Buttonwood Zero—A zero-liquidation web3 bond market*

Manny Rincon-Cruz
uwu@prl.one

v.2 June 2022

Abstract

Margin leverage is best suited for sophisticated traders. It is an instrument with asymmetric downside exposure which requires great risk management in volatile environments. All Decentralized Finance (DeFi) leverage today is margin leverage. To provide long-term permissionless credit, DeFi needs debt with zero margin calls and zero liquidations. In this paper we propose a design for one such debt instrument, which we call Buttonwood *Zero*, and which is a router contract built around the Buttonwood *Tranche* core contracts. We begin by offering a framework for understanding the effects of tokenizing debtor obligations and creditor claims. This allows us to classify various types of debt as zero-token, single-token, or double-token instruments. These insights frame our design for *Zero*, and how it can help anchor a web3 bond market.

*The first version of this whitepaper, then called *ButtonBonds*, was released on November 29, 2021

1 Introduction

Margin leverage and volatility are a dangerous mix, and not only in web3. Margin calls and liquidations have been at the center of numerous firm failures and market crises throughout financial history—from the catastrophic losses of Robinhood day-traders in 2020 [1], to Lehman Brother's 2008 collapse, to the 1929 Wall Street Crash.

Decentralized Finance (DeFi) users face numerous risks—smart contract bugs, project team "rug-pulls", and losing control of one's private keys. The industry tries to reduce these risks through audits, vesting, and operational security. However, there is one type of risk that today's DeFi does not mitigate, but in fact augments—margin calls and liquidations. Lured by traditional bond markets' massive size, standing at $123.5 trillion in 2020,[2] DeFi lending projects have focused their energies on the wrong problem—building fixed-rate instead of variable-rate debt. While fixed rates can soften the risk of liquidation, they are still margin instruments that create asymmetric downside exposure to volatility—a significant shortcoming in crypto. Their primary users (by value) are the sophisticated funds and traders that are also the primary users of margin leverage in traditional markets.

To provide an alternative, we outline a design for peer-to-peer (P2P) lending transactions with zero margin calls and zero liquidations. We call this design Zero (previously ButtonBonds). Its protocol is a router around the Buttonwood Foundation's Tranche smart contracts.

We first review the state of DeFi lending and articulate the motivation for creating zero-liquidation debt. We then present our framework of zero-, single-, and double-token debt, and explain why this design makes the loans non-callable. We then explain how to build the *Zero* router. In concluding, we outline how an automated market maker (AMM) like Uniswap v3 could be used to build a web3 fixed-income market, and explore the benefits that the upcoming Buttonwood *Auctions* contracts might bring.

---

[1] https://www.wsj.com/articles/robinhood-three-friends-and-the-fortune-that-got-away-11619099755; https://www.nytimes.com/2020/07/08/technology/robinhood-risky-trading.html

[2] https://www.sifma.org/resources/research/fact-book/

2 State of the field—margin, margin everywhere

The vast majority of DeFi borrowing happens on margin lending platforms such as Aave and Compound. The oldest such protocol is MakerDAO.[3] A user first opens an account and collateralizes it with ETH.[4]. In return they mint DAI tokens up to a certain loan-to-value (LTV) against their collateral, where:

$$LTV = DAI\_minted/collateral\_value$$

For example, if the LTV limit is 75%, a user will be able to mint up to 75 DAI for every $100 of ETH they deposit. Users pay a variable interested rate on the DAI minted, which Maker calls a stability fee. When the value of the collateral drops, it raises the LTV. Once it gets close to the limit, the user's debt is margin called. Users have three options—they can raise $collateral\_value$ by depositing more collateral, they can lower DAI_minted by repaying back their DAI, or the protocol can liquidate their assets. This system of margin calls and liquidations enforces the LTV limit, such that, in general, each DAI token is backed by a "dollar's worth" of collateral.

If Maker's users are debtors, then who are the creditors? DAI is widely accepted in DeFi. Debtors take their DAI to buy assets elsewhere, making DAI holders the final creditors, for to them accrues Maker's risk of undercollateralization. For example, in March 2020 the platform became undercollateralized when liquidation proceeds in a volatile environment fell short by 5.4 million DAI. Thus, the protocol minted and auctioned off 20,980 MKR (its governance token) to recapitalize itself so that each DAI was again backed by a dollar's worth.[5]

This model has been copied widely. For example, Liquity is a Maker clone whose "efficient liquidation mechanism allows users to get the most liquidity for their ETH."[6] Liquity charges a one-time fee when users mint LUSD dollar equivalents, instead of Maker's variable rate, and has an LTV limit of 91% versus Maker's 66%.[7]

Yield Protocol is a Maker-inspired project, except that their debt tokens have a fixed ma-

[3] https://makerdao.com/en/

[4] Today MakerDAO accepts a number of other Ethereum-based assets, subject to governance approval, each with different LTV limits

[5] https://blog.makerdao.com/the-market-collapse-of-march-12-2020-how-it-impacted-makerdao/

[6] https://www.liquity.org/

[7] Liquity requires a 110% minimum collateralization ratio, that is, collateral:debt must be at least 110%; Maker's minimum collateralization ratio for ETH is 150%.

turity, preventing their use as money exchangeable for other assets.[8] Instead, the Yield team has built a custom automated market maker (AMM) called YieldSpace where users sell debt tokens for stablecoins.[9] Users sell these tokens at a discount, much like a zero-coupon bond, thereby paying a fixed implied interest rate upfront. YieldSpace's AMM curve narrows the discount between yield tokens and stablecoins down to zero at the time of maturity, shielding liquidity providers (LPs) from unnecessary arbitrage losses. Notional Finance is another platform with a similar structure.[10]

Compound and Aave offer "closed loop" margin lending, which has led to massive success as all lending and borrowing happen directly on their protocols. Like on Maker, users open a position or vault, they deposit assets, and then borrow up to a certain LTV. The key difference is that debtors do not mint debt tokens. Instead, they directly "borrow" assets from the platform. When a user deposits assets into their vault, those assets are in fact deposited into the lending pools from which other users can borrow. Thus, to borrow on Compound and Aave one must deposit collateral to lend—though of course creditors are not necessarily debtors.

However, unlike other projects, debtors on Compound and Aave have two sources of margin liquidation risk:

$$LTV = value\_borrowed/value\_deposited$$

As shown through the formula above, debtor's LTV will drop if *either* their collateral depreciates or their borrowed assets appreciate. The LTV is calculated using oracle-provided prices for both the collateral assets and the borrowed assets, and each asset deposited has an individual LTV limit, set by protocol governance, which is called "borrowing power."

[8] Dan Robinson, Allan Niemerg. "The Yield Protocol: On-Chain Lending With Interest Rate Discovery." April 2020, v2. https://yield.is/Yield.pdf

[9] Allan Niemerg, Dan Robinson, Lev Livnev. "YieldSpace: An Automated Liquidity Provider for Fixed Yield Tokens." August 2020, v1. https://yield.is/YieldSpace.pdf

[10] https://notional.finance/

We can summarize the state of the field as follows:

	Fixed rate	*Non-callable*
Maker	No	No
Liquity	Yes	No
Yield	Yes	No
Notional	Yes	No
Compound	No	No
Aave	No	No
Aave (stable)	Yes	No
Buttonwood Zero	Yes	Yes

3 The scourge and terror of margin call liquidations

Loan callability—the ability to trigger a margin call and liquidation—adversely affects debtors, creditors, and sometimes aggregate financial stability.[11] For debtors, callability introduces path-dependency to portfolio returns, which in many cases outweighs the benefits of using leverage in the first place. It is well known that leverage increases the volatility of portfolio returns and generally leads to underperformance. We now have ample empirical evidence of the underlying mechanism. A recent study of online retail traders found that "after controlling for forced liquidations, leverage does not play any significant role in gross DRR [daily rate of return]; in other words, the impact of leverage on gross investment returns occurs mainly via forced liquidations."[12]

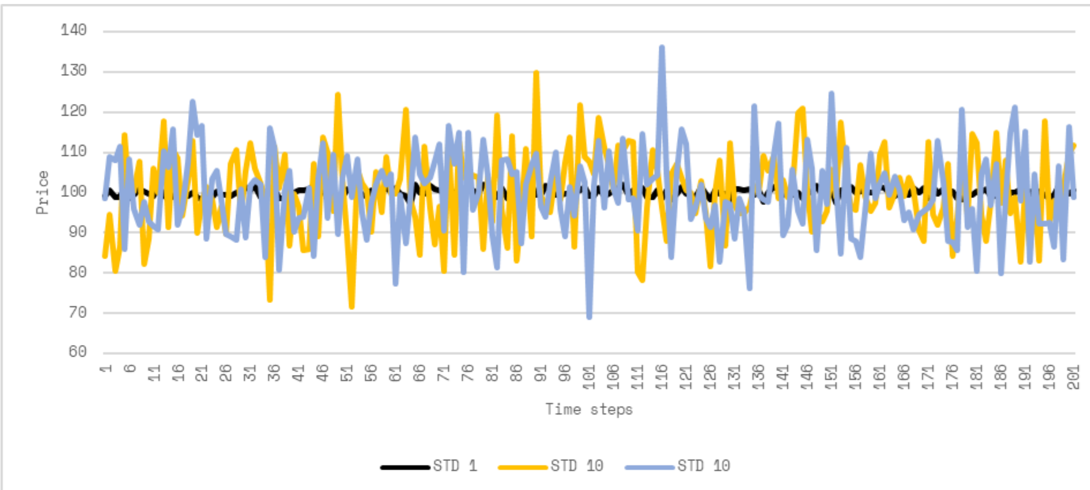
Protocol designers focused on increasing "capital efficiency" through higher LTV thresholds are delusional to think this adds meaningful value to crypto investors. Why? Even if collateral generally appreciates in the long-term, high-volatility environments (of which

[11]"Callability" means that repayment of principal and accrued interest can be demanded ahead of a debt's maturity. Confusingly, "call bonds" are bonds which the debtor (rather than the creditor) has the option to "call back" and pay off a debt. For our purposes and general clarity, we use "callability" for the creditor's right to demand early repayment, and "prepayment" for the debtor's right to pay a debt early.

[12]Avanidhar Subrahmanyam, Ke Tang, Jingyuan Wang, and Xuewei Yang. "Leverage is a Double-Edged Sword." November 2, 2021. Page 17. First published May 21, 2021. https://papers.ssrn.com/sol3/papers.cfm?abstract$_i d = 3855181$

crypto is the perfect example) will still trigger margin liquidations, which are asymmetric in their impact. Debtors are effectively forced sellers at the lowest possible price and realize large losses, but are locked out from any subsequent appreciation in the value of their collateral.

Margin leverage creates fragile portfolios—they lose, but do not gain, from volatility. Consider the graph below, representing the price of three imaginary assets. The long-run mean of all three assets is 100, however their price changes per time steps are random. As can be seen, two of them are more volatile than the first. While STD1 could comfortably support an LTV of 96%, while the two STD10 assets would trigger liquidations in-between steps at LTV thresholds as low as 70%.[13]



For creditors the situation is a bit more nuanced. Unlike what is often implied by existing DeFi projects, margin calls and liquidations do not create "risk-free" lending. These mechanics can help protect against individual bad debtors, but not against market volatility. Rather than destroy risk, margin lending transforms it into a more opaque form.

[13]This is a simple, illustrative graph. The price change per time step is drawn from a normal distribution, the first with a standard deviation of 1, the second two series with a standard deviation of 10. Of course, there are many other ways to model random processes and volatility.

Specifically, margin lending's efficacy hinges on the capacity and willingness of the market to absorb liquidated assets. Thus, margin lending fails to protect creditors when there is not enough liquidity relative to sell pressure. Driving this process are three hard-to-measure variables:

	Liquidity and Liquidation Risks
Auctions	Creditor protection depends on how well a liquidation market is running, the effectiveness of current auction designs, and liquidator access to capital.
Leverage	A highly leveraged market is less able to absorb liquidations since losses to even a few players can trigger general deleveraging.
Volatility	General changes in market trajectory leads market makers to pull back liquidity, accentuating price volatility and increasing liquidation risk.

Putting aside liquidation auction technical risks,[14] we can think of margin liquidations in the same way we think of mortgage bundling. It protects creditors against the stochastic default of a single debtors, but does little to protect against mass defaults triggered by general changes in the housing (or crypto) markets. These general changes are quite hard to discern. For example, creditors might know the current ratio of debt to collateral in a pool or market, but they cannot know to what extent debtors can post additional collateral to prevent liquidations. This has become most obvious as many large reputable players in crypto, including funds like Three Arrows Capital, suffered margin calls that they were unable to meet. Alternatively, spikes in volatility can produce liquidations that overwhelm market liquidity, posing serious risks of various borrowing protocols like Solend.[15] And as mentioned earlier, Maker became undercollateralized in March 2020 when a sudden drop in the value of ETH triggered liquidations at prices too low to cover the value of outstanding DAI.

[14] In fairness, auction design and capital access have been improved by implementations of Dutch auctions and flash-loan-based liquidator purchases, as in the case of MakerDAO's upgraded module. https://docs.makerdao.com/smart-contract-modules/dog-and-clipper-detailed-documentation

[15] https://www.coindesk.com/business/2022/06/27/solanas-biggest-defi-lender-almost-got-rekt-then-binance-stepped-in/

4 Zero-token, single-token, and double-token debt

To help articulate an alternative to margin lending, we propose a novel framework for thinking about the nature of debt. We trace the evolution of debt from zero-token (or account-based), to single-token and double-token instruments.

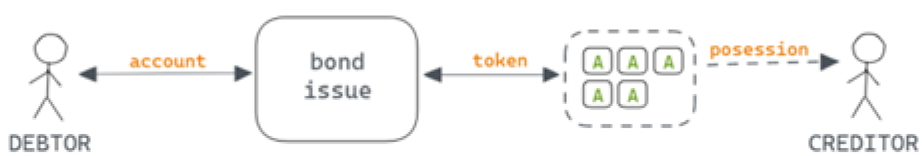
It helps to think of debt is a transaction across time. Most trades are instantaneous—Alice gives Apples to Bob, conditional on Bob giving Alice some Bananas. With debt the "trade" is like-for-like, but across time—Alice gives $100 to Bob today, conditional on Bob giving Alice $120 a year from now.

The earliest forms of debt tied a specific lender to a specific debtor—this is zero-token (ZTD), or "account-based" debt. The claims and contracts attached to legal people we call parties and counterparties. Imagine an uncle lending his nephew $1,000 for a car.

Zero-token debt

European sovereign bonds represented a watershed development in financial history. The bonds still represented claims on a specific sovereign's collateral, cash flows, or tax receipts. However, the creditor's position in the debt contract was replaced by a token—in traditional terminology, bonds were bearer securities for *creditors*. Tokens—as we use the term—are fungible, transferable instruments. For this reason, we can think of traditional bonds as single-token debt (STD).

Single-token debt



It is further possible to also tokenize the debtor side of a debt, so that debtor obligations are fungible and transferable. Historically, such arrangements are quite rare. The closest analogy we have is selling hypothecated collateral without extinguishing the attached loan; for example, selling a home to a new buyer *with the mortgage still attached*. Another, admittedly imperfect, example is a public corporation. Debtors and creditors hold tokenized claims—the first hold fungible stock, and the second fungible bonds. On-chain, one could build permissionless double-token debt (DTD) if, instead of hypothecating non-fungible homes or corporate cash flows, the debt was backed by a fungible digital commodity such as ETH.

Double-token debt

This framework offers three insights. The first insight is that traditional fixed-income instruments are single-token debts since they represent claims on specific debtors. The specificity of that claim allows these debts to be called. Consider the common house mortgage. Unlike a margin loan with your broker, a bank cannot call a mortgage because the house dropped in value. However, the mortgage is callable under certain circumstances, such as when the debtor misses their scheduled payments.

Surprisingly, DeFi leverage today is comprised entirely of single-token debt. This might not be obvious, given that positions on almost all protocols are partially represented with tokens. But a careful look reveals that debtors are tied to idiosyncratic vaults or "borrowing positions" which they must monitor and keep properly collateralized. The creditor pool is comprised of fungible tokens, while the debtor pool is a blend of non-fungible debtor accounts. With this insight we can add two more columns to our previous table summarizing the state of the field.

	Fixed rate	*Fungible debtor obligations*	*Fungible creditor claims*	*Non-callable*
Maker	No	Yes	No	No
Liquity	Yes	Yes	No	No
Yield	Yes	Yes	No	No
Notional	Yes	Yes	No	No
Compound	No	Yes	No	No
Aave	No	Yes	No	No
Aave (stable)	Yes	Yes	No	No
Buttonwood Zero	Yes	Yes	Yes	Yes

The second insight is that double-token debt is practically non-callable and impossible to liquidate. Because debtors hold fungible, transferable tokens it is impossible to margin call or call specific debtors. Because of this, the debt's value is a function of the underlying collateral. It should be clear that DeFi projects do not realize that the fixed- versus variable-interest question is a red herring. What matters is eliminating margin calls and liquidations—and in a permissionless environment this requires fungible debtor obligations. We can synthesize the above table into a two-by-two matrix:

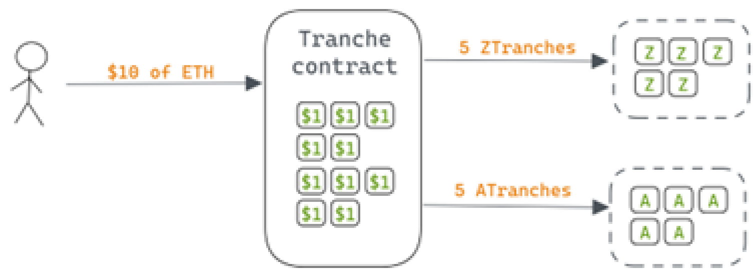
	non-fungible creditor claims	fungible creditor claims
fungible debtor obligations		Buttonwood Zero
non-fungible debtor obligations	Pawn.fi peer-to-peer lending non-securitizable loans	MakerDAO/Liquity Yield/Notional Compound/Aave traditional bonds

The third insight is that double-token debt can link large pools of creditors and debtors in a permissionless environment. Traditional finance is account-based—creditors have specific claims against specific debtors. Natively, DeFi has no parties or counterparties on-chain. In its natural, uncorrupted form, Web3 is addresses and tokens. Tokenizing the debtor's obligations is a simple adaptation of debt to this environment. Double-token debt saves us the unnecessary complexity of recreating pseudo-identity and accounts-based claims on-chain.

	non-fungible creditor claims	fungible creditor claims
fungible debtor obligations	1-token	2-token
non-fungible debtor obligations	0-token	1-token

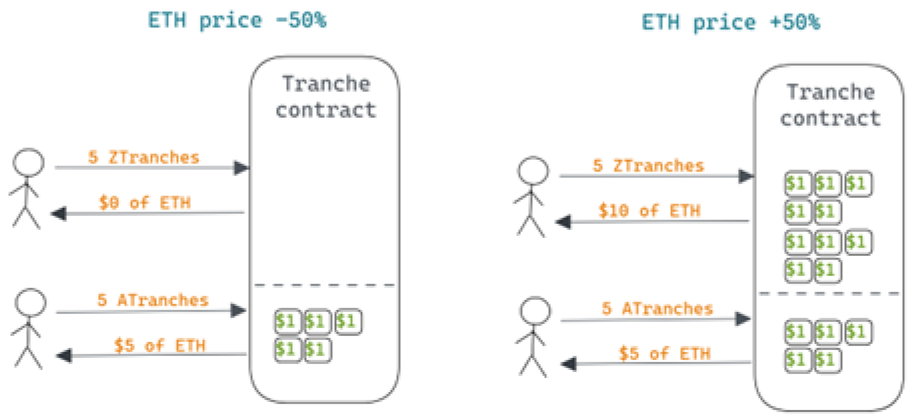
5 Buttonwood Zero

We encourage the reader to read the documentation for Buttonwood Tranche, but nonetheless provide a quick review of the *Tranche* contracts here. Tranching works by creating two or more claims against the future value of a crypto asset. The contracts are arbitrarily configurable, so we only review a simple example here. Assume there exists a *Tranche* contract with two tranches, A- and Z-, with a 50:50 claim on the value of the underlying collateral. A user depositing $10 worth of ETH user would receive 5 A-Tranche tokens and 5 Z-Tranche tokens.



The magic of tranching comes from ordering claims on the value of underlying collateral. At maturity, the A-Tranches have a claim on the first $5 of value, and Z-Tranches have a claim on the remainder.[16] Another way to frame this property is to think of A-Tranches as debt and Z-Tranches as equity. When the collateral drops in value, the Z-Tranches lose value first. But if the collateral increases in value, the Z-Tranches capture all the upside.

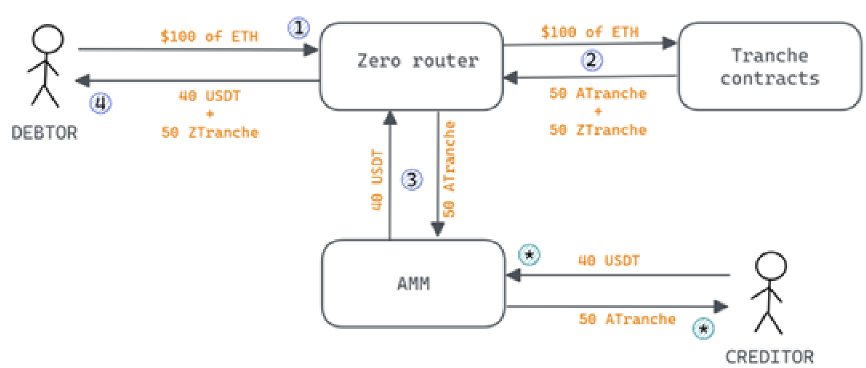
[16]For a wonderful essay on how tranching underpins almost all of finance, read Matt Levine's "Looking for Tether's Money," https://www.bloomberg.com/opinion/articles/2021-10-07/matt-levine-s-money-stuff-looking-for-tether-s-money; "You have a risky thing. It will be worth a lot of money in some states of the world and less money in some other states of the world. You divide that risky thing into junior and senior claims... When you find out how much the risky thing is worth, you pay off the senior claims first, and then the junior claims get whatever's left."



Zero is a router built around the *Tranche* core contracts. Assume that A-Tranches are trading at 0.80 USDT ($0.80) on an AMM, implying an interest rate of 25%. Then the *Zero* router should be able to handle the following sequence of events when a user deposits ETH to borrow USDT:

1) Receive the user's $100 worth of ETH.
2) Deposit the ETH into the right Tranche contract, and receive 50 A-Tranches and 50 Z-Tranches.
3) Swap 50 A-Tranches into an AMM to receive 40 USDT.
4) Return to the user 40 USDT, which is their loan, and 50 Z-Tranches, which is their debtor obligation.

The process looks like this:



6 A web3 bond market

The example diagram is the simplest possible *Zero* router, which executes transactions at the current AMM price. However, there are still two other components missing from a fuller web3 bond market—a primary market for price discovery, and a secondary market that can handle larger trades priced differently from an AMM's current price.

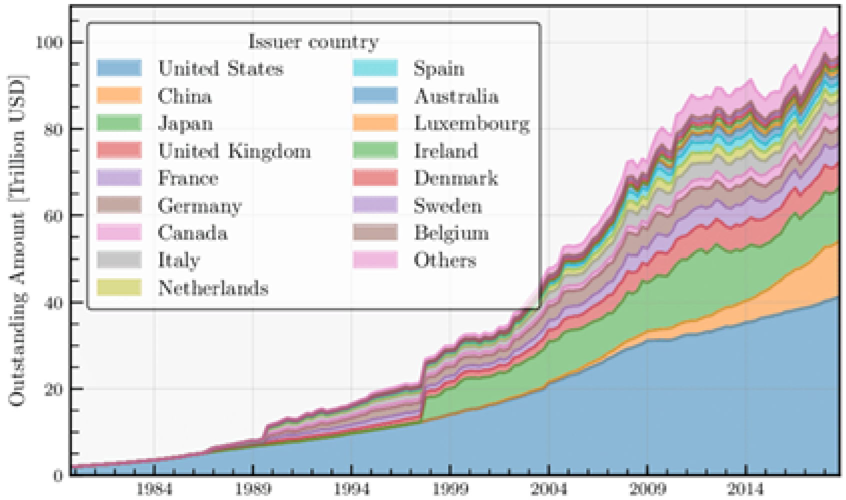
	Function	*Protocol*	*Type of trade*
Primary Market	Price discovery	Auctions	Large and small orders
Secondary Market	Fast trades	Zero	Small orders
Secondary Market	Priced trades	Zero	Large orders

The Buttonwood *Auction* protocol can serve as a primary market for new tranches. The protocol is a permissionless means to create a double-sided auction between an arbitrary pair of ERC-20 tokens. In the case of tranched tokens, this will allow price discovery to happen without the need for market-maker liquidity. Before an auction has settled a clearing price, users could place buy or sell bids both large and small.

After a *Zero* market has been created for a particular Tranche bond, the *Zero* router allows small orders to be processed quickly. However, larger orders, or orders at a price different than the current price, require a different approach. One of the reasons we favor an implementation with an AMM like Uniswap v3 is because one-tick liquidity ranges on Uniswap v3 can function like limit orders. Users can provide single-sided liquidity in ranges above or below the current market price. Once those one-tick ranges get "flipped," a user would then pull their range to effectively "fill" their order. Our implementation of the *Zero* router allows users to easily place these one-tick ranges onto an underlying AMM.

Combined, *Zero* and Auction provide a nearly complete, permissionless on-chain bond market. We expect that this market will be anchored by organizations or individuals that need longer-term borrowing—namely, those with longer time horizons, ongoing projects, or predictable expenses and revenues.

Global Bond Market Size[17]



In traditional finance, margin leverage is almost wholly inadequate for most borrowers. We believe the vast majority of future web3 leverage will likewise prefer debt with zero margin calls and zero liquidations, allowing a more stable and robust way to borrow against their digital assets.

7 Conclusion

Margin leverage is best suited for sophisticated traders. It is an instrument with downside asymmetric exposure which requires great risk management in volatile environment. For that reason, margin leverage is by nature short-term debt. DeFi leverage today is primarily composed of margin leverage, and as such cannot serve individuals or organizations with longer timelines, including foundations, DAOs, and project teams.

We argue that the tokenization of debtor obligations and creditor claims offer the best framework for thinking about the properties of debt and its evolution through history. More importantly, double-token debt—when both obligations and claims attach to tokens rather than parties—offers a web3-native way for debtors and creditors to create debt with zero margin calls and zero liquidations.

[17] Hagenbjörk, Johan. (2020). Optimization-Based Models for Measuring and Hedging Risk in Fixed Income Markets. 10.3384/diss.diva-162576. Global bond market size for the largest markets (Bank for International Settlements, 2019b). SIFMA. Capital Markets Fact Book, 2021.

We believe our design for such an instrument—which we call **Buttonwood Zero**—can help anchor a permissionless, web3 bond market.

References

Ensign, Rachel Louise. (2021). “Robinhood, Three Friends and the Fortune That Got Away,” The Wall Street Journal, April 22, 2021 *https://www.wsj.com/articles/robinhood-three-friends-and-the-fortune-that-got-away-11619099755*.

Hagenbjörk, Johan (2020). ”Optimization-Based Models for Measuring and Hedging Risk in Fixed Income Markets. ” *paper available at: http://www.diva-portal.org*.

Kolchin, Podziemska, Mostafa. (2021). ”Capital Markets Fact Book, 2021”*report available at: https://www.sifma.org/resources/research/fact-book/*.

Levine, Matt (2021). “Looking for Tether’s Money” *article available at: bloomberg.com*

Liquity Protocol (2022). ”Liquity Protocol Docs” Liquity *docs available at: liquidty.org/*.

Liquity Protocol (2022). ”Core Features” Liquity *available at: liquity.org/features/collaterization-ratio*.

Maker Team (2022). ”MakerDAO Protocol,” MakerDAO *docs available at: https://makerdao.com/en/*.

Maker Team. (2020). “The Maker Protocol: MakerDAO’s Multi-Collateral Dai (MCD) System,” MakerDAO *paper available at: https://makerdao.com/en/whitepaper/*.

Maker Team (2021). ”The Market Collapse of March 12-13, 2020: How It Impacted MakerDAO,” MakerDAO Blog, April 1, 2020. *paper available at: https://blog.makerdao.com/the-market-collapse-of-march-12-2020-how-it-impacted-makerdao/*.

Maker Team (2020). ”Liquidation 2.0 Module.” *paper available at: https://docs.makerdao.com/smart-contract-modules/dog-and-clipper-detailed-documentation*.

Nelson, Danny (2022). ”Solana’s Biggest DeFi Lender Almost Got Rekt. Then Binance Stepped In.” *paper available at: https://www.coindesk.com/business/2022/06/27/solanas-biggest-defi-lender-almost-got-rekt-then-binance-stepped-in/*.

Notional Finance(2022). ”Notional Finance Protocol Docs”*paper available at: https://notional.finance*.

Popper, Nathaniel(2020). ”Robinhood Has Lured Young Traders, Sometimes With Devastating Results,” *https://www.nytimes.com/2020/07/08/technology/robinhood-risky-trading.html*.

Robinson, Niemerg. (2020). “The Yield Protocol: On-Chain Lending With Interest Rate Discovery” *paper available at: https://research.paradigm.xyz/Yield.pdf*.

Robinson, Niemerg. (2020). "YieldSpace: An Automated Liquidity Provider for Fixed Yield Tokens." *paper available at: https://yield.is/YieldSpace.pdf*.

Subrahmanyam, Tang, Wang, Yang (2021). "Leverage is a Double-Edged Sword." *paper available at: https://papers.ssrn.com/sol3/papers.cfm?abstractid = 3855181*.