The Space Race For Open Markets: Vega

The Next Evolution of Derivatives

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Executive Summary

Are modern markets open markets? Markets are part of our lives in unimaginable ways yet have never been more mysterious. Today, trading is a game of warring algos and enigmatic finance, addicted to obfuscating collateral and hiding system risk. Crypto promised to get us a step closer to open markets, gifting us perfect and incorruptible collateral as well as the power to verify everything without a ratings agency or bank.

Yet the mysteries of market structure linger, and are in *some new ways* worse than TradFi. Nobody can contest the pristineness of crypto collateral, but crypto market infrastructure is addicted to its own redlining – from the existential CeFi cascade to HFT's adversarial cousin, MEV.

Vega is the world's first open protocol for creating, maintaining and aligning markets. It is a decentralized launchpad for all trading. In some sense, Vega concepts are more than a subset of DeFi – they represent an evolution in the history of markets. If Vega succeeds, it will become a modular galaxy for everything from market creation to risk modeling and incentive alignment. It marries active and passive liquidity, encourages risk model experimentation and ultimately solves the derivatives trilemma.

A true Blue Ocean opportunity, Vega is the multi-verse of markets, dragging humanity out of an adversarial war of all and leading us to a new space race for open liquidity.

Mesopotamian Clay, where we find history's first derivative.

"Six shekels silver as a loan, Abuwaqar, the son of Ibqu-Erra, received from Balnumamhe. In the sixth month he will repay it with sesame according to the going rate. Before seven witnesses (their names are listed). These are the witnesses to the seal. In month eleven of the year when king Rim-Sin defeated the armies of Uruk, Isin, Babylon, Rapiqum and Sutium, and Irdanene, king of Uruk."

Abuwaqar, son of Ibqu-Erra, in the presence of seven witnesses (nodes), financed his trading mission to the Indus Valley by going LONG SILVER and SHORT SESAME.

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Introduction: The Myth of Open Markets

Humanity's relationship with markets is more profound today than at any time in history. Just decades ago, markets were a mystery for "locals", for the specialists in Chicago or Singapore who could buy their way into the CME. Today's pits are global. Not only can anyone watch a ticker, the ticker has become a universal force of culture, transforming volatility from a newspaper footnote to one of society's ever-present viral loops.

Modern markets are inescapable. The stress and glory of price action feeds all of our primal needs – security, wealth, entertainment, emotion. Price is everywhere from our savings accounts to our newsfeed, feeding us periodic swings of euphoria and despondency.

Two catalysts fuel this mass financialization: central banking and technology. Banker liquidity pushed the masses to speculate on asset prices, just as technologists made it easier, faster and cheaper to speculate. Computerized trading killed the astrology of the broker while Internet futurists accidently gave everyone a free Terminal.

In short, one could argue that not only are the markets more pervasive than ever, they are more open, less asymmetric and more transparent. *Markets are open.*

Or are they?

Does this narrative survive deeper examination?

In this paper, we argue that it doesn't. We pose the thesis that markets are deeply closed, stuck in a primitive era of adversarial games and non-transparency. In some ways they are more primitive than before, despite technological leaps – something we also think is as true of crypto as TradFi.

Markets are more accessible but microstructure is more mysterious. Does the financial class even understand how markets actually work? Our mind can tempt us to the modern image of a quant reclined on a gaming chair, glued to a split-screen awash with Python. But in truth: the overlords of price are not these developers, but the algorithms they (sometimes) command.

The old fortresses of finance have taken new forms, now more ruthless and computerized. High Frequency Trading (HFT) has changed the character of markets completely. The game theory of HFT turns the market into a giant prisoner's dilemma centered on speed. Price is no longer a barometer for information flow, but a bodycount for competing algos, optimized for one thing and one thing only: latency.

How has this unprecedented microstructure impacted markets? Who does it benefit and who does it hurt? From misalignment across participants and the chaos of the flash crash, the enigma of HFT is a critical piece in this myth of open markets. The end-game is a hobbesian market: machine against machine, exchange versus client and institutions feuding with retail (or the other way around, if GME has set a new trend).

Secondly, modern markets are dominated by the obfuscation of risk. Derivatives products are non-transparent, disguising bad collateral as well as counterparty and system risk. Computerizing credit didn't make it easier to manage these risks; in some ways it made them more perverse.

Finally, in the era of closed markets, markets are standardized. Exchange operators have incredible monopoly power, creating high barriers to entry for market creation. Derivatives are thus one-size-fits-all, as market makers flock toward liquid markets and neglect nascent liquidity. Everything from market types to parameters like risk models live inside of stale and standardized defaults.

Crypto introduces a number of wild cards in this evolution of markets. Namely, it gives birth to the idea of pristine collateral. Crypto collateral is perfect collateral, as the bearer asset can ultimately speak for itself. Yet the trading ecosystem that has formed around crypto is far from perfect: we argue that it suffers from many of the same (and some worse) fundamental challenges in microstructure, non-transparency and standardization.

Ultimately, our search for open markets leads us to Vega, the world's first decentralized protocol for customizable market creation. Vega is a stepchange function not just in crypto derivatives, but in the history and evolution of markets. It is a fundamentally new way of thinking about how markets can exist and how participants can work together to build and maintain them. In some ways, the Vega story is far more profound than DeFi derivatives – which is why we spend the first two sections of this report exploring fundamental challenges in microstructure, risk management and market customizability.

This report will be broken up into three sections:

PART I: TRADITIONAL MARKETS ARE CLOSED MARKETS

Computerized markets are not open markets. A continuous market comes with a natural need for speed. Markets may be part of our lives in more ways than before, but does accessibility equal openness? The war of all against all begs to differ: the rise of the algos fuels a deeply adversarial environment premised on the prisoner's dilemma. Modern markets are also stuck trading with ghosts – wedded to opaque products that obfuscate toxic collateral, hide counterparties and disguise system leverage.

PART II: ARE CRYPTO MARKETS OPEN MARKETS?

There is crypto in theory and crypto in practice. We cannot mistake the pristineness of one's collateral base with the health of one's market. Crypto market structure is deeply fragile, prone to CeFi flash crashes that rival none and cursed by DeFi's close cousin, MEV. Old challenges of microstructure take a new yet familiar form. Ultimately, DeFi derivatives face a fatal trilemma. Existing products are often good at one thing and one thing only but fail at all three: self-custody, customizability and capital efficiency.

PART III: VEGA: THE MULTIVERSE OF MARKETS

Open markets are a space race akin to the search for new habitable planets. Solving the trilemma needs a fundamentally new way of thinking. No market is the same, so why standardize microstructure or risk? Customizing risk just so happens to be DeFi's answer to capital efficiency. In Vega, the answer to most questions is to let the market decide. Vega ultimately escapes the arms race of modern markets and enters a cooperative multi-verse, aligning participants into iterative games. Modular in its bones, anything can live on Vega; the expressive fairground not just for DeFi, but all markets.

1 Traditional Markets Are Closed Markets

1.1 Market Microstructure: HFT's Prisoner's Dilemma

In the days of the trading pit, the whales bought seats at the exchange. They spent millions for the *right to trade*. In the electronic era, the industrialized prop desks play a different game: they buy co-location rights and scour the earth for fiber-optic cables.

Inside the online pits, speed is the only currency that matters, giving rise to the world of HFT, which according to some estimates accounts for over 50% of trading volume.

1.1.1 The CLOB Creates A Need For Speed

Why is this brand of trading dominating markets in just decades?

HFT is the natural byproduct of modern market microstructure. Markets live on continuous-time systems. Orders execute on a central limit order book (CLOB). To win a trade, one must get to the front of the book. The order book thus bakes in a natural need for speed, pushing proprietary traders to sprint for low latency. Often executing below ∼1ms, HFT traders focus on intraday strategies from vanilla market making to relative value arbitrage.

The lifeblood of computerized trading is latency of signals and execution. How quickly can my machine receive a piece of information, and will it press the green or red button faster than yours? How quickly can I not only anticipate another trader's propensity to buy or sell, but react to how your machine may interpret the same data?

On the surface, HFT is benign, possibly even useful. Proponents argue that HFT cushions markets with deep liquidity. Fast execution reduces friction and gets traders an immediate fill. As Python scripts exploit latency arbitrage, HFT makes asset prices more efficient. Advocates go as far as to say that HFT market making is an ally to the fundamental investor – for without a deep book, how can they buy the prized IPO or punt "undervalued" assets?

1.1.2 Weapons of A Prop Desk

As we dig deeper, the research paints a more harrowing picture. A growing body of literature argues the "speed race" harms non-HFT participants and damages markets. It can reduce liquidity and increase trading costs. Weaponizing speed can destabilize markets in ways we will explore below. HFTs may foster the illusion of liquidity – during peacetime – only to plunge markets into illiquidity just when they become most vulnerable, at the tails of the distribution.

HFT suffers from a prisoner's dilemma. If all firms cooperate and agree to end the arms race, they are each better off. Every trader has a higher payoff. Yet like the accumulation of nuclear power amongst competing nations, no prop desk will be first to lay down its sword. It takes one to break ranks and profit at the expense of others, incentivizing all firms to defect.

Achieving speed is each firm's dominant strategy, leading to a non-cooperative Nash Equilibrium.

[1] URL: https://academic.oup.com/qje/article/130/4/1547/1916146?login=true.

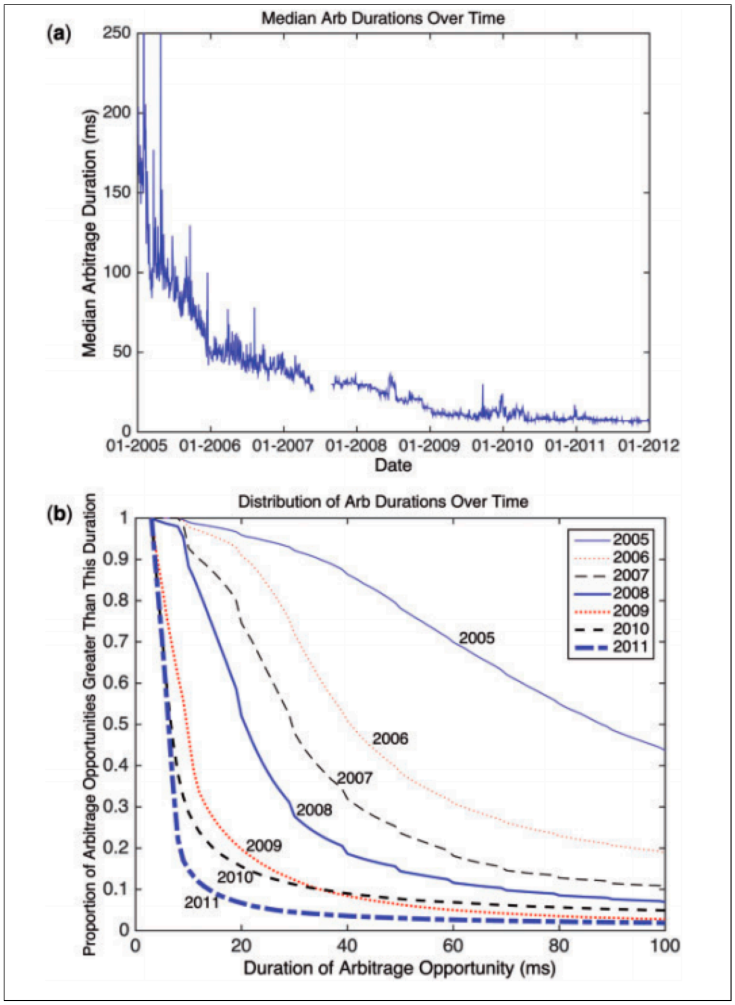

Figure 1: Capturing the rise of latency arbitrage, HFT firms have been investing aggressively in speed technology, compressing arbitrage opportunity durations.[1]

As we discuss below, this game theory creates an extremely adversarial environment, destabilizing markets and pinning participants against one another. These dysfunctions are most pronounced during moments of financial instability, creating liquidity cascades that can not only wipe away trillions in market cap, but fundamentally alter the course of economic history.

1.2 Flash Crashes & Vanishing Liquidity

It takes one firm to destroy a peace talk, so peace never comes. What are the implications of the adversarial algos? How do they damage markets? We think the best way to answer this question is to study distinct periods of stress and panic (something the crypto world is all-too familiar with, as we will cover in Section 2), rather than lulled periods of apparent stability.

As is often the case in finance, we can find a fair amount of truth in the tails.

Table 1: Game theory of HFT. Although it would be optimal for all firms to agree to not invest in HFT technology, each firm has the incentive to deviate, thus resulting in an HFT arms race.

		Firm A: No HFT	Firm A: HFT
Firm B	No HFT	Most Profit (Pareto Optimal)	Less Profit
	HFT	Less Profit	Least Profit (Nash Equilibrium)

1.2.1 Running At The First Sight of Blood

Market makers provide a straightforward service. They help the impatient trader transact. They use their inventory to tighten bid-ask spreads. Good spreads beget more flow, but it's far from an easy business. Not only is it extremely competitive, market makers face adverse selection. They are constantly coming up against better informed traders. To survive this *toxic flow* and remain profitable, they need to be nimble, adjusting liquidity according to market imbalances.

The challenge is that HFT-based market making exacerbates the costs of toxic flow. In an ideal world, *market makers are aligned with a market's integrity* – they take on short term costs (toxic flow) to boost the market's health in the long run. In reality, knowing that the next machine will *run at the first sight of blood*, all firms are incentivized to defect. It's a similar dynamic to the prisoner's dilemma above: all it takes is one defector breaking ranks for the frontline to crumble and the enemy's "fat finger" to create a higher body count than it really should.

HFT market makers vanish when they're needed most. We can see how this plays out at the micro level during the phenomena of a flash crash, an increasingly "normal" feature of the algo-dominated markets.

1.2.2 The Crash of 2:45: May 6, 2010

On May 6th 2010, the S&P 500 futures lost 5% of their value in fifteen minutes[2]. Subsequent research found no evidence of an exogenous, fundamental event which may have caused this breakdown. The literature instead points to a pathological interaction between a large algorithmic trader and HFT market makers. Toxic order flow (chunky selling from one informed trader) caused HFTs to suddenly withdraw liquidity and reduce or stop their trading.

Minutes of computerized chaos turned the world's most liquid market – US equities – into a market with vols and illiquidity that resembled the low cap penny stock.

This captures the warped incentives of HFT. Liquidity providers have weak incentives to stay when the going gets tough. They quickly turn from liquidity providers to *liquidity consumers*. Not only did the HFTs get out of the way during the crash, they offloaded their inventory and exacerbated the cascade.

The 2010 Crash highlights the circular and sometimes "dumb" nature of HFT flow. Some evidence suggests that during the crash, HFTs were liquidity consumers in large part blindly moving flow between

[2] URL: https://onlinelibrary.wiley.com/doi/full/10.1111/jofi.12498?casa_token=l4I-KRWiptMAAAAA%3A3ecS0jdj2SUBGzCnlfEJTyVU9yg0NXN1tmR6hmiIIhfh1llGTrMXDtD-u-NK_PYQspldve8tBQBH8GOH.

[3] URL: https://onlinelibrary.wiley.com/doi/full/10.1111/jofi.12498?casa_token=l4I-KRWiptMAAAAA%3A3ecS0jdj2SUBGzCnlfEJTyVU9yg0NXN1tmR6hmiIIhfh1llGTrMXDtD-u-NK_PYQspldve8tBQBH8GOH.

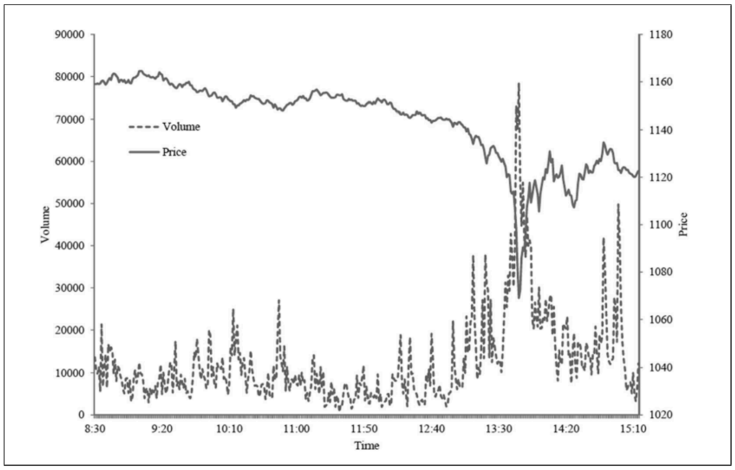

Figure 2: Flash crash event of May 6, 2010 in US equities[3].

one another[4] – hot potato for the bots. HFTs also failed to adjust inventory in the face of liquidity imbalances like bespoke market makers usually would.

Some have argued that market making was more resilient before HFTs dominated the order book. It's not as though large sellers or buyers weren't around before computers. Back then, a market makers' default reaction wasn't to run at the first sight of blood or blindly react to other traders. They had to assess and adjust to the market, which programs often fail to do.

The question then becomes: who commands liquidity during a flash crash? If it's not the quant, and each algo is theoretically forced to react a certain way, who causes the crash? This is where it gets strange. Nobody. Again reflecting the prisoner's dilemma, it's the pathological interaction *between machines* that drives the flash crash. The crash is an "emergent property" of the system. In a sense, each developer loses control of their creation, creating a set of "dumb" and algorithmic Frankensteins.

HFT malfunctions then spill to other designated (non-HFT) market makers who struggle to calculate inventory and delay their eventual return to the market.

1.2.3 Microstructure Doesn't Incentivize Market Integrity

Fundamentally, HFTs are overshadowed by the grey clouds of a prisoner's dilemma. These poisonous and non-cooperative games change not just their own incentives, but everybody else's. Traders have to (rationally) align themselves to short term games optimized for speed and immediate rent extraction over long term market integrity.

Markets thus become incredibly one-dimensional. HFT reduces markets to one single metric, latency, losing the ability to assess reputation and the longevity of liquidity. These misaligned incentives are costly at *all times* – war or peace – but it's during moments of panic they become most apparent.

HFTs ultimately make microstructure less transparent. Everyone is playing a game where they are motivated to conceal as much as possible. What if markets were completely open-book – what if we could make transparency a feature (not a defect) of the system?

[4] URL: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2336772.
[5] URL: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2336772.

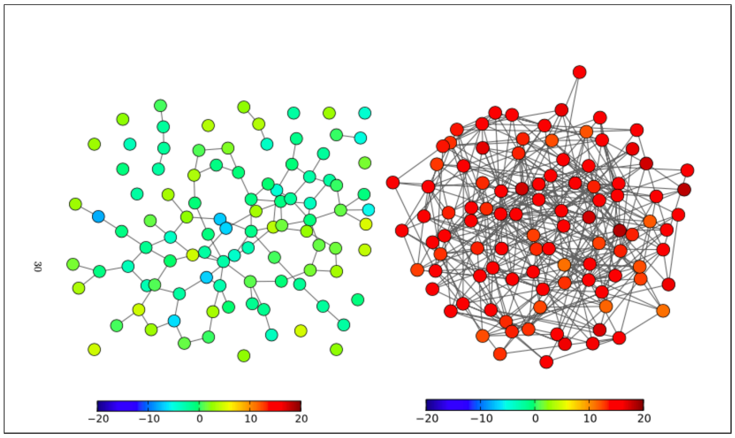

Figure 3: Simulated behavior of HFT agents before and during a liquidity crisis. The color range depicts inventory size. Instead of supporting market liquidity, the HFT firms trade mostly amongst themselves[5].

1.3 Trading With Ghosts: The Obfuscation of Risk

While modern microstructure results in adversarial behavior, risk is illusive. The second feature of closed markets is the obfuscation of risk, with opaque products that disguise counterparties, hide system leverage and leave investors guessing about who or what they're exposed to.

Below we examine the blowup of 2008 (the Global Financial Crisis), but we first encourage the reader to ask the following questions. In TradFi:

- Is there a way to reliably verify counterparties and their credit history?
- Can we quantify their debt obligations?
- How can we quantify system leverage?
- In the presence of rehypothecation, can we trust these measures?

1.3.1 The Mother of All Blowups: 2008

One of the most extraordinary aspects of 2008 was the relationship between opaque financial products and unquestioned risk-taking. Seduced by the hunt for yield, nobody understood what they were buying and very few knew what they were selling. Subprime mortgages were financed by mortgage-backed securities (MBS) and then sold to special purpose vehicles (SPVs). MBS were securitized into Collateral Debt Obligations (CDOs), held on institutional balance sheets. Banks repackaged and retranched risk, using CDOs as collateral – CDO^2 – making it impossible for lenders to not only redeem collateral upon default, but identify their counterparties altogether[6].

Who are the borrowers? What is their credit risk? Do they even have any collateral?

Unfortunately for most left holding the subprime bag, these questions would only arrive at the final hour. For years, leverage piled around products nobody understood, collateral that didn't exist and

[6]URL: https://www.journals.uchicago.edu/doi/full/10.1086/648293.
[7]URL: https://practicalquant.blogspot.com/2008/10/subprime-crisis-reviewed-cdos.html.
[8]URL: https://practicalquant.blogspot.com/2008/10/subprime-crisis-reviewed-cdos.html.

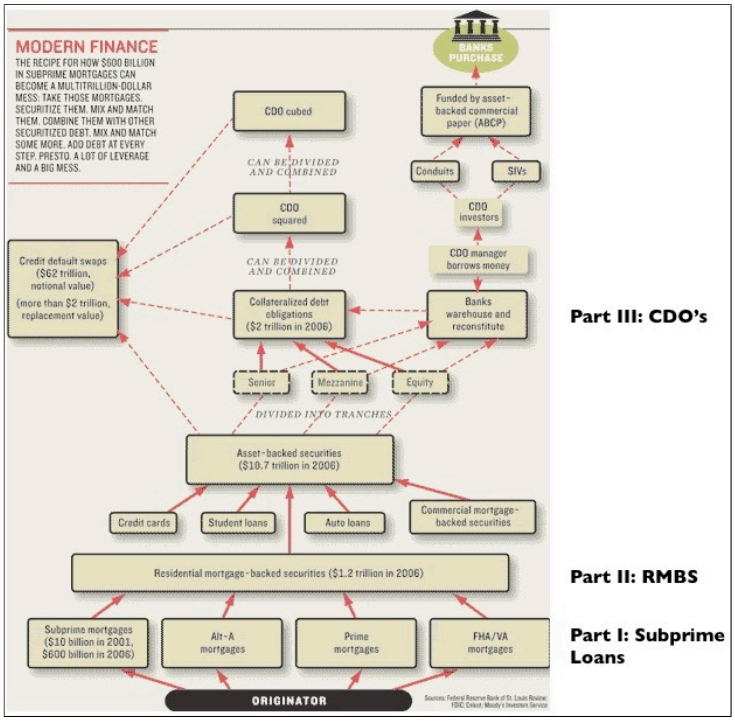

Figure 4: Securitization and the subprime crisis. Securitization of debt obligations obfuscated risk and made it difficult to determine the value of the underlying collateral[7].

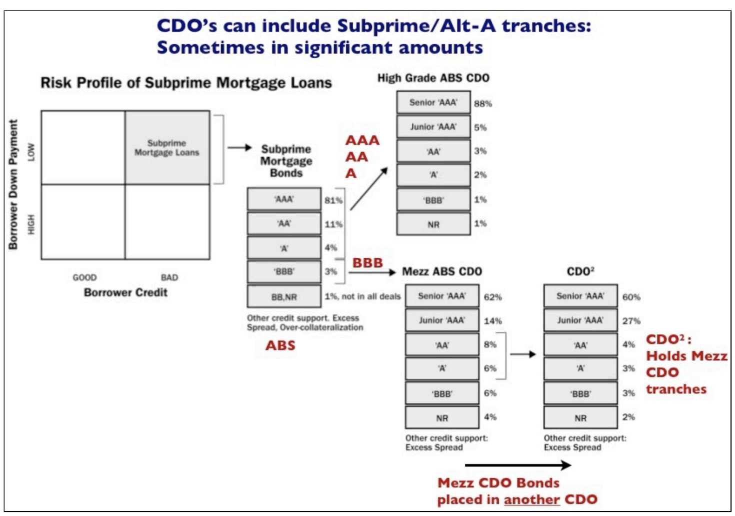

Figure 5: Structure of CDO products and tranches[8].

pooled counterparties who could never be identified. Once the market realized that none of this credit or counterparty risk could be accurately priced, the trade had no choice but to unwind: anyone exposed to MBS realized their (unidentifiable) counterparties were similarly exposed to the same pool of risks.

Why didn't the market question these opaque products? Assured by the false omniscience of the credit rating system, the market had the completely wrong view of system leverage. Securities were rubber stamped by credit agencies like S&P and Moody's who overstated the safety of the tranches – else they would lose customers. Issuers would pay for the ratings, shopping their tranches and giving their business to the firm who issued the highest score.

Relatively quickly, pristine collateral became risky collateral. Sudden downgrades descended upon the market. Imagine believing your position was safe and overcollateralized, only to realize that your AAA collateral was the furthest thing from AAA. Over 31% of downgrades involved AAA- collateral. It would be like thinking one's leveraged long was collateralized by Bitcoin only to realize it was truly collateralized by Dogecoin – or Safemoon. Put another way, an institution may have thought its balance sheet was 10x levered, only to discover that they needed to multiply that number by a factor of five.

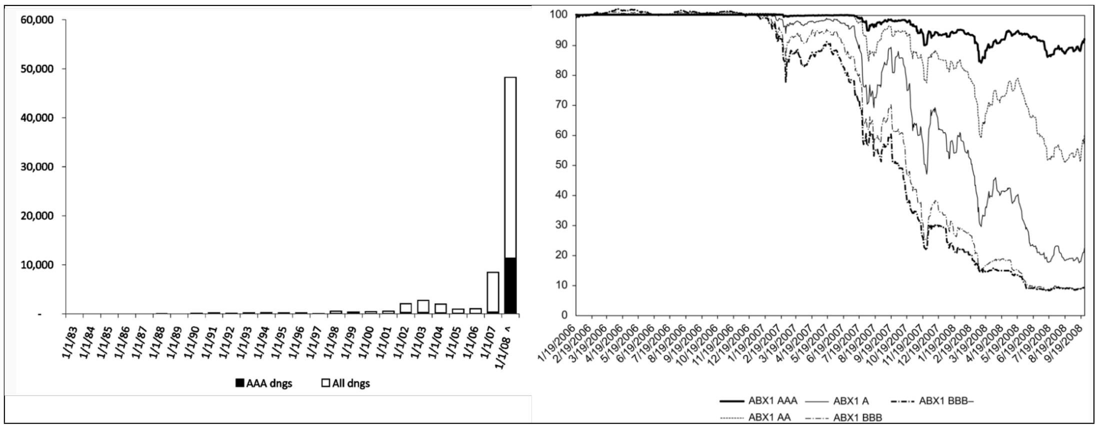

Figure 6: Collapse of subprime MBS in 2007-2008 as a result of widespread default and financial panic[9]. The left chart depicts the number of investment grade security downgrades. The right chart shows rapid decline in the CDO market in 2008.

Quantifying system leverage required investors to value opaque CDOs, backed by unidentifiable collateral and corrupted by the rubber stamp of credit agencies. When the "true" value of the collateral became apparent, the holders of toxic collateral became immediately insolvent. The system was extremely leveraged not because borrowers were nominally leveraged, but because their collateral was so fundamentally mispriced – for so long.

1.3.2 A Lesson of Hindsight

Ultimately, what lessons did markets take from the mother of all contagions?

In the aftermath of 2008, pundits, regulators and (some) traders settled on the uncontroversial conclusion that financial markets, left to their own devices, were agents of uncontrolled greed. The answer, clearly, was regulation.

We come to a different view. We think that trying to impose transparency on financial markets by government decree may solve a short term problem, but it won't make the financial system robust in the long term. Participants find ways to exploit new rules and put on a new disguise.

Our takeaway is a lesson not of history, but of hindsight: *centralized* markets suffer from the obfuscation of risk and no amount of government regulation will change this reality. What we need instead is a properly-designed, robust and transparent financial system where the game theory of the system encourages honest behaviour. In the transition from closed to open markets, what we need are rules without corruptible and flawed rulers.

[9] URL: https://www.journals.uchicago.edu/doi/full/10.1086/648293.

If a system is transparent by design – by code – then counterparties can *always* be identified, collateral can always be verified and system leverage is something the layman can determine without the rubber stamp of an apparently omniscient institution. We are of course pointing to decentralized financial markets, which we introduce in Sections 2 and 3 of this paper.

1.4 The Curse Of One-Size-Fits-All: Derivatives Are Not Fit For Purpose

On any day of the week, a well-capitalized institution can sit down with Goldman's trading desk and design a structured product that fits their hedging needs. If one's balance sheet is big enough, any risk can be managed. The rest of the market, however, must take what it is given: arbitrarily standardized derivatives. Exchanges must ultimately decide on standard contract types and specifications, limiting access to new derivatives products.

Users rely on exchanges to not just list an asset, but set parameters like contract size and collateralization levels. In open markets, any type of market can exist, with customizable microstructure as well as modular risk models. This is where open markets foster a *free market for market types* (see Section 3). Closed markets, in contrast, shove all participants in just a few cramped corners and demand they tell them to trade what's given to them.

Exchanges don't support a wide variety of markets because it would be too expensive to do so. They need to locate trading demand, manage regulatory costs and establish bespoke market making arrangements. They need to incentivize market makers to develop, enter, and maintain markets. Effectively, the exchanges themselves have become artificial monopolies that price out the creation of nascent markets.

Moreover, in closed markets, market makers are not *owners*; they have little incentive to grow nascent markets and must instead focus their business on already established ones. We thus end up with an overcapitalization of already mature and liquid markets and an undercapitalization of nascent and illiquid markets – not because the latter wouldn't be useful, but because of the monopolistic nature of the exchanges.

1.5 A Hobbesian End State

The above discussion paints a bleak picture for closed markets. To recap previous takeaways:

- Closed markets have adversarial microstructure built into their design, tied to continuous trading and the HFT's prisoner's dilemma
- Closed markets create financial instability; liquidity vanishes just when it is most needed, pinning participants against one another during moments of panic
- Closed markets exacerbate counterparty risk, credit risk and fuel the accumulation of leverage
- Closed markets are highly standardized, unfit for purpose and tend toward monopolistic structure, pricing out the creation of nascent markets.

Ultimately, this Hobbesian endstate creates a short-sighted relationship between participants. A war of all against all. Incentives break and markets become an antagonistic race to scrape at a shrinking pool of capital, with flash crashes and de-leveraging cycles wiping away a dwindling trader base.

2 Are Crypto Markets Open Markets?

2.1 Crypto In Theory, Crypto In Practice

On the surface, crypto derivatives are a momentous leap toward open markets. In its purest form, crypto represents a 24/7 trading pit free from central operators and trading restrictions. The inherent transparency of the collateral base punishes the reckless lender tempted by rehypothecation. Markets can chase yield, but they bear the costs of their own greed. The end result is undoubtedly a volatile system, but one that comes with a deep sense of antifragility: with no Fed to rescue the reckless, the system trains itself to become open and transparent.

We again ask the same question we posed in our opening thesis: does this narrative survive deeper examination? When we dig deeper, what is the true nature of crypto's contribution to open markets? Have we solved the challenges of closed markets? Have some become worse?

In our view, crypto's openness comes from *the nature of the collateral*, not improvements in market structure. Microstructure remains deeply flawed, both in centralized and decentralized settings. The pros of crypto derivatives don't stem from the wits of the exchanges, but the simplicity and elegance of the bearer asset at their core. Bitcoin set the stage as the world's most pristine collateral – and it is in some ways it makes crypto derivatives look healthier than they actually are.

The venues, products and trading experience are extremely fragile. In the centralized setting, crypto derivatives suffer the exact (and some worse) afflictions of modern market microstructure – brought to bear on dark days like Black Thursday. There is no flash crash like a CeFi liquidation candle, what the worn-down crypto trader colloquially calls the "scam wick". Moreover, one can even argue that supercharged, perfect collateral *combined* with piecemeal implementations of TradFi microstructure leads to cascades that are fundamentally *worse* than typical TradFi flash crashes.

Putting derivatives on the blockchain does not solve these problems. On-chain derivatives spawn new ones altogether. The HFT race to the bottom has a close cousin in crypto – Miner Extractable Value (MEV). While projects have focused on building a "decentralized Bitmex", they have failed to consider the *fundamental problems at the heart of closed markets*, and thus end up replacing one set of animals with a new and sometimes more rabid species.

Ultimately, crypto derivatives (CeFi and DeFi) come with a set of tradeoffs. We unpack these tradeoffs below, concluding that the path toward open markets should not be about trading one terrible outcome against another. Open markets, if they are going to exist, need a fundamentally new paradigm that escapes these inevitable shortfalls.

2.2 The Trappings Of CeFi

2.2.1 Pristine Collateral Shapes CeFi Market Structure

CeFi derivatives inherit some parts of TradFi microstructure (such as CLOBs), but they also differ in a number of important ways. These differences reflect crypto's unique properties as a collateral asset. Crypto is unlike any other type of collateral. It is a bearer asset that lives on a global network that can't be shut down by any one party, ultimately shaping CeFi market structure in a number of key ways.

Table 2: Features of CeFi derivatives.

Features of CeFi Derivatives	Why They Exist
Continuous, marked-to-market collateral (fast top-ups, auto-liquidations)	Exchanges manage risk and solvency in real time as crypto collateral lives on top of 24/7 networks. Topping up margin in TradFi requires a bank wire while settlement in crypto is immediate, naturally leading venues to mark collateral to market.
Extreme capital efficiency (high leverage)	Venues offer up to 125x leverage because they can manage their risk in real-time, given continuous pricing.
Robust insurance funds	Crypto's superior properties as non-falsifiable collateral makes insurance funds feasible. Whereas TradFi relies on centralized bailouts, crypto trading encourages high turnover and the gradual accumulation of insurance funds to backstop the system.
24/7 trading	Crypto networks are 24/7, and thus so are CeFi venues. Blockchains don't have trading sessions.
Protection from negative equity	Together with the extra-judicial nature of some retail venues, crypto's qualities as a bearer asset has encouraged venues to build products that can't go into negative equity. In crypto, users are more readily liquidated than they are in TradFi, but they are also protected from the black swan of a "negative account".
Openness	Venues are fundamentally open – often allowing users of any class, income or net worth trade. Ultimately, this is again a reflection of crypto as a bearer asset: "1 BTC = 1 BTC".

2.2.2 Inheriting TradFi Microstructure

Despite being tailored to crypto's unique properties, CeFi derivatives inherit many of TradFi's failings. Venues remain highly centralized and non-transparent. Markets are just as prone (if not more so, for reasons we describe below) to the HFT's prisoner's dilemma and inorganic flash crash.

2.2.3 2010 Was Nothing: Introducing Black Thursday

The 2010 Crash is no match for Black Thursday. We are of course referring to March 12 2020, when Bitcoin crashed over 50% to a momentary low in the low $3,000s. The move happened in hours and had very little to do with "real selling". Like the 2010 Crash, warring algos played their role, but March 12 looks a lot more systemic. It was a market-wide wipeout. Not only did liquidity vanish and take open interest with it, the crash unwound the entire foundation of CeFi market structure.

The crypto masses were liquidated, but so were the venues. In the throes of COVID19 panic and soaring cross-asset correlations, most features of CeFi microstructure shattered to pieces. Venues lost control of liquidation engines. Futures pricing entered a state of extreme backwardation. Coin-margined perpetual swaps showcased downward convexity that *could theoretically have taken Bitcoin to zero.* Orderbooks were barren wastelands as market makers not only ran at the sight of blood, but blew up before they could even smell it.

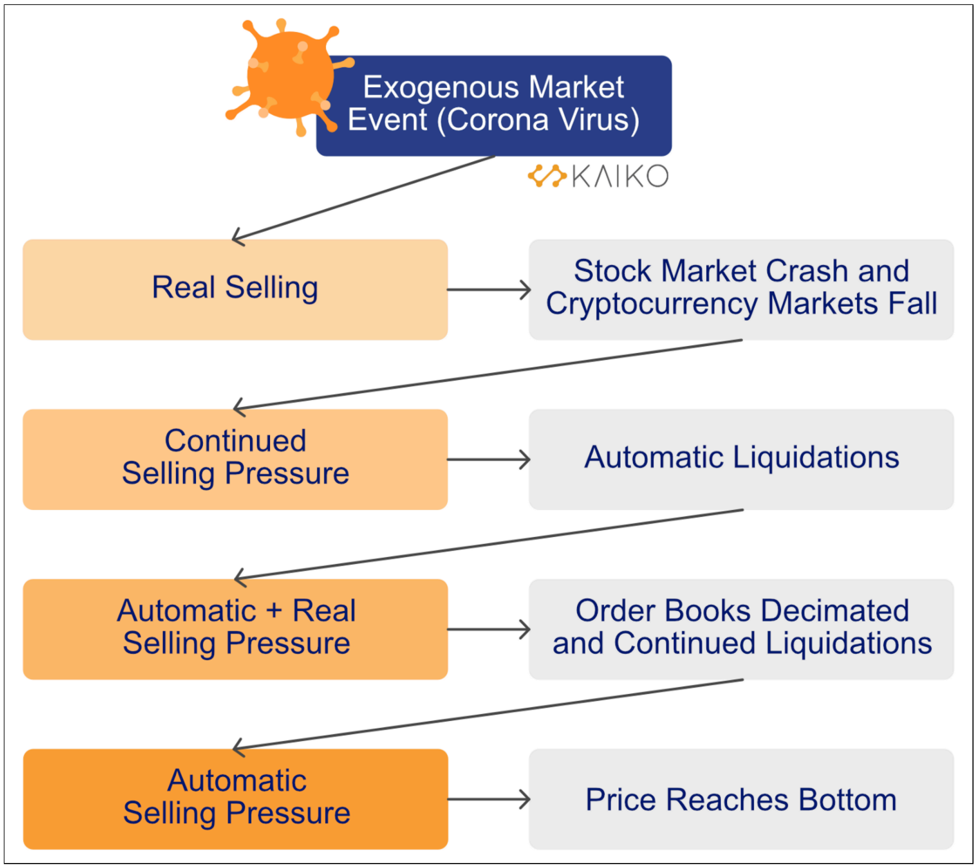

Figure 7: Sequence of events leading to the crypto liquidity crisis of March12th, 2020[10].

As auto-liquidations hit a vanishing orderbook, Bitcoin price hung on by a thread. *Was it going to zero?* Possibly. Bitmex would soon announce a conveniently-timed "server failure". By decree, the liquidations stopped as Bitmex entered an effective pause. Arthur Hayes laid down CeFi's first circuit breaker and spot buyers took advantage of a temporary firesale. Liquidity slowly recovered, though it would arguably take months for CeFi market structure to return to any semblance of normalcy.

Again, we stress that this *was not just an extreme selloff.*

Part of the breakdown has to do with the idiosyncrasies of Bitmex's perpetual swap (XBTUSD), a fundamentally new derivatives product invented by Bitmex. *The perp* is a futures contract with no settlement. Rather than expiring on a certain date and inviting arbitrageurs to capture the "futures basis", the perp has a regularly intervalled funding rate, incentivizing traders to sell the instrument when it's higher than spot and buy the instrument when it's trading below.

The inverse XBTUSD contract makes Bitcoin – the asset traded – the margin currency. This introduces

[10]URL: https://blog.kaiko.com/how-black-thursday-decimated-cryptocurrency-order-books-58167bf9157d.

downside convexity: if one is long XBTUSD and Bitcoin price falls, then the position is not just underwater, it becomes under-margined, since the value of the margin itself is falling. Downside moves can thus trigger liquidation cascades and create a positive feedback loop of position closure, with each liquidation successively pushing price down.

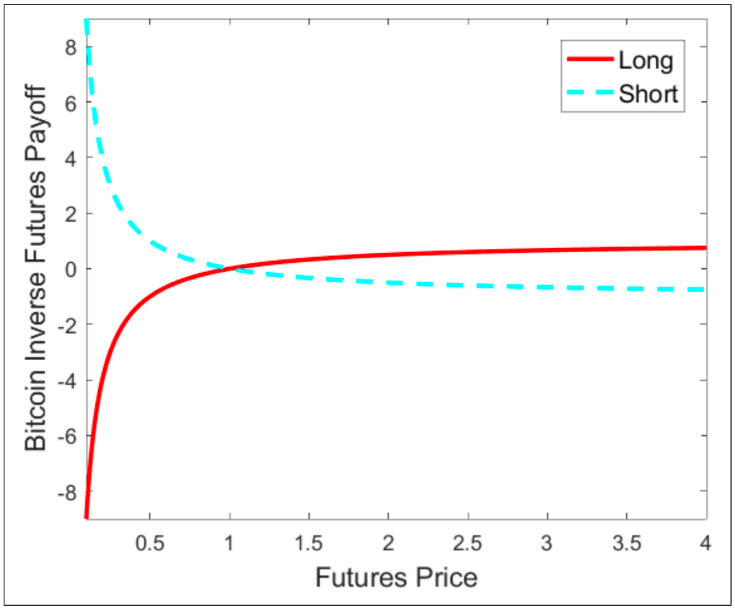

Figure 8: Inverse perpetual contract downside convexity. As the price of BTC decreases the value of both the collateral and the position decreases, amplifying downside.[11].

As Bitmex broke, fees on the Bitcoin blockchain soared. Traders tried to send collateral to re-margin before they were liquidated but their transactions were stuck in a now-clogged mempool. This had the odd effect of wiping out even the best-capitalized market maker, *liquidating those who should never have been liquidated*.

In the course of our research, we have come to an unfortunate conclusion about the Bitmex wipeout: it was not an anomaly of COVID19. Albeit an extreme case, Black Thursday is a symptom of CeFi market structure, in the same way that the 2010 Crash is a symptom of TradFi's HFT addiction. It was exaggerated by macro forces, but these blow ups are unusually regular occurrences in crypto and they're leaving lasting impacts on market health as a whole (to see a more recent example, see May 2021).

2.2.4 Why CeFi Blows Up: Supercharged Collateral Plus TradFi Infrastructure

We argue that CeFi's regular blowups reflect a paradox of market structure. In TradFi, infrastructure isn't pushed to its limits. It's usually the collateral that breaks (see CDO^2). In crypto, the collateral never breaks, but infrastructure breaks regularly. Crypto is perfect collateral, and as we discussed above, it encourages a certain type of derivatives offering. But when supercharged collateral is combined with a naive version of TradFi infrastructure *without any of its backstops*, the system becomes prone to these extreme wipeouts.

[11]URL: https://link.springer.com/article/10.1007/s10479-021-04125-w.
[12]URL: https://blog.kaiko.com/how-black-thursday-decimated-cryptocurrency-order-books-58167bf9157d.
[13]URL: https://www.bitmex.com/app/restAPIMessages.

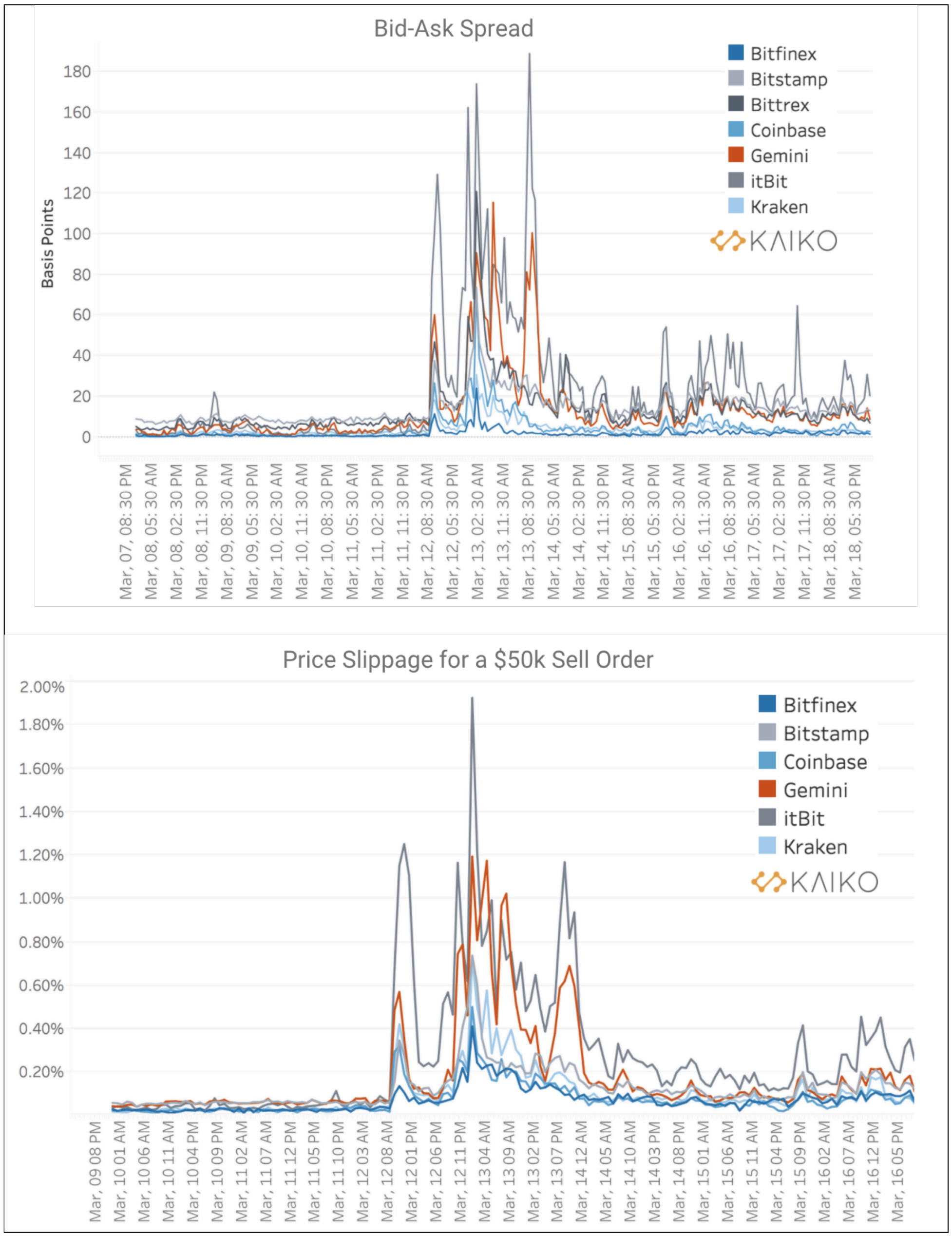

Figure 9: Bid-ask spreads and market microstructure during March 12th, 2020[12].

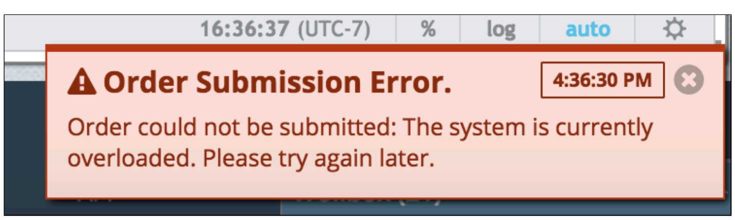

Figure 10: The dreaded Bitmex Order Submission Error, taunting traders during high volatility, when a live, functioning exchange is precisely most important.[13].

The crypto-native may disparage circuit breakers, trading sessions and user restrictions as features of closed markets. Yet in the confines of TradFi, these features are why markets can experience flash crashes without risking the existential collapse of market infrastructure.

Crypto inherits many of the failings of TradFi microstructure, but because of the unique nature of crypto collateral, none of the corresponding failsafes. It is like getting the worst of both worlds, redlining the market's engines and threatening collapse with each liquidation event.

Ultimately, we believe that crypto derivatives need a new type of market structure – something fundamentally aligned with the unique nature of crypto collateral. Supercharged collateral is incredibly powerful, but when combined with a naive implementation of legacy markets, it is arguably *net worse* than TradFi's closed markets.

2.2.5 CeFi Derivatives Create Systemic Risks

Bitcoin is a right tailed asset – it goes up over time. With this right tail comes the risk of large corrections. In some sense, volatility is the price we pay for "perfect" collateral. CeFi derivatives are introducing a new dynamic to crypto volatility, one that the market might not be able to handle as readily as traditional markets.

Legacy markets have a buyer of last resort. The Fed can always step in to re-collateralize the system when collateral fails, as in 2008. In contrast, crypto has no fundamental, non-speculative buyer of last resort – which again may be the price we pay for collateral that never fails.

However, CeFi tail events create systemic, left-tail risks that could be damaging crypto's progress. Buyers will always have a price at which they will take a Bitcoin firesale, but do these inorganic firesales – fuelled not by real supply and demand – hurt inflows and leak fundamental value?

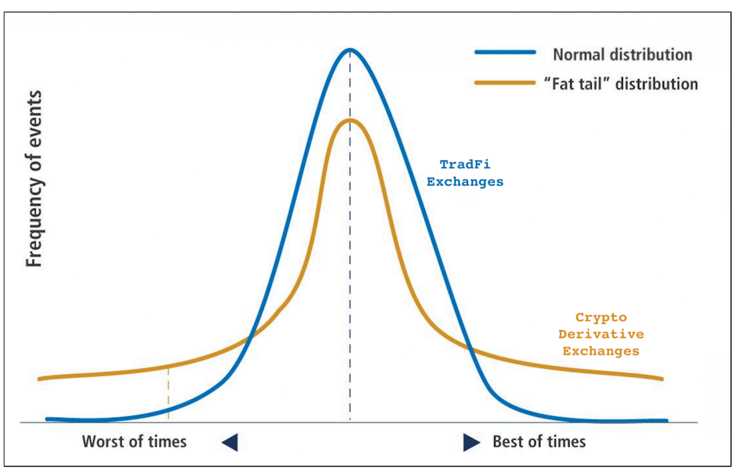

Figure 11: Fat tail events and crypto. In CeFi, the combination of pristine collateral (and the ability to offer high leverage) with the poor market infrastrcture inherited from TradFi results in massive tail events[14].

We can only speculate. Our conjecture would be, yes: fragile market structure is limiting crypto's growth. We have to fix market microstructure for crypto to continue to become *more investable* as it grows. Put

[14] URL: https://www.pimco.com/en-us/resources/education/understanding-tail-risk.

another way, inorganic price moves are distorting crypto's long term volatility curve, creating speculative moves that diverge from Bitcoin's fundamental value.

2.3 DeFi Derivatives, Promise & Reality

Even with these successive CeFi wipeouts, demand for crypto derivatives is incredibly resilient. DeFi derivatives projects have also begun narrowing in on the challenges of CeFi. Perhaps the answer to the brokenness of Bitmex is a decentralized protocol, replacing an opaque venue with a credibly neutral codebase.

In the same way that Bitcoin promises pristine collateral, DeFi derivatives dream of a world where we can eliminate counterparty and credit risk altogether. Collateral is on-chain, seen by all, and traders deal not with a venue housed in an offshore jurisdictional, but with a protocol owned by none. The promise is thus a world of self-custody, where we can trade derivatives without having to trust a gatekeeper – whether its Bybit or the CME.

The trading pit is not owned by anyone. Is this the evolution toward open markets that we've been searching for so far?

Despite this narrative, DeFi derivatives face a set of fundamental tradeoffs that may be stunting their takeoff, *at least in the way they have been conceived so far*. Does building Bitmex on the blockchain solve the fundamental challenges in open markets, or does it simply respawn a clunkier version of old problems?

2.3.1 HFT's Close Cousin: MEV

As we outlined in Section 1, HFT is a game theoretic race to the bottom, a war of all against all. This breakdown in microstructure has a close on-chain relative in the form of Miner Extractable Value (MEV). MEV refers to on-chain arbitrage opportunities where traders frontrun or manipulate transaction ordering on DEXs to extract rent from other traders. In the same way that algos have a need for speed, the army of on-chain bots hunt for DeFi latency.

2.3.1.1 Sandwich Attacks

One such example of MEV is the sandwich attack, popular on AMMs. This is where adverse traders observe transaction information and place their own transaction immediately before or after the targeted transaction. As HFTs are the natural consequence of continuous time trading, sandwich attacks are the natural consequence of price gas auctions (PGA) on Ethereum. These attacks increase network congestion, pile on transaction costs and reduce social welfare. Strong evidence suggests that sandwich attacks become more likely as DEXs scale, making them more profitable as AMMs gain adoption. Ultimately, this adversarial environment is a fundamental roadblock to DeFi's mainstream growth.

2.3.1.2 Network Miners & MEV

More general classes of arbitrage arise when attackers are also miners (hence "MEV"). Miners can mount a range of assaults: they can front-run the transaction, back-run the transaction, clog the network and even privately mine transactions. These are all common modes of MEV on Ethereum. Like the HFT

[15] URL: https://arxiv.org/abs/1904.05234.

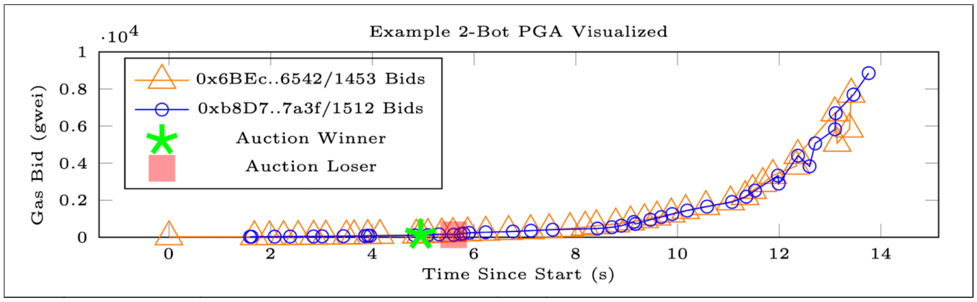

Figure 12: Rapid increase in gas prices on Ethereum during price gas auctions.[15].

flash crash, MEV is most harmful during liquidation events. According to recent literature, the majority of transactions near liquidation events involve some kind of arbitrage.

2.3.1.3 MEV In The Wild

For instance[16], on Aave, Compound and dYdX, nearly 13% of liquidations back-run oracle price feeds (price feed arbitrage) and nearly 60% of all trades have some other type of network state arbitrage (such as back-running trades after learning of a transaction). Exactly when the network needs honest arbitrageurs to properly liquidate positions, attackers create congestion and reduce the incentive of these honest parties. Illiquidity begets illiquidity, and arbitrageurs can (like liquidity providers) run at the first sight of blood.

Consider fixed spread liquidations on dYdX, a DeFi derivatives exchange on Ethereum. Fixed spread liquidations are a way to pay off system debts by offering liquidators a discount on loaned collateral in an auction.

Empirically, researchers have observed two popular strategies. Firstly, attackers may notice a transaction to complete a liquidation and then front-run the liquidation by issuing their own transaction at a higher fee. Secondly, an adversarial liquidator can find “victim transactions” that will lead to a liquidation and then back-run the victim transaction with their own liquidation transaction. An adversary could (for instance) observe an oracle price feed that will push a safe debt position into a distressed debt position and then get ahead of this information.

Since protocol inception to November 30th, 2020, researchers found 6,750 front-running transactions and 713 back-running transactions. These attacks deter usage more broadly as the gas war makes the network more expensive for regular users.

2.3.2 The Threat of MEV: Tensions Between The Base & Application Layer

MEV doesn’t just damage individual markets and protocols, it undermines network security. MEV creates perverse incentives where the security of the application-layer (e.g. a DEX) incentivizes attackers to undermine the security of the consensus-layer (Ethereum). Arbitrageurs can make money by blocking consensus. Ethereum’s security relies on incentives that motivate rational actors to promote network security, not attack it. MEV can ultimately create positive feedback loops that destabilize and threaten the network entirely.

For instance, if fees generated by optimizing transaction order exceed the block reward, a rational miner

[16] URL: https://arxiv.org/abs/2101.05511.

has every incentive to delay consensus and fork the chain. This makes the chain more susceptible to other forks by secondary agents – a similar discussion to Bitcoin security in a world without block rewards. The problem is even worse for smart contract networks since they have potentially lucrative revenue streams (and thus, more carrots for attackers) beyond transaction fees and block subsidies.

Ultimately, we find it hard to see how open markets can live on top of this inherently adversarial environment. Attempts to solve MEV are beyond the scope of this paper. Our analysis leaves us with one important takeaway for DeFi derivatives: open markets need to separate the application and consensus layer if they want to avoid a new version of an old dilemma.

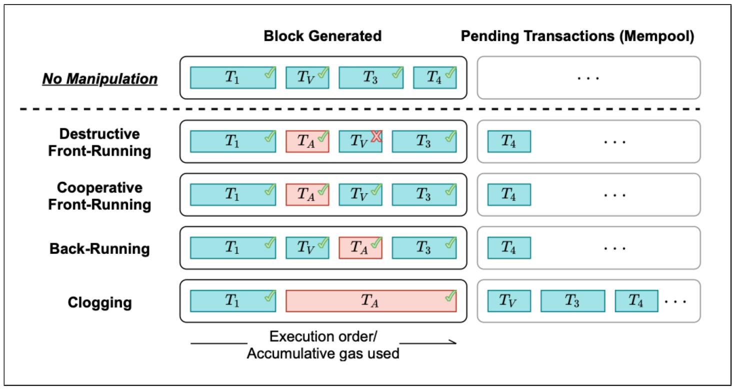

Figure 13: Types of MEV transaction ordering strategies commonly used on the Ethereum network[17].

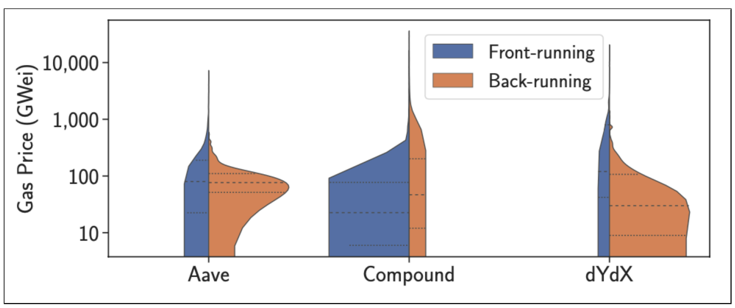

Figure 14: Gas fee distributions as a result of MEV liquidation transactions on different DeFi protocols[18].

2.3.3 The Derivatives Trilemma

Can DeFi derivatives compete with CeFi's offering? We think this depends on whether or not they can break free from today's set of tradeoffs. Everywhere we have looked in DeFi derivatives, we find the same set of tradeoffs in one form or another, preventing existing protocols from beating centralized experiences.

By nature, all of DeFi is self-custodied – a stepchange above CeFi where users must trust venues with their coins. CeFi is capital efficient, while most DeFi derivatives struggle with capital efficiency. Moreover, when a DeFi derivatives protocol *is* capital efficient, it is usually highly specialized. Perhaps it is a protocol focused solely on options markets or perpetual swaps with static models for risk management.

[17] URL: https://arxiv.org/abs/2009.14021.
[18] URL: https://arxiv.org/abs/2009.14021.

Put another way: capital efficient DeFi derivatives protocols are good at *doing one thing* – but they usually fail at creating a more customizable environment.

We have termed this set of tradeoffs *the derivatives trilemma*. In our view, unless a protocol can be both capital efficient and customizable, DeFi derivatives can't compete with CeFi – even if CeFi keeps abusing us with unending cascades. There will always be a cohort of radicals who prize self-custody above capital efficiency and customizability, but this won't move the needle for most.

Today's DeFi derivatives are as one-size-fits-all as TradFi's closed markets. Protocol collateralization ratios and risk models are either hard-coded by protocol developers or voted by governance. All markets must thus conform to a narrow set of rules. In the same way that we described the challenges of standardization in TradFi in Section 1, DeFi is similarly stuck in a stone age of unexpressive markets.

To eat CeFi market share, protocols need to be expressive enough to capture any permutation of risk. Risk changes between assets, and so why should a protocol have one way of managing risk? Rather, a protocol should simply be a platform for markets to discover the "correct" parameters over time. DeFi today subjugates all markets to the same models and blanket parameters, and thus – as MEV is to HFT – we find yet another old problem of TradFi.

What if there was a way to build DeFi derivatives to encompass all three dimensions of the derivatives trilemma? Fundamentally, the goal is not to build a "decentralized Bitmex", but to create an entirely new paradigm for market structure – its innovations should reimagine the ocean of TradFi as much as they influence this tiny lake of crypto derivatives.

The end result: a self-custodied, capital efficient and highly customizable protocol – *an open market.*

Introducing Vega.

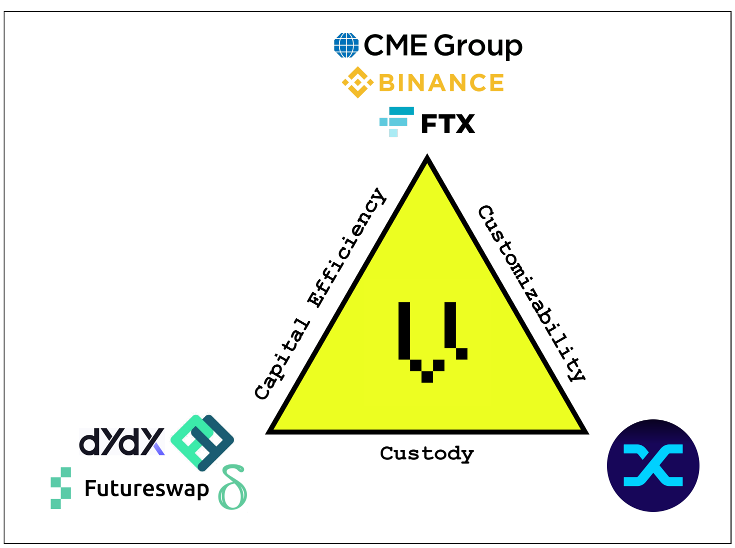

Figure 15: The derivatives trilemma, showing the current tradeoffs between capital efficiency, customizability, and custody. Vega is the first protocol to escape the trilemma.

3 Vega: The Multiverse of Markets

3.1 A Networked Galaxy

The journey toward open markets is the space race of finance. It is an incredibly wide mission that requires us to do far more than patch together TradFi concepts with crypto dreams. Open markets need fundamentally new ways of thinking. Open market idealists face adversaries and mirages from old and new lines of battle – from the war of the algos to the seductive hopes of DeFi.

Closed markets are like the zero-sum fight for the earth's resources, while open markets are like discovering a new planet (or set of planets) whose resources everyone will ultimately enjoy. Open markets are galactic and unbounded. They leave behind the prisoner's dilemmas of TradFi, CeFi & DeFi and embrace a new set of cooperative games.

Yet as we have discussed, nothing in today's TradFi, CeFi or DeFi infrastructure is up to the task. Derivatives are stuck in a trilemma and force traders to pick between lesser evils. In the end, open markets – like any genuine technological leap – are not about managing trade offs, but inventing new and positive-sum paradigms.

3.2 Solving The Trilemma

Vega is the world's first open protocol for creating, maintaining and aligning markets. While focused on derivatives, it is far more than a "decentralized Bitmex". It is an open system for creating and customizing new types of markets. Vega's concepts invent new ways of imagining markets altogether, birthing the first "free market" for market microstructure, risk models and product offerings. In a sense, Vega is a meta-play on markets: we think of it as not just a venue where traders can buy and sell, but a smart contract platform for markets as a whole.

Vega builds open markets by allowing anyone to create and launch any market permissionlessly. Moreover, it is more than just a place for market makers to instantiate a particular product or trading pair – traders can choose trading modes and risk models and customize them based on their needs. Vega is thus a credibly neutral breeding ground for trader experimentation, a kind of space race to discover untapped trading demand.

Vega escapes the derivatives trilemma: it is self-custodied, customizable and capital efficient. Traders can design highly customizable, on-chain stochastic risk models that govern market solvency, leverage, collateral and liquidations and escape the "one-size-fits-all" approaches found in TradFi, CeFi and DeFi derivatives.

Importantly, Vega's space race is a cooperative game. Open markets are not riddled with prisoner's dilemmas. Vega's markets align incentives across participants. The protocol achieves this through a fundamentally novel incentive scheme that merges the lessons of CLOB-based liquidity provision with the innovative power of AMM liquidity. Market makers are owner-operators with skin-in-the-game, while passive LPs are financiers, betting on the best maker makers.

Finally, Vega's open markets are fair and transparent. They tackle information asymmetries and give everyone a level playing field. Moreover, Vega defends against the MEV onslaught through a novel anti-frontrunning protocol called the *Wendy* protocol. At both the blockchain and application level, there are no second class citizens in Vega: the little guy has the same right to and knowledge of microstructure as the well-capitalized prop desk.

3.3 Vega's Fundamental Design

3.3.1 Underlying Infrastructure

Vega is built as an independent, vertically integrated Proof-of-Stake blockchain network:

- Vega separates the exchange application layer from the underlying consensus layer, eliminating incentives for miners to undermine network security
- Vega implements *Wendy* – an anti-frontrunning protocol – at the protocol layer to eliminate frontrunning & MEV extraction by sophisticated HFTs or miners
- Vega takes a radically transparent approach to market data – everything from open positions (entries, stops), leverage and collateral is verifiable on-chain.

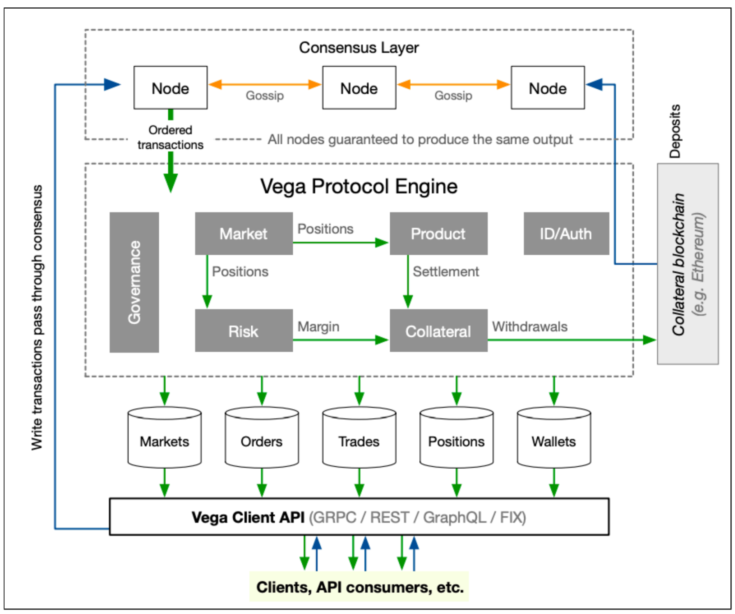

Figure 16: Vega logical architecture summary[19].

Vega is the first custom-built layer one protocol optimized for derivatives trading free from resource competition from the base chain. Traders aren't second-class citizens fighting for valuable block space. Rather, the consensus layer is designed to serve the application layer – an infrastructure focused solely on derivatives – with its Tendermint-based consensus targeting ∼0.8 second block time, 0.5-1.5 second latency, and a throughput of at least 10,000 TPS.

3.3.2 Beyond Staking: Policy-Driven Delegated Proof-of-Stake

Vega implements a novel policy-driven delegated proof-of-stake to incentivize decentralization of validators. Specifically, the proof-of-stake reward system is designed to prevent the accumulation of staking rewards, promote diverse, decentralized validator characteristics, improve validator performance through minimum stakes, promote network stability by restricting staking changes and incentivize "trustworthiness".

[19] URL: vega.xyz.

Table 3: Vega as the evolution of markets

Characteristic	TradFi	CeFi	DeFi	Vega
Market Creation & Microstructure	Closed, standardized products are introduced by monopolistic exchanges based on long term evidence of institutional demand	Closed, products are rapidly introduced by exchange operators based on short term evidence of retail demand	Closed (but more open than CeFi), products are introduced by protocol developers, generally limited to protocol speciality (e.g. strictly options or perpetuals)	Open, products of any type or market are proposed by anyone and voted into production by governance regardless of existing supply & demand
Capital Efficiency	Low, margin is reliant on fiat rails, with delayed (up to 24 hour) margin calls	High, margin is reliant on crypto rails with instantaneous liquidations	Low, existing blockchain infrastructure and / or risk models are not sophisticated enough to facilitate highly leveraged products	High, purpose built blockchain and open risk models allow for extremely capital efficient markets
Incentive Alignment & Liquidity	Poor, market makers are extrinsically incentivised by exchange operators and do not have "skin in the game" – long term alignment with market heatlh	Poor, incentive schemes resembling TradFi	Improved, extrinsic liquidity incentive schemes attract market makers, albeit as long as these schemes persist	High, liquidity providers are positioned as "owner operators" intrinsically incentivised to ensure the long term health of markets through all conditions
Transparency & Fairness	Low, simple exchange data is not openly distributed (high subscription costs), designated market makers are privy to special orderbook information & HFT is the norm	Better, simple exchange data is openly available, yet designated market makers are still privy to special orderbook information & HFT is the norm	Better, data is freely available onchain but trading is subject to MEV and frontrunning)	High, all standard and non-standard information is freely available via node APIs & anti-frontrunning measures are integrated into the protocol layer

3.4 A Free Market For Market Creation

3.4.1 Proposing A Market

On Vega, anyone can propose and support the instantiation of a new market. When proposers put a new market forward, they specify the actual instrument, product parameters, market parameters, price feeds, trading modes, market expiration times; and so on.

Token holders can vote for or against the creation of a new market for any reason whatsoever – from a poor choice in risk models to suspicion toward price oracles. When voting concludes, markets are seeded with initial market maker liquidity.

Holders with a financial stake in Vega have the incentive to approve novel and productive markets and reject disruptive and malicious markets. Holders are the ultimate guardians of the trading pit, contributing to market integrity not just as traders, but as partial governors of the network.

3.4.2 Product Abstraction, The Language of Vega

Vega supports market instantiation with a native smart contract language – the "smart product" language – allowing for custom product development. Traders can propose any type of market, from futures contracts, options, swaptions, perpetuals, and so on. This is why Vega is a meta-play on DeFi derivatives: the product abstraction layer makes it a neutral breeding ground for any *type* of product, not just a place where traders can trade one particular type of product (e.g. options or perpetuals).

The smart contract language is optimized for derivatives. Having a derivatives-native smart product language allows traders to deploy an essentially infinite combination of products, replicating any payoff diagram at expiration. We think this makes Vega itself a fundamentally new primitive, empowering participants to experiment with a limitless universe of products. This is the Vega space race, an unbounded race to find, seed and maintain new types of markets, akin to the interplanetary quest to discover all of the universe's *habitable* planets.

3.4.3 Dynamic Microstructure: Choose A Trading Mode

In Section 1, we discuss how HFT is the natural offspring of continuous-time trading. Vega is not inherently pro or anti-CLOB. There may indeed be powerful use cases for continuous-time trading and possibly even for HFT.

What's different about Vega is that there is no one-size-fits-all design for market microstructure. Vega is about creating choice in microstructure. Traders can pick their market's mode, ultimately seeding nascent trading demand across liquid, illiquid, and bespoke instruments. In addition, one market can transition between trading modes, responding to market events and volatility.

There are three primary trading modes in Vega.

3.4.3.1 Over-The-Counter (OTC)

OTC exchanges allow for on-chain decentralized trade settlement while eliminating counterparty risk. Trading happens through Request for Quote (RFQ) and matched trading, where counterparties pre-agree to pricing off-chain and then proceed to match and settle on-chain.

3.4.3.2 Continuous Time Trading

Vega enables continuous time trading through classic central limit order book (CLOB) exchanges where market makers provide liquidity at all times. At any time, traders can place bids and asks on the book. The orderbook matches corresponding bids / asks and orders are partially filled if prices match but quantities don't.

3.4.3.3 Discrete Trading

One of Vega's most powerful innovations is for markets to function under modes of discrete trading. Batch auctions are Vega's most common method of discrete trading. Frequent batch auctions take place at regular intervals synchronized with the block time. This creates efficient pricing while preventing attacks from adversarial traders. Batch auctions work in the following way:

1. Markets enter an *auction call period*
2. Traders place bids and asks on the book without being filled
3. The market then finds a clearing price, the highest bid and the lowest ask
4. Anyone who bid above the clearing price and anyone who placed asks below the clearing price is filled at the clearing price.

In contrast to continuous trading, trading occurs only once, at a discrete interval known as the auction call period. In the same way that HFT is the natural offspring of continuous trading, we think about frequent batch auctions as the natural extension of blockchain trading. **Batch auctions and blockchains are**

a perfect fit: the consensus layer already imposes a natural timescale for trading execution – the block time.

Vega's focus on batch auctions has strong empirical foundations. A growing body of work has focused on batch auctions as a fundamental solution to the dysfunctions of HFT-dominated markets:

> *"For both of these reasons, frequent batch auctions eliminate the cost of liquidity provision in continuous limit order book markets associated with stale quotes getting sniped. Intuitively, discrete time reduces the likelihood that a tiny speed advantage yields asymmetric information, and the auction ensures that symmetric information does not generate arbitrage rents. Batching also resolves the prisoner's dilemma caused by the continuous market, and in a manner that allocates the welfare savings to investors. In equilibrium, relative to the continuous limit order book, frequent batch auctions eliminate sniping, enhance liquidity, and stop the HFT arms race."*[20]

Under this trading mode, trading is provably fair, continuing to reward the most informed participants, but now eliminating any benefits from information about future trading that will soon be available to the rest of the market.

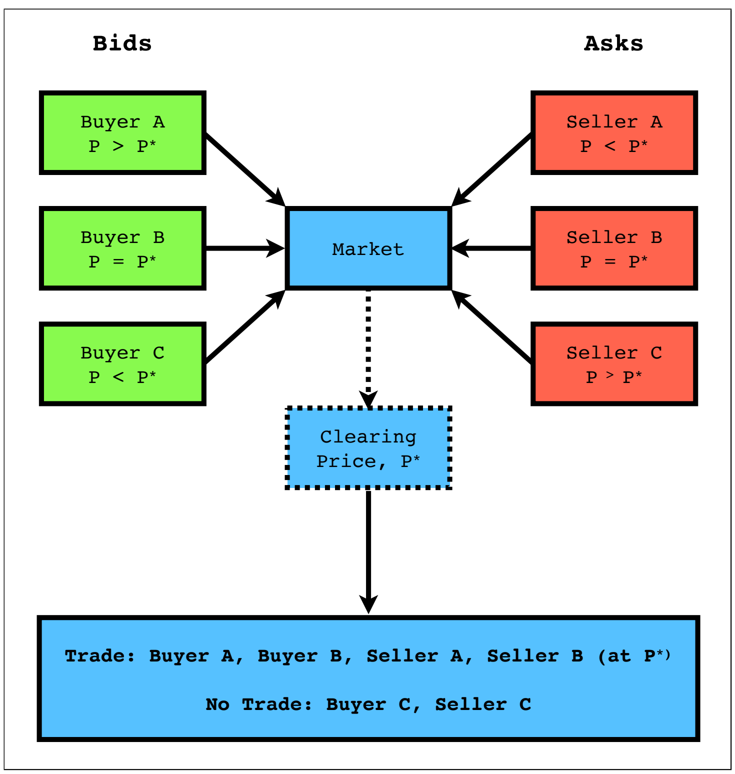

Figure 17: Batch auction structure. Batch auctions are one of the discrete modes available on Vega, removing the incentive to perform latency arbitrage.

3.4.4 On-Chain Circuit Breakers: Graceful Start, Shutdown & Restart

Vega auctions are profound for reasons beyond price discovery. Vega can transition markets into temporary price monitoring auctions during periods of illiquidity. This temporarily increases latency and gives

[20] **Budish2015.**.

liquidity providers a chance to enter the market and compress spreads. It's a way to prevent the war of all-against-all we see amidst TradFi and CeFi flash crashes, preventing cascades caused by microstructure breakdowns as opposed to "real" selling.

This doesn't make cascades impossible – genuine sellers can still enter the auction queue. It does, however, curb the curse of inorganic cascades.

Let's take the following example. Assume that a market on Vega is trading in a continuous time mode and there is a sudden liquidation cascade, forcing a large (but temporary) crash. A properly calibrated risk model could immediately trigger a protective auction and replace the CLOB with an auction.

This works preemptively. Vega detects orders that would – if executed – create a liquidity crisis, and rather than filling that order, transitions the market into a protective auction. Price should then only fall if the selling is real – since the seller will also participate in the auction.

Vega's ability to transition a market's microstructure is like an on-chain circuit breaker. Moreover, in some ways, Vega's circuit breakers are more profound than their TradFi counterparts. Some evidence suggests that circuit breakers in TradFi can actually increase volatility and exacerbate price movements. **By definition, Vega's circuit breakers – auction periods – drive the market toward efficient price discovery and dampen volatility.**

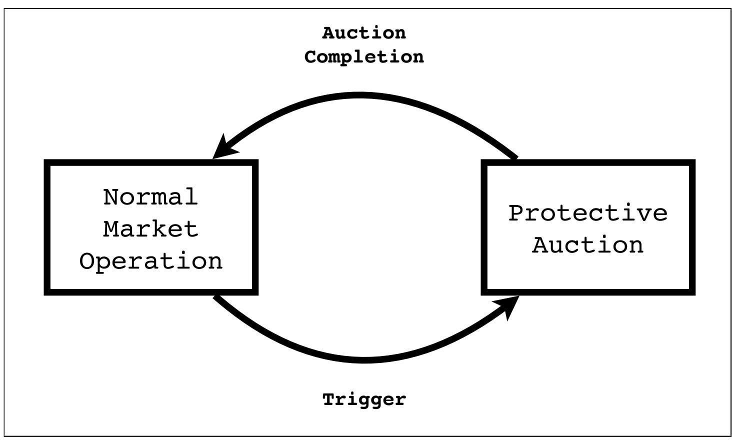

Figure 18: Price monitoring auction during liquidity crisis. During times of illiquid trading, Vega triggers a price monitoring auction in order to prevent large slippage and liquidity cascades as a result of inorganic selling pressure.

3.4.4.1 Black Thursday On Vega?

Could March 12 have happened on Vega? Vega's dynamic microstructure protects against these kinds of tail events. Pre-programmed risk models could have detected orders that could crash prices beyond the price monitoring level, automatically transitioning the market into an auction state.

This pause would give market makers a chance to breathe and gracefully re-enter the market, bidding in the auction. It's not as though the price wouldn't have crashed on Vega – it's that the auction would have helped determine the "true" price, which was likely not in the low $3,000s as on Bitmex. The auction would give buyers a chance to bid the firesale, but it would also likely clear above the inorganic and "fake" print on Bitmex.

3.4.4.2 Protective Auctions On Any Trading Mode

As we conclude our discussion on Vega's inherently dynamic and protective microstructure, it's important to note that price monitoring auctions can be triggered on any trading mode – discrete or continuous. This fundamentally strengthens microstructure for **any** market built on top of Vega.

3.5 Customizing Risk: Capital Efficiency In Vega

Risk models are tricky but fundamental to any derivatives protocol. Overly conservative models result in low capital efficiency – offering traders too low leverage – while loose models improve capital efficiency but increase the risk of insolvency. There is no one way to rule all risk: the blanketing of risk only hurts individual traders and stunts a market's growth.

Why should a market for crude oil be governed by the same risk model as a market for 10 year US treasuries?

Customizable risk models are analogous to specialized Automated Market Makers. Curve Finance is the dominant decentralized exchange for stablecoin swaps strictly because the underlying AMM-curve is optimised for swapping similar assets (USDC to USDT or WBTC to renBTC). Similarly, no two derivative markets have the same risk profile.

3.5.1 Risk Models

Each market needs a way to calculate the risk of insolvency for individual traders and thus the risk of insolvency for the entire market. Risk models are how a market determines the maintenance margin requirement for open positions. **How much collateral needs to be posted in the margin account, below which the collateral will be sold to liquidate and cover the position?** On Vega, every market has its own uniquely calibrated risk model quantifying a position's expected loss during typical and atypical market conditions.

3.5.1.1 The Basics

When managing leveraged positions – outstanding debt – market designers need to find a way to estimate expected losses – the shortfall – for any given position at expiration. On Vega, they do this by implementing stochastic models that approximate the trajectory of price for an underlying asset from inception to expiry.

Risk models make assumptions about the characteristics of the underlying asset's functional form based on historical data, constructing a probability distribution. They use this to define an appropriate risk measure known as the **Risk Factor**. This risk factor provides a quantitative estimate for how much drawdown a portfolio of assets will likely experience during a given period.

Supported by Vega out-of-the-box are log-normal models, a typical class of risk models. These assume the logarithm of price for the underlying is normally-distributed. Specifically, the price of the underlying satisfies a stochastic differential equation for geometric Brownian motion:

$$dS_t = S_t(\mu dt + \sigma dW_t),$$

$$\begin{aligned} \text{where } S_t &= \text{the price of the underlying,} \\ \mu &= \text{annualised growth rate,} \\ \sigma &= \text{annualized volatility,} \\ t &= \text{time,} \\ dW_t &= \text{Brownian process differential.} \end{aligned}$$

The log-normal model admits simple closed-form expressions for the expectation and variance of price for the underlying at any time.

At its core, this risk model incorporates multiple parameters to determine the risk of any position at any time. A discussion of other risk models beyond the log-normal model is beyond the scope of this paper.

3.5.1.2 Any Model Can Live On Vega

Vega allows market proposers to customize these models. One market creator – perhaps with limited computational resources – can use simple computations using a log-normal distribution. Another market creator may opt for a sophisticated and computationally-expensive risk model, executing Monte Carlo simulations to predict the *actual distribution* of price trajectories rather than assuming their form a priori.

There is no clear consensus about which risk models are best suited for different markets. This is an active area of research in TradFi as well as DeFi. **Vega's answer is a fairground for risk modeling, where the market can converge on appropriate risk models as they are tested over time.**

Ultimately, Vega lets market creators customize how risk is managed depending on the characteristics of the underlying asset and its need (or lack thereof) for a particular degree of capital efficiency.

In this sense, Vega *is positioned as a meta-market for risk.* At any one time, for example, multiple Bitcoin markets can live on Vega, each governed by differing risk models. Over time, performance under extreme market conditions will determine the long term survivability of the markets. **This is survival-of-the-fittest not only applied to market participants, but market microstructure itself.**

3.5.1.3 The First Fairground For Risk

As far as we can tell, Vega's approach is the only fairground for risk modeling across TradFi, CeFi and DeFi. Most existing on-chain derivative protocols don't use explicit risk modelling and instead hard code minimum collateralization ratios. The result: lower capital efficiency. Existing DeFi derivatives slap on arbitrary risk models that have no idiosyncratic relationship to each underlying market.

This fairground for risk modeling represents a fundamental evolution in markets. A Vega liquidation engine can replicate any liquidation engine. Put another way, a market proposer could (if they wanted to and had access to the model specifications) port Bitmex's risk engine onto a Vega market. Any risk model can live on Vega.

This puts the "decentralized Bitmex" analogy into context: not only is Vega not an attempt at putting "Bitmex on the blockchain" – the precise opposite might be true. **In the long run, it's conceivable that market proposers could "put Bitmex on Vega".**

3.5.2 The Risk Factor

The Risk Factor is a normalized value that represents the state of risk computed by a risk model, where $0 \leq \mathrm{RF} \leq 1$. The lower bound corresponds to a risk free instrument while the upper bound represents a very risky instrument (which would allow for no leverage). As discussed in the previous section, this factor determines the maintenance margin of any position in a particular market. Mathematically:

$$\mathrm{MM} = \mathrm{Y} \times (\Delta + \mathrm{P} \times \mathrm{RF}),$$

$$\begin{aligned} \text{where } MM &= \text{Maintenance margin,} \\ \mathrm{Y} &= \text{Position size,} \\ \Delta &= \text{Close-out slippage,} \\ \mathrm{P} &= \text{Price,} \\ \mathrm{RF} &= \text{Risk factor.} \end{aligned}$$

The position size represents the number of outstanding contracts on the derivative and the close-out slippage represents the slippage incurred by closing the position.

Providing market makers with the freedom to calibrate risk models on a market-by-market basis incentivizes them to support the smooth functioning of markets. In fact, Vega's implementation of a dynamic risk factor – as opposed to a static, unchanging variable reminiscent of DeFi's status quo – encourages liquidity provision during ***all*** market conditions.

3.5.2.1 Margin, Capital Efficiency & Leverage

Getting risk models right lies at the heart of market design. The risk factor ultimately feeds into optimal maintenance margin levels and allowable leverage. **Customized and properly-calibrated risk models are thus the lifeblood of capital efficiency in any derivatives market.** On Vega, appropriate risk model calibration can allow for at least 100x leverage in a fully decentralized setting.

3.5.2.2 Risk Universes & Portfolio Margining

Vega maximizes cross-market capital efficiency by implementing a system of portfolio-margining. By using total account profit & loss (P&L) together with coherent risk measurements, trader's can offset P&L in one market against P&L in another, a stepchange for capital efficiency. **Fundamentally, Vega does not require traders to close one position to capitalize (or recapitalize) another**. Moreover, this forces a trader with losses in several markets to increase their maintenance margin, reducing individual credit risk.

Cross-market collateralization is possible in Vega because markets with different risk parameters can be made comparable on a net P&L basis, again only possible through the use of coherent risk measures.

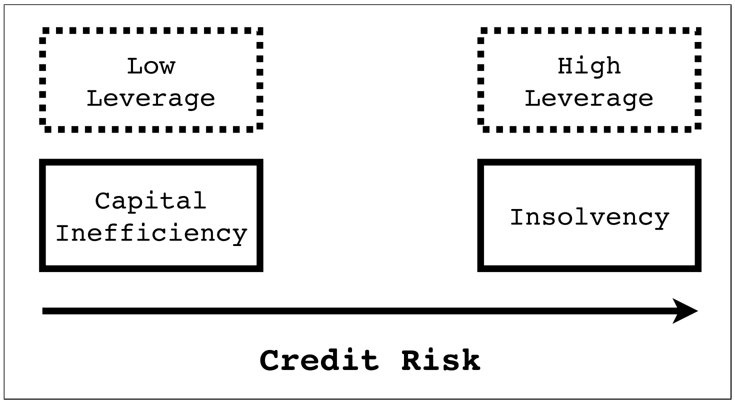

Figure 19: Capital efficiency and solvency risk trade-off. Depending on the market parameters, market designers attempt to optimize the capital efficiency without becoming unnecessarily exposed to high credit risk.

Risk comparisons are apples to apples. This brings the widest possible range of instruments into the same risk orbit: we can trade multiple instruments as though they were one.

3.5.3 Protocol Solvency

There is an inherent tradeoff between capital efficiency and insolvency risk on Vega. Vega reduces the risk of market insolvency by implementing:

1. Insurance pools
2. Socialized losses when individual insurance pools are undercollateralized.

3.5.3.1 Insurance Pools

Each market's solvency is insured by a market-specific insurance pool. Vega also has a general insurance pool (a treasury) with multiple asset types, which market-specific pools can leverage when their pool is depleted. When a specific market expires, its insurance pool is moved to the general insurance pool. Market-specific pools are capitalized by fees from trade closures as well as market maker slashing penalties (discussed in Section 3.6).

3.5.3.2 Socialised Losses

Markets that use loose risk parameters can offer high leverage but must often socialize losses across winning participants to ensure solvency. On the other hand, markets that use tight risk parameters can only offer low trade leverage, but will rarely need to socialize losses as the insurance pool will almost always be able to guarantee solvency.

As such, market makers are incentivized to design capital efficient markets that maximize the welfare of all market participants. Bybit has one giant insurance fund and all users are exposed to the same fundamental risks – whereas Vega once again empowers users to manage risk in a more idiosyncratic fashion, leveraging this combination of individual insurance pools as well as socialized losses through a general pool.

It's interesting to note that loss socialization on Vega can run in perpetuity because of the zero-sum

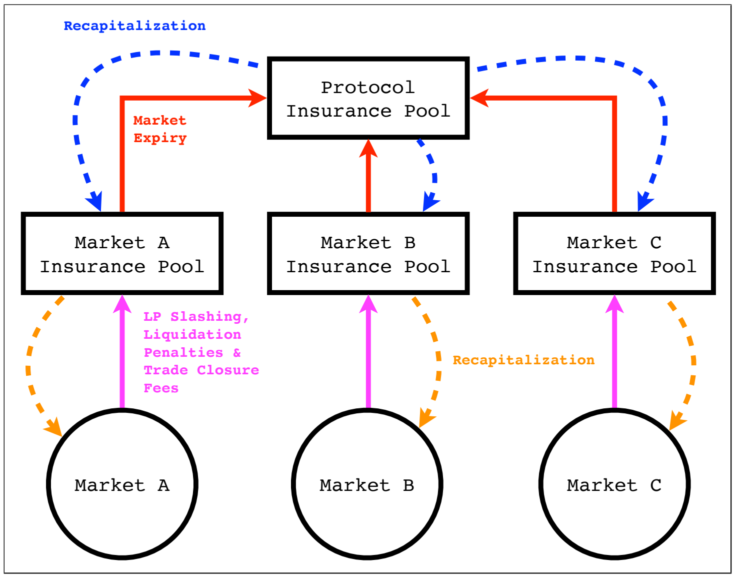

Figure 20: Structure of insurance pools on Vega. Residues from closing trades and slashing penalties accumulate in market pools. At the expiration of any market, its insurance pool is transferred to the general protocol insurance pool. The protocol pool can recapitalize market insurance pools when they are depleted. Market insurance pools are used to close net credit trades (with debt larger than the margin).

nature of the protocol. Of course, if a market needs to continue socializing losses, it's likely a poorly-designed market and may not survive the test of time. However, the very existence of this emergency measure backstops the protocol during liquidity crises and enables truly autonomous markets.

3.6 Beyond The Hobbesian War: How Vega Aligns Incentives

As we discussed in Sections 1 and 2, the modern market maker has weak incentives to support illiquid markets, often running at the first sight of blood. Markets have become adversarial, with a zero-sum war of all as their natural state. Is there a way to incentivize a more iterative game in markets, one where we can escape the prisoner's dilemma and align participants not just with each other, but with market integrity as a whole?

3.6.1 Skin In The Game: Staking & Slashing Liquidity

In Vega, market makers need to provide a bond – a minimum stake denominated in the traded assets – to provide liquidity. If they stop providing liquidity, the network can slash and take this bond. This staking mechanism helps reduce (but not entirely eliminate) liquidity shocks we describe in previous sections – from May 6, 2010 to March 12, 2020. Vega can motivate market makers to continue providing liquidity *even at a loss* so long as the slashing penalty is greater than the losses they are taking to better informed traders.

If a market maker withdraws liquidity and takes this slashing penalty, the slashed amounts will then fund a market's insurance pool. A larger insurance pool creates higher capital efficiency in the next round of trading, incentivizing more participants to trade. In other words, this simple slashing mechanism not only incentivizes market makers to *stand their ground and take the onslaught of toxic flow*, it helps maintain broader system solvency and encourage higher trading volumes.

If they withdraw liquidity, this slashing encourages new entrants to provide liquidity, subsidized by the bond of a now delinquent market maker. This creates a self-fulfilling prophecy: the slashing mechanism helps guarantee liquidity in the case of a liquidity shock, reducing the likelihood of said liquidity shock to begin with.

3.6.2 Market Makers As Venture Capitalists

In addition to this clever slashing mechanism, Vega creates powerful incentives for market makers to seed early markets. In Vega, fees are distributed in a non-linear fashion: the protocol thinks of market makers like seed investors, giving them an outsized portion of fees when they seed markets early on.

3.6.2.1 Get There Before Anyone Else

In Vega, liquidity providers who help a market meet the minimum staking requirement for its instantiation are allowed to set that market's fees. Liquidity providers who complete the market are fee givers, while providers of extra liquidity beyond the minimum staking requirement are fee takers. This mechanism minimizes excess liquidity and incentivizes late market makers to inject liquidity in other smaller and more nascent markets.

This distribution of fees attracts early liquidity and helps bootstrap nascent markets. Put another way: for the same amount of liquidity, an early liquidity provider receives a higher proportion of collected fees than later participants. All liquidity is not created equal. Fees are distributed in proportion to the notional value of trading volume in the market when each liquidity provider joins. This mechanism incentivises early participants to make nascent markets and support their growth – termed *equity-like market share*.

3.6.2.2 The Owner-Operator

In this way, Vega thinks of market makers as owner-operators. They are founders who build early markets. They win if the market wins. Contrast this to closed markets where liquidity providers have no skin in the game, focused not on the long term success of a market, but on the aggressive extraction of rent **today**. Market makers become profitable in Vega by not only seeding nascent markets, but continuing to support them over time – tweaking their parameters to optimize notional trading.

These incentives create a self-regulating dynamic between market makers and traders. When a market has low liquidity, it will attract market makers who want an outsized portion of fees. As a market becomes more liquid, traders enter and compress these fees. The market thus finds the equilibrium for liquidity provision, the point which maximizes both market maker and trader profitability.

3.6.3 Bridging Active & Passive Strategies: Passive LPs Are Financiers

The AMM boom gave retail traders the opportunity to become liquidity providers. Vega does not neglect the passive LP. Rather, passive LPs can deploy capital into active liquidity provider strategy. This marries active and passive strategies: the active market maker is an owner-operator, while the passive LP is a financier, deploying capital into these active strategies.

[21] URL: vega.xyz.

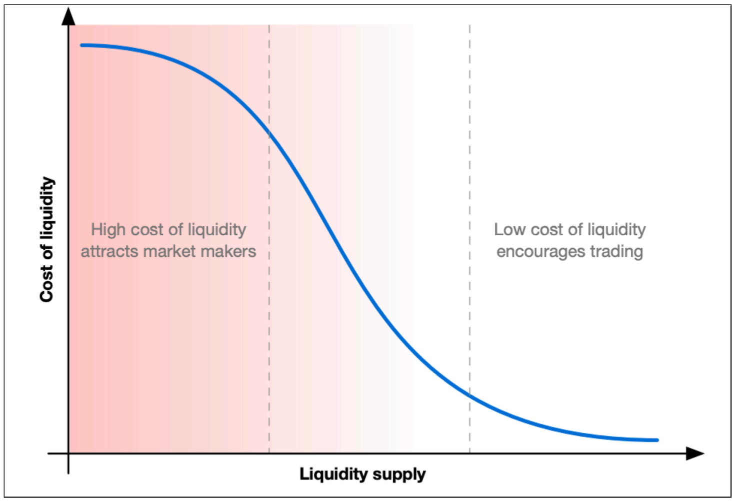

Figure 21: Liquidity equilibrium and the cost of liquidity. Low liquidity attracts market makers, while high liquidity attracts traders. Market designers attempt to optimize the use of liquidity, depending on market parameters[21].

This marriage of passive and active LPs not only aligns market participants, it makes successful liquidity provision all the more lucrative. If a market maker can seed, build and maintain healthy markets, they stand to attract huge pools of passive capital, only growing their potential profits.

Passive participants generate yield and active participants now have a natural source of funding. The market maker is thus akin to the general partner (GP) of a hedge fund, raising outside capital and motivated to showcase strong performance and protect their reputation over the long term.

3.6.3.1 Pure AMMs On Vega: Is Uniswap A Subset Of Vega?

Importantly, pure AMM-type markets are also possible on Vega. This point once again captures the breadth of Vega – just as Bitmex could live on Vega, Uniswap could similarly be imagined as a subset of the Vega galaxy.

Vega markets don't need to be inherently leveraged. The protocol also supports unleveraged trading: a market proposer *could set the risk factor to unity*, implying full liability and thus emulating an AMM-type spot market.

Traders can speculate on contracts with no leverage and the collateral can simply shift from one account to another following expiration. Vega can thus house spot markets. Again, because Vega can fundamentally replicate *any payoff function*, these markets become possible.

3.7 Fair & Transparent Markets

In the last section, we saw how Vega aligns participants and creates long term thinking in markets, contrasting the war of all observed in Sections 1 and 2. Vega motivates makers through carrots (an equity stake) and sticks (slashing) and also finds ways to get the smaller LP in on the venture.

Instituting fairness and transparency is also foundational to keeping participants aligned. There are two main ways that Vega creates transparency and fairness. Firstly, all data is transparent in Vega, reducing asymmetry and creating a level playing field. Secondly, Vega institutes specific anti-frontrunning mechanisms, combatting DeFi's struggle with MEV.

3.7.1 Democratized Data & Transparency: Achieving The Nash Equilibrium

The promise of DeFi lies in its fundamental transparency. We avoid the opacities of 2008 by putting all counterparties on-chain. Transparent positions, risk parameters, collateral and price feeds help the market accurately calibrate risk and guarantee its solvency. Again unlike in 2008, it's much harder for DeFi markets to realize they have completely mispriced their own collateral and misjudged system leverage.

In the context of Vega, participants can see the state of a market for a particular asset (and the position of its market maker) at all times. Markets are completely transparent. This incentivizes "back-stop" strategies by other non-participant market makers and liquidity providers. Sophisticated market makers can see distressed markets and step in to turn a profit – again only possible because a market's distress is knowable by anyone.

On Vega, all market parameters are transparent and readily available. Not only can they manage risk based on the realities of system leverage, traders also have a perfect view into orderflow. In TradFi and CeFi, it's only the broker, venue or sophisticated market maker that knows where the stops are – leading to attacks on retail positions known as "stop hunts". Contrast this to Vega: everyone knows not just where the stops are, but where the entries are as well as the state of other traders' P&L.

This openness again leads to a fundamentally different set of incentives. Less asymmetry creates an inherently less adversarial environment, fostering healthier markets. Market designers can observe these dynamics and incorporate them into fundamental market design, systematically reducing the possibility and impact of market manipulation.

3.7.2 Institutionalizing Fairness: Attacking MEV

The design of Vega has built-in features that prevent against market manipulation, HFT and frontrunning. For example, and as discussed previously, the use of frequent batch auctions on Vega disincentivizes HFT since it would be of no value. In this section, we discuss Vega's main mechanisms to wage its own war on MEV.

3.7.2.1 *Wendy*: The Good Little Fairness Widget

To combat frontrunning, Vega has developed a transaction pre-protocol called *Wendy*. *Wendy* is a "fairness" gadget on top of Vega that enables the optimal, consistent, and fair ordering of transactions. *Wendy*'s implementation allows different markets to:

1. Define their definition of fairness in ordering
2. Alternate between definitions of fairness to react to changing market conditions.

The ultimate goal of *Wendy* is to make transaction orders fair, consistent, and optimal for different markets. As a result, *Wendy* eliminates transaction-based adversarial trading at Vega's base layer, solving the issue of MEV and institutionalising fairness at the protocol level. The complete specification of *Wendy* is beyond the scope of this work, found in the protocol paper[22].

[22] URL: vega.xyz.

3.7.2.2 Commit-Reveal Schemes & Transaction Ordering

Vega also integrates a commit and reveal (C&R) scheme with *Wendy*. C&R can provide additional protections against MEV. The aim of a C&R scheme is to prevent adversarial traders from acting upon a transaction once they are able to view its contents. In other words, at the point they "see" the transaction, they can no longer influence it.

C&R transaction encryption is implemented using non-interactive threshold cryptography. This (1) allows traders to encrypt transactions with validator public keys, and (2) allows validators to decrypt transactions with their corresponding private key shares. This ultimately avoids the issue of traders committing to trades yet refusing to reveal trades.

It is important to note the integration of *Wendy* with the C&R scheme minimises any potential network latency added by the reveal phase of the C&R scheme. In a normal C&R scheme, the reveal only starts once the block with the corresponding transaction is finalized, leading to a significant latency-add. By integrating *Wendy* with the C&R scheme, the reveal begins earlier. Namely, once a transaction cannot be frontrun anymore without violating *Wendy*'s fairness policy.

C&R schemes are only applicable to discrete time trading, since they introduce a minimum trading time scale (on the order of the block time).

3.8 The Vega Token: Governing The Exchange

The Vega token (VEGA) is the native staking asset of the network. The token's value is intrinsically tied to the growth of the exchange, entitling stakers to a share of all fees generated on the platform. This couples the fundamental value of VEGA to growth in trading volume across all live markets.

Token holders execute three general functions: network validation, permissionless market creation, and network parameter governance:

- **Network Validation** – the consensus layer of the Vega blockchain uses a novel policy-driven delegated Proof-of-Stake mechanism, which we described in Section 3.7. Token holders delegate to network validators who uphold network. Stakers, active and passive LPs share profits from trading fees
- **Permissionless market creation** – token holders vote on proposals to introduce new markets. They are the guardians of Vega's galaxy, voting on active markets in order to change their governing parameters. This governance system aligns the incentives of token holders with the health and integrity of the markets on Vega
- **Network parameter governance** – token holders vote on network parameters including finality conditions (number of block confirmations before settlements are credited), governance vote participation thresholds, and so on.

Conclusion

The path from closed to open markets is the difference between an arms race and a space race. One is a zero-sum race to the bottom, a ruthless scrap for resources ruled by machines and ghosts with toxic collateral. The other – a true Blue Ocean strategy – moves past adversarial games and searches for a new way of thinking – embarking on a quest to find all of the universe's habitable markets and give traders the chance and a place to trade them.

TradFi is stuck in a Hobbesian end state, underpinned by non-cooperative foundations. Crypto promises a more inclusive future, but inherits many old and some new trappings – from flash crash malfunctions in microstructure to gas wars that threaten to undermine not just DEXs, but layer one security.

CeFi is stuck inside of an odd paradox: it has evolved around the perfection of crypto as supercharged collateral, but its infrastructure is naive and can't keep up. This combination may be creating net worse outcomes than TradFi, which experiences the flash crash, but doesn't need to break each time. We can't conflate the pristineness of Bitcoin with the functionality of CeFi. Game theory dictates CeFi's drift towards inefficiency.

The 2010 Crash is nothing compared to Black Thursday. DeFi has its own cascading episodes, plagued by an unwelcome family history. DeFi's MEV is to TradFi's HFT.

DeFi derivatives are held back by a set of unavoidable tradeoffs, asking users to choose between lesser evils. Existing projects take CeFi products and naively port them on-chain. They miss – for the most part – an entire history and evolution of markets, ignoring the deeper challenges at the heart of closed liquidity.

Ultimately, DeFi derivatives are a monumental project way bigger than crypto: it's a project for markets as a whole. If Vega succeeds, then all markets theoretically become a subset of Vega primitives – all markets become a home for democratic market creation, customizable risk models and cooperative alignment across participants.

What this push for open markets needs is a new type of thinking that isn't wedded to staying on any particular planet, but focused on creating a language and platform for a boundless multiverse. We need a protocol for competing risk models, experimental microstructure and cooperation between active and passive capital.

We think of Vega as a free market for market creation, not a subset of DeFi. It is its own paradigm. Vega is not decentralized Bitmex – but a new way to think about all aspects of markets, building them with open markets in mind: transparency, fairness and customizability.

We are very excited to be part of Vega's journey and to watch the space race for DeFi derivatives – and ultimately, the world's financial markets – enter its next and most aggressive phase. It begins.