Software White Paper - Project Plutus

After witnessing the catastrophes that ensued from banks losing billions of investor funds during the COVID market crash, the idea for Project Plutus was born, a program which helps evaluate a portfolio's performance during events of absolute uncertainty, or black swan events. This program assesses a portfolio's overall expected gain and loss through days of turmoil, and assesses its performance against the performance of the market to determine whether it can outperform the market as well as point out specific stocks or groups of stocks which may be vulnerable to these events.

Since it is impossible to accurately predict the exact date and time of black swan events using mathematics and statistics this project simulates the situation of a black swan event, with the capability of over 1 million simulations being run to simulate different events and outcomes to accurately predict the price of the portfolio after a year of stress. This whitepaper aims to evaluate how the software works as well as discuss the logic behind such a simulation.

This software uses Monte Carlo simulations to simulate different possible events, and then produces its mean as the expected rate of return. Therefore, the accuracy of this software depends on the accuracy of Monte Carlo simulations.

Monte Carlo Simulation

Monte Carlo simulation is a powerful computational technique used to model the probability distribution of complex systems through the generation of numerous random samples. In the context of financial analysis, it is employed to simulate potential future scenarios for investment portfolios. The methodology involves the following key steps:

1. Random Sampling: Random samples are drawn from probability distributions that represent uncertain variables, such as asset returns. For the simulation, a modified Student's t-distribution is often used due to its ability to capture the fat tails observed in financial data.

The mathematical representation of the t-distribution probability density function (pdf) is given by:

$$f(t;df) = \frac{\Gamma\left(\frac{df+1}{2}\right)}{\sqrt{\pi \cdot df \cdot \Gamma\left(\frac{df}{2}\right)}}(1+\frac{t^2}{df})^{-\frac{df+1}{2}}$$

Where:

- $f(t;df)$ represents the probability density function of the t-distribution with df degrees of freedom evaluated at t.
- Γ represents the gamma function
- t represents the variable of the t-distribution
- df represents the degree of freedom parameter in the function.

2. Stress Factor: The stress factor is a parameter that introduces a level of severity to the simulated scenarios, representing adverse conditions or extreme events. It scales the random samples generated from the t-distribution, effectively magnifying the impact of deviations from the mean. The stress factor is a user-defined input that allows for the customization of the simulation based on the perceived level of stress in the market.

3. Degree of Freedom (df): The degrees of freedom in the t-distribution determine its shape and play a crucial role in capturing the variability of asset returns. In the context of financial modelling, the degrees of freedom represent the number of observations minus one. A lower degree of freedom results in fatter tails, allowing the simulation to account for the increased likelihood of extreme events.

The t-distribution with (df) degrees of freedom is characterized by heavier tails compared to the normal distribution, making it suitable for modelling financial returns, which often exhibit non-normal behaviour.

4. Standard Distribution and its Limitations: The standard distribution, such as the normal distribution, assumes a symmetrical and bell-shaped curve. However, financial markets frequently experience extreme events that deviate from normality. Black swan events, characterized by their low probability and high impact, challenge the assumptions underlying standard distribution models. Therefore this program has been created to plot stock returns on a distribution which accounts for tail risks to accurately predict if a portfolio will be able to perform under periods of stress and volatility.

The normal distribution probability density function is given by:

$$f(x;\ \mu,\sigma) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2}}$$

Although this distribution is widely used by quantitative analysis firms as well as major fund houses, its failure to account for extreme events results in it not being able to accurately construct a portfolio which is resistive to black swan events. Therefore the Monte Carlo simulation, when tailored with a modified t-distribution, stress factor, and degrees of freedom, becomes a sophisticated tool for modelling and assessing the impact of extreme events on investment portfolios. This methodology goes beyond the limitations of standard distributions, offering a more realistic depiction of financial uncertainties.

This software also contains a special rating called the 'Shllok's Rating'. This rating helps evaluate a portfolio and rate it from a scale of 1 to 10. This rating is broken down into the following ratio:

- Diversification score – 20% weight
- Expected return – 40% weight
- Sharpe (risk to return) ratio – 40% weight

This score can be used to judge whether a portfolio is comprehensive or not.