S and P 500 Index Modelling and Growth Analysis Using Python

1. Introduction

This project analyses monthly S and P 500 closing prices from 2020 to 2024 using Python.

The objective was to model index behaviour, identify turning points in 2024, and estimate cumulative growth in 2023 and 2024 through numerical and analytical techniques.

The project combines polynomial approximation, spline interpolation, numerical differentiation, Newton Raphson, and Simpson's rule to produce quantitative insights that align with asset management and financial risk analysis.

2. Data and Tools

Dataset:

Monthly S and P 500 closing prices from January 2020 to December 2024.

Programming Tools:

Python, pandas, numpy, matplotlib.

3. Methodology

A. Modelling Index Behaviour in Selected Windows

Two time windows were selected to model and compare index behaviour:

- February to May 2021
- February to April 2023

Polynomial approximation and cubic spline interpolation were applied to each window.

Both techniques were evaluated based on accuracy, smoothness, and stability relative to the actual data.

B. Identifying Local Maxima in 2024

To analyse turning points in 2024, a spline model was fitted to the monthly index data.

Numerical differentiation was used to compute the first derivative of the spline, allowing identification of points where the slope equals zero.

The Newton Raphson method refined these solutions to locate critical points more precisely.

Second derivative checks were then used to confirm which critical points were local maxima.

C. Estimating Cumulative Growth in 2023 and 2024

Spline interpolation was used to create smooth curves for the index across both years.

Simpson's rule was then applied to numerically approximate cumulative growth in each year:

• January to December 2023

• January to December 2024

These results were compared to understand differences in market performance between the two years.

4. Key Insights

• Spline interpolation produced smoother and more reliable models than polynomial fitting.

• Numerical differentiation and Newton Raphson successfully identified turning points in 2024.

• Simpson's rule provided consistent estimates of cumulative growth.

• The combined techniques demonstrate how quantitative methods can help interpret market movements.

5. Technical and Analytical Skills Demonstrated

• Python programming

• Data cleaning and preparation

• Polynomial approximation and spline interpolation

• Numerical differentiation

• Newton Raphson optimisation

• Simpson's rule for numerical integration

• Time series interpretation

• Communicating quantitative findings clearly

6. Conclusion

This project strengthened my understanding of how quantitative techniques can be used to analyse financial markets.

By applying modelling, numerical methods, and interpretation, the work mirrors the analytical reasoning used in asset management, portfolio research, and risk analysis.