Evai Technical Whitepaper

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Introduction

Founded in 2019, Evai Ratings and Research LLC has developed a cutting-edge crypto asset rating methodology designed to provide investors of all levels with an accessible and unbiased entry point to the emerging asset class. Our approach utilises Artificial Intelligence (AI) and features a portfolio of intuitive tools and analytical models, each contributing to a holistic investment experience.

Evai is a ratings agency built for the Web3 era of investment. We analyze and rate digital assets, offering clear and reliable guidance using models tailored to meet market demands. Our aim is to make the instruments that large funds use accessible and understandable for individual investors. Ultimately, Evai's ratings are designed to be a trusted resource and a universally accepted method for evaluating digital assets

After four years of development, Evai has released the 2.0 version of our platform, featuring comprehensive ratings of cryptocurrency assets. In adopting the traditional rating nomenclature - AAA, AA, A, etc. - we align with familiar market standards, making our analyses instantly recognizable and accessible. Our system undertakes a rigorous analysis of assets on an hourly basis, with updates reflected in the "Position" section, showcasing the degree to which an asset has ascended or descended since the last evaluation. This feature is pivotal for identifying Outliers, assets that demonstrate significant movements either upwards or downwards throughout the day. These fluctuations could stem from various factors, including liquidity or security issues, return on investment (ROI), and more. Importantly, any asset experiencing such notable changes is automatically placed on a 24-hour Watchlist, providing users with the opportunity to conduct a detailed analysis and make informed decisions about these assets.

Our Rating Model transcends traditional ratings by offering a dynamic, in-depth analysis that effectively supersedes the need for a large analytical department. Users gain access to ready-to-use, hourly updated analyses covering the entire cryptocurrency market, a significant advancement in making informed investment decisions more accessible.

Ensuring the ratings are available to retail investors, institutions and crypto exchanges, we have created the Evai Crypto Ratings API, which will allow for increased adaption of our technology. This tool is especially beneficial for institutions seeking a robust and powerful analytical instrument. The Ratings API stands as a testament to our commitment to delivering cutting-edge, valuable resources to the broader financial and cryptocurrency communities.

Furthermore, we are excited to introduce the Evai Efficient Frontier is a cutting-edge analytical tool designed to optimize cryptocurrency investment strategies by identifying the best possible balance between risk and return. Leveraging advanced Evai Ratings AI algorithms and real-time market data, it helps investors construct diversified portfolios that aim to maximize returns for a given level of risk, drawing upon the principles of modern portfolio theory adapted for the crypto market.

In the following sections, we delve into the intricacies of the Evai Crypto Ratings model and Efficient Frontier model, showcasing its capacity to redefine market analysis. This model excels in identifying the most promising investment opportunities by selecting standout assets from our comprehensive ratings.

The role of the EV token within the Evai Ratings Ecosystem

At the core of our ecosystem and vibrant community is the EV token, which has experienced significant evolution since its launch. Evai embarked on its journey with the release of its token on April 14th, 2022, marking a significant milestone in the company's history. Detailed transaction history and token information are publicly accessible on BSC Scan here. Since the inception of our token, our commitment to innovation and excellence has been unwavering. This period has been instrumental in allowing us, with the invaluable support of our community, to develop a sophisticated Artificial Intelligence-based crypto ratings model. This model stands out by its ability to analyze the entire crypto market in real-time, offering groundbreaking insights into the dynamic world of cryptocurrency.

Initially introduced on the Binance Smart Chain (BSC), the EV token was initially crafted to streamline transactions within the Evai platform, serving as a fundamental utility token. However, as the cryptocurrency market has evolved and our platform has expanded, the role and functionality of the EV token has also advanced.

In this strategic phase, we have decided to migrate from the Binance Smart Chain to Solana. This move to SOL capitalizes on Solana's advanced transaction speed and reduced fees, aiming to significantly improve user experience and extend our platform's offerings. This transition is more than just a technical upgrade it's a testament to our unwavering commitment to innovation and excellence.

Q2 2024 marks a new era of utility for the EV token as users will be able to pay for all Evai products using the native token. This enhancement not only augments the token's utility but also aligns with our vision of creating a more integrated and user-centric platform. By facilitating payments with the EV token, we're empowering our users with greater flexibility and reinforcing the token's value within the Evai ecosystem. The implementation of the EV referral program is ready to reward our users with EV tokens for inviting new users to the platform, fostering growth and engagement within our community.

Building upon the groundbreaking capabilities of the Evai AI Rating Model and Efficient Frontier Solution, our vision extends to the trading fund with efficient frontier and buy and burn model. This strategic plan is designed to harness the full potential of our technological advancements, thereby offering our users an unprecedented opportunity to participate directly in the success of the Evai Efficient Frontier Fund.

Evai token unlocking access to the Evai Efficient Frontier Fund

Evai is embarking on a token sale in Q2 2024 aimed at raising capital to further the development and expansion of its offerings. A portion of the funds raised from this sale will be allocated to the Evai Efficient Frontier Fund. This fund will operationalize Evai's proprietary trading signals derived from the

Efficient Frontier model to engage in strategic trading activities within the cryptocurrency market. The profits generated from the trading activities of the Evai Efficient Frontier Fund will be distributed in a threefold manner:

- Company Profit: A predetermined percentage of the trading profits will contribute directly to Evai's operational profitability, supporting the company's growth, development, and the continuous improvement of its products and services.
- Fund Reinforcement: To ensure the sustainability and resilience of the Evai Efficient Frontier Fund, a portion of the profits will be reinvested into the fund. This reinvestment strategy is designed to cover potential drawdowns and to facilitate further fund development, allowing for more significant and strategic trading operations.
- Token Buyback: The remainder of the trading profits will be used by Evai to buy back EV tokens from the market. This buyback initiative serves to reduce the overall supply of EV tokens, potentially increasing their value and demonstrating Evai's commitment to its token and token holders.

The EV tokens purchased through the buyback program will be partially burned permanently removed from circulation, distributed between the loyal users and reinvested back into the Evai Efficient Frontier Fund. This action decreases the total supply of EV tokens. Adopting a buy back model underscores Evai's innovative approach to creating tangible value for its token holders. It reflects a forward-thinking strategy that not only seeks to enhance the token's market performance but also solidifies the relationship between Evai's operational success and its community's prosperity. Through this model, Evai is poised to set a new standard for its token economics described in further detail within the Evai Tokenomics Paper.

By participating in the Evai token sale, users are supporting the ongoing development and enhancement of the Evai platform and joining a collective mission to democratize access to advanced financial instruments for everyone. We are committed to providing tangible returns to our community, reflecting the performance and success of our Efficient Frontier Fund.

Evai Rating Model Introduction

As we venture into the dynamic era of Web3, the landscape of digital assets has expanded dramatically, presenting a myriad of investment opportunities. These assets, though valuable, are covered in a veil of uncertainty and complexity. For most users, navigating this new terrain is similar to charting unknown waters, where the risks and potential values of these assets are unclear and challenging to detect. This inherent uncertainty presents a dangerous obstacle in understanding and leveraging the true value and potential pitfalls associated with these digital assets.

The world of Web3, with its decentralized nature and innovative technology, created a radically different ecosystem in contrast to the traditional financial systems. Yet, it lacks the clarity and risk assessment frameworks necessary for users to make informed decisions. This gap in understanding and accessibility forms the core of the challenges that our methodology seeks to address.

In contrast to the opaque world of Web3, traditional financial sectors have long benefitted from the use of proprietary risk models. These sophisticated tools, however, remain largely exclusive to large hedge funds and institutional investors, creating a significant knowledge gap in the market. This disparity highlights a pressing need for more inclusive and accessible methodologies that democratize the understanding of digital asset risks and potentials. The average investor, often left in the dark, is in dire need of tools and frameworks that can level the playing field.

To address these challenges for the crypto assets universe, it is instructive to look at how similar issues have been tackled in the traditional financial world. The methodologies employed by major credit rating agencies like Standard & Poor's, Moody's Investors Service, and Fitch Ratings offer valuable insights. These agencies use ratings as a tool to assess the creditworthiness of an asset, providing a measurable indicator of default likelihood. While their approaches have their limitations, they offer a structured way to evaluate risk - a concept that is critically underdeveloped in the realm of Web3.

However, the application of these traditional rating systems to Web3 and crypto assets reveals significant shortcomings. The unique characteristics of crypto assets - such as their high volatility, technological complexities, and market dynamics - make traditional models ill-suited for this new landscape. Furthermore, the crypto market's inherent high inter-correlation and lack of tangible factors pose unique challenges that require a more nuanced and multidimensional approach to risk assessment.

Existing rating systems applied to Web3, such as On-chain Security Ratings and Weiss ratings, provide a good foundation. These models offer a glimpse into the potential of crypto asset evaluations but often fall short in addressing user needs, particularly in practical portfolio management applications.

At the core of the Web3 investment experience is the user's quest to balance risk and profitability within their capital constraints. Feedback from users predominantly centers around the need for guidance in applying these ratings effectively to build crypto portfolios. This highlights a gap between existing rating methodologies and the practical needs of users.

To bridge this gap, we propose a novel methodology: Nested Efficient Frontiers-based crypto ratings. This approach is designed to offer users an intuitive and practical tool to navigate the crypto asset universe. It represents a synthesis of traditional financial wisdom and the unique aspects of the Web3 world, providing a more comprehensive view of risk and return.

The nested Efficient Frontiers crypto ratings methodology is a practical framework. It is designed to empower users with actionable insights, enabling them to make informed decisions and construct portfolios that align with their risk appetite and investment goals.

The proposed and described in this document methodology is poised to transform the way investors approach Web3 assets. It offers a beacon of clarity in an otherwise opaque market, demystifying the complexities of crypto investments. As we delve into the specifics of this approach in the following pages, we aim to illuminate the path for investors, providing them with the tools and understanding necessary to navigate the evolving landscape of digital assets confidently.

This document is a practical guide, designed to be accessible and applicable for users ranging from seasoned investors to those new to the world of Web3. It describes in detail the proposed methodology, giving insights into the key moments as well as in-depth formula derivations for the main components of the approach.

Our goal is to redefine the paradigm of crypto asset ratings, making it an inclusive, insightful, and indispensable part of every investor's toolkit, publicly available for everyone, with the hope of it becoming the new industry standard.

What Is Asset Rating?

A rating is an assessment tool an analyst or rating agency assigns to a stock or bond. The rating assigned indicates the stock or bond's level of investment opportunity. Standard & Poor's, Moody's Investors Service, and Fitch Ratings are the three major rating agencies. While these agencies have equivalent rating grades (ranging from AAA to D for Standard & Poor's and Aaa to C for Moody's) most investors/regulators/analysts treat these ratings as the same, there are indeed subtle differences in what the credit ratings for the two agencies measure. Whereas S&P ratings are the agency's opinion on the likelihood or probability of default by a corporate or sovereign, Moody's ratings are based on expected losses, reflecting both on the likelihood of default and expected financial losses in the event of default (Loss Given Default)

It is generally accepted that AAA and AA-rated securities have a default risk of less than 1%, and the probability of default increases for each subsequent rating.

Known issues with existing rating approaches

1. Currently, ratings are manually assigned by people which is labor-intensive
2. Are subject to human bias within the decision-making process
3. Agencies do not give the exact % of default of the asset but rather assign the letter code, which has different connotations for each agency

Principles and Requirements for EVAI Crypto Rating Model

In this section, the main requirements for the new rating model are listed:

- Automated calculation of ratings on measurable factors without human bias is a must
- The new crypto rating shall be a useful indicator for selecting crypto assets for an investor's portfolio
- The crypto rating formula shall take into account the following factors:
    - How large is the Market cap of the asset - the bigger the capitalization of the market of the asset - the harder it is to move the price, therefore the better the rating shall be (the less slippage it has)
    - High Liquidity - the more liquid the asset - the better
    - How small is the Slippage (for different sizes of Investment) - the more one-time investment amount is needed to achieve a slippage of 1% - the better
    - Adjustable Risk level - each investor has a different risk perception, for one the less risky/volatile the asset - the better, and for another - vice versa. So if market **Volatility** is taken into account it shall reflect the risk levels of different investors.
    - Profitability - the higher the expectation of the asset return, the better. Assuming that not all returns can be predicted (as seen in pump&dump schemes), for this iteration of the formula we will use past performance for the previous period.
    - Interasset consistency - this means that the rating formula shall allow for the comparison of assets between each other, ranking them, so for any 2 assets it's possible to say which is better or equivalent.
    - The final rating rank shall be easily interpretable
- In the next versions of the Evai formula improvement, social, and other factors might be added like:
    - Social adoption (how big the community is) - still it will require measuring its strength, which for now we consider one of the factors of liquidity.
    - Security (Risk of smart contracts being hacked) - requires an audit of code. Not all assets have it available (scope for the next iteration of the formula).
    - Team and expertise (once again, we want a uniform formula, however we appreciate there are still some enigmas as we are unaware of the identity of Satoshi and his background).

- Periods and frequency of updates.

  It is possible to define a rating on any time resolution. Which one is the optimal and for whom?

- High frequency - sub-seconds, seconds and minutes resolution is good for high-frequency traders, but for the majority of the coins nothing interesting happens due to the absence of liquidity in such time frames, so high-frequency time resolution is not very significant.

- Low frequency - (days, weeks, months) - assuming that agencies give updates every 6 month which is explained by the cost of rebalancing investors' portfolios, as well as the effort needed to calculate ratings for the whole universe of assets, therefore, long-term rating metric is preferable.

Problem statement

- When defining a rating system - it is important to have in mind - what value it will have and for whom. Classical ratings - give the risk of default on the assets, giving investors a hint or a factor for their decision-making process to include this or that asset into their portfolio or not.

- From here, we can conclude that the final goal of the rating system in the crypto universe for the end-users is to help them combine their optimal portfolios.

The Goal:

Is to come up with such a ranking system where a higher-rated crypto asset will represent a better candidate for a user's optimal portfolio.

Evai Rating Definition

Evai Ratings v2.0 - is the automatic approach for ranking the crypto assets universe from AAA to D based on analyzing nested portfolios' (sub)efficient frontiers and determining risk-adjusted profitability scores weighted by the probability for each asset to be included in the optimal portfolio.

Evai Ratings Methodology

How to apply a portfolio management approach to ratings

From the perspective of the **Inter-asset consistency** principle, it is clear that for different assets to be comparable it is required to have a holistic view of the whole market. In Evai Rating V1.0, such a picture was obtained by ranking relative asset market cap and adding it into the formula as a new factor. It is a viable approach, but at the same time, it is heavily biased towards market capitalization.

In Evai Rating V2.0 to reach the declared goal, for each asset, we define the relative rating of this asset in comparison to the universe of all ratings as a risk-adjusted profitability score of the asset, weighted by the probability of this asset getting into the n-th (sub)efficient nested portfolio frontier.

Nested Efficient Frontiers

The main idea is that the assets from the universe that are located on the efficient frontier shall have the highest rank in comparison to all other assets.But, taking into account that for the majority of methods after applying optimization procedure, the efficient portfolio frontier holds only some of the assets, where the rest are excluded from the portfolio completely (due to being fully hidden under the current efficient frontier) it is needed somehow to rank the rest of the underlying assets that are not on the efficient frontier.

To resolve this, we iteratively remove assets from the current efficient frontier, uncovering new hidden layers (deeper sub-efficient frontiers), which gives us the possibility to rank the whole space of assets.

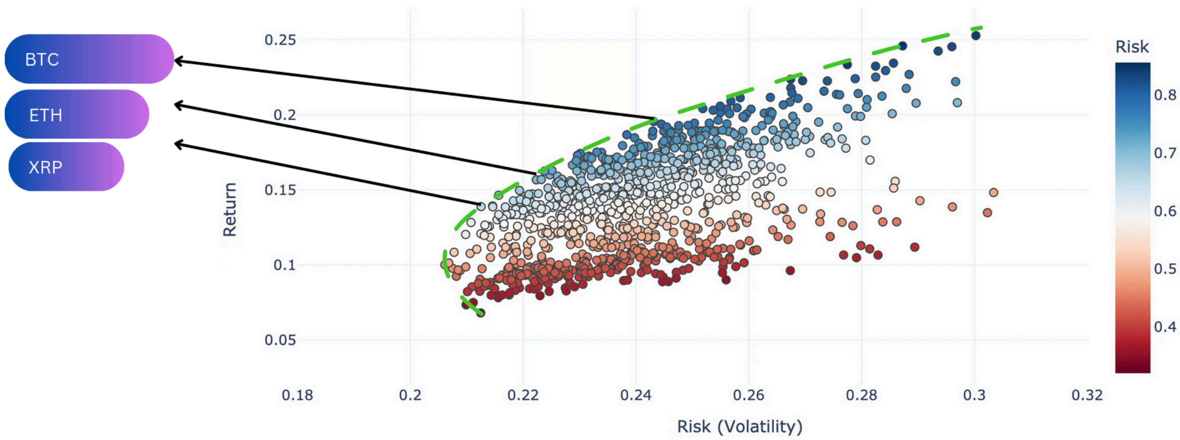

Figure 1. - Finding Top1 efficient frontier and retrieving the top coin from it

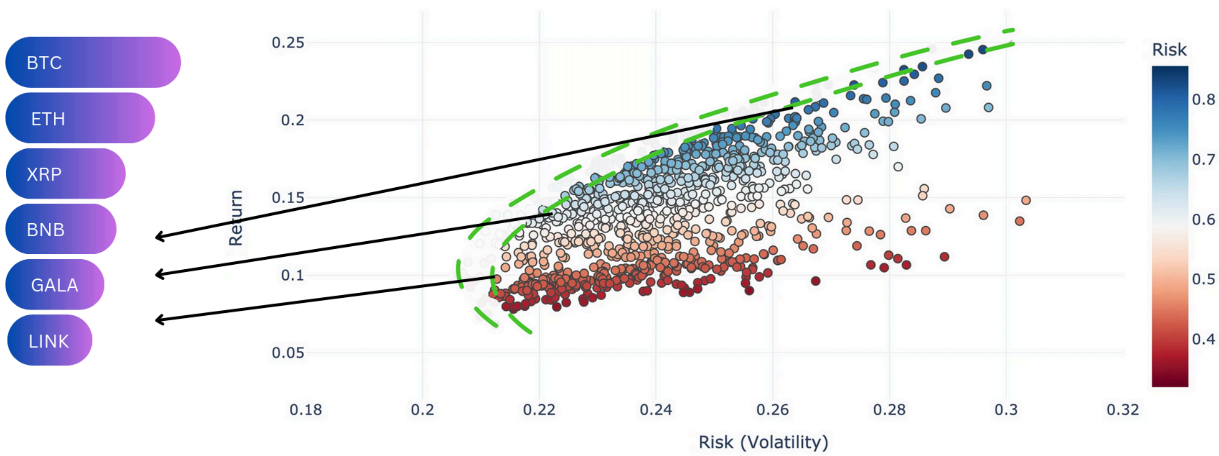

Figure 2. - Finding the next sub-efficient frontier and retrieving the top coin from it

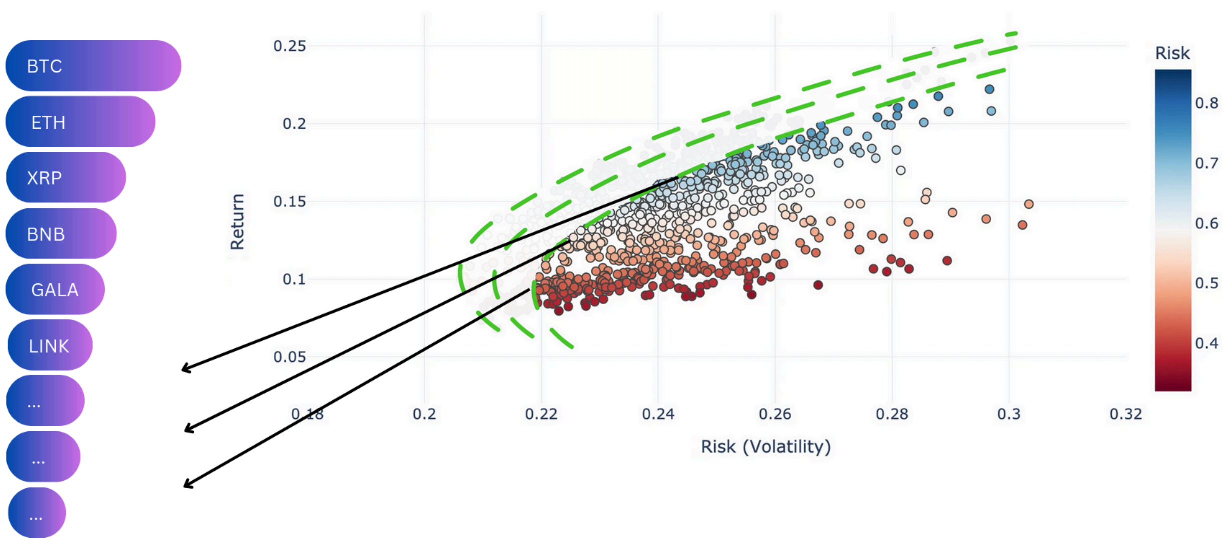

Figure 3. - Iterative continuation of finding the next sub-efficient frontiers and uncovering new hidden assets underneath, creating a ranked list of assets

It is assumed that all assets from superior frontiers that were excluded from the analysis are still present with a weight equal to 1 for all deep sub-efficient frontiers.

If the previous efficient frontier was removed, then any asset that was underneath it in any sub-efficient frontier, cannot have a higher rank than the assets from the previous (better) efficient frontier.

Optimal portfolio definition for crypto assets

Existing approaches to portfolio management

In the pursuit of effective investment strategies, financial theorists and practitioners have developed various models to construct portfolios that could withstand market vicissitudes while offering satisfactory returns. This chapter provides a historical overview of portfolio construction methodologies, setting the stage for the introduction of an innovative approach tailored to the complexities of the crypto asset space.

Modern Portfolio Theory (MPT)

The bedrock of portfolio construction is Modern Portfolio Theory (MPT), introduced by Harry Markowitz in the 1950s. MPT's core principle is diversification, premised on the idea that a mix of non-correlated assets can reduce risk without proportionately reducing expected returns. The optimal mix of these assets, known as the 'efficient frontier', is where the investor achieves the maximum expected return for a given level of risk.

The core formula of Modern Portfolio Theory (MPT) revolves around the optimization of a portfolio's expected return and its variance (or standard deviation), which represents risk. The expected return of the portfolio is calculated as a weighted sum of the individual assets' returns, while the risk is measured by the portfolio's variance or standard deviation. The basic formulas for these two components are:

1. **Expected Return of Portfolio**

$$E(R_p) = \sum_{i=1}^{n} w_i \, E(R_i)$$

where:

- $E(R_p)$ – is the expected return on the portfolio,
- w_i – is the weight of the ith asset in the portfolio,
- $E(R_i)$– is the expected return of the ith asset,
- **n** is the number of assets in the portfolio.

2. **Variance of Portfolio σ_p^2 or Standard Deviation σ_p:**

$$\sigma_p^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j \sigma_{ij}$$

where:

- σ_p^2 - is the variance of the portfolio's return,
- w_i, w_j are the weights of the ith and jth assets in the portfolio,
- σ_{ij} is the covariance between the returns of the ith and jth assets.

These two calculations form the basis of the efficient frontier concept in MPT, which is a graphical representation of optimal portfolios that offer the highest expected return for a defined level of risk or the lowest risk for a given level of expected return. The optimal portfolios that lie on the efficient frontier are those where the investor cannot reduce risk without reducing expected return, or cannot increase expected return without increasing risk, which is the essence of MPT's risk-return tradeoff.

Kelly Criterion

A notable extension of MPT is the Kelly Criterion, a formula used to determine the optimal size of a series of bets to maximize wealth over the long run. When applied to classical optimal stock portfolio selection, the Kelly Criterion can be used. It reduces the optimization problem to quadratic programming, providing an elegant and practical solution for investment decisions. The unconstrained solution would be:

$$u = (1 + r)(\hat{\Sigma}) - 1(\hat{\vec{r}} - r)$$

where $\hat{\vec{r}}$ and $\hat{\Sigma}$ are the vector of means and the matrix of second mixed noncentral moments of the excess returns. There is also a numerical algorithm for the fractional Kelly strategies and for the optimal solution under no leverage and no short-selling constraints.*

Drawbacks of existing portfolio theories

- Portfolio management is usually driven by two major factors - risk and profitability and its goal is to select a specific set of uncorrelated assets that have maximum profitability under acceptable risk.
- The problem with crypto assets is that they all are highly correlated and super volatile, moreover the expectations and risk tolerance of crypto investors are quite different from regular investors.
- Another problem is the exponential distribution of liquidity among crypto asset markets, meaning that the majority of the crypto asset types, having good profitability and moderate risk, might not be suitable for medium and large investors who could easily shift these markets due to the lack of liquidity - and this is the problem because the majority of portfolio management theories do not take these factors into account at all.

So, in conclusion, we can state that the dynamic and often turbulent domain of cryptocurrencies presents new challenges that these classical models were not designed to address. The volatile nature of crypto assets, coupled with factors like market capitalization, liquidity, and trade volume, necessitates a more nuanced approach to portfolio construction.

The solution for semi-liquid cryptomarkets portfolio problem

In the next section, a Artificial Intelligence algorithm from the operations research domain is introduced that allows calculating optimal funds allocation between sets of assets with nonlinear profitability from initial investment which we are going to use for defining crypto asset portfolios. This algorithm allows us to go beyond ROI and risk and incorporate a multitude of factors into nonlinear market dynamics simulation.

Artificial Intelligence for Efficient Frontiers Portfolio Search

Problem definition

The goal is to find an optimal distribution(s) of capital investments among a given set of assets so that the overall portfolio return is maximal.

Each asset is represented by a (non)linear function of capital return $Q(I)$ from initial investment size I that encodes the relationship on how much quote currency the investor will receive if (s)he invests I quote currency units into this asset.

From the formal point of view, the addressed task is from the operations research domain and has a solution in the form of Artificial Intelligence - Bellman optimization problem, where the overall return value of the whole portfolio represents the maximized criterion.

The intuition behind Artificial Intelligence for Efficient Frontiers Portfolio Search

Bellman optimization problem considers a controlled discrete (step-by-step) process of transferring some system S from the initial state S_0 to the final state S_M. Assuming that the process is discrete, each its k-th step, where k runs through all process steps till the last one (M-th), supposes taking some decision x_k, that in its turn transfers the system from its previous state S_{k-1} to the current state S_k. This decision is called "control at the step k". The measure Z_k, correspondingly, demonstrates, how efficient would be control x_k. Therefore, S_k depends only on the previous step S_{k-1} and control x_k, disregarding all pre-previous steps and controls. In its turn, the final efficiency criterion Z, being a sum of all Z_k's, would show how efficient have been all taken solutions x_k at each k-th step from 1 to M.

The main objective of the optimization process is to find such sequence of solutions $X^* = \{x^*_1, x^*_2, \ldots, x^*_M\}$ that transfers the system S from its initial state S_0 to the final state S_M in such a way that the final Z-criterion would be optimal (*let us assume that we are always dealing with maximization problem, so here and below "optimal" will mean "maximal"; usually, optimal solutions are highlighted with a superscript asterisk: for instance, Z^* stands for an optimal Z-criterion value*). As far as all possible values of Z are sums of different Z_k's combinations, "the best" Z^* value should be a sum of all "best" Z^*_k's. It supposes that optimal, the most effective solution x^*_k should be taken at each k-th step. There can also be cases when the k-th step may have more than one x^*_k, which means that any them would yield the same best possible Z^*_k.

The assumptions above are formalized through Bellman's optimality principle: for any state S_{k-1}, the control x_k should be taken in such a way that Z_k plus all subsequent $Z_{k+1} \ldots Z_M$ would be optimal. This principle is fundamental for the whole optimization process and is supposed to lead to the global optimum Z^* in a way by a large margin more efficient than those suggested by the brute-force or similar combinatorial algorithms.

To sum it up in a very simple words: if one wants to achieve optimal ("maximal", "the most efficient") final solution Z^*, (s)he should take the most optimal "local" solution x^*_k at each step. How does (s)he know whether some x_k is x^*_k, i.e. optimal? Answer: if x_k leads to the best possible solution Z^*_k at the current step as well as at all subsequent steps up to Z_M, it is optimal and called x^*_k. Each step k may (but not necessarily should) have more than one x^*_k. The application of these assumptions to the problem of portfolio efficient frontiers search may be found below.

Formal task definition

Consider M assets and the available capital of size X quote currency units, split into N even intervals. Let's call the latter an investment grid. Each j-th asset among the M given, being invested the i-th amount of capital from the N grid cells, is expected to yield $Q(x_i, asset_j)$ of return, where Q stands for the Q-function described below. In this statement, investment into each of the M assets is considered a j-th step of Bellman's optimization process, while the i-th asset x_i represents itself an optimal control at this step, and $max[Q(x_i, asset_j)]$ is a local optimum correspondingly. The state of the system S_k represents the number of quote currency units remaining after the k-th step (i.e. after assigning capital to k assets). Given the return criterion being additive, together with Bellman's optimality principle, the problem of finding the global maximum comes down to summing up the local optima among all stages.

Algorithm description

The algorithm consists of two principal optimization stages, or passes: the backward pass (conditional optimization), and the forward pass (unconditional optimization).

Conditional optimization, or the backward pass, seeks for an optimal control $x^*_k(S_{k-1})$ at the k-th step, $1 < k <= M$, such that the local optimum $Z^*_k(S_{k-1})$ is reached at this step, provided that the system has been in an arbitrary state S_{k-1} at the previous (k-1-st) step. With relation to the problem investigated, $Z^*_k(S_{k-1})$ means the local maximum of the $Q(x_i, asset_k)$ function, $i = 1..N$, i.e. such investment x_i that would yield the highest profit Q for the asset k, taking into account investments already assigned to all previous k-1 assets. Generally, according to Bellman's optimality principle, for each S_{k-1} at k-th step, an optimal control $x^*_k(S_{k-1})$ resulting in a local optimum $Z^*_k(S_{k-1})$ should be found. This principle allows finding all previous criterion values in a backward order from M to 1, under the condition that the subsequent criterion values have already been calculated. Here, the conditional optimization is split into three subroutines depending on the k-th step processed:

- $k = M$, $S_M = 0$ (the last $asset_M$, all capital allocated)

  =>

  $Z^*_M(S_{M-1}) = \max_{0<=x\_M<=S\_M-1} Q(x_M , asset_M)$

- $k = 2..M-1$

  =>

  $Z^*_k(S_{k-1}) = \max_{0<=x\_k<=S\_k-1}\{Q(x_k, asset_k) + Z^*_{k+1}(S_k)\}$

- $k = 1$, $S_0 = X$ (the first $asset_1$, no capital allocated yet)

=>

$Z^*_1(S_0) = \max_{0<=x\_1<=S\_0}\{Q(x_1, asset_1) + Z^*_2(S_1)\}$

After calculating all optimal controls x^*_k and respective local optima $Z^*(k)$ for each k-th asset from the M-th to the 1-st, the forward pass (unconditional optimization) is used for finding the optimal control strategy. This time we start the sequence of actions described in the backward pass stage above, from the 1-st step (asset), and proceed to the M-th, finding an optimal control x^*_k for each $Z_k(S_{k-1})$, $1 < k <= M$. Using S_{k-1} and x^*_k, respective state S_k (k-th local optimum) is being found. After the M-th stage is complete, an optimal problem solution vector $X^* = (x^*_1, x^*_2, \ldots, x^*_M)$ is achieved. In the context of the current task, this solution demonstrates the most effective assignment of respective amounts of capital x^*_k, among M assets, so that the whole X quote currency units yield the greatest income Q. Forward pass is split into two principal subroutines:

- $k = 1$, $S_0 = X$ (the first $asset_1$, no capital allocated yet)

=>

$Z^*_1(S_0) = \max_{x\_1}\{Q(S_0, x_1)\}$

- $k = 2..M$

$Z^*_k(S_{k-1}) = \max_{x\_k}\{Q(S_{k-1}, x_k) + Z^*_{k-1}(S_{k-2})\}$

Complexity and Speed constraints

Computational complexity of Artificial Intelligence procedure is $O(N*M^2)$.

Respective memory complexity $O(N*M+M^2)$.

The final implementation uses GO language.

For the current asset space of 800 crypto assets with 1 month of historical prices, volumes, and market caps it is possible to find all optimal frontiers under 11 minutes with 1000 investment grid resolution using 1 CPU core. The theoretical number of portfolio combinations is around 6.67×10^{242} for 800 assets, for comparison the known universe has $\sim 10^{80}$ atoms.

It is possible to make consecutive computations not to store the whole Z matrix, which greatly reduces memory constraints.

Q-function interpretation

The function of capital return *Q(I) which* depends on initial investment size *I*, in the classical form represents the amount of dollars the investor will receive if (s)he invests *I* dollars into this asset.

It takes into consideration all possible non-linear effects, where for example actual ROI for $1 can be completely different from ROI for the same asset for $10M.

In Evai Ratings v2.0 we have encoded into Q function many factors that give a fuller picture and more complex view of the market dynamics. In the next section the details of how Q-value functions are defined for crypto assets.

Defining Q-value Functions

As it was shown in the previous section, the Artificial Intelligence optimal portfolio calculation method can take non-linear relations between the invested amount *I* and the overall return *Q_i(I)* for each asset *i* as input. This means that we can design function *Q* in the way, it incorporates into its nonlinearity the following aspects:

- profitability of the asset
- risk effect on ROI,
- investor riskiness,
- market-related factors (like slippage and market liquidity in case of huge investments),
- different behavior for different types.

So high-level formula idea draft for an asset *i* might look like this:

$$Q_i(I) = I * expected\_risk\_and\_market\_adjusted\_roi(I)$$

where:

expected_risk_and_market_adjusted_roi(I) can be defined as

$$expected\_risk\_and\_market\_adjusted\_roi(I) = expected\_risk\_adjusted\_roi_i - liquid\_market\_slippage(I)$$

And in its turn:

$$liquid\_market\_slippage(I) == Amihud_i * I$$

liquid_market_slippage(I) can be interpreted in the following way:

$$Amihud_i = E\left(|roi_{ij}| / vol_{ij}\right)$$

Amihud is an illiquidity measure and it shows how many percentages of absolute roi value change are caused by the change of adding $1 volume into the market.

For large input investment size "***I***", that can be treated as a volume that stress-tests the market, so $Amihud_i * I$ gives us an approximation of slippage of our ROI (measured in percentages).

Regarding the $expected\_risk\_adjusted\_roi_i$, we define it as:

$$expected\_risk\_adjusted\_roi_i = roi_i - risk\_factor * (1 - marketcap_i / (\sum_j marketcap_j))$$

where

roi_i - our ROI expectation of the asset *i*

risk_factor - is the weight assigned to the riskiness of small markets vs big ones. It can be interpreted as investor risk tolerance. For example, coins with small markets might get pumped and dumped easily because of the small size of the market, and it can be totally OK for some types of investors, but at the same time, it is completely unacceptable for less risky investors. So this parameter helps to find the middle ground between ROI of the asset and the market type.

$marketcap_i$ - is i-th asset market capitalization

$\sum_j marketcap_j$ - is the overall crypto market capitalization

So the final formula is:

$$Q_i(I) = I * (roi_i - risk\_factor * (1 - marketcap_i / (\sum_j marketcap_j)) - Amihud_i(I) * I)$$

This is one of the possible ways of incorporating risk factors into the Q equation. We are working on adding many other factors like known incidents, insurance, bug-bounty, tokenomics audit etc.

Optimal investment calculation for Q-matrix

To define *Q-matrix* for the whole portfolio, it is necessary to understand what the maximum investment *I* across all markets is.

From the Artificial Intelligence perspective, we need an equidistant linear scale for the independent variable of I, and it shall be the smallest dimension possible due to the computational complexity of the algorithm. Having the smallest dimension, at the same time it shall capture all the nonlinearities of return for all markets to give the highest resolution possible.

To solve this, for each market, *I_optimal_i* is calculated for each asset *i* that corresponds to the *Q_i* maximum value, and the maximum of all *I_optimal_i* is taken to guarantee that all nonlinearities are preserved for all markets.

I_{opt} for some particular market is derived as follows:

$$Q_i(I) = I * (expected\_risk\_adjusted\_roi_i - Amihud_i * I)$$

$dQ_i(I)/dI == 0$

=>

$$expected\_risk\_adjusted\_roi_i - 2 * Amihud_i * I_{opt} == 0$$

=>

$$I_{opt} == expected\_risk\_adjusted\_roi_i \ / (2 * Amihud_i)$$

Q_i*_optimal* is derived as follows:

$$Q_i(I) = I*(expected\_risk\_adjusted\_roi_i - Amihud_i*I)$$

=>

$$Q_i(I_{opt}) == expected\_risk\_adjusted\_roi_i \ / (2 * Amihud_i) * (expected\_risk\_adjusted\_roi_i - Amihud_i * expected\_risk\_adjusted\_roi_i \ / (2 * Amihud_i))$$

=>

$$Q_i(I_{opt}) = expected\_risk\_adjusted\_roi_i^2 / (4 * Amihud_i)$$

Optimal investment Q-matrix view

The plot below shows Q(I) functions for 35 randomly selected markets. Each curve represents one market. Small and risky markets are curves on the left bottom. Bigger and stronger ones have a higher span. For example, the yellow line with the peak on the top right of the plot represents the BTC market.

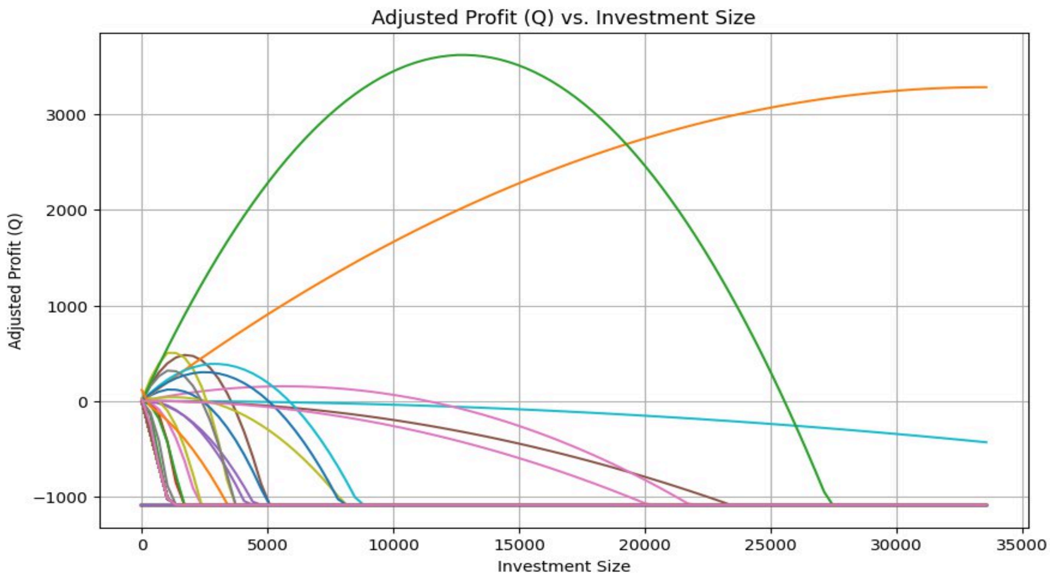

Figure 4. - Q-value functions for random 35 crypto markets.

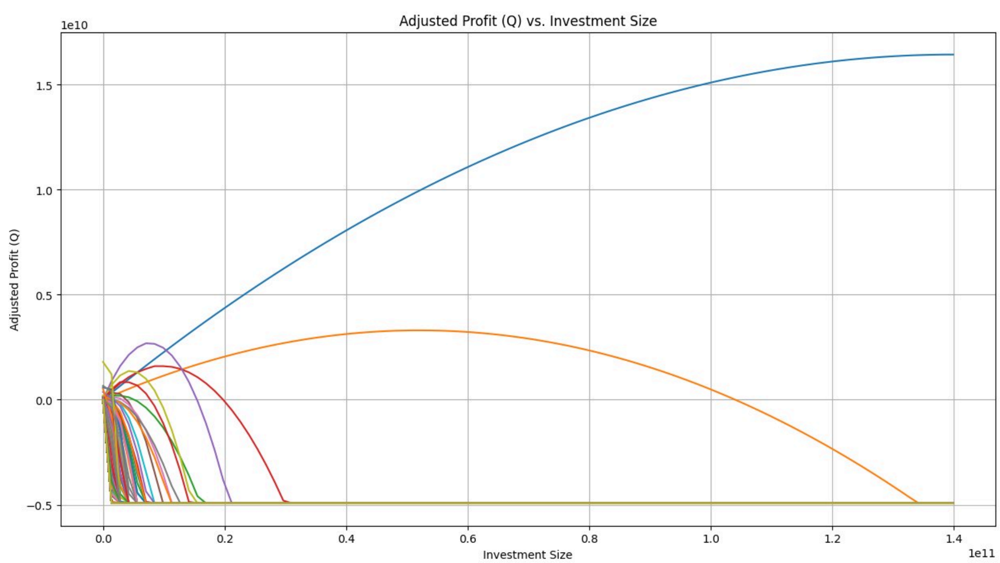

Figure 5. - Q-value functions for the top 800 crypto markets.

The plot below shows a similar plot but in the form of a 2D matrix, where the X-axis represents the markets (147 of them) and the Y-axis represents the I-scale. Color represents Q-values (the brighter the bigger).

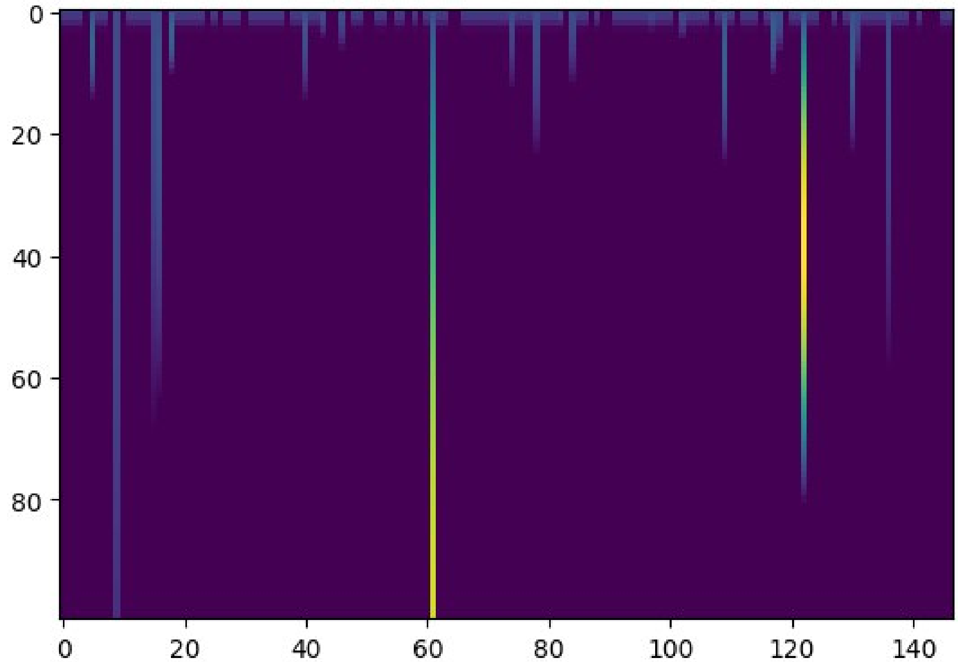

Figure 6. - Q-values matrix for the top 147 crypto markets.

Influence of ROI calculation methodology on Q-functions

Assets' ROIs shift the whole curve up (if positive) and down (if negative).

So the whole solution can be susceptible to pumps and dumps of asset prices, so to avoid this influence, it is necessary to be sure that the roi input factor covers this risk.

One of the possible solutions is to average ROI for the M-last time periods.

Another more complicated one - would be to track the volatility change in time and put smaller weights to the rapid bursts of ROI (that might be caused by pumps).

More detailed research on which algorithm performs better is yet to be conducted.

The (sub)-efficient frontiers selection procedure visualization

For every iteration of the (sub)-efficient frontiers search algorithm adds a new row to the matrix of efficient frontiers that represents the optimal portfolio for the current iteration.

We define the one-to-one mapping between the efficient frontier in this stage and the current efficient portfolio on the subset of assets that remain on the given iteration of the algorithm. So each row of the matrix that represents the portfolio, can be treated as the corresponding (sub)efficient frontier for the given iteration of the algorithm.

From each portfolio in the current iteration, the top-performing asset is selected and added to the ranking of all assets. This asset as well as all the previously selected assets are removed from the candidates-assets that are left to unlock further frontiers.

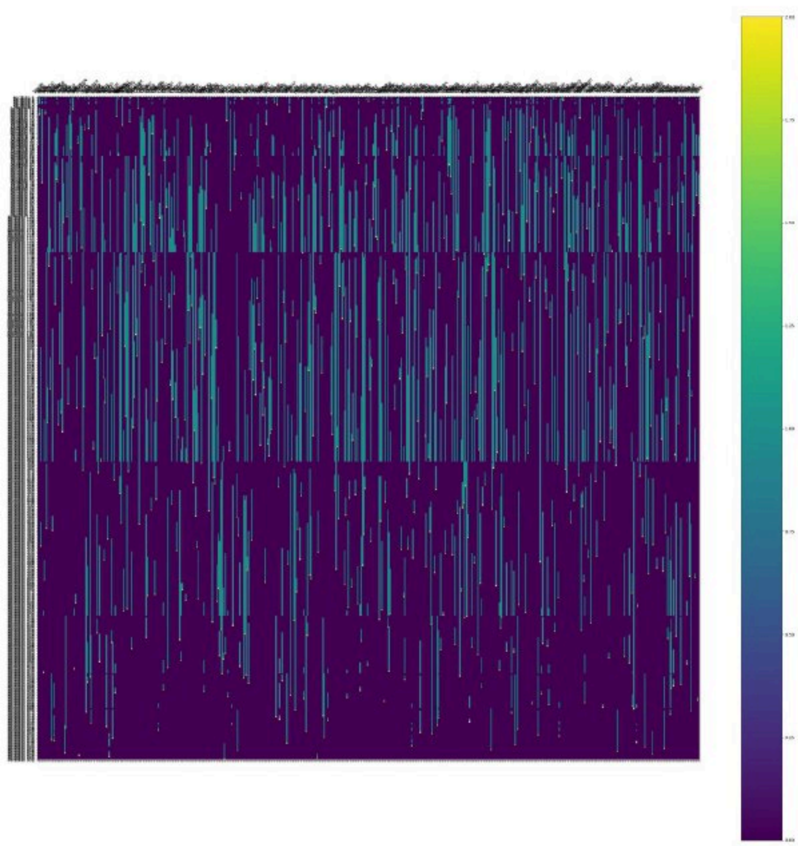

Figure 7. - Matrix of the selected asset for each (sub)-efficient frontier

The figure above shows the matrix for 750 assets (X-axis) and 750 (sub)optimal portfolio frontiers (Y-axis).

Each yellow dot in each row represents a selected asset on the current iteration as the representative of the current efficient frontier (portfolio), which is added to the all-assets ranking for a given iteration. The top row is the first one, representing the most efficient portfolio of all. Light-blue dots in each row represent the assets that are part of the efficient portfolio on the current iteration. Dark blue background - represents assets that were not considered in the current iteration.

The scoring mechanism for Ratings

After finding the optimal portfolio on the current iteration of the algorithm, the top-performing asset in the portfolio is selected and added to the final ranking map, which is represented by the dictionary where keys are represented by ASSET_NAME and corresponding values store ASSET_SCORE.

The overall procedure for calculating asset scores is the following:

For every asset in the found optimal portfolio on the current iteration by the algorithm, the following actions are performed:

- If the ASSET_NAME is present already in the dictionary then its corresponding value is calculated as the previous value plus the current performance, received from the portfolio which was calculated by the Artificial Intelligence algorithm.
- In case this ASSET_NAME is not present in the dictionary, then the new key (ASSET_NAME) is added and its ASSET_SCORE is assigned as a corresponding value from the computed portfolio.

For the top-performing asset on the current iteration of the algorithm, that is removed on the current iteration, its ASSET_SCORE is updated as the following, to guarantee that it will always stay in the current rank:

$$TOP\_ASSET\_NEW\_SCORE = CURRENT\_ASSET\_SCORE + N_i \times MAX\_PORTFOLIO\_FUNDS$$

where

TOP_ASSET_NEW_SCORE - is the final resulting score for the asset,

CURRENT_ASSET_SCORE - previous asset score that was accumulated till this point from previous efficient frontiers,

MAX_PORTFOLIO_FUNDS - is the total amount of capital allocated by the Q-values computation algorithm for the given iteration. (Is defined as *I_max* for the investment grid for the current iteration i of the efficient frontier algorithm search).

N_i - number of assets that are left to include in the next iterations of the efficient frontier algorithm search. This guarantees that any other asset from the following iterations will overperform the current asset allocating for this asset an “isolated financial level” which is lower than all previous levels and higher than all consecutive levels due to decreasing *I_max* for every following iteration by the definition.

Ratings calculation

Assuming the exponential and cumulative nature of the received assets scores, to map them into the letter codes the following procedure is used:

- First of all ***log(ASSET_SCORE)*** is computed to remove exponential "isolated financial levels" to make it more uniform.
- A Linear Min-max scaler is applied to the log scores to normalize them from 0.0 to 1.0 (between min and max score values)
- Linear mapping of even diapasons is applied to the letter codes like (*[1.0 .. 0.9] → AAA*). Having the score it is also possible to define non-linear mapping functions, depending on the need (for example, if too many assets fall under one category while the rest of the rank categories are empty), but the Evai team has shown that linear mapping function on log scales works just fine.

The rankings letter codes are following:

ID	**Letter Code**	**Description**
0	AAA	Is the top-rated frontier of assets, AAA shows the top performers residing on the most efficient frontiers possible.
1	AA	Shows the top performing assets, which reside on top sub-efficient frontiers, but due to the risk or lower performance are covered by AAA level.
2	A	A-rank shows great assets, which reside on the following sub-efficient frontiers after AA
3	BBB	BBB rank shows good assets, which reside on the following sub-efficient frontiers after A
4	BB	This rating is lower in the hierarchy, indicating assets with lesser efficiency and performance compared to those ranked higher.
5	B	Similar to BB, but further down in terms of efficiency and performance.
6	CCC	Crypto asset is volatile in nature, and in the majority have huge risks associated with big slippage and relatively small market cap. Due to the big impact of investments with relatively small volumes very often might change the "optimal portfolio" and even jump between B, CCC, CC, and C rank classes.

7	CC	This rating is lower than CCC, indicating increased risks and volatility.
8	C	Assets with a C rating are even lower than CC, suggesting higher risks and lower efficiency
9	D	The lowest rank possible shows that the asset does not have any investment interest containing huge risks.
10	U	Unrated due to missing information (like prices/volumes etc.) Mainly for the new coins

Evai Rating Model Conclusions

Above we have presented a novel approach for calculating crypto asset ratings that use a Nested Efficient Frontiers approach for ranking all the crypto-assets universe.

Important innovation is the introduction of Q-value Functions that allow to capture of nonlinear risk and ROI from investment amount. This allows us to include in the portfolio a calculation method that is capable of capturing the complex dynamics of semi-liquid crypto markets with high slippage. It is worth mentioning that our approach greatly differs from classical portfolio estimation methods which all start with the assumption of liquid markets (which is not the case in crypto).

As was mentioned above our system undertakes a rigorous analysis of assets on an hourly basis, with updates reflected in the "Position" section, showcasing the degree to which an asset has ascended or descended since the last evaluation. This feature is pivotal for identifying Outliers, assets that demonstrate significant movements either upwards or downwards throughout the day. These fluctuations could stem from various factors, including liquidity or security issues, return on investment (ROI), and more. Importantly, any asset experiencing such notable changes is automatically placed on a 24-hour Watchlist, providing users with the opportunity to conduct a detailed analysis and make informed decisions about these assets.

Our Rating Model transcends traditional ratings by offering a dynamic, in-depth analysis that effectively supersedes the need for a large analytical department. Users gain access to ready-to-use, hourly updated analyses covering the entire cryptocurrency market, a significant advancement in making informed investment decisions more accessible.