A Quantitative Framework for Asset Risk Analysis and Probabilistic Forecasting

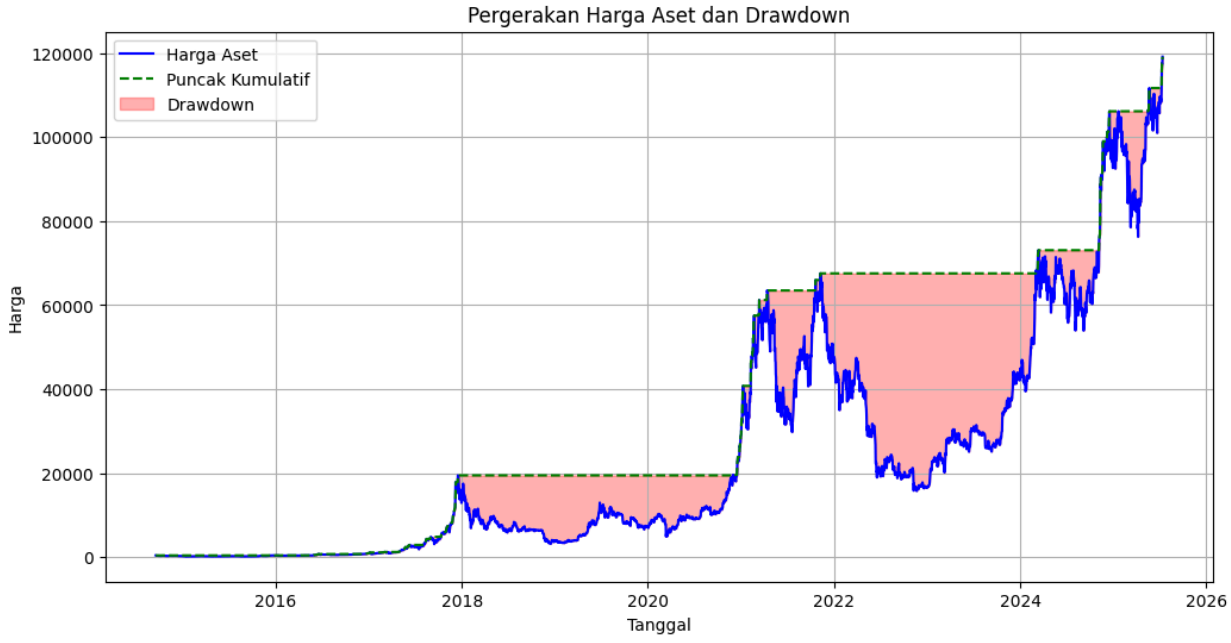
From my experience analyzing financial markets, I have learned that the most critical first step, before any attempt at price forecasting, is a deep and objective understanding of an asset's inherent risk. I believe that jumping directly to price prediction without first quantifying historical volatility, the potential for significant losses (drawdown), and true risk-adjusted performance can lead to misguided investment decisions. This conviction, born from personal experience, was the catalyst for this project. My goal was to build a comprehensive Python-based program that could serve as a robust foundational tool in any investment analysis process, focusing first and foremost on creating a clear, data-driven overview of an asset's risk and reward profile.

A Quantitative Approach to Investment Analysis

This project involved developing a dual-function command-line tool. The first function is a deep dive into an asset's historical data to calculate and interpret a suite of key performance and risk metrics. The second function uses the asset's historical characteristics to run a Monte Carlo simulation, generating a probabilistic forecast of its future price across multiple scenarios. The entire system is designed to deliver a 360-degree quantitative snapshot of an asset's character, complete with automated qualitative assessments.

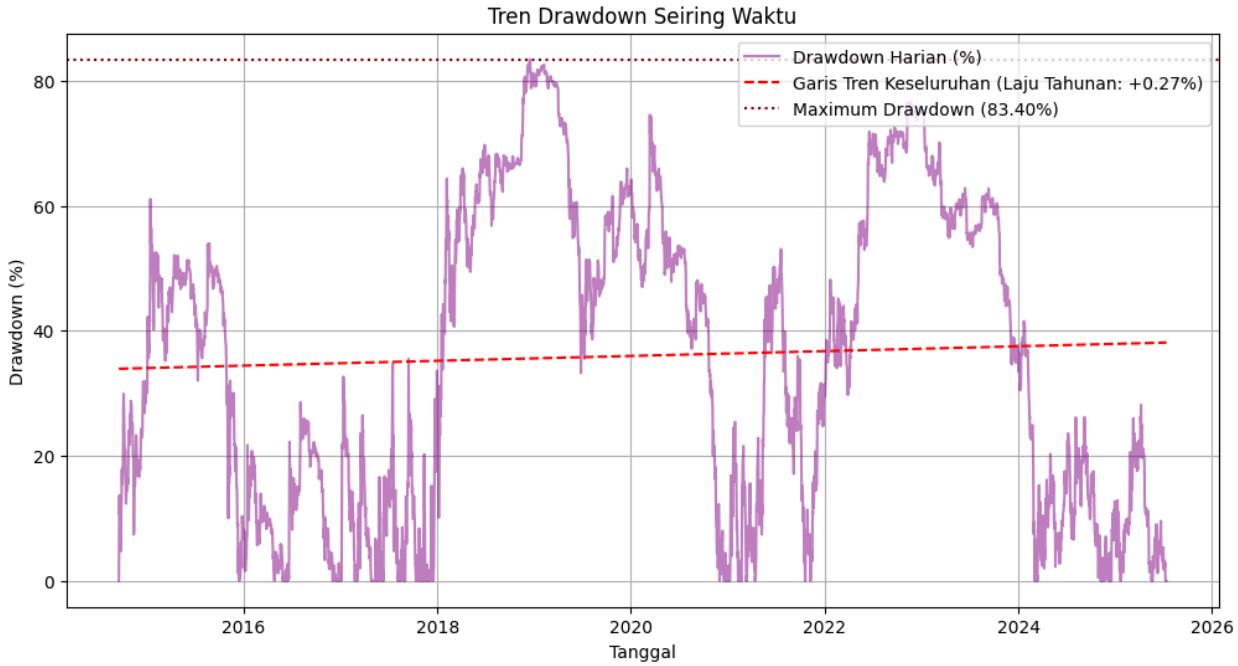
I. Comprehensive Risk & Performance Analysis Engine

The core of the program is its ability to perform a multi-faceted analysis of an asset's historical price data. I designed specific Python functions to calculate several industry-standard metrics to create a holistic risk profile:



- **Advanced Drawdown Analysis:** My tool moves beyond a single Maximum Drawdown (MDD). It visualizes each historical drawdown period against the asset's cumulative price peak and, most importantly, applies **linear regression to the daily drawdown percentages** to determine if the asset's risk profile is trending upwards or downwards over time.
- **Risk-Adjusted Returns:** I implemented the **Sharpe Ratio** (measuring return per unit of total risk) and the **Sortino Ratio** (measuring return per unit of downside risk). These ratios provide a clear measure of how effectively an asset generates returns relative to the risks taken.
- **Volatility and Value at Risk (VaR):** The tool calculates annualized volatility to measure price fluctuation and the 95% historical VaR to estimate the potential loss on a given day under normal market conditions.
- **Performance and Trend Metrics:** The program calculates the overall Compound Annual Growth Rate (CAGR) and also analyzes the trend of annual returns to determine if the asset's growth is accelerating or decelerating.

To make these metrics actionable, the program provides not only the numerical values but also a qualitative interpretation (e.g., "RISIKO TINGGI," "BAGUS," "NORMAL").

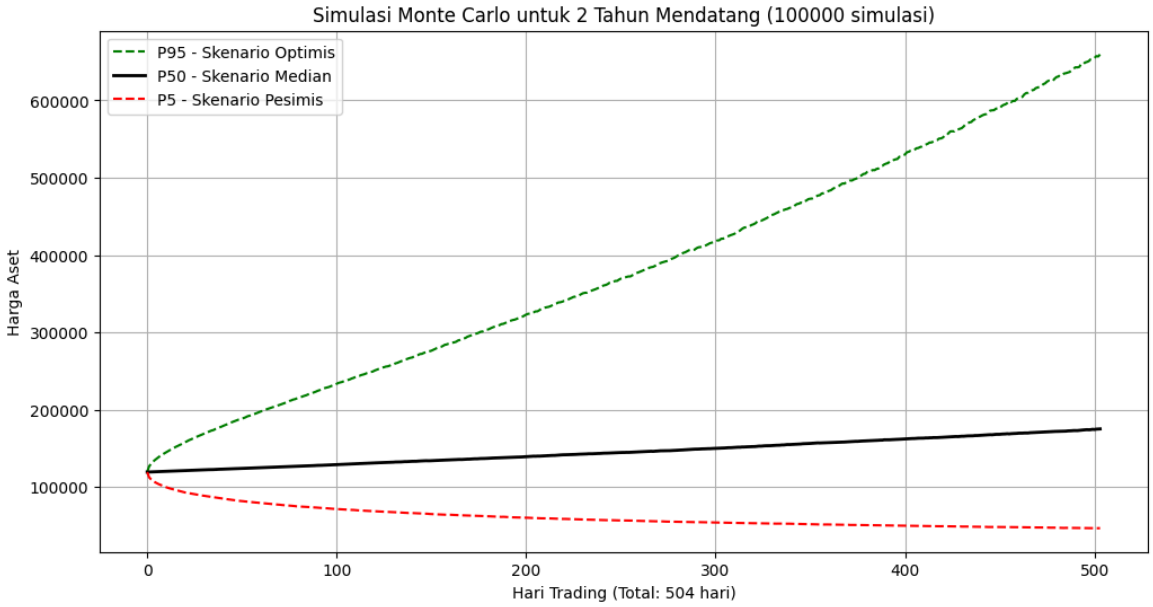


Historical Drawdown Analysis: A visualization showing the percentage drawdown from cumulative peaks over time, including a trendline to assess if risk is increasing or decreasing.

II. Probabilistic Forecasting with Monte Carlo Simulation

The second function of the tool is to project a range of potential future outcomes. For this, I implemented the **Monte Carlo simulation** method. My reasoning for choosing this method was to establish a robust, statistically sound baseline for future price paths.

- **Methodology:** The simulation uses the historical daily log returns of an asset to calculate its statistical properties (mean and standard deviation). It then runs thousands of randomized simulations (e.g., 100,000) of future price paths based on these properties, using a geometric Brownian motion model.
- **Multi-Scenario Output:** The results of the simulations are aggregated to produce three key scenarios: P95 (Optimistic), P50 (Median), and P5 (Pessimistic).
- **Probability of Profit:** As a key enhancement, my program analyzes the endpoint of all simulations to calculate the **probability of the asset's price being higher** than its starting price, providing a simple, intuitive measure of its upside potential.



Monte Carlo Simulation Scenarios: A graph showing the probabilistic forecast for an asset over several years, displaying the P5 (Pessimistic), P50 (Median), and P95 (Optimistic) paths.

III. Implementation & Detailed Case Study on Asset X

The framework was implemented as a user-interactive command-line tool in Python. To demonstrate its capabilities, I ran a full analysis on a case study, **Asset X**. The program ingested the historical data and produced the following detailed quantitative results and automated interpretations:

- **Performance Analysis:**
    - The long-term **Compound Annual Growth Rate (CAGR) was 67.21%**, a figure the program interprets as **"BAGUS"**.
    - However, the **trend of its annual returns was "Menurun (Melambat)"** at a significant rate of **-33.64% per year**.
- **Risk Profile Assessment:**
    - The **Maximum Drawdown (MDD) was a substantial 83.40%**, interpreted as **"RISIKO TINGGI,"** highlighting its potential for severe capital loss.
    - Despite this, the overall long-term **drawdown trend was "Stabil" (+0.27% per year)**, suggesting the asset's risk profile has not worsened over time.
    - The **annualized volatility was 56.69%** and the **95% daily Value at Risk (VaR) was -5.45%**, both flagged as **"TINGGI."**
- **Risk-Adjusted Return Ratios:**
    - The **Sharpe Ratio was 1.10**, interpreted as **"BAGUS."**
    - The **Sortino Ratio was 1.41**, interpreted as **"NORMAL."**

When synthesized, these individual metrics tell a compelling story about the asset's evolution. The combination of a decelerating annual return trend and high volatility, contrasted with a stabilizing long-term drawdown trend, strongly suggests that **Asset X is undergoing market maturation**. As its market capitalization has grown over the years, it inherently becomes more difficult for the asset to sustain the explosive, volatile growth of its early phase. This maturation process naturally leads to a deceleration in returns.

Therefore, the analysis paints a picture of a high-growth asset transitioning into a more mature phase. Despite the high historical risk and slowing growth, the asset remains attractive. Its proven ability to deliver excellent returns that more than compensate for its risk is evidenced by a strong **CAGR** and robust risk-adjusted returns (**Sharpe Ratio of 1.10 and Sortino Ratio of 1.41**).

Project Conclusion

This project resulted in the successful development of a powerful, dual-function tool for quantitative asset analysis. It serves as an essential first step in any investment process by offering a clear, data-driven narrative of an asset's historical risk/reward profile, complemented by a probabilistic view of its future potential. This tool effectively establishes the "character" of an asset, allowing for more informed decisions based on a philosophy of understanding risk first.

VI. Acknowledged Limitations and Future Development

While this framework provides a robust quantitative snapshot, I recognize its inherent limitations and areas for future enhancement.

- **Assumption of Stationarity:** The Monte Carlo simulation operates on the critical assumption that the statistical properties (mean, volatility) of past returns will continue into the future. This can be a significant limitation, as the model does not inherently account for fundamental shifts or "regime changes" in a maturing market.
- **Performance on High-Volatility Assets:** For assets with extreme volatility, the model's probabilistic forecast will naturally produce a very wide range of outcomes, which can make the P5 and P95 scenarios less actionable, and the probability of error increases.
- **Evolving Methodologies:** The field of quantitative finance is constantly advancing. This model is based on established methods, but I acknowledge that my research does not encompass the absolute latest, cutting-edge algorithms (e.g., advanced stochastic volatility models like GARCH).
- **Disclaimer:** This tool is intended as a proof-of-concept and an analytical reference, not as a primary source for financial advice. Its strength lies in risk assessment, and all investment decisions should be made with independent research and professional guidance.

VII. Skills & Competencies Demonstrated

This project enabled me to strengthen my skills in the following domains:

- **Quantitative Financial Analysis:** Implementing and interpreting a wide range of financial performance and risk metrics.
- **Risk Management:** Applying concepts like multi-level Drawdown Analysis, Value at Risk (VaR), and risk-adjusted ratios (Sharpe, Sortino).
- **Probabilistic Modeling:** Developing and implementing Monte Carlo simulations based on Geometric Brownian Motion for financial forecasting.
- **Python for Finance:** Extensive use of libraries such as `pandas`, `numpy`, and `yfinance` for data manipulation and analysis.
- **Statistical Analysis:** Applying statistical concepts like linear regression, standard deviation, and percentiles to financial data.
- **Data Visualization:** Creating clear and informative charts to present analytical results using `matplotlib`.