

RESEARCH REPORT

Pendle Finance, Yield Tokenisation, and Fixed Rates in DeFi

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The page features several large, overlapping geometric shapes in shades of blue, red, and dark blue, creating a modern, abstract background design.

REPORT DISCLOSURES

Apollo Capital and the members of the team own PENDLE tokens at the time of publication, and may own other tokens mentioned in this report from time to time. This statement is intended to disclose any conflict of interest and should not be misconstrued as a recommendation to purchase any token mentioned in this report. All content in this report represents the opinions of Apollo Capital. This document is for informational purposes only and does not contain financial advice. Do your own thorough research before interacting with or investing in any of the projects discussed in this report.

EXECUTIVE SUMMARY

In this report, we take a deep dive into Pendle Finance and the respective sectors of DeFi the project sits under; Yield Tokenisation and Fixed Rates.

Pendle Finance leverages the composable nature of DeFi to allow users to trade and receive fixed rates of interest on lending protocols and in liquidity pools. Pendle Finance's design improvements from older fixed-rate protocols solve the major problems preventing these protocols from achieving significant adoption.

These problems are:

1. Liquidity of the fixed-rate position;
2. Pricing of the fixed-rate position.

While Pendle Finance is not without competition in the Yield Tokenisation sector, Pendle's design choices make the protocol more useful and composable than competitors such as Element Finance. There are many ways in which users can interact with Pendle Finance to trade fixed rates and earn high yield through market neutral yield farming strategies.

We would like to thank TN Lee from the Pendle Finance team for the help and feedback received throughout this report.



1.0 INTEREST RATES AND YIELD IN DECENTRALISED FINANCE

Yield opportunities from various pioneering protocols within Decentralised Finance (DeFi) have traditionally been variable due to the nature of how yield is generated by liquidity providers. It wasn't long after "DeFi Summer" (June, July, August 2020) that fixed-rate protocols began to launch in an effort to add a level of certainty to returns across DeFi. Interest rate swaps are an extremely popular and useful financial derivative in traditional finance, and it was only a matter of time before teams of developers began to reinvent these products within the Ethereum DeFi ecosystem.

The early fixed rate protocols fall into two categories:

1. Protocols that leverage the composable nature of DeFi to bring fixed rates to existing yield opportunities, e.g. BarnBridge, 88mph, Saffron Finance.
2. Protocols that aim to create their own lending market with fixed rates to borrowers and lenders, e.g. Notional, Yield Protocol. These protocols have struggled to gain traction due to the low yield available to depositors in comparison to other DeFi opportunities.

1.1 Why Are Yields from Lending Protocols Variable?

For lending protocols like Aave and Compound, the yield on offer to suppliers/lenders fluctuates based on the supply and demand of crypto assets in the protocol. It is impossible to predict what the supply and demand of credit will be in the future due to the permissionless nature of the protocols.

Users can withdraw, supply, borrow or repay at any time, and all of these actions have an impact on the underlying interest rate that is calculated autonomously and constantly.

The yield described in this report refers to economic yield (fee revenue, interest repayments) rather than governance token yield (liquidity incentives).



1.2 Why Are Yields From Decentralised Exchanges Variable?

The yield on offer to liquidity providers of Decentralised Exchanges (DEXs) is also variable as it is dependent on the exchange volume of the pool. Much like lending protocols, it is impossible to predict the exact yield that will be generated due to variations in the Total Value Locked (TVL) of the DEX liquidity pool and exchange volume. Fixed rate & yield tokenisation protocols such as 88mph and Element Finance are targeting DEX liquidity pool variable rates by leveraging the yield aggregator vaults of Yearn Finance and Harvest Finance. These vaults turn both the economic yield and governance token yield of Curve Finance (the leading stablecoin DEX) liquidity pool tokens into a single interest bearing token.

Protocols that aim to create their own lending market have struggled to gain traction and liquidity due to the low yield on offer to depositors while composable fixed-rate protocols have enjoyed moderate success with Barnbridge (BOND) gaining the most TVL (US\$77 million) and market capitalisation (US\$111 million). Overall, the first wave of fixed-rate protocols have failed to gain significant traction in the DeFi market and the various governance tokens of the sector have broadly underperformed.

1.3 DeFi Fixed-Rate Innovation: Yield Tokenisation

Pendle Finance is among an innovative new wave of fixed-rate projects that aim to create a new class of financial primitives in DeFi called 'yield tokenisation'. These protocols leverage the composability of DeFi to create a market for the hedging and speculation of future yield on major lending protocols and even DEX liquidity pools. These projects separate interest bearing tokens into their yield and principal components over a given timeframe and create a market for trading these components. The prices of these components on the open market determines the fixed rate available. This is known as the 'implied rate'.

Pendle Finance and yield tokenisation protocols are pushing forward innovation in the DeFi fixed-rate sector by overcoming the biggest problems associated with existing competitors. These drawbacks include the liquidity of fixed-rate positions and the interest rate price discovery. Several competitors will be covered later in this report.



2.0 OVERVIEW OF YIELD TOKENISATION

When comparing the competitive landscape of yield tokenisation to established DeFi sectors such as lending, DEXs, and derivatives, the yield tokenisation sector is small, new, underutilised and relatively undiscovered.

To take advantage of Pendle Finance's product offering, investors need to have an in-depth understanding of interest-bearing tokens, the DeFi interest rate landscape, and providing liquidity to automated market makers (AMMs). Through education and continued DeFi adoption, yield tokenisation platforms have the opportunity to pioneer a highly useful and composable new primitive in DeFi.

The main players in the yield tokenisation space are Pendle Finance and Element Finance with APWine, Sense Finance, and Tempus Finance also coming to Mainnet in the medium term. As previously mentioned, there are also several established indirect competitors in the fixed-rate space.



There are three components that make up the Pendle Finance protocol:

1. Yield Tokenisation: Yield Token (YT) and Ownership Token (OT);
2. Pendle's Automated Market Maker (AMM); and
3. Governance (will become more prevalent as the protocol develops).



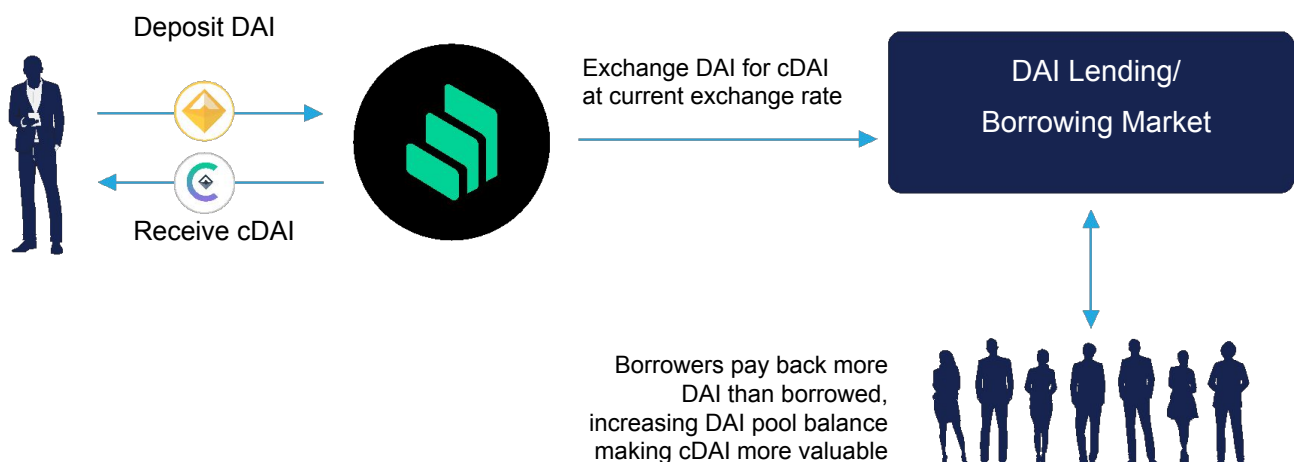
2.1 Interest-Bearing Tokens

To properly understand Pendle Finance and yield tokenisation, we must first gain an understanding of interest-bearing tokens (IB tokens). IB tokens are tokens that earn holders interest via one of two methods:

1. An appreciation in the exchange rate between the IB token and the underlying asset the IB token represents ownership over, e.g. cDAI ([DAI stablecoin deposited into the lending protocol Compound](#));
2. Streaming holders' additional IB tokens, e.g. aUSDC ([USDC stablecoin deposited into the lending protocol Aave](#)).

Example cDAI:

- Investor A allocates 1000 DAI into the Compound lending protocol and receives 46,232 cDAI at the current exchange rate.
- Multiple borrowers use this 1000 DAI liquidity for varying time frames throughout the next year. The interest rate these borrowers are paying is variable because the demand for funds fluctuates as borrowers come and go from the market.
- Over this one year, the average variable yield ends up being 5%. This means there will be 1050 DAI in the pool that is owned by the 46,232 cDAI.
- Over this one year, the exchange rate between DAI and cDAI has appreciated 5% from 0.02163 to 0.02271



3.0 PENDLE FINANCE DESIGN

Splitting cDAI into Yield Token (YT) & Ownership Token (OT)

The fundamental entry point to Pendle is to deposit cDAI (or other supported IB tokens) and mint YT and OT at the desired expiry. Pendle currently supports two expiration dates for both cDAI and aUSDC, 29Dec2022 & 29Dec2021.



Holders of YT have a right to the future yield of the interest-bearing token for as long as they own it and holders of OT have a right to the notional value deposited. As cDAI appreciates in value throughout the contract duration, cDAI is streamed away from OT holders to YT holders so that at expiration, OT holders are left with the balance of DAI deposited.

It is important to note that after expiry OT holders will be able to claim all of the remaining DAI that was deposited into the smart contract. Before expiry, 1 YT and 1 OT is required to claim the DAI deposited.

Splitting aUSDC into Yield Token (YT) & Ownership Token (OT)

Pendle Finance also supports the interest bearing token aUSDC, which is USDC deposited into Aave. aUSDC accrues interest to holders differently to cDAI as a user's balance of aUSDC will grow over time. If 1000 USDC is deposited into Aave, the user will receive 1000 aUSDC. After one year earning 5%, the user's balance will be 1050 aUSDC.

This means that holders of YT are streamed the yield of all the aUSDC deposited into Pendle Finance at the given expiry, and OT holders will receive the deposited aUSDC after expiration.



4.0 STRATEGIES TO TRADE FIXED/VARIABLE INTEREST RATES

The Yield Tokens are traded on Pendle Finance's native AMM and the Ownership Tokens are traded on SushiSwap. The prices of YT and OT on these AMM's determines the 'implied interest rate'. Apart from the incentivised yield strategies that will be discussed in the next section of this report, there are three main strategies that traders can implement to hedge and speculate on the implied interest rate set by the market.

Strategy 01

Mint OT & YT, sell YT at the current market rate, use proceeds to buy OT.

This strategy will lock in a user's interest rate for the desired contract expiration.

Example using current market rates of **YT-aUSDC-Dec2022** & **OT-aUSDC-Dec2022**:

1. Deposit 1000 USDC into Aave, receive 1000 aUSDC, deposit 1000 aUSDC into Pendle Finance;
2. Mint 1000 YT and 1000 OT;
3. Sell 1000 YT at \$0.15855 (through Pendle's AMM) for proceeds of 158.55 USDC;
4. Buy 190.51 OT (through SushiSwap) with the 158.55 USDC at a price of \$0.83223;
5. The user now owns 1190.51 OT which can be exchanged for 1190.51 aUSDC in 478 days;
6. This strategy has locked in a 14.55% p.a. Interest rate for the user.

This strategy can be used to express a bearish view on the current implied interest rate and will push down this implied interest rate due to a depreciation of YT and appreciation of OT.

This strategy can also be achieved by simply purchasing OT off the open market (1000 USDC buys 1,201.59 OT at a price of \$0.83223). To determine whether minting OT/YT or purchasing OT is more optimal to lock in a fixed rate at any given time, traders must analyse the OT/YT pool liquidity and pricing efficiency for the given contract.



Strategy 02

Mint OT & YT, sell YT and use proceeds outside of Pendle.

This strategy will both lock in an interest rate and allow the user to unlock liquidity to be used elsewhere. The fixed rate received will be lower than in Strategy 1 as additional OT is not purchased.

Example using current market rates of **YT-aUSDC-Dec2022** & **OT-aUSDC-Dec2022**:

1. Deposit 1000 USDC into Aave, receive 1000 aUSDC, deposit 1000 aUSDC into Pendle Finance;
2. Mint 1000 YT and 1000 OT, sell 1000 YT at \$0.15855 (through Pendle's AMM) for proceeds of 158.55 USDC;
3. The user's 1000 OT can be exchanged for 1000 aUSDC in 478 days, meaning the fixed rate achieved from selling YT for 158.55 USDC is 12.11% p.a.

The advantages to securing a fixed interest rate and unlocking this future yield includes increased capital efficiency and certainty of returns. This strategy also expresses a bearish view on the current implied interest rate and will push down the implied interest rate due to a depreciation of YT.



Buy YT off the open market.

This strategy is used to express a bullish view on the implied interest rate as users will gain leveraged exposure to the underlying variable rate of the interest-bearing asset.

Currently, the implied interest rates on Pendle are far greater than the variable interest rates on offer through Compound and Aave due to governance token incentivisation of the YT/USDC liquidity pools. This means that Strategy 3 is currently less appealing as the variable rate received by YT holders is lower than what can be locked in through strategies 1 and 2.

Example when implied rate is 5% and variable rate is 4.5% p.a:

- If a user believes that the variable rate will increase to average 7% over the contract duration (1 year), they have two options:
 1. Deposit 1000 DAI into Compound and earn 70 DAI over the next year;
 2. Buy 22,241 YT off the open market with the 1000 DAI at a price of \$0.04496.

This purchase will give the user exposure to the yield of 22,241 DAI over the contract duration. If the investor is correct and the average variable interest rate over the next 12 months is 7%, then this strategy will earn a profit of 556.87 DAI as $22,241 \times 0.07 = 1556.87$. Note that these 22,241 YT will be worthless after expiry.

This strategy will push up the implied interest rate due to an appreciation of YT. This strategy can also be achieved by minting OT/YT, selling OT and using proceeds to purchase YT. To determine whether minting OT/YT or purchasing YT is more optimal to go long on the implied rate at any given time, traders must analyse the OT/YT pool liquidity and pricing efficiency for the given contract.



Markets on Pendle Finance

Markets launched on Pendle Finance:

- 16 June 2021: 29 Dec 2022 expirations for cDAI and aUSDC
- 7 July 2021: 30 Dec 2021 expirations for cDAI and aUSDC
- 18 Aug 2021: 29 Dec 2022 expirations for 2 SushiSwap liquidity pool tokens

These two SushiSwap (SUSHI) liquidity pool tokens (SLP) are interest bearing tokens that represent a deposit of two assets into a liquidity pool. They are interest-bearing because traders using the liquidity pool to swap between crypto assets pay a fee, ranging from 0.3-1% depending on the pool. SLPs can also earn additional SUSHI rewards, which increases the yield available.

The SLP future yield markets on Pendle Finance are:

- ETH / USDC 29 Dec 2022
- PENDLE / ETH 29 Dec 2022

Traders can use similar strategies to those mentioned above to hedge and speculate on the 'implied yield' of these liquidity pools. It is important to note that OT holders in the ETH/USDC & PENDLE/ETH contracts accrue the SUSHI liquidity incentives associated with the deposited SLP's. This means that the YT only represents the fee revenue yield of the SUSHI liquidity pools.

Yield Farming on Pendle Finance

Pendle Finance's AMM liquidity pools are heavily incentivised with PENDLE rewards, making them an attractive yield farm for investors, who understand the complexities of the protocol.

Example using 2,000,000 USDC capital to deploy into aUSDC-DEC2022 yield farms:

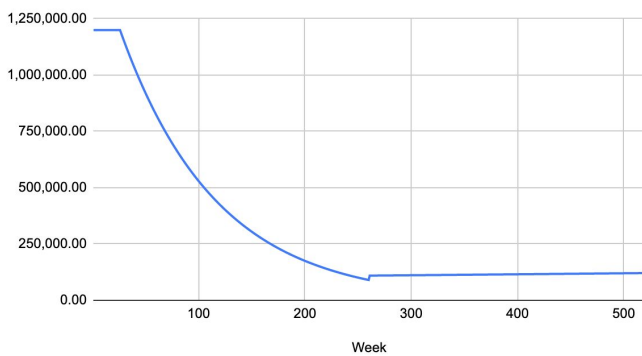
1. Deposit 1,000,000 USDC into Aave, mint 1,000,000 aUSDC;
2. Deposit 1,000,000 aUSDC into Pendle Finance, mint 1,000,000 YT and 1,000,000 OT;
3. Pair 1,000,000 YT with 158,550 USDC and add liquidity to Pendle's native AMM. This liquidity provision is currently earning 196% APY in PENDLE rewards and exchange fees;
4. Pair 1,000,000 OT with 832,230 USDC and add liquidity to SushiSwap's AMM. This liquidity provision is currently earning 22.91% APY in PENDLE rewards and exchanges fees;
5. This strategy will earn an investor 50.61% APY (highly variable) on their \$2 million.



5.0 PENDLE FINANCE TOKENOMICS

Token Emission Schedule & Valuation

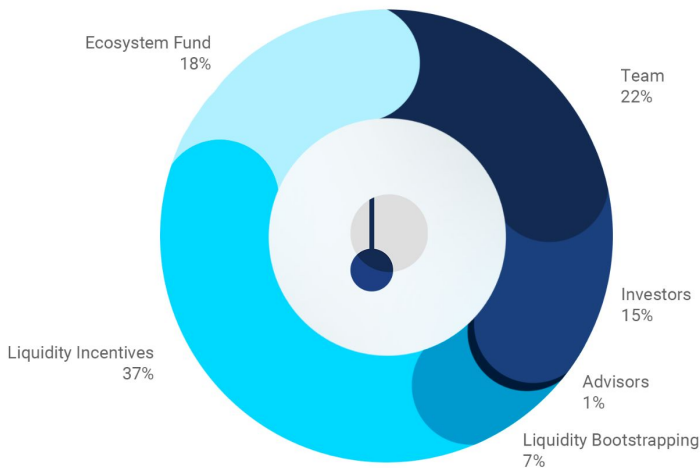
Pendle adopts a hybrid inflation model. The emission begins with stable incentives of 1.2 million PENDLE per week for the first 26 weeks, following which, liquidity incentives will decay by 1% per week until week 260. At this point, there will be a terminal inflation rate of 2% per annum based on the circulating token supply.



Market Capitalisation	\$27.6M
Fully Diluted Valuation	\$110M
Total Value Locked	\$62.1M
Market Cap / TVL Ratio	0.44

Allocation & Vesting Schedule

The highest percentage is allocated to liquidity incentives as the team places a high priority on creating deep and liquid yield markets. The Pendle team have decided the initial incentive distributions and this will evolve into community governance as the protocol matures.



Segment	Vesting Schedule
Team	2-year vest 1-year cliff, followed by quarterly release
Investors & Advisors	1-year vest Quarterly release starting 3 months after liquidity bootstrapping event
Ecosystem Fund	50% no vest 50% unlocked after 1 year

As PENDLE is a highly inflationary token, it is important to keep up with this inflation by allocating to the highly incentivised PENDLE pools.



6.0 SMART CONTRACT RISK

Pendle Finance has been audited by reputable smart contract audit firm, Least Authority, as well as independently audited by several 'white hats' from the Pendle community. Three of these audit reports can be viewed [here](#). We have assessed the smart contract risk associated with Pendle to be medium. This is because of the novel complexities involved in various parts of the protocol.

Pendle Finance's automated market maker (AMM) has been designed to support tokens with time decay in order to mitigate the guaranteed losses that liquidity providers would suffer in a traditional AMM. As Yield Token (YT) contracts near expiry, the market will enter a 'Frozen State' where the swapping of tokens and adding of liquidity will be disabled. This changing of states increases smart contract risk due to complexity.

Insurance Coverage

Smart Contract Vulnerability cover has recently been enabled for Pendle Finance on [Insurance](#). This means that users can take out insurance in order to protect themselves against a loss of funds in Pendle Finance due to smart contract faults. Insurance internally verifies the quality of the smart contracts that they offer cover on, so users can take some confidence out of the fact that a leading DeFi insurance protocol have deemed Pendle's contracts safe enough to cover. The current annual cost of 7.75% is very low in comparison to the yield available from strategies that involve providing liquidity to the OT & YT pools.

Pendle
Smart Contract Vulnerability

Security Rating ★★★★★

Daily Cost 0.0212%

Capacity ≈ 1k ETH / 4m USD

Select

Weekly Cost: 0.1490%
 Monthly Cost: 0.6458%
 Quarterly Cost: 1.9375%
 Annual Cost: 7.7500%



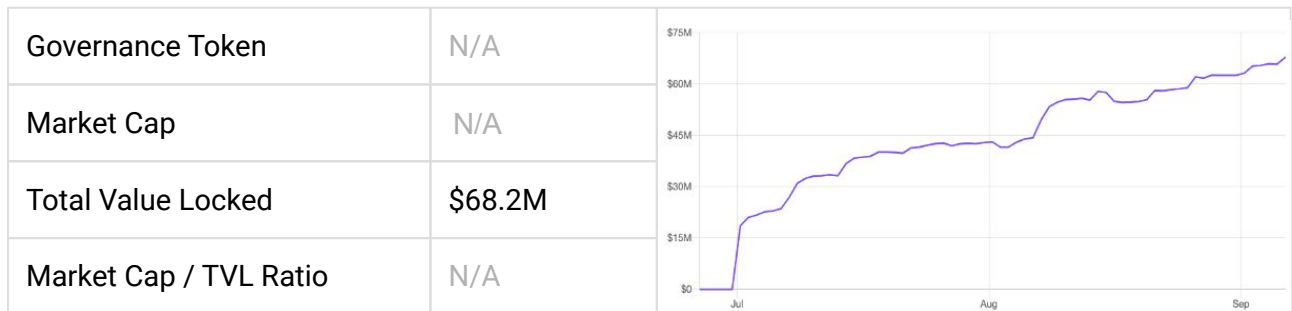
7.0 DIRECT COMPETITORS

7.1 Element Finance

element.fi



Total Value Locked in Element Finance



*Metrics taken from <https://defipulse.com/>

Overview

Element Finance is currently the only other yield tokenisation platform on Mainnet (Ethereum Layer 1) and currently has a larger total value locked (TVL) than Pendle at US\$68.2 million compared to US\$62.1 million. Element's core mechanism very closely resembles Pendle Finance, although there are some key differences.

Element Finance

- Focus on Yearn Finance Vaults only.
- 8 active markets (yvWBTC, yvUSDC, yvDAI, crvSTETH, 2 x crvTricrypto and 2 x crvLUSD at different expiries).
- Does not currently have an active token or incentivised pools.
- Short contract expirations ranging from 40 - 180 days.

Element Finance splits an interest bearing token into a Principal token (ownership token) & a Yield Token. The Principal Token represents the base principal on the interest-bearing token and the Yield Token represents the variable interest gained from the yield generated.



Key Pitfalls in Element Finance's Design are:

Increased risk due to layered smart contract risk: 5 of the 8 active markets on Element Finance are Curve Finance liquidity pool token vaults, meaning that these markets contain the smart contract risk associated with Curve Finance, Yearn Finance, and Element Finance. While Curve and Yearn are highly reputable DeFi protocols, the [February 2021 Yearn vault exploit](#) shows that no DeFi protocol is risk free.

Finding a market implied interest rate for Yearn Vaults is not as useful as finding a market implied interest rate for the largest lending protocols in DeFi: Yearn Vaults contain multiple strategies that aim to maximise yield in the vault's denominated asset. For example, the yvUSDC Vault utilises up to 6 different strategies that incorporate 6 different protocols [as outlined here](#). Finding an implied interest rate for this vault is like finding an implied rate for a traditional high-yield bond fund; the information gained is not very valuable. The implied interest rate of USDC and DAI on Compound and Aave is similar to the overnight rate of a central bank as it is the base cost of borrowing for the financial system it operates in.

Short contract duration doesn't allow for:

1. Adequate implied interest rate discovery;
2. Large yield token markets to form: largest yield pool liquidity on Element is \$351,000 whereas the largest YT pool liquidity on Pendle is \$3.7 million

Element Finance has impressively gained significant TVL without the use of a governance token to incentivise liquidity. This is due to the large selection of assets and a relatively simple user interface making interaction easy for investors. Element's focus on the principal value (PT/OT) is the key differentiator to Pendle Finance, which focuses on the yield token.

Pendle Finance's focus on building a large and liquid market for the yield token is more attractive as yield tokens are the key innovation driving these yield tokenisation protocols. Building a large market for YT will enable YT to become a composable primitive in DeFi, e.g., the ability to use YT as collateral in a lending protocol.



7.2 Alchemix

alchemix.fi



Total Value Locked in Alchemix



*Metrics taken from <https://defipulse.com/>

Overview

Alchemix sits somewhere in between a direct and indirect competitor of Pendle Finance and the previously mentioned yield tokenisation protocols (Element, APWine, Tempus). Launched in late February 2021, the protocol is the first reasonably successful attempt at tokenising future yield. Alchemix allows for the creation of synthetic tokens that represent the future yield of a deposit. It enables users to retrieve near-instant tokenised value against deposits of stablecoins.

When a user deposits DAI (or ETH) into Alchemix, a debt position of up to 50% of deposited collateral can be minted in 'aUSD'. The debt position created by users is referred to as 'future yield' as a user's deposited DAI earns yield in Yearn Finance's DAI vault; this yield is used to pay back the loan. Alchemix enjoyed rapid TVL growth in the first 3.5 months after launch as yield farmers took advantage of the lucrative ALCX incentives, peaking at a TVL of over US\$600 million in mid-June.

Key Considerations

While [Scoopy Trooples](#) and the rest of the Alchemix team have proven that there is an appetite for the idea of future yield tokenisation in DeFi, Alchemix in its current form is primarily a synthetic asset platform that is enabled through over-collateralised debt positions. The US\$241 million aUSD in circulation is not future yield, it is tokenised debt.

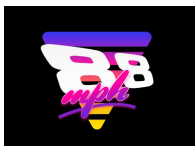
When using Alchemix, an opportunity cost is associated with the variable and relatively low repayment rate in the DAI Yearn Finance vault of around 5%. There is also the layered smart contract risk of both Alchemix and Yearn Finance that must be taken into account when using the protocol.



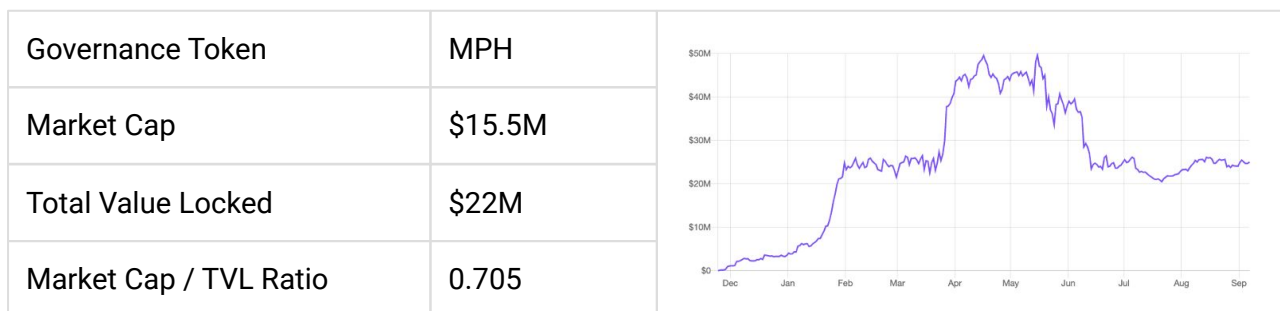
8.0 INDIRECT COMPETITORS

8.1 88 mph

88mph.app



Total Value Locked in 88 mph



*Metrics taken from <https://defipulse.com/>

Overview

Launched in November 2020, 88 mph was one of the first protocols that aimed at giving investors a fixed rate on various interest-bearing tokens. After launch, the protocol steadily gained traction from yield farmers, who were intrigued by the protocol's relative complexity. Total Value Locked peaked at US\$50 million in April 2021, and the current TVL of US\$22 million signals dwindling demand for 88mph's stagnant product range.

88mph leverages the composability of DeFi by creating a fixed-rate market for interest-bearing tokens on Aave, Compound, Yearn Finance and Harvest Finance. 88mph's approach was certainly novel and innovative when launched, however, the design lacks the sophistication needed to scale dramatically. The two products that make up the majority of 88mph's TVL are 'Fixed-interest rate bonds' (FIRBs) & 'Floating-rate bonds' (FRBs).

Fixed-interest Rate Bonds

The protocol offers a 50% discount on the 30-day exponential moving average (EMA) of the variable rate of various interest-bearing tokens as the fixed rate. When purchasing a fixed-rate bond, the user will define their lending duration and receive an ERC-721 non-fungible token that represents their deposit. Once the defined lending period is over, users can then withdraw this principal along with the fixed rate of interest earned.



Floating-rate Bonds

Floating-rate bonds are used to cover the fixed rate of interest earned by fixed-rate bond holders. When a user takes out a FIRB, it creates a debt that must be paid to the FIRB holder at bond expiry. FRB investors pay the full value of this debt in order to earn the variable interest rate that is earned from the interest-bearing asset.

Zero Coupon Bonds

88mph's latest product is a zero coupon bond (ZCB). These ZCBs are an attempt to make fixed-interest rate bonds liquid and tradable on markets like SushiSwap. A FIRB holder can use their ERC-721 NFT to mint a ZCB, although only 2 of the 16 FIRB markets have the ability to mint a ZCB due to liquidity issues. ZCBs have had very little traction with TVL of only around US\$1.5 million.

Key Design Issues

The three key issues that inhibit 88mph's ability to become a core piece of the Ethereum DeFi ecosystem are:

1. Pricing of fixed-interest rate bonds: Pendle/Element's market-determined fixed rates of interest are a superior pricing source to a discounted exponential moving average of the variable rate;
2. No working solution to FIRB liquidity. Having a predetermined lock up in order to receive a fixed rate of interest deters a significant amount of users; and
3. Strong reliance on FRB purchasers to cover FIRB debts. The need for floating rate bonds to be purchased manually after a FIRB is created is inefficient. Floating rate bonds also suffer from illiquidity and uncertainty around returns.





BARNBRIDGE

Total Value Locked in BarnBridge

Governance Token	BOND	
Market Cap	\$111.5M	
Total Value Locked	\$77.2M	
Market Cap / TVL Ratio	1.44	

*Metrics taken from <https://defipulse.com/>

Overview

BarnBridge’s fixed-rate product named ‘SMART Yield’ launched in February 2021 while the protocol’s governance token, BOND, launched in November 2020. SMART Yield uses a similar mechanism to 88mph’s fixed-interest rate bond in order to offer investors a fixed rate, but with an added level of sophistication and complexity.

Token Name	Senior Liquidity	Senior APY
USDC USD Coin	5.75M USDC \$5.75M	2.31%

The annual percentage yield (APY) displayed as ‘Senior APY’ is the APY available to the next marginal senior bond to be minted. This figure fluctuates in accordance with a rolling average of the underlying interest rate market. When a user deposits into the Senior pool, this is the maximum fixed yield they can expect to lock in. Slippage occurs when the principal size brings the Senior pool size closer to, or greater than, that of the Junior pool.

- Senior Pools offer lower risk with fixed-rate rewards.
- Junior Pools offer higher risk with levered variable rate rewards.



Junior Tokens (jTokens)

SMART Yield Junior pool positions are represented by ERC-20 fungible tokens, called junior tokens (jTokens). Junior tokens are minted each time the user purchases them at a current conversion rate using BarnBridge app.

Token Name	Senior Liquidity	Senior APY	Junior Liquidity	Junior APY
 USDC <small>USD Coin</small>	5.75M USDC <small>\$5.75M</small>	2.31%	85.94M USDC <small>\$85.94M</small>	3.53% <small>+17.09% APR</small>

Junior APY (3.53%) is the annual percentage yield for the junior tokens at the current time. It is realised only when exiting the position and converting jTokens into the underlying asset. This is because yield is earned through an appreciation in the jToken:USDC exchange rate on the Barnbridge app. However, this exchange rate can depreciate in scenarios where the Junior pool has Senior pool yield obligations.

This is the risk that Junior liquidity providers take on when they deposit, their capital can be used to cover senior pool yield obligations. This capital can be taken from them when they attempt to 'instant withdraw' from the pool or through the depreciation in the exchange rate of jTokens. Junior liquidity providers also have the option of exiting through a Junior bond. Junior bond maturity date is dependent on the average maturity date of all senior bonds.

Design Problems

While Barnbridge has significant design advantages compared to 88mph and has attracted significant TVL because of it, there are still limitations associated with the 'Tokenised Fixed-Rate Bond' model.

- No working solution to Senior Bond liquidity. Having a predetermined lock up in order to receive a fixed rate of interest deters a significant amount of users and has meant that Senior Bond TVL across all pools has been low.
- Pricing of the fixed interest rate available is not solely discovered by the market and relies on a rolling average of the underlying variable rate.

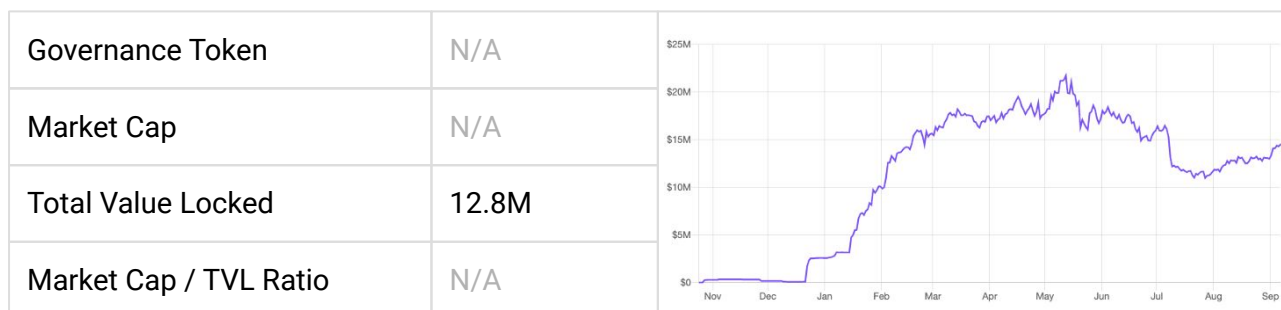


8.3 Notional Finance

notional.finance



Total Value Locked in Notional



*Metrics taken from <https://defipulse.com/>

Overview

As Notional Finance's whitepaper stipulates, 'fixed-rate, fixed-term lending is by far the most common type of lending in traditional financial markets.' Notional Finance is an on-chain Ethereum protocol that enables users to lend and borrow at fixed rates at predefined maturities.

Fixed-rate loans give users a greater level of certainty than variable rate markets such as Aave and Compound. The variable-only interest rates on offer through these major DeFi protocols makes planning for the future, making financial decisions, and hedging difficult when borrowing and lending.

Notional currently offers the ability to lend or borrow in two contracts, expiring Sep-21 and Dec-21 for USDC and DAI crypto assets. With a TVL of only \$12.8M, Notional Finance is still a very small project and plans on rolling out fixed-coupon bonds and fixed-rate yield farms.

Key reasons why Notional has struggled to gain traction are: low yield available to depositors when compared to other DeFi opportunities and illiquidity of borrowing and lending positions.

Notional has [announced the roll out of their native governance token](#), NOTE, which will be used to incentivise liquidity. This token is likely to have an extremely positive impact on the TVL of the protocol.





Governance Token	N/A
Market Cap	N/A
Total Value Locked	4.87M
Market Cap / TVL Ratio	N/A

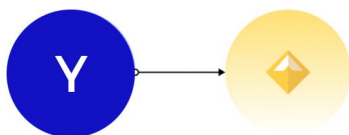
**Metrics taken from Yield Protocol Discord Channel. Graph not available*

Overview

Yield Protocol is another fixed-interest rate protocol. Like Notional Finance, it allows users to have a "set and forget" experience, instead of constantly rebalancing their assets across DeFi in an effort to minimize borrowing rates or maximize lending yields, the most common method to generate yield. Yield Protocol is able to accomplish this via a new primitive, fixed-yield tokens (fyTokens).

fyTokens

fyTokens are Ethereum-based tokens (ERC20) and may be redeemed one-for-one for a target asset after a predetermined maturity date. fyTokens operate in the same fashion as a zero-coupon bond would function in traditional finance.



At maturity, fyDai are redeemable for Dai one to one

An example of how Yield Protocol works using the image above is as follows.

Suppose a user buys 1 fyDai that settles exactly a year from today for 0.95 Dai. The yield is fixed because there is a fixed amount of invested capital (0.95 Dai) and a known amount of future return (1 Dai, one year from now).



A zero coupon bond's price is calculated by the following formula, where P is the price of the bond, M is the value of the underlying at maturity, r is the interest rate and n is the number of years to maturity.

$$P = \frac{M}{(1 + r)^n}$$

Using this zero-coupon bond formula, the r can be calculated as 5.26%.

$$0.95 = \frac{1}{(1 + r)^1} \leftrightarrow r = \frac{1}{0.95} - 1 = 0.0526$$

The Yield Protocol App allows users to be borrowers, lenders, and provide liquidity. Borrowers borrow DAI against the ETH they put up as collateral at an over-collateralized rate.

For users wanting to take a lending position through Yield Protocol, they can buy fyDai of any maturity with DAI. The discount the lenders receive from the face value of the fyDai locks in a fixed return that can be calculated based on the time to maturity.

Much like Notional, Yield Protocol has not managed to gain significant traction due to the low APY on offer to depositors. Notional and Yield offer investors a valuable product, but the market has broadly ignored their offerings and have adopted protocols that leverage the composable nature of DeFi in order to achieve a fixed interest rate for depositors.





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