TL;DR

- History has shown that derivatives can strengthen spot markets and provide additional tools to stakeholders in the supply chain to manage their businesses. Similarly, Ethereum's spot gas market could potentially benefit from derivatives markets
- With the development of Ethereum gas derivatives, there is an opportunity to enable a comprehensive suite of products for better user and developer experiences (i.e., they can rely on paying a fixed price for gas) as well as increased efficiency around price discovery of Ethereum blockspace. Further, in most markets, the volume of derivatives greatly surpasses the spot, providing significant opportunities across a large design space
- When designing these products, there are regulatory/legal, market, and protocol-specific considerations that need to be accounted for. Furthermore, the sophistication of market stakeholders must improve to support the active trading of these products
- It's difficult to know when this market will develop, but there are some tailwinds around consolidation of gas buyers (i.e., due to the development of L2s / account abstraction), an increase in products available for hedging (i.e., staking products), and an increase in the sophistication of various stakeholders in the transaction supply chain (i.e., through improvements in infrastructure)

Throughout history, there have been examples of commodity markets that have experienced increased volatility due to the impact of exogenous events. While factors outside of markets helped reduce these risks for those producing and consuming the commodity (i.e., globalization resulting in more efficient shipping/transport and networking), derivatives act as a tool for broader price discovery. Furthermore, derivatives can be used to better manage businesses that are reliant on the commodity. There is a similar opportunity around Ethereum blockspace. With the development of blockspace derivatives stakeholders can provide better user experiences, have more tools to manage their businesses, and increase efficiency for price discovery of blockspace. Below we provide an overview of the current state of Ethereum blockspace, historical analogies to traditional markets, and seek to build upon others' research demonstrating the key considerations for developing a market for blockspace derivatives.

Introduction to blockspace in Ethereum

Ethereum's business model revolves around selling blockspace. Blockspace is leveraged by a variety of participants to interact with smart contracts that power applications, support additional layers of infrastructure, or directly settle transactions. However, as with most resources, there is limited supply. To determine who or what consumes that supply, gas was created. Gas is used by stakeholders to specify how much they are willing to pay for their transaction to be included.

Gas in Ethereum and its usage have evolved, with the most recent key changes taking place in August of 2021. With the London hard fork and implementation of EIP-1559, Ethereum shifted its fee market to consist of a base fee, which is burned, and a tip that goes to the validator. Post this change, the market now has a protocol driven reference rate via the base fee and ensures that for physical delivery, there is a minimum cost associated with the inclusion of a transaction in a block.[2]

In September of 2022, the Merge happened! While subtle, this also changed some dynamics related to any potential derivatives market. Post the Merge, the validator that is responsible for proposing the new block for ultimate finalization is known two epochs out, giving the market about 12 minutes of knowledge of who will stack the next block (this could have interesting implications on a potential physical delivery market).

Lastly, in the near-term the community will likely introduce a new fee market tied to data storage, referred to as

EIP-4844

. This market will be Ethereum's first multi-dimensional fee market that separates data storage and execution. More on the implications of this, and other road map items, are discussed below.

What we can learn from other commodity markets

To begin to understand potential designs and market structures for a blockspace derivatives market and the potential impact on spot[1], we surveyed the traditional markets observing various attributes. Below are a few features we identified as key to

markets that are most comparable.

- Untradeable underlier: In its current form, Ethereum gas is not directly tradeable; we looked for markets that are based on an underlying index that is non-tradeable[3]
- Cash vs spot: Given varying dynamics between physically delivering blockspace versus cash being exchanged at expiry, we looked for derivative markets that are cash-settled, but the spot market is physically settled
- Stakeholders: A significant amount of the activity and speculation needed to be driven by actual usage of the commodity / good
- Market microstructures: Where a transaction is placed in a block can have significant impact / drastically change what a buyer is willing to pay. Because of this, we looked for markets where there were similar microstructure dynamics driven by quality / geography / other metrics

The markets we found most relevant based on these factors are Oil and VIX. More details are discussed below, but it's important to note that both markets have become heavily used by various stakeholders to achieve an array of goals (i.e., better manage their business, hedge, take a view, among others).

Oil

Until the 1980s, oil markets were largely dictated by a select group of market participants, namely parties with significant oil exports. By the end of the 1980s, a healthy spot market had developed, slowly replacing fixed-term set-price contracts. Even with this development however, there was still one problem—this market required physical delivery. Given the complexity of delivering oil, these markets continued to be dominated by fewer players with long-term partnerships instead of being open to a broader set of participants.

As these markets continued to mature, benchmarks such as US WTI developed to track an aggregate of the spot price of grades from certain regions. This allowed for marketplaces and other stakeholders to support and exchange oil in a standardized way (i.e., you didn't need to understand the nuances of a region or market to trade oil). Through this development, not only were more actors able to take a view on price, increasing the depth of liquidity of the market, but now derivatives could develop on this index (products based on an index are largely cash settled). The result of this was even more stakeholders being able to contribute to price discovery, arguably increasing efficiencies and providing stronger tools for producers and consumers to manage their businesses. Currently, the WTI and Brent

futures contracts

on the ICE and NYMEX exchanges can reach several billion barrels/day while global oil demand sits at around 100 million barrels/day; futures trading volume exceeds daily oil consumption by a factor of over 25x.

The Volatility Index / VIX

The VIX market originated from financial economics research in the late 80s - early 90s, proposing a set of volatility indices that could act as an underlying asset for futures and options trading. A volatility index plays a similar role to a market index in the sense that traders can speculate upon an aggregated set of equities, or in VIX's case, speculate on underlying volatility within a wider market. This allows participants to both speculate on market uncertainty in the future, but also hedge against market downturns when volatility will be elevated but investor equity portfolios can suffer. Unlike equity indices, however, VIX itself cannot be traded. Because of this, only derivatives on top of the VIX that are cash settled can be traded. Despite this, the VIX futures market since its inception in 2004, has

grown

from averaging a daily volume of only ~460 contracts to ~210k contracts in 2022. This market structure is analogous to the current gas market. Underlying gas cannot be traded but is an

observable

and

quantifiable

property of the Ethereum blockspace market. Because of this, creating a standardized gas reference price is necessary for cash settlement of futures / options / swaps / ETPs. Luckily, this has become easier post EIP-1559, which acts as a credible oracle for congestion blockspace.

Considerations for product design

While we can draw from historical analogies to demonstrate the impact derivatives markets could have on the robustness of Ethereum blockspace markets, Ethereum blockspace carries unique features that will also determine how reference benchmarks and derivatives products can be designed. We believe the following should be top of mind for anyone working to develop markets / products. Segmented below are considerations around:

- Market structure: This section covers considerations around blockspace / gas market participants, whether price makers can effectively hedge, potential consolidation of buyers, reference rate design, regulation, and some miscellaneous items
- Protocol / roadmap: This section covers considerations around multi-dimensional spot gas markets, heterogeneity of blockspace, miscellaneous items, and potential future roadmap items
- Cash vs physically settled: Defines cash versus physical settlement and a discussion on a few design potentials for physically settled blockspace

Market Structure

Blockspace / gas market participants:

In any market such as this, there are price takers and price makers:

- Price takers

have a need to interact with the market to manage the risk in their businesses. To go back to oil markets, these are both producers of oil and the subsequent supply chain players involved in refining or commercial use cases of oil. Similarly, in a gas derivatives market, there are validators supplying blockspace, but then subsequently developers / users of applications that require blockspace.[4] Stakeholders may want to secure fixed revenue for blockspace in advance, while applications / wallets may want to secure a predictable fixed cost for their future blockspace demand.[5] These players ultimately desire a means of avoiding exposure to the dynamic price changes in the spot market but form two opposing sides:

- Short:

A party commits to selling blockspace in the future at a currently agreed upon price. This side is exposed to the risk of selling future blockspace too cheaply

- Long:

A party commits to buy blockspace at a currently agreed upon fixed price in the future. This side is exposed to the risk of paying too much for future blockspace

- Price makers

are market participants who speculate and take pricing risk. In traditional markets, these roles are played by market-making desks at banks, asset managers, high-frequency trading entities, etc. These participants are crucial to creating more liquid and efficient markets. In the gas market, we see this role being played by digital asset market makers, investment firms, and in the long-run (like how oil producers have their own trading operations), validators themselves. Currently, however, the market does not have sufficient price makers, largely due to the inability to hedge blockspace risk with no liquid spot market

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paying too much for future blockspace

Price makers can't effectively hedge:

The auction mechanism that drives the base fee of blockspace can potentially be manipulated (particularly in the

shorter-term

), and the tip can be uncapped.[6] As seen below, the average gas price is volatile, and if observed on a block-by-block basis is considerably volatile.

These factors create significant risk for price makers who leave themselves exposed to the uncapped variable costs for blockspace. Some of this can be handled by smoothening the variable blockspace cost via a time-based index (reducing the impact of one-off spikes in cost on the reference rate) or by using alternative investment products that cap losses / gains. However, these approaches have trade-offs as they may not meet the needs of the sellers / buyers and generally decay the hedge effectiveness of the derivative for both the long / short. Given this, we expect validators, block builders, and searchers to play a role in initially seeding the short side of the market given their natural supply or access to physical blockspace, existing capabilities around optimizing and using the supply of blockspace, and experience around managing blockspace risk.

Consolidation of buyers:

With the development of L2s and likely shift of most users accessing blockspace via roll-ups / not the L1, we expect there to be a consolidation of buyers of L1 blockspace via L2 operators / those finalizing L2 transactions on L1. Outside of L2s we expect further consolidation of blockspace buyers to shift to infrastructure and actors who abstract users from purchasing blockspace such as block builders / AA / MPC + middleware. Designing a product for these stakeholders instead of individual consumers with widely varying goals and needs should help narrow product design.

Reference rate design:

If a product is cash settled, the reference rate is a critical design feature for the market to flourish. The design of this is a balance of the long / short's needs as well as the considerations of the protocol's underlying gas auction mechanisms. Any team building in the future will need to optimize this reference rate. Even just deciding whether the reference rate will be constructed on the base fee and tip will have trade-offs and impact the time-period used / a variety of other factors.[8]

Regulation:

Financial products such as derivatives (i.e., swaps, options and futures) are often highly regulated. For example, in the United States, the Commodity Futures Trading Commission is the primary regulator responsible for oversight of most commodity-based derivatives when offered, accessed by, or sold to "U.S. Persons." If teams go down this path, they may be required to (i) comply with certain CFTC rules and (ii) register with the CFTC. Additionally, to the extent that products are offered outside of the United States, there are likely a number of other regulatory regimes that will need to be complied with. Lastly, the global regulatory environment for digital asset derivatives is highly uncertain and in many jurisdictions, there is a lack of a clear framework and guidance around the legal treatment, regulation, and classification of digital assets and market participants. As such, teams involved in building products – such as the Ethereum blockspace-linked derivatives – should seek out appropriate legal advice before offering any such products, whether in the United States or elsewhere.

Miscellaneous items:

There are also practical items that will need to be optimized for, including how these products will be settled (i.e., daily / month), how collateral will be managed, mark-to-market of the derivative for both settlement and collateral management, and the type of hedge each side of the trade is taking a view on (i.e., an insurance like product).

Protocol / Roadmap

Multi-dimensional spot gas markets:

For the first time in Ethereum's history, as part of EIP-4844 there will be a multi-dimensional fee market that creates two prices for Ethereum blockspace—one for data and one for execution. Both spot markets will use independent but similar pricing / auction mechanisms. However, given the difference in consumers and usage of data blockspace versus execution blockspace, there will likely be pricing variation between the two markets. Because of this, anyone designing a blockspace

derivative may need to take this into account and depending on how the spot markets develop post EIP-4844, may provide buyers / speculators and risk managers interesting hedging / trading opportunities across these two markets.[9] Furthermore, while very early, there have been references by researchers across the community about additional bifurcation of fee markets that will create additional

microstructures

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Heterogeneity of blockspace:

Not all blockspace is

homogeneous

. For instance, there is block congestion, which encompasses blockspace where users simply pay a fee for

inclusion

. Then there is contention, where users pay a fee to express the desire to be included in a

certain order

in the block. Given the behavior of the consumers across each of these microstructures, a derivative may need to take these dynamics into account or be designed for those specific participants. While it is difficult to estimate, we looked across quantitative and qualitative sources to understand where historical user preferences lay to help inform where the near and longer-term opportunities may exist.

In the above chart we can see that some users are willing to pay exponentially higher prices for top-of-block and back-of-block blockspace (i.e., for contention), but that a majority of users just pay to be included (i.e., congestion). A leading Ethereum Foundation researcher also

recently speculated

that a significant number of users prioritize congestion versus contention. While there is likely a near-term market related to contention, based on above and other

dynamics related to MEV

, we do expect that long-term the largest blockspace derivatives markets will be focused on congestion.

Miscellaneous items:

Beyond the above, there are additional considerations that may impact a derivatives market. These include forks and probabilistic finality, inclusion rate, and potential censoring by block builders and / or validators.

Further developments:

While likely a few years out, there will be further dynamics that impact blockspace and any derivatives products. Other than EIP-4844, we believe the most relevant and top of mind changes are

MEV-Burn

, any form of a validator cap / changes in staking economics [11],

Single Slot Finality

, and

ePBS

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Cash settled vs physical delivery

Gas derivatives could either be settled with “cash” or via “physical delivery.” More details are below, but cash settled products generally cannot perfectly replicate the deliverable spot markets as they offer synthetic exposure to the commodity, typically based on a reference rate. Because of this, the existence of mechanisms for derivatives with physical delivery settlement is critical to ensure that wider derivatives markets on blockspace accurately reflect the deliverable spot market conditions.

Physical delivery

: Physical delivery in Ethereum blockspace (and really any commodity market) is more complex when compared to cash markets. At expiration of the derivative, the two sides of any such derivative must physically settle the good. In the case of validators trading with applications, this would entail the validator providing blockspace to the buyer. We discuss a few potential means for physical delivery of blockspace below:

- Block builders offer this as a service: As previously

written about

, as block building likely continues to be dominated by a few actors due to the economies of scale and technical requirements around full dank sharding, these actors are well-positioned to be active in these markets. Block builders are clearly natural buyers / sellers of blockspace (after all they are in the business of managing / optimizing blockspace) and could also run services for applications / consumers of blockspace to provide physical delivery of blockspace

- Validators coordinate / middleware: In addition to block builders, validators are prime stakeholders in the blockspace physical delivery market. This will be driven by a desire to help manage volatile revenue currently across the validation business and allow for a new market to develop where validators could sell future blockspace to capture the premium. To execute on this, validators will need to come together and leverage a middleware as a coordination mechanism[12]

- In-protocol selling future blockspace: While this requires significant protocol changes, there have been

others

who have contemplated in-protocol mechanisms to sell future blockspace, some precedent from other networks [13] who have discussed designs, research posts by folks such as Vitalik on

inclusions lists

, Barnabe Monnot / Ma around initial PBS research [14], and Alex Stokes on

soft pre-confirms

. We have also seen a few teams try and leverage smart contracts and OTC style trading to get

proof of concepts

in Ethereum’s testnet. Last, other POS chains have

contemplated

integrating and embracing in-protocol blockspace futures to more efficiently allocate blockspace based on needs from the consumer

Wen blockspace derivatives

We recognize that attempts have been made at various hash rate derivatives around the Bitcoin network. There has been some growth in these markets, but it is still

currently limited

. While these markets could be ahead of their time, there are also market structure frictions around hash rate derivatives that do not exist in a potential Ethereum blockspace markets—the most important being a wider range of natural market

participants, increasing the likelihood of growth in a liquid, two-sided market. Nevertheless, we simultaneously acknowledge that it is early. After all, the volumes of futures in the more established ETH market are still dwarfed by derivatives volumes of traditional commodity markets. Furthermore, for this market to flourish, actors such as block builders, validators, and applications will need to become more sophisticated with competition across these parties becoming so fierce that teams leverage these products for a competitive edge over one another or can offer a one-of-a-kind product[15] that relies heavily on a managing future blockspace. Even with this timing in mind, we believe blockspace futures could have unique impact on Ethereum, helping stakeholders to better manage the frictions around gas and harden blockspace. We hope this post inspires a wave of discussions, tinkering by developers, some hackathon projects(!), and innovation to come over the next decade.

Disclosures and references

[1] Spot market refers to the cash or physical markets (i.e., non-derivatives market).

[2] Readers can find more details about the auction mechanism in Tim Roughgarden's paper:

https://timroughgarden.org/papers/eip1559.pdf

[3] Prior to the London Fork, gas token did allow indirect gas exposure, but did not facilitate direct exposure since it capped gas refunds at 50%, limiting user's ability to capture full gas savings if gas prices fell.

[4] For more discussion, please see Julian Ma's post

https://mirror.xyz/0x03c29504CEcCa30B93FF5774183a1358D41fbeB1/WKa3GFC03uY34d2MufTyD0c595xVRUEZi9RNG-dHNKs

[5] We note that there are nuances to this that any stakeholders (i.e., validators) and any product will need to consider given the burn of the base fee.

[6] As highlighted in

Structuring Blockspace Derivatives

by Julian Ma, "...if a block is larger than the target block size, the base fee increases. It decreases if the block size is smaller than the target. A block builder has full control over how large to make the block, hence if it is profitable, builders will manipulate the size of the block and increase or decrease the base fee in the next block." While the block builder can supply an empty or smaller than target block, any user can also manipulate the base fee by artificially increasing demand.

[7]

https://etherscan.io/chart/gasprice

: We note that this is the average gas price, but if you look at the minimum and maximum gas price there are significant spikes showing derivatives could be used to hedge this volatility.

[8] White paper discussing reference rate design.

https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4123018

[9] This is similar to how oil trades in the markets today.

[10] Data averaged over Q1 2023.

https://github.com/ankitchiplunkar/crypto_charts/blob/master/notebooks/Congestion vs Contention.ipynb

[11]

https://twitter.com/DrewVdW/status/1654275946122297344?cxt=HHwWgIC-karNlfUtAAAA

and

https://ethresear.ch/t/increase-the-max-effective-balance-a-modest-proposal/15801

[12]

https://forums.manifoldfinance.com/t/better-eth-better-blockspace-pt2/495#resource-bound-markets-block-building-4

and

https://youtu.be/zTPKnKsfxek

[13] Some conversation in this

https://twitter.com/i/spaces/1vOxwMOAMooGB

and more details in this

https://www.youtube.com/watch?v=P0CNA_zryBc

[14]

https://barnabe.substack.com/p/pbs

and

https://mirror.xyz/0x03c29504CEcCa30B93FF5774183a1358D41fbeB1/CPYI91s98cp9zKFkanKs_qotYzw09kWvouaAa9GXBrQ

[15] Some interesting product ideas / trade-offs presented by Julian Ma:

https://www.youtube.com/live/ymVd2Ch7wBc?feature=share&t=13022