Crypto Index Plus

Narwhal GmbH

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(1) Introduction

(1.1) Narwhal

Narwhal GmbH is a quantitative investment product company working in decentralized financial systems, dedicated to producing exceptional investment products for its clients by strictly adhering to mathematical and statistical methods.

At Narwhal GmbH, we apply the vast array of quantitative tools built for classical finance, to the novel space of DeFi and cryptocurrency more generally. Our proprietary methods for modelling risk and returns in blockchain assets incorporate both the tried-and-true fundamentals of classical statistics and machine learning, with the most prominent contemporary methods and research in the digital asset space. We are actively researching new methods in Automated Market Makers (AMMs), Constant Function Marketplaces, applications of classical methods to DeFi systems, modelling stable-assets, blockchain process automation and more.

(1.2) Crypto Index Plus

Crypto Index Plus is a crypto-asset product, diversified across Layer 1 and Layer 2 blockchains. Contrary to its peers, *Crypto Index Plus* leverages on-chain data to make better predictions about price volatility and movement in the crypto-asset universe. *Crypto Index Plus* generates returns consistent with the broader crypto space, while eliminating counterparty risk by keeping assets on-chain, as opposed to keeping assets with a centralized custodial exchange. Profits are further compounded by staking in proof-of-stake consensus protocols. Crypto Index Plus focuses on safety, quantitative accuracy, quick reactivity, and technical reliability.

The objective of *Crypto Index Plus* is to apply the vast array of on-chain and proprietary datasets available, to the crypto-asset universe, while staking assets and eliminating custodial counterparty risk. Until now, there have existed no crypto-asset indices that use the vast available on-chain and off-chain datasets to understand and model the flow of value, value creation, or other key indicators of price movement. Additionally, currently available indices expose investors to hidden counterparty risk via their custodial exchange. Crypto Index Plus maintains secure custody of assets on-chain (via Multi-Party Computation, or MPC, technology), thereby leveraging the true power of blockchain to eliminate this hidden risk.

(1.3) Motivation

Digital assets have proven to be an excellent investment for generating high returns over a long period of time. Holders (or "hodlers") of digital assets have seen hundreds to thousands of percentage point increases to their digital-asset portfolio values over the last decade. However, the barrier to entry to this asset class, in terms of technological understanding and understanding of risk for example, is comparatively high. Additionally, digital assets are not monolithic: there exist a multitude of digital crypto-assets, that may be used on myriad blockchains, blockchain applications (dapps), and crypto-asset exchanges. The consensus mechanisms, global supplies and use cases for these crypto-assets vary widely across the ecosystem, with each potential investment requiring separate analysis to understand the network and protocol specific risks, and potential returns.

Market-level indices are a simple way to overcome these barriers for both sophisticated investors, and investors completely new to this asset class.

As of the date of this writing, there are no available market indices which fully leverage the power of blockchain technology in order to maximize returns, and minimize risk for investors. To account for this need, we present *Crypto Index Plus*.

The major problems with currently available crypto-market indices include:

- Nearly all available indices follow a market-capitalization based weighting scheme.
- Nearly all available indices subject their investors to inflation by abstaining from staking.
- Nearly all avaialble indices subject their investors to major custodial counterparty risk, by storing assets off-chain with a 3rd party custodian.

Despite the fact that fundamentals-based indices have historically outperformed market-cap weighted indices, the majority of indices built from crypto-assets (for instance: SEBAX from Seba Bank, MOON from Sygnum, and HODL from 21 Shares) use a market-capitalization-based weighting scheme to calculate the portfolio weights of their index. In general, this method is inherently reactive, and closely follows the market average by design. The vast majority of the total market capitalization of the crypto asset class, resides in Bitcoin and Ethereum. Therefore, the majority of market-cap-weighted indices closely follow the price of Bitcoin and Ethereum, and thereby fail to realize the returns enjoyed by new projects who bring technological innovations to the ecosystem.

In this scheme, undervalued assets are underrepresented in the portfolio, and overvalued assets are overrepresented. This is by design, as market-cap weighting is reacting to the current market state.

Fundamentals-based indices, look at the "fundamentals" of an asset. In equity markets, this corresponds to things like revenue and liabilities of a company, while in the crypto market, this corresponds to things like total value locked (TVL) on-chain, distribution of wealth on-chain, on-chain transaction volume, diversity of DeFi smart contracts on-chain, and an array of other valuable metrics that can be extracted from raw blockchain data.

Because blockchains provide a public ledger of every transaction that has ever occurred since genesis, the feature-space of these models is comparatively massive. In equities, where stock prices roughly correspond to some simple function of revenue, profit, expenses, liabilities, etc. . . , fundamentals-based models can easily leverage a companies balance sheet to make price predictions, and subsequently outperform market benchmarks. In the digital asset space, we have at our disposal far more vast quantities of data, many of which is highly correlated, and not relating in a simple linear fashion. Elucidating complex non-linear relationships like this, is what machine learning algorithms were built for. This is why *Crypto Index Plus* has implemented modern machine learning architecture to derive our pricing models, and ultimately build a fundamentals-based index that outperforms its market-cap weighted peers.

The major contributions of *Crypto Index Plus* are:

- *Crypto Index Plus* performs due diligence on all assets considered for investment, with strict thresholds for systematic risk allowed in the portfolio.
- *Crypto Index Plus* prices assets based on fundamentals, an inherently forward-looking strategy.
- *Crypto Index Plus* rebalancing periods are dynamic, and computed via numerical optimization.
- *Crypto Index Plus* stakes assets (with AML compliant validators) compounding returns for investors, resulting in a 4 to 8 percent per year performance boost compared with its peers.
- *Crypto Index Plus* implements on-chain execution and settlement, taking advantage of the zero-counterparty-risk landscape of blockchain. Products with assets hosted on centralized exchanges do not enjoy such benefit.

(2) Fundamentals

Crypto Index Plus is an investment product with a focus on quantitative accuracy, quick reactivity, and technical reliability. *Crypto Index Plus* is the first true bankable index of the crypto-asset space, leveraging the power of on-chain data and proprietary off-chain datasets, to protect investors and capitalize on market opportunities.

(2.1) General Definitions

Prospective Assets is the name of the database we maintain, which contains data on all potential investments we would like to consider in the optimization procedure. This list is maintained by Narwhal GmbH and our contracted *industry partners.*

Crypto-Assets, *Digital Assets* & *Cryptocurrencies* are digital currencies in which transactions are verified and records maintained by a decentralized system using cryptography on blockchains, rather than by a centralized authority.

Data Sources refers to our list of data service providers. For a non-exhaustive list please see our technical documentation.

Custodian refers to an exchange or brokerage platform, tasked with safeguarding funds and facilitating trades for an investment product.

Industry Partners refers to our officially-contracted industry and academic collaborators. These collaborators are not partners in the legal sense, however we work together to facilitate development of our products. For a non-exhaustive overview of our *industry partners* please see our website

underlying asset distribution is the distribution of holdings of digital assets, retrieved from the rebalancing optimization procedure discussed in section (3.2). This underlying asset distribution can be found at any time on our website.

Investments in the context of this document refers to digital crypto-assets which are held in cold storage by Narwhal GmbH and / or our industry partners.

DeFi, or Decentralized Finance, is a set of protocols on blockchains, that attempt to replicate and automate the functions of classical financial institutions and banks, thereby removing a massive intermediary from the process of storing, transacting with, and investing digital assets. By removing the cost of operation for these middlemen, users of DeFi protocols naturally achieve greater returns, corresponding with increased capital efficiency.

Total Value Locked (TVL) in the context of this document refers to the US dollar value of all assets locked in DeFi protocols on a specific blockchain.

For further information regarding these definitions, please see our research page where you can find a non-exhaustive list of contemporary research in DeFi markets.

(2.2) Fee Structure

Crypto Index Plus charges a 2.5% p.a. management fee. This fee pays for (among other things):

- 4 to 8 percent boost in returns, per year, from staking assets alone, when compared against peers
- Worldclass Multi-Party Computation private-key security implementation
- Due diligence procedure on each asset present in the underlying holdings
- Fully automated rebalancing execution
- Best-in-class live smart-contract monitoring and protection for each proof-of-stake consensus protocol
- Live dataset generation ($>$ 1,000 features scraped live from $>$ 16 blockchains)
- Best-in-class model generation for digital-asset returns
- Numerical optimization of returns and volatility

(2.3) Universe Selection

Assets must meet the following critereon in order to be included in the universe of *prospective investments.*

- The asset must be sufficiently liquid (relative to the market cap of *Crypto Index Plus*)
- The asset must correspond with a Layer 1 or Layer 2 blockchain which makes some novel technological contribution to the blockchain ecosystem.
- The asset must meet our threshold for systematic risk tolerance, outlined in section 3.3

(2.4) Historical Performance

Fundamentals-based indices have been shown to vastly outperform market-cap weighted indices in classic equity markets. This can be attributed, in part, to the difference in paradigms. While fundamentals-based indices are inherently predictive, setting portfolio weights based on principles of the efficient market, market-cap weighted indices are inherently reactive, setting portfolio weights based on the current trading value.

Given that each blockchain provides us with a perfect history of transactions, this is the ideal environment to apply principles of fundamentals-based indexing. This is one major contribution of Crypto Index Plus.

Many on-chain metrics are used to facilitate the calculation of portfolio weights, including Total Value Locked (or TVL), Transaction Volume, inflow and outflow from centralized exchanges, and more. Measuring these statistics, and using them to model the expected returns of an asset can immediately improve the overall performance of Crypto Index Plus (in terms of Sharpe Ratio, Daily σ, Value at Risk and Average Daily Return, shown below). All of the metrics shown in this section are computed using the last 2 years of daily data price data. Below you will find backtested historical performance over the last 2 years. These are not live trading results. For live trading results, see section (2.5).

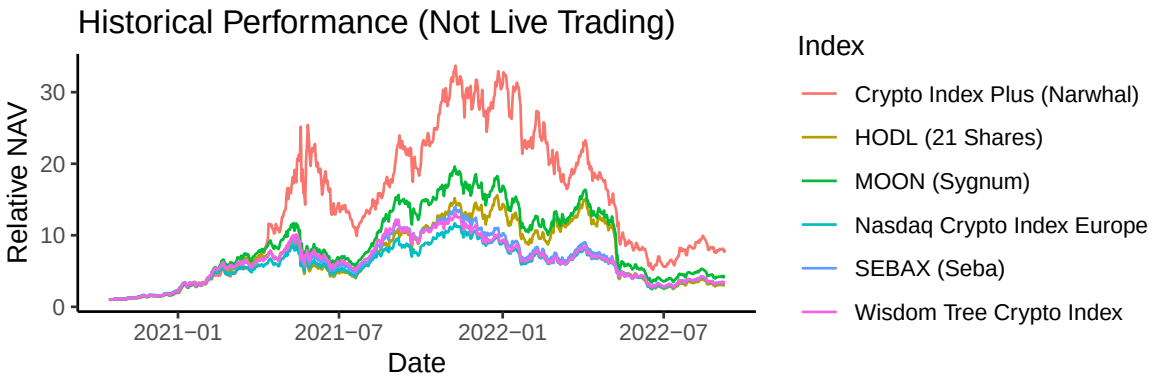


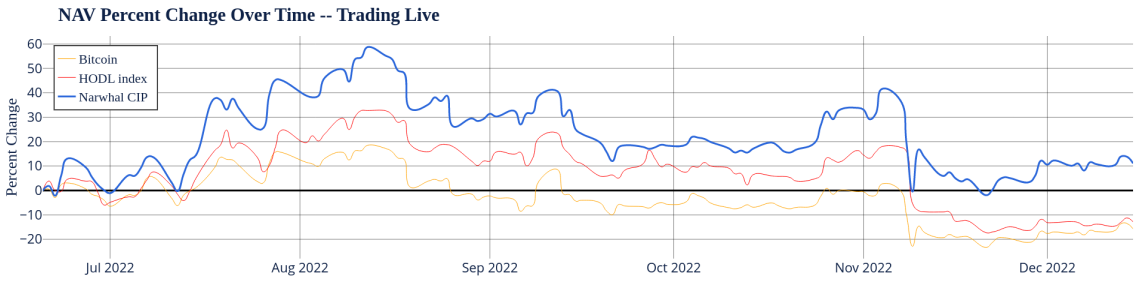
Table 1: Statistics

	Narwhal	MOON	HODL	NCE	SEBAX	WisdomTree
Sharpe Ratio	2.0741	1.0339	0.9222	0.8885	0.9087	0.9099
Daily σ	0.0583	0.0580	0.0576	0.0528	0.0542	0.0540
0.1% Value at Risk	-0.2710	-0.4376	-0.4238	-0.3921	-0.4065	-0.3998
Average Daily Return	0.0048	0.0023	0.0020	0.0018	0.0019	0.0019

Over this 2 year period, our Sharpe Ratio is nearly greater than 2 times that of the nearest index, σ of daily percent change is in line with our peers, we have the lowest 0.1% Value at Risk, as well as an Average Daily Return, twice that of the nearest other index. It is clear that the use of on chain data, and subsequent modelling, allows us to more accurately preempt the movement of asset prices in the crypto space.

(2.5) Live Trading Results

For an up-to-date chart of live trading results from Crypto Index Plus, you may check www.narwhal.ch/our-products/ any time. The chart below has been pulled from this webpage on December 15th, 2022. It should be noted that NAV live trading values from before the issuance date of Crypto Index Plus AMC, come from our private wallets where Narwhal has been prop-trading this strategy since November of 2021.



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(3) Portfolio Optimization

(3.1) Investments Overview

Crypto Index Plus is an investment product, built out of portfolios of digital crypto-assets. Regular portfolio rebalancing ensures minimal exposure to any single blockchain, protocol and investment, and ensures that *Crypto Index Plus* can capitalize on potentially short-lived opportunities in the market. Pricing regime in the overall crypto-asset market is well modeled by our pricing models (covered in section (3.2)). Regular rebalancing helps us to capitalize on trends and maximize realized returns.

(3.2) Rebalancing Overview

Weights $\vec{\omega}$ are calculated via the following procedure, for each asset i:

- X_i, a matrix of features on the ith asset, is pulled from our Data Sources (the contents of which is left generalized to protect trade secrets).
- $D(X_i)$, a proprietary function, is a dimensionality-reduced funtion of X_i, used to reduce our feature space, with little information loss.
- $f(D(X_i), \vec{\beta}_i)$ yields a single value, scoring the ith asset for the next rebalance event.
- Scores for asset i are stored in the ith position of a vector $\vec{s}$ which is then normalized to 1 to generate ω (i.e. $\frac{1}{sum(\vec{s})} \cdot \vec{s} = \vec{\omega}$)

Notes:

- f is a non-linear function of a reduced feature space $D(\vec{X})$, parameterized by $\vec{\beta}_i$, a unique set of parameters for each asset, which are regularly updated as the model is trained (on a minutely basis)

(3.3) Risk Assessment and Due Diligence

This procedure serves to document the due diligence process implemented by Narwhal GmbH during the development of our products, and the generation of our research. This process is specifically designed to protect investors from multiple points of risk inherent to investing in the novel asset class of cryptoassets.

Each underlying asset and network protocol is investigated before investment. For digital assets, the diligence procedure includes points on the following topics:

Overview of the scope, history and native blockchain of the underlying asset:

The purpose of this diligence point is to discern the use and purpose of the asset in question. Although there are various utilities for cryptoassets, they generally fall into one of the following categories:

- Native payment asset for a Layer 1 or Layer 2 blockchain (example: Ethereum / ETH)
- Native payment asset for a network protocol (example: The Graph / GRT)
- Native reward asset for a network protocol (example: Saber / SBR)
- A purely speculative asset, or "meme token" (example: Dogelon Mars / ELON)

The central thesis of Crypto Index Plus relies on the relationship between the price and the utility of digital assets, and therefore we avoid investing in native reward assets with high inflation rates and frequent minting schedules, and abstain completely from investing in purely speculative assets with no major utility or technological contribution.

Global and Specific Market Liquidity

Here we investigate the Global and specific market liquidity of the asset in question, in order to assess the liquidity risk that investors may expect to sustain upon asset exposure. For global market liquidity, the Amihud Estimator is used to assess risk. We except those assets whose Amihud Estimator falls within the top 25 of all major assets within its class. For cryptoasset classes with generally high liquidity risk, a threshold value of 30 is used to disqualify particularly illiquid assets.

For marketplace specific liqudity, we assess relevant estimators for the specific marketplace hosted by the instrument-specific custodian. These values vary from custodian to custodian, therefore these values are rarely reported in our asset-specific due diligence reports.

Total market capitalization

Here, overall market capitalization is used to qualify cryptoassets for investment within our products. Top 30 assets by overall market cap (per class) are heuristically accepted for investment.

Total value locked in native network (DeFi) protocols

Here we assess the total US Dollar value of digital assets locked in associated DeFi protocols. This is in general a good proxy for understanding the utility of digital assets, and has been shown in many cases to be positively correlated with cryptoasset price.

The distribution of Algorithmic, Fiat-Backed, and Crypto-Backed Stablecoins

Here we assess the distribution of on-chain stablecoin distributions locked in an assets associated protocol or blockchain, depending on the cryptoasset class of the asset in question. In general, we do not accept payment assets for protocols or networks with greater than 40% of their on-chain or on-protocol stablecoin liquidity coming from algorithmic stablecoins. Although the algorithmic stalbeocin debate is still very much alive, thus far, no algorithmic stablecoin has survived the test of time. In many cases, large quantities of stablecoin liquidity being dervied from algorithmic stablecoins has been shown to produce extreme price volatility events (particularly downward) for the assets associated with their host network or protocol.

Tokenomics such as minting rate, adoption rate, stock to flow ratio etc...

Here, we assess the various token-specific economic features. We require that for Layer 1 and Layer 2 native payment assets, that the minting rate should be less than 10% per year, or lower than the

current rate of adoption, in order to qualify for inclusion in our investment products. This is done to protect investors from major inflation events which have been shown to occur within frequent and large issuance / minting scheduling pardigms.

Distribution of assets between top holders, Gini coefficient, etc..

Here we assess the physical distribution of assets across wallets for a particular asset. Although wealth distributions in cryptoassets are quite stark in general, we require that the top 1% of all addresses hold less than 99.8% of all network assets for proof of stake systems, and make no requirement for proof of work systems. This is because on-chain assets are not necessary in proof of work to excecute a 51% attack, which is the network-specific risk a requirement here protects against. In general, cryptoassets have very high Gini coefficients, and holders of digital assets should always understand the risks involved with investing in such systems.

Minting Schedule (where applicable)

Here we note the minting schedule, and refer to the requirements outlined in the tokenomics section for deciding on inclusion in an investment portfolio.

Contract and Protocol Safety

The importance of contract safety cannot be overstated when assessing network and protocol inherent risks associated with a cryptoasset investment. To quantify contract characteristics into a rigorous system of evaluation is neither trivial nor arbitrary. This system of evaluation has been designed to protect investors from both network and protocol specific risks, inherent to cryptoasset investments. It is in this section that the qualitative features of a protocol or network associated with a cryptoasset, and how they pertain to our evaluation system, are discussed. Below are the list of characteristics that are used to evaluate, and ultimately score, the blockchain networks and network protocols, associated with a potential underlying cryptoasset portfolio constituent.

For Protocol Payment Assets and Reward tokens:

- Visibility of smart contract addresses
- Activity of the primary contract
- Public accessability to software repository
- Publicly available development history
- Confirmed identity of developers / team
- Existence of Whitepaper
- Availability of software architecture documentation
- Coverage of software architecture documentation
- Cross-references between software architecture and its documentation
- Amount of testing done on deployed code
- Availability of unit test software / scripts
- Availability of protocol test results
- Formal Verification of protocol
- Deployment of smart contracts to a test net
- Sufficiency / availability of protocol audits
- Size of bug bounty
- Public availability of information regarding admin controls
- Smart contract labelling (immuntable, upgradable, etc. . .)
- Indication of smart contract ownership
- Documentation of smart contract change capabilities

- Comprehensiveness of admin control documentation
- Sufficiency of pause control documentation
- Sufficiency of timelock documentation
- Length of timelock
- Documentation of protocol's oracle
- Mitigation of front-running
- Mitigation of flash-loan attacks (where relevant)

For Blockchain Payment Assets:

- The number of nodes executing software on the network
- What percent of network nodes are archiving the full chain
- Geographic distribution of execution nodes
- Accessability of becomming a node operator
- Accessability of node source code
- Number of node source code implementations
- Average amount of time to accept software changes and merge to main branch (applicable for open source implementations)
- Is archive node operation publicly available
- Comprehensiveness of block explorer
- Comprehensiveness of whitepaper
- Existence of system specifications for node operation
- Comprehensiveness of existing system specification documentation
- Existence of cross-referencing between system specification documentation and system source code
- Amount of publicly available test results on deployed source code
- Total code coverage during publicly available test results
- Availability of unit testing scripts
- Availability of unit testing results
- Has the blockchain undergone Formal Verification
- Size of bug bounty
- Number of audits of node software

Categorical outcomes and quantitative (where possible) outcomes are used to evaluate the above points for the blockchain or protocol associated with each payment asset. These are then used as predictors of the probability of experiencing a "major security event" as characterized by several of our data service partners. This value is predicted by a Poisson model over the count of "major security events" associated with the respective blockchain, with the above blockchain characteristics used as exogeneous variables.

Blockchains with a predicted probability of 0.4 are accepted for potential investing. Protocols with a predicted probability of 0.8 are accepted for potential investing. This discrepency is justified by the fact that "major security events" on the network scale rarely result in total loss for investors, while protocol-level "major security events" often do.

(3.4) Emergency rebalancing

The following metrics are evaluated on 1-second intervals:

- anomalous transactions interacting with the assets underlying our investments
- stablecoin de-pegging events
- anomalous outflow from the protocols containing our investments
- anomalous outflow from the blockchains containing our investments

- smart contract updates
- anomalous interaction with smart-contracts

Any one of these events may trigger an "emergency rebalancing" procedure. This is executed in the same way as the standard re-balancing procedure however omitting the blockchains/platforms/assets in question, from the *Prospective Investments*

(3.5) Data Transparancy

All clients receive personal access to a dashboard, illustrating the Blockchain Distribution, Asset Distribution, Overall Fund Performance, Client Returns, Narwhal Returns, Fund Volatility, Expected Returns, Transaction Log pertaining to their individual investments. For clients invested in *Crypto Index Plus,* this dashboard can be found here

(4) Product Maintenance

The crypto-asset ecosystem is a rapidly emerging and mercurial field. New protocols, new research and new models emerge almost daily that may improve the performance of *Crypto Index Plus*. In order to maintain flexibility and follow emerging trends in the marketplace, we allow for regular product maintenance of *Crypto Index Plus*.

(4.1) Basic Maintenance

Updating of the list of *Prospective Investments* falls under the category of *Basic Maintenance*.

Basic Maintenance is logged on our website (here) as it occurs.

Regular rebalancing and emergency rebalancing are not considered maintenance. These events are logged and available at request.

(4.2) Major Maintenance

Major Maintenance consists of all other maintenance to the modified Markowitz optimization procedure, definitions of terms contained herein, this document, and all other changes that render *Crypto Index Plus* functionally distinct from a previous version of the product.

Major Maintenance is also logged on our website, found here.