- If you can't pay back the money, tx fails, so you never borrowed it in the first place!
- Flash loans available from Aave, Compound...

Flash Loans: Consequences

- In tradfi, arbitrage requires capital and infrastructure
  - Hedge funds can do trades you can't, because they have money and trading infra
- In defi, infra is democratized by default; flash loans democratize capital
- If there are arbitrage opportunities, anyone can extract them!
- A number of interesting consequences...

Case Study: The Cream Finance Hack

- See my blog post on the CREAM finance attack
- Attacker submitted a bundle of 20 transactions, borrowed a billion dollars, made $130mil, paid $6,500 in gas fees!
- Details complicated, but essentially:
  - CREAM finance allows you to borrow collateralized, borrowing amount determined by price oracle
  - Attacker builds a large collateral + debt position through "rehypothecation"
  - Flash borrow $1.5bil, deposit in CREAM
  - Manipulate price, to make CREAM think $1.5bil of collateral is worth $3bil
  - Borrow $2bil of ETH against collateral, worth only $1.5bil
  - Default on collateral, keep $2bil in ETH, pay back $1.5bil flash loan, keep $500mil ish in profit (actually only $130mil)

Case Study: The Beanstalk Farms Attack

- See my tweet thread on the Beanstalk attack (cited by Matt Levine!)
- Beanstalk is an algo-stable, holds a bunch of collateral
- Governance done through equity tokens: majority token vote approves any change
- Attacker proposed: "send entire treasury to my address"
- Flash borrowed a bunch of equity tokens, passed the proposal, took all the money!

Flash Loans: Consequences

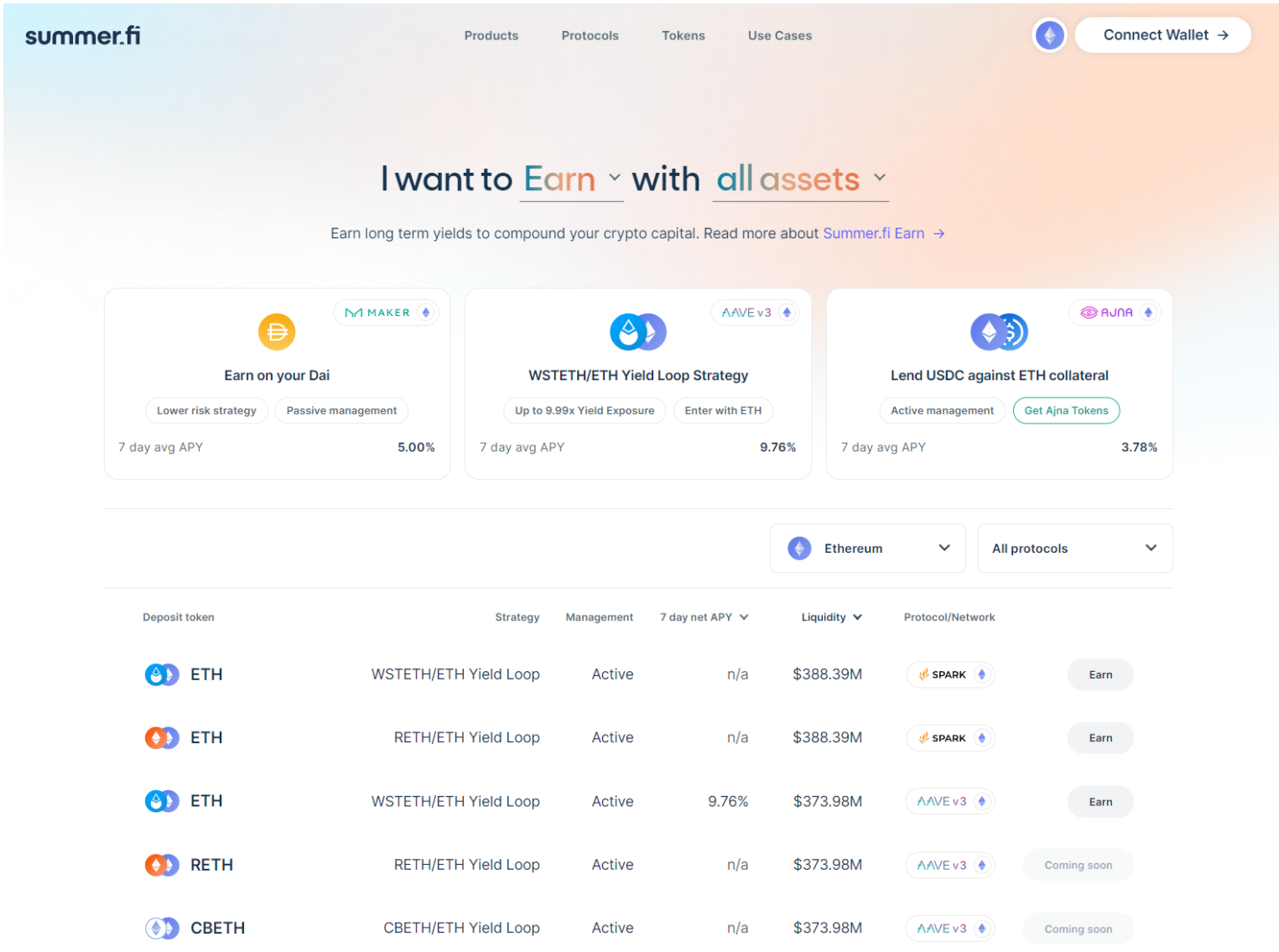
Consequences of flash loans:

- "On-chain" price oracles (for collateral valuation, derivatives settlement, etc.) very rarely used: often attackable
- Hacky solution: just use Binance prices, imported through Chainlink, instead
- Governance attacks rarer: beanstalk a unique case
  - However, Curve/Convex demonstrates that the "market for votes" – flash loans aside – still very important

Other things

- Aggregators
- Fixed rates
- Credit Derivatives
- Other kinds of lending

Aggregators



Source: summer.fi

Aggregators

Where does the yield come from?

The return comes first from the ETH staking yield provided by StETH. That yield is multiplied by increasing exposure to StETH by borrowing ETH in AAVE v3. An ongoing cost of the variable ETH borrowing rate in AAVE must be continually paid. This means that the strategy remains profitable as long as the borrowing cost of ETH is lower than the returns from StETH.

Source: summer.fi

The AdaptiveCurveIRM

Overview

The AdaptiveCurveIRM is engineered to maintain the ratio of borrowed assets over supplied assets, commonly called utilization, close to a target of 90%.

In Morpho, the collateral supplied is not rehypothecated. Removing this systemic risk removes the liquidity constraints imposed by liquidation needs. It enables more efficient markets with higher target utilization of capital and lower penalties for illiquidity, resulting in better rates for both lenders and borrowers.

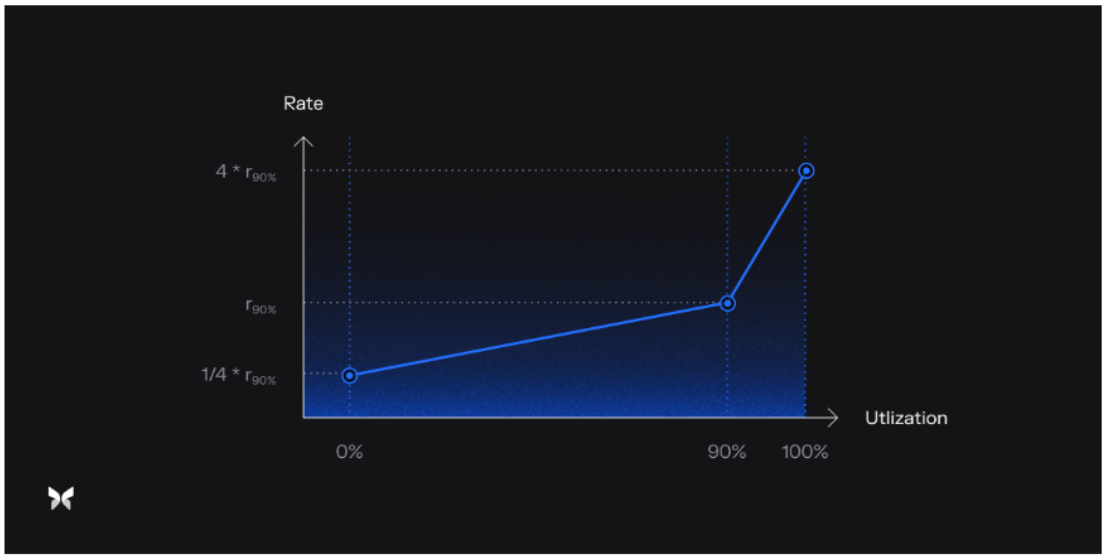
As with every parameter of a Morpho Market, the IRM address is immutable. This means that neither governance nor market creators can change it at any given time. As such, the AdaptiveCurveIRM is designed to adapt autonomously to market conditions, including changes in interest rates on other platforms and, more broadly, any shifts in supply and demand dynamics.

Its adaptability enables it to perform effectively across any asset, market, and condition, making it highly suitable for Morpho's permissionless market creation.

Source: Morpho and Coinbase

Morpho

1. **The Curve Mechanism** This mechanism is akin to the interest rate curve in traditional lending pools. It manages short-term utilization effectively, maintaining capital efficiency while avoiding excessively high utilization zones that could lead to liquidity issues.



$r_{90\%}$

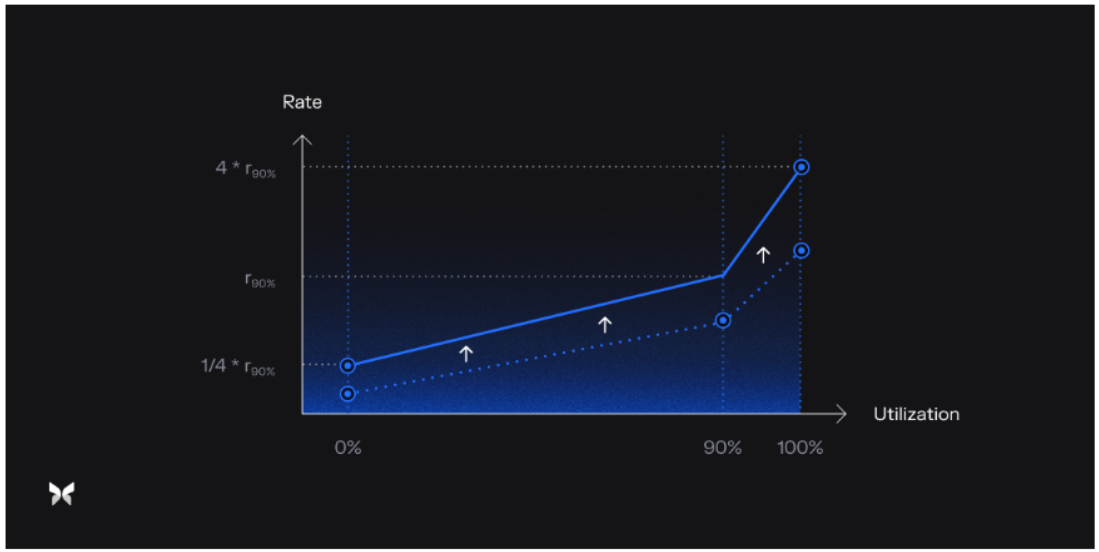
is the target rate at utilization target

$u_{target} = 0.9$

Source: Morpho and Coinbase

2. **The Adaptive Mechanism** This mechanism fine-tunes the curve over time to keep the range of rates in sync with market dynamics. It achieves this by adjusting the value of the target rate, which in turn shifts the entire curve:

- When utilization exceeds the target, the curve continuously shifts upward. This incentivizes loan repayment and thus decreases utilization.
- When utilization falls below the target, the curve continuously shifts downward. This incentivizes borrowing and thus increases utilization.



The speed at which the curve adjusts is determined by the distance of current utilization to the target: the further it is, the faster the curve shifts. This incremental adjustment of the curve allows for rate exploration, ultimately stabilizing when the interest rate at the target utilization aligns with the market equilibrium.

Source: Morpho and Coinbase

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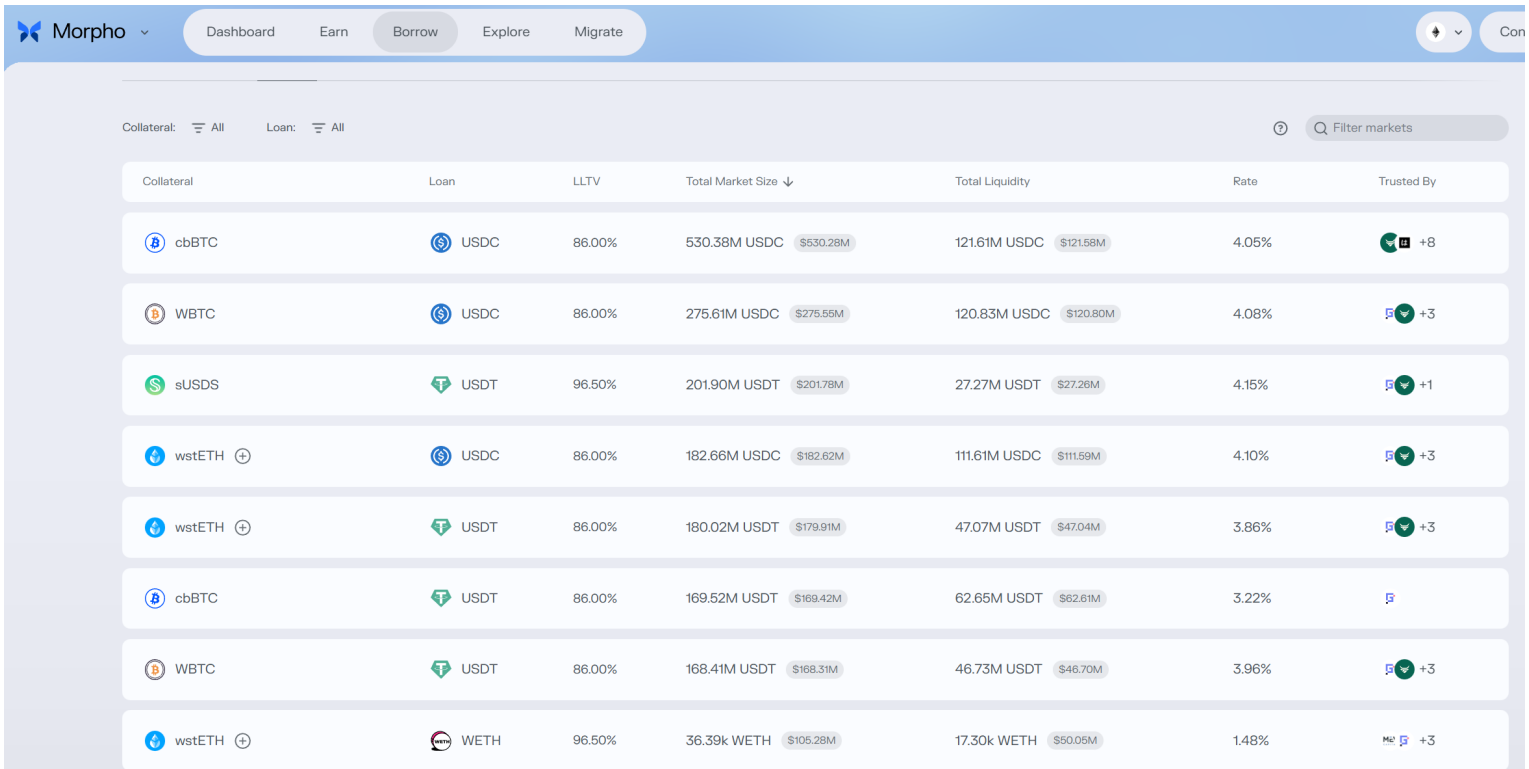


Source: Morpho and Coinbase

Morpho

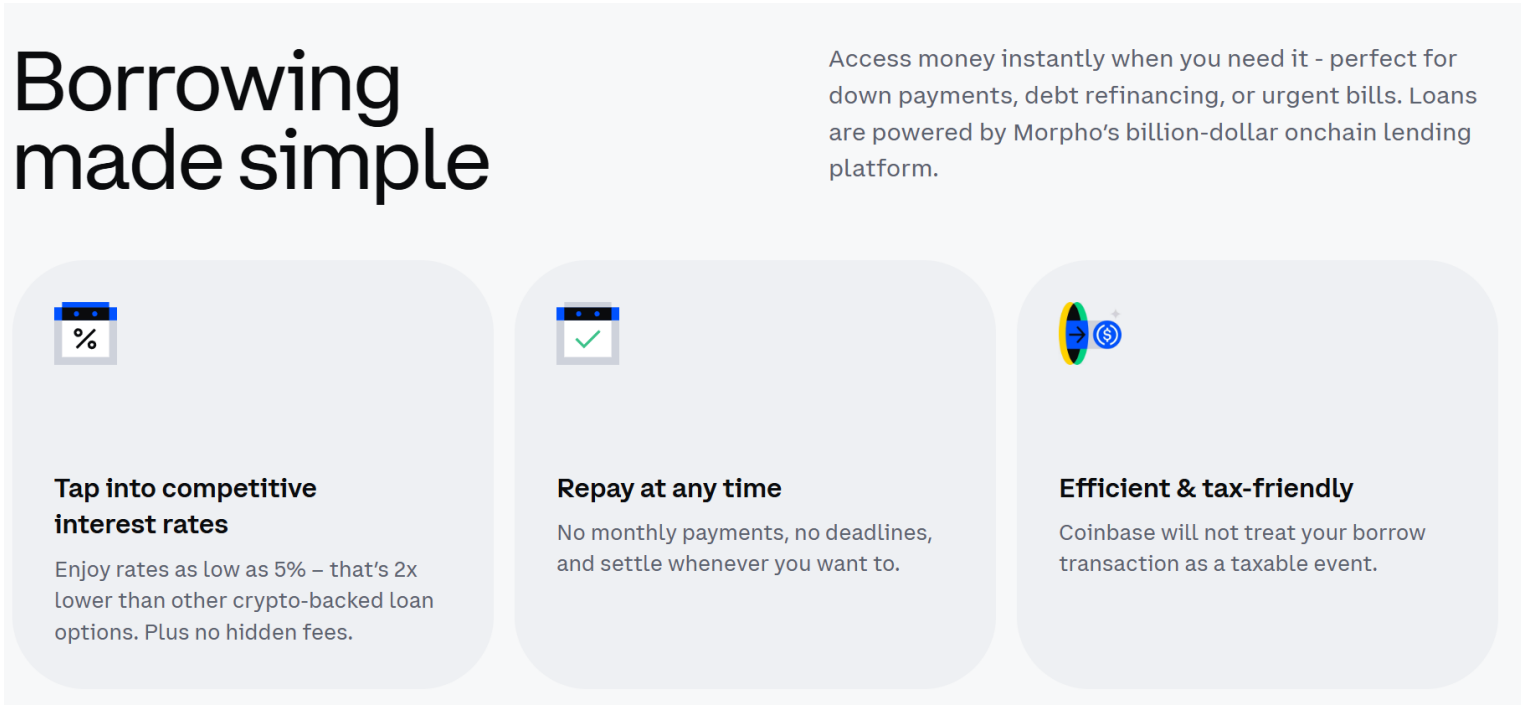
Cryptocurrencies Individuals Businesses Institutions Develo

Borrow against your bitcoin without selling it

Get instant loans in USDC while continuing to hold your crypto. Loans powered by Morpho.

Borrow today via mobile

Morpho



Source: Morpho and Coinbase

How borrowing works

1

Choose how much to borrow

Borrow up to $1,000,000 USDC. How much you're able to borrow depends on the amount of bitcoin you have available for collateral. Available in the U.S. to start, excluding New York State.

2

Receive your loan instantly

USDC will be deposited into your Coinbase account and the chosen amount of bitcoin will be moved onchain to Morpho as collateral.

3

Repay on your timeline

There are no repayment schedules or deadlines. Your loan to value (LTV) ratio must remain under 86% to avoid triggering an automatic liquidation and be charged a penalty fee.

Source: Morpho and Coinbase

Morpho Association

The Morpho Association is a French nonprofit entity grouping the main contributors and users of the Morpho protocol.

Its aim is to develop the Morpho protocol by funding contributors, or by facilitating access to the protocol for users and developers. In practice, the association:

- Hosts a front end to the protocol to facilitate the access of new users to Morpho: morpho.org
- Hosts technical documentation to facilitate the work of new Morpho developers
- Holds the intellectual property of open-source codebases such as morpho-optimizers and hosts it on the morpho-org GitHub under a GPL3 license.

The association does not research or develop Morpho software, contributors or Institut Louis Bachelier (ILB) do.

Source: Morpho and Coinbase

Fixed Rates (2024-ish)

- Defi rates mostly floating
- Many tradfi institutions prefer long-term fixed rates (why?)
  - **Lenders:** asset-liability matching, pensions have fixed long-term liabilities, want predictable-return assets
  - **Borrowers:** predictable interest payments (most mortgages, auto loans are fixed-rate)

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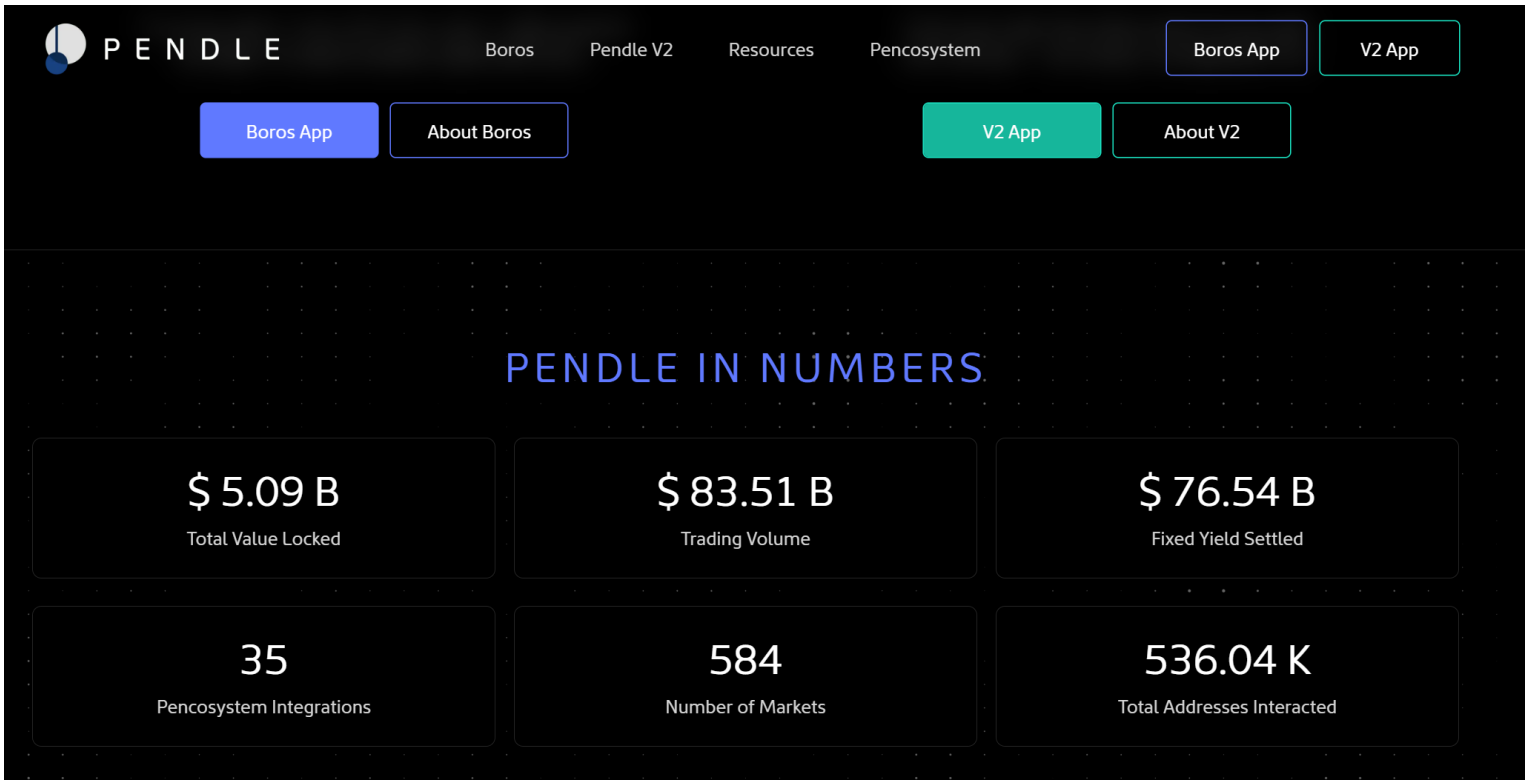
  - **Borrowers:** predictable interest payments (most mortgages, auto loans are fixed-rate)
- Financial engineering: fixed rates can be synthesized out of floating rates, through interest rate swaps
  - Pay me all your Aave interest on $1,000 for 1 year, and,
  - I'll pay you fixed 5%
- Aave now allows stable-rate borrowing
- Some groups working on this: ElementFi, Yield protocol, Notional, and more

Fixed Rates/Interest Rate Swaps: Pendle



Source: Pendle and Talenttribe

Fixed Rates/Interest Rate Swaps: Pendle

Introduction to Pendle

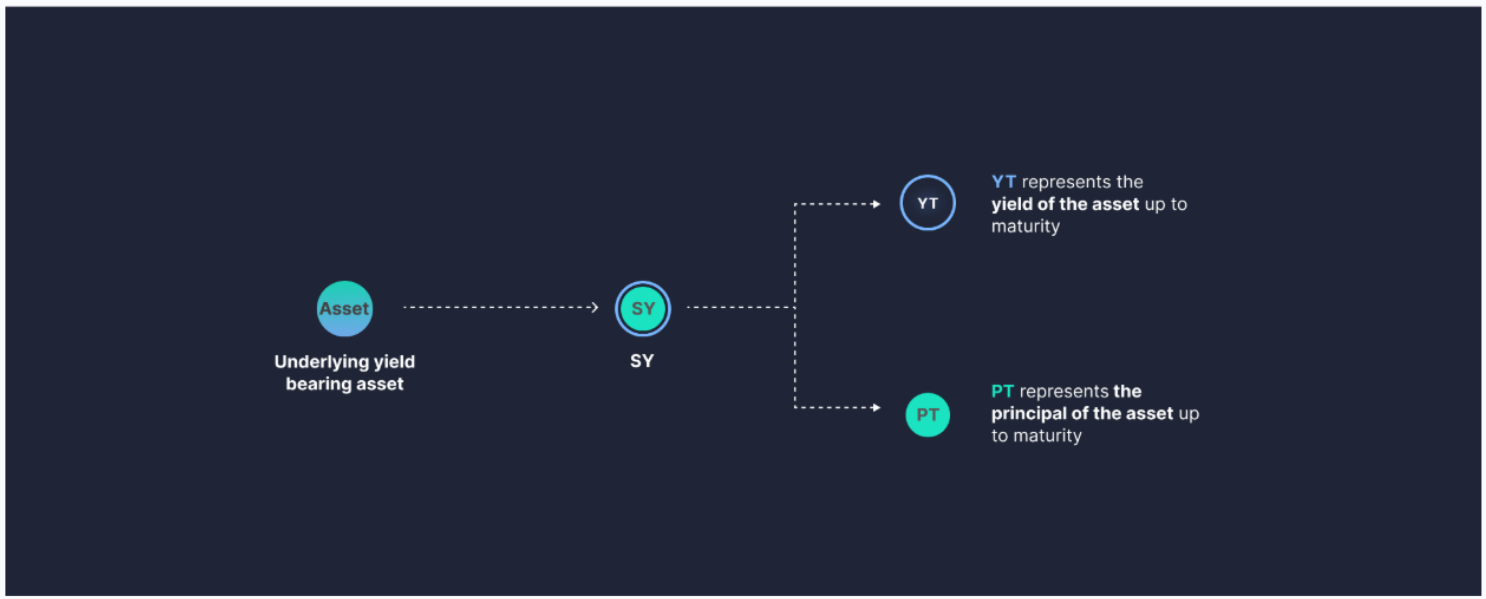
How much will you earn from lending 1,000 USDC on Aave? 1%? 3%? 5%?

Truth is, you can't say for sure. Yield fluctuates just like token prices. It tends to go up in bull markets, and go down in bear markets, and there are further micro-factors that cause fluctuations within those general market trends.

Source: Pendle and Talenttribe

Fixed Rates/Interest Rate Swaps: Pendle

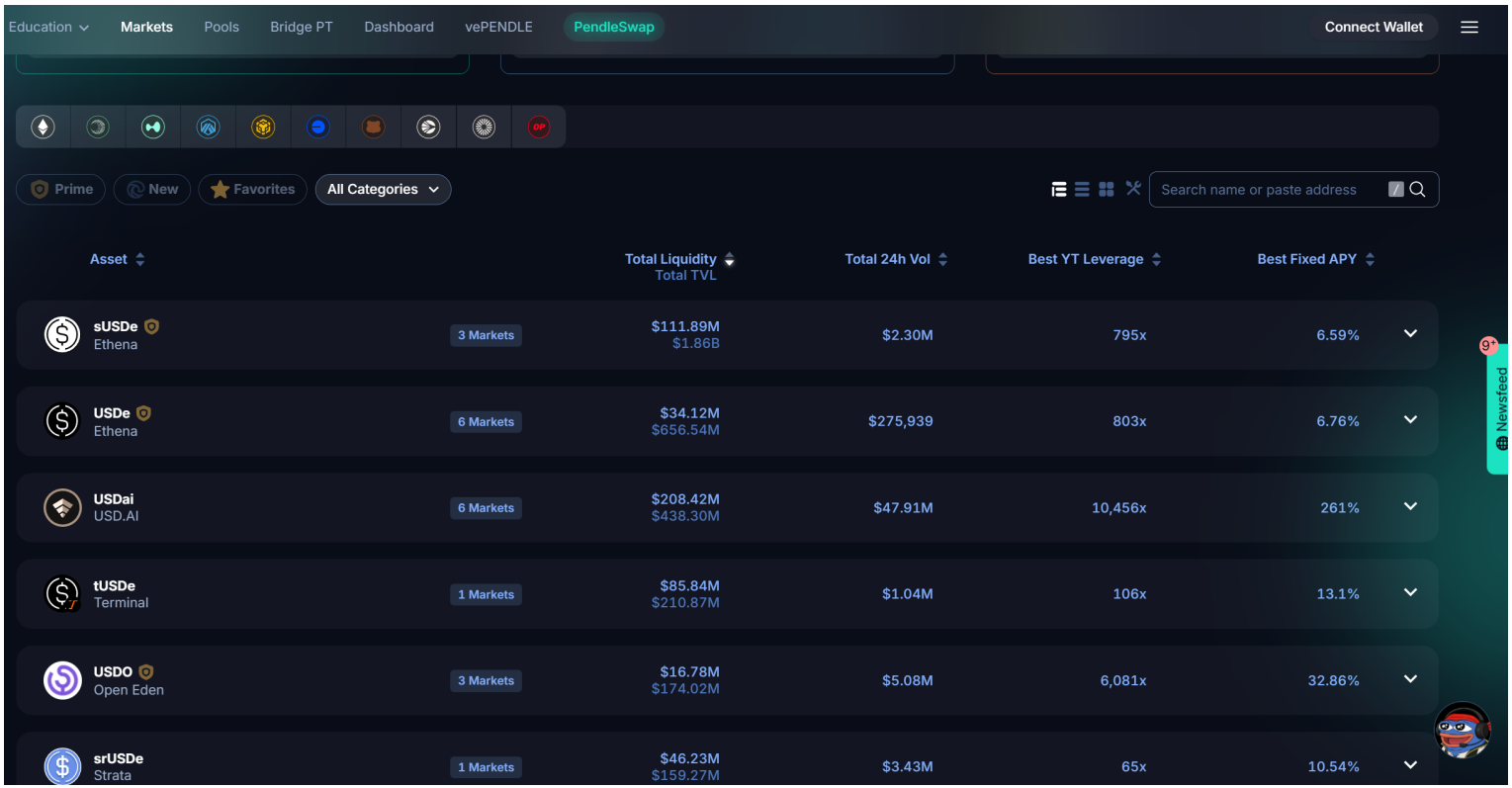
In Pendle, yield-bearing assets are split into two components: Principal Tokens (**PT**) and Yield Tokens (**YT**). PT represents the principal of the underlying yield-bearing token, while YT represents entitlement to all the yield of the asset. YT and PT can be traded on Pendle.



What Pendle does is similar to bond stripping in traditional finance, where the principal and interest of bonds are separated. In this, PTs are equivalent to zero-coupon bonds, while YTs are the detached coupon payments.

Source: Pendle and Talenttribe

Fixed Rates/Interest Rate Swaps: Pendle



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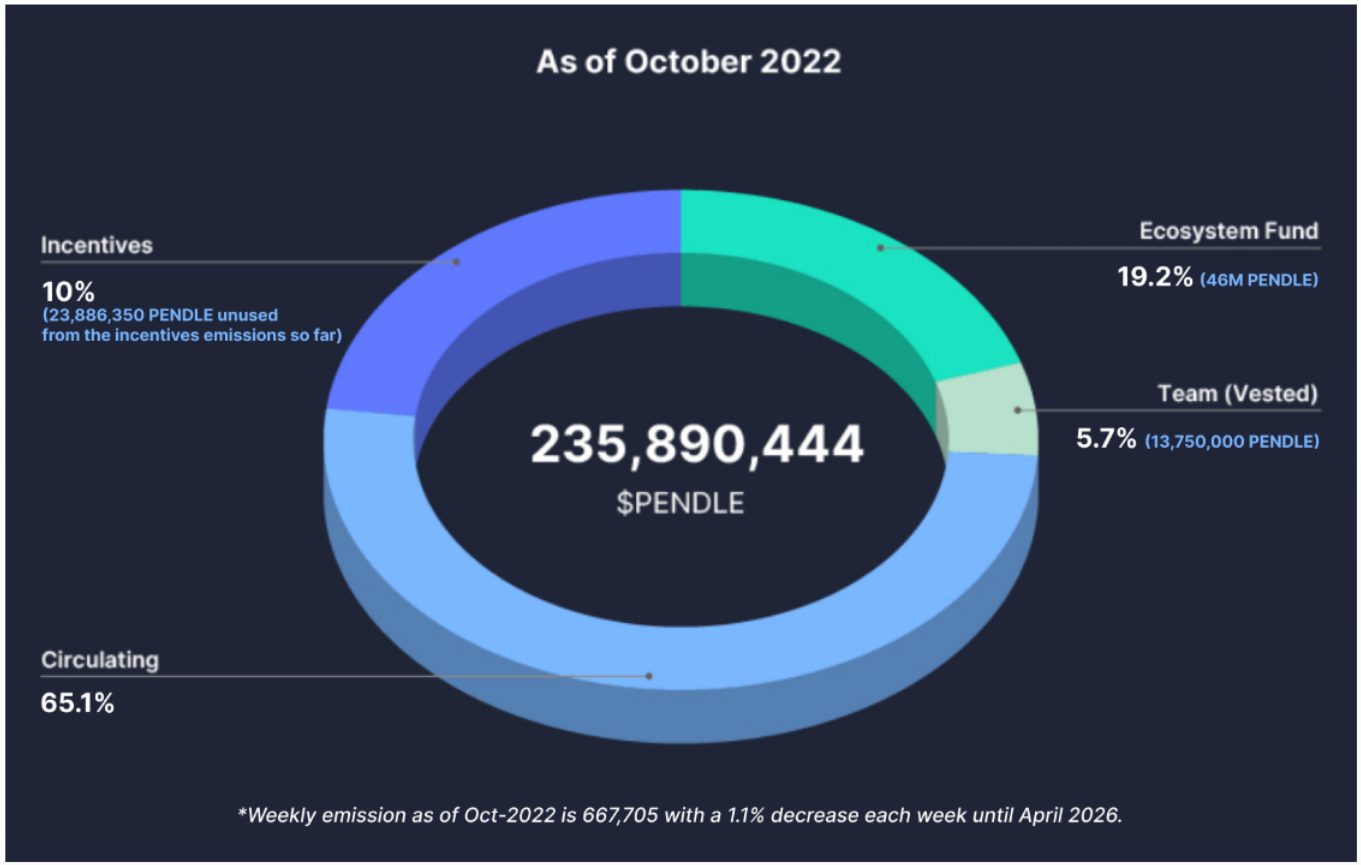
Fixed Rates/Interest Rate Swaps: Pendle

Tokenomics



PENDLE distribution as of Oct-2022

As of September 2024, all team and investor tokens have fully vested. Any increase to circulating supply will be contributed by incentives and ecosystem building.

Source: Pendle and Talenttribe

Fixed Rates/Interest Rate Swaps: Pendle

- **Fee Distribution**

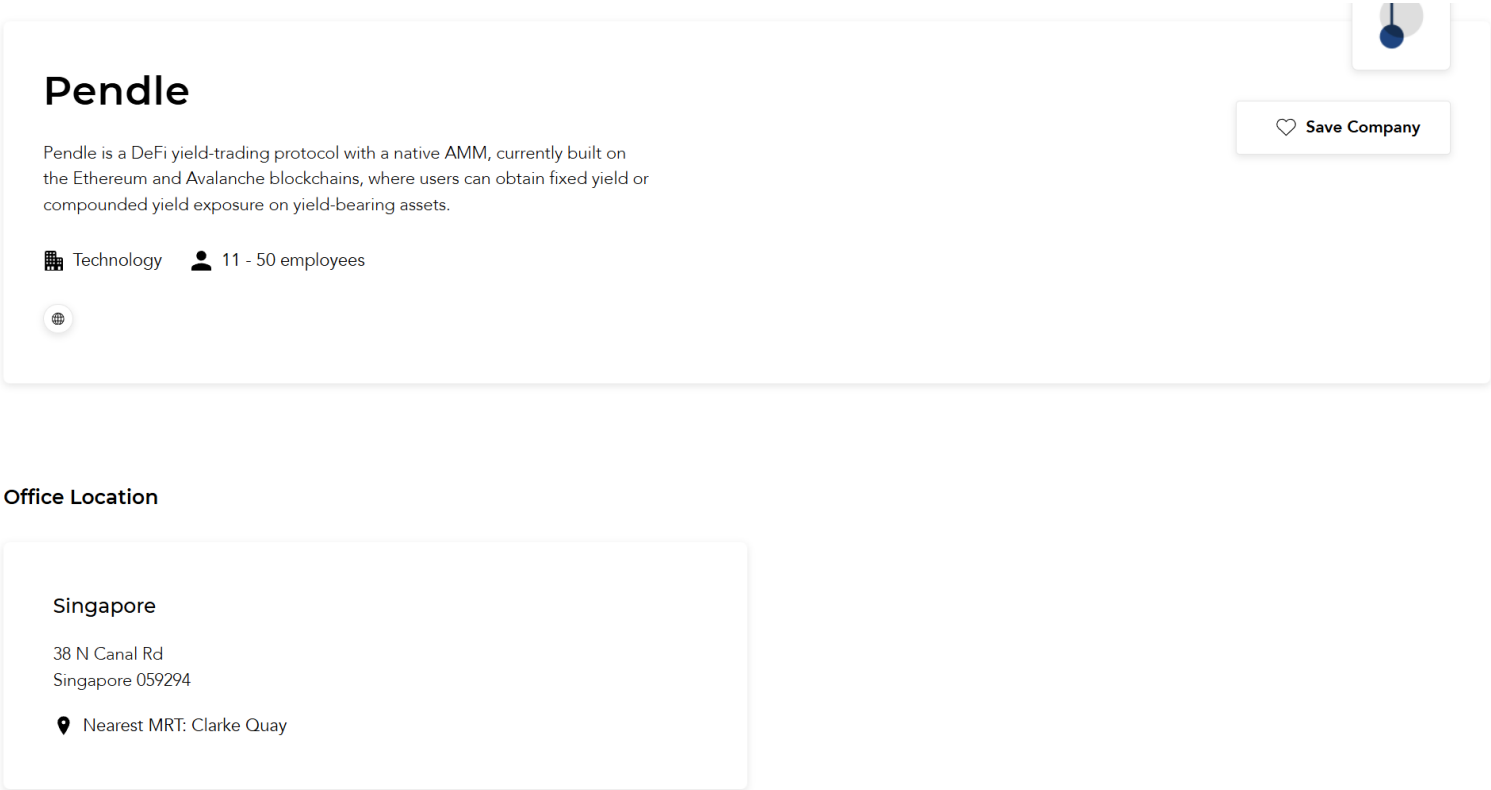
Pendle has 2 sources of fees **YT fees** and **Swap fees**. 20% of all swap fees are given to LP providers of the pool as yield.

The remaining swap fees and all YT fees are split between vePendle holders and Pendle protocol in the following ratio

- 80% to vePendle
- 10% to Protocol Treasury
- 10% to Protocol Operations

Source: Pendle and Talenttribe

Fixed Rates/Interest Rate Swaps: Pendle



Source: Pendle and Talenttribe

Credit Derivatives

- You can think of:

$$r_{risky} = r_{safe} + \Delta_{credit}$$

- Sometimes, different people want to hold Δ_{credit} versus r_{safe}
  - Mortgages: tranched MBS
  - Bonds: repo

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- But protocol itself has risk!
- Credit derivatives protocols: marketplace for insurance against protocol risk
- One player in this space is Subsea (formerly Risk Harbor)

Other Kinds of Lending

- Lending/borrowing in defi is essentially only "margin loans" collateralized by liquid assets – very restrictive! What about:
  - Illiquid asset-backed borrowing? (Mortgages, secured corporate debt)
  - Undercollateralized, reputation-based borrowing? (Credit cards)
  - Cash flow/equity-backed borrowing? (Corporate bonds)
- What are barriers to each of these?

See here on undercollateralized lending

Other Kinds of Lending: Readings

- Undercollateralized lending: Maple finance major player. See Delphi Digital report
- Illiquid assets: see RWA
- "Equity upon default" design: doesn't appear to exist yet!
- All potentially good ideas for class projects!