# Computational Portfolio Analysis and Investment Recommendations: UK Energy and Financial Markets

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August 23, 2025

## 1 Introduction

This report analyses the relationship between market indices of a portfolio based in the UK financial and energy markets, the global index market, UK macroeconomic factors, and portfolio performance between 2020 and 2025. The study examines how macroeconomic variables, such as interest rates, GDP growth, inflation, and commodity prices, influence sector-specific equities and overall portfolio returns.

By combining historical financial data with portfolio simulations, the report identifies patterns in asset behaviour, volatility dynamics, and risk-adjusted performance. The analysis also evaluates the benefits of diversification across sectors and international markets in mitigating portfolio risk during periods of economic uncertainty.
The central thesis of this report is:

> *Slow and steady increases in UK interest rates create favourable conditions for investment in the financial sector, particularly banking equities, while diversification across energy and global indices mitigates portfolio volatility and supports consistent risk-adjusted returns.*

By examining historical market responses to macroeconomic shifts, this report seeks to demonstrate that gradual interest rate adjustments, in combination with strategic sector allocation, allow investors to optimise returns while controlling for systemic and sector-specific risks.

To conduct this analysis, a structured workflow was implemented combining data extraction, cleaning, and visualisation with Python, Excel, and Power BI. Financial time series for equities, ETFs, and UK government bonds were retrieved and processed, while macroeconomic indicators including GDP, CPI, unemployment rates, and commodity prices were integrated to provide context for portfolio performance. Subsequent analyses involved portfolio simulations, calculation of risk-adjusted metrics, and scenario testing to evaluate the impact of macroeconomic shifts on returns and volatility.

# Contents

## 2 Portfolio Variables

Key Indices and Macroeconomic Indicators Considered

| **Category** | **Items** |
|---|---|
| Equities / Indices | BP plc (GBP)<br>Shell PLC (GBP)<br>HSBC Holdings (GBP)<br>Barclays PLC (GBP)<br>FTSE 100 (GBP)<br>S&P 500 (USD) |
| Macroeconomic Indicators | UK Gross Domestic Product (GDP)<br>Yield Rates for 10-Year Gilt UK Government Bonds<br>UK Consumer Price Index (CPI)<br>UK Unemployment Rate<br>Brent Crude Oil Prices |

Table 1: Summary of Key Portfolio Indices and Macroeconomic Indicators

- $R_{p,t}$ = Portfolio return at time $t$
- $R_{i,t}$ = Return of asset/index $i$ at time $t$
- $w_i$ = Portfolio weight of asset $i$ in the simulation
  - UK Financial Markets: 30% (HSBC 15%, Barclays 15%)
  - UK Energy Markets: 20% (BP 10%, Shell 10%)
  - FTSE 100: 10%
  - S&P 500: 40%
- $R_f$ = Risk-free rate (e.g., 10Y UK gilt yield)
- $\sigma_p$ = Portfolio volatility
- $\rho_{ij}$ = Correlation between asset $i$ and $j$
- $\text{AvgDailyReturn}_p$ = Average daily return of portfolio
- $\text{CumulativeReturn}_p$ = Cumulative return of portfolio over time
- $\text{Sharpe}_p$ = Sharpe ratio of portfolio
- BenchmarkDailyReturn = Daily return of benchmark index (S&P 500)
- Macroeconomic variables: GDP growth rate (%), CPI inflation (%), Unemployment rate (%), Brent crude price (USD/bbl)

# 3 Methodology

This project evaluates a diversified investment portfolio consisting of UK energy and financial stocks (BP, Shell, HSBC, Barclays), ETFs (FTSE 100, S&P 500), and UK 10-year government bonds. Historical price data and macroeconomic indicators, including GDP, commodity prices, unemployment, and CPI, were collected, cleaned, and queried using SQL for filtering and alignment.

## 3.1 Data Collection and Preprocessing using Financial APIs

1. Data Extraction:
   - Python packages Yahoo Finance (`yfinance`) and Federal Reserve of Economic Data (`fredapi`) were used to download stock prices, ETFs, government bond yields, and macroeconomic indicators.
   - World Bank's API was used to retrieve UK GDP data.
2. Data Cleaning:
   - Unnecessary columns (e.g., Open, High, Low, Volume, Dividends) were removed using `pandas`.
   - Dates were converted to datetime objects, and datasets were filtered to include data from 2020 onwards.
   - Missing values were forward- and backward-filled where appropriate.
3. Data Storage: Cleaned datasets were saved as CSV files for subsequent analysis.

## 3.2 Exploratory Data Analysis using `Python` and `pandas`

1. Excel Analysis: Visual exploration and annotation of time series data for initial understanding of trends and volatility.
2. Power BI Dashboards: Aggregated and interactive summaries of key metrics for portfolio and benchmark comparisons.

## 3.3 Portfolio Metrics Calculation using `NumPy` and `SQL`

1. Daily Returns: SQL queries with `pandasql` were used to calculate daily returns for each asset and government bonds.
2. Portfolio Construction: Weighted daily returns were combined to compute:
   - Average daily return
   - Annualised volatility
   - Cumulative return
   - Sharpe ratio
   - Maximum drawdown
3. Benchmark Comparison: Daily returns of the S&P 500 were calculated and aligned with portfolio returns for performance benchmarking.

### 3.4 Simulation and Stress Testing

1. Shock Scenarios: Applied hypothetical shocks to financial sector assets to assess portfolio sensitivity.
2. Accelerated Return Simulation: Introduced linear acceleration factors to daily returns over a selected time window to model hypothetical market trends.
3. Visualisation: `matplotlib` plots were used to compare original, shocked, and accelerated portfolio returns over time.

### 3.5 Automation and Reproducibility

1. All Python scripts were structured to enable reproducible workflows: extraction, cleaning, metric computation, simulation, and visualisation.
2. Key datasets, including cleaned prices, bond yields, macroeconomic indicators, and simulated returns, were exported as CSVs for further analysis or reporting.

# 4 Interest Rates, UK Financial Markets, and Portfolio Returns

## 4.1 Data Visualisations

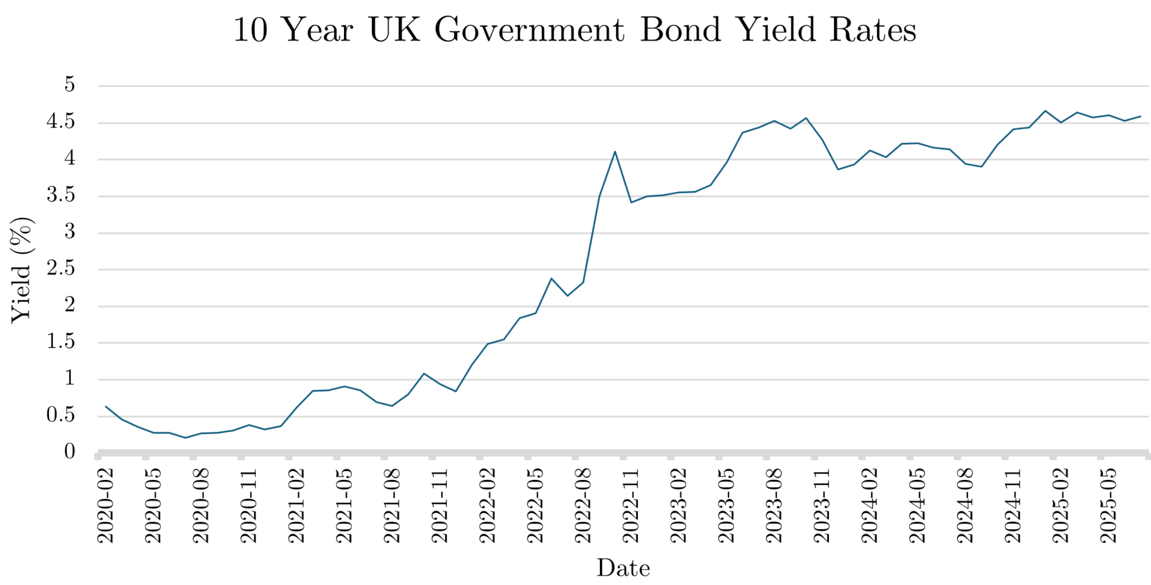


Figure 1: 10 Year Government Bond Yield Rates

- $Y_t$ = 10-Year UK Government Bond Yield Rate at time $t$ (%)

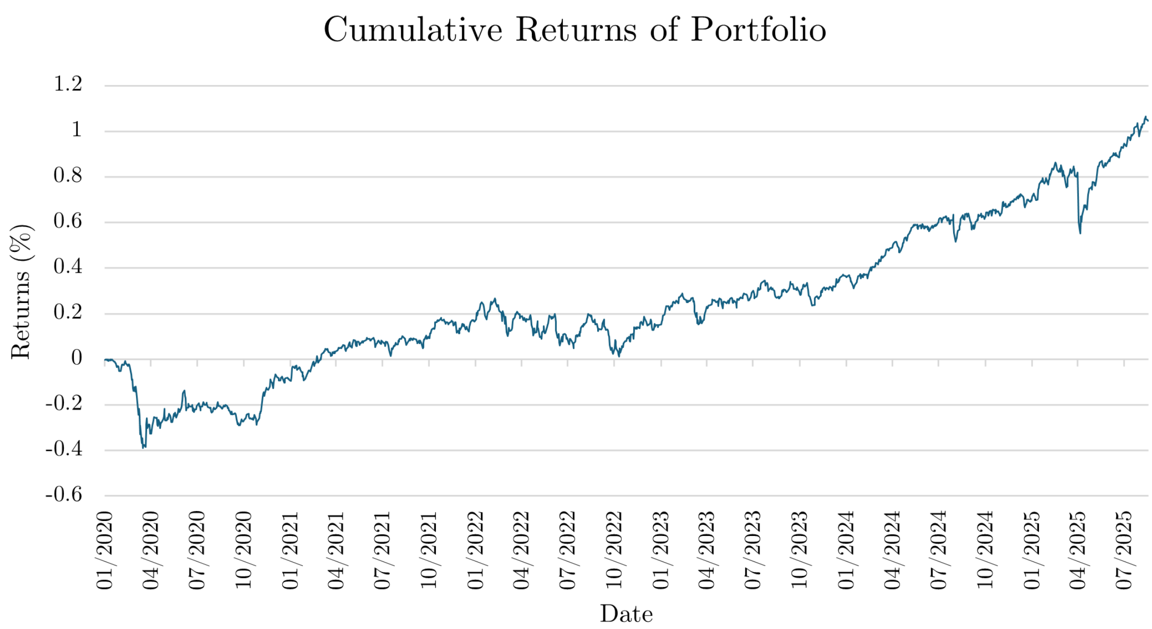


Figure 2: Cumulative Returns of Portfolio

- $R_{p,t}$ = Portfolio average daily return at time $t$ (%)

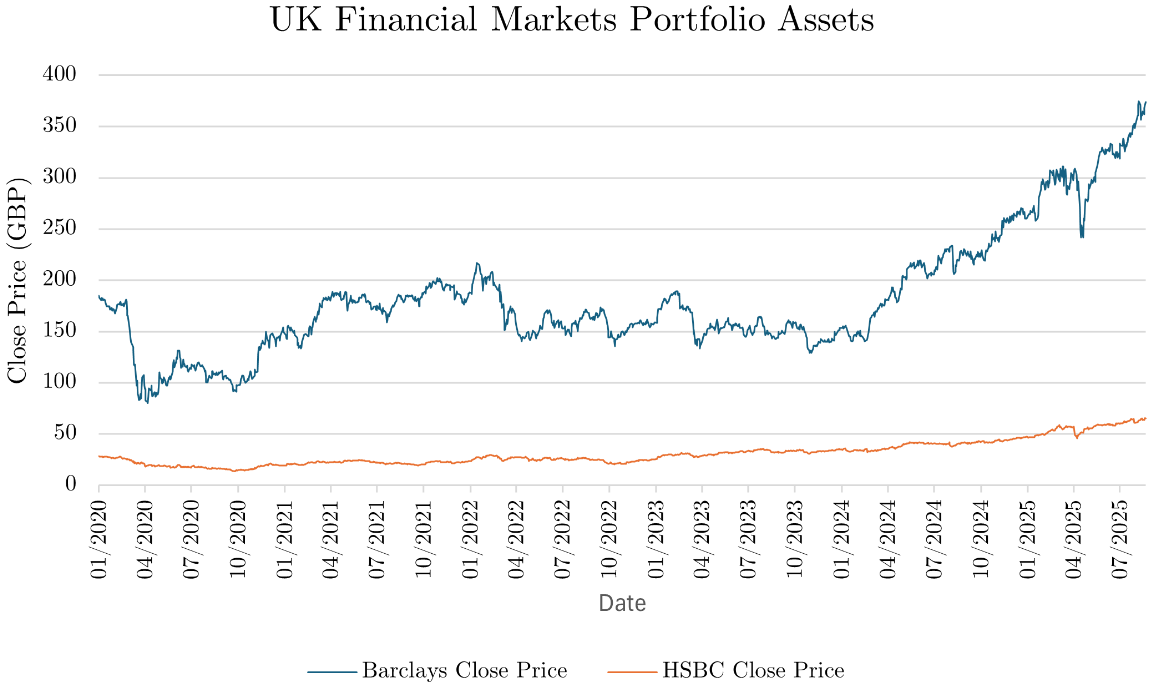


Figure 3: UK Financial Markets Portfolio Assets

- $P_{i,t}$ = Financial sector stock price of asset $i$ (Barclays, HSBC) at time $t$ (GBP)

Period Covered: January 2020 – July 2025

### 4.2 Formulae

Portfolio Returns

The portfolio return is computed as a weighted sum of asset returns:

$$R_{p,t} = \sum_{i=1}^{n} w_i \, R_{i,t}$$

where:

- $w_i$ = weight of asset $i$ in the portfolio
- $R_{i,t}$ = daily return of asset $i$ at time $t$, computed as

$$R_{i,t} = \frac{P_{i,t} - P_{i,t-1}}{P_{i,t-1}}$$

### 4.3 High-Level Observations

- Higher $Y_t$ generally corresponds with stronger financial sector performance (Barclays, HSBC).
- Lower or sharply dropping $Y_t$ often corresponds with negative portfolio returns or weaker financial stocks.

- Gradual, steady increases in $Y_t$ produce more consistent growth, while rapid spikes or drops induce short-term shocks.

### 4.4 Impact on Portfolio Returns

- $R_{p,t}$ reacts noticeably to interest rate changes, sometimes with a slight lag.
- Rapid rate increases can stagnate or slightly depress portfolio returns.
- Gradual trends in $Y_t$ are associated with steady positive returns.

### 4.5 Patterns and Takeaways

- Steady vs. Rapid Changes: Gradual interest rate increases $\rightarrow$ positive, stable returns; sudden spikes/drops $\rightarrow$ short-term shocks.
- Banks vs. Portfolio Sensitivity: Barclays and HSBC react similarly but not identically; portfolio returns smooth out some volatility.

# 5 Energy Markets, Crude Oil, and Portfolio Returns

## 5.1 Data Visualisations

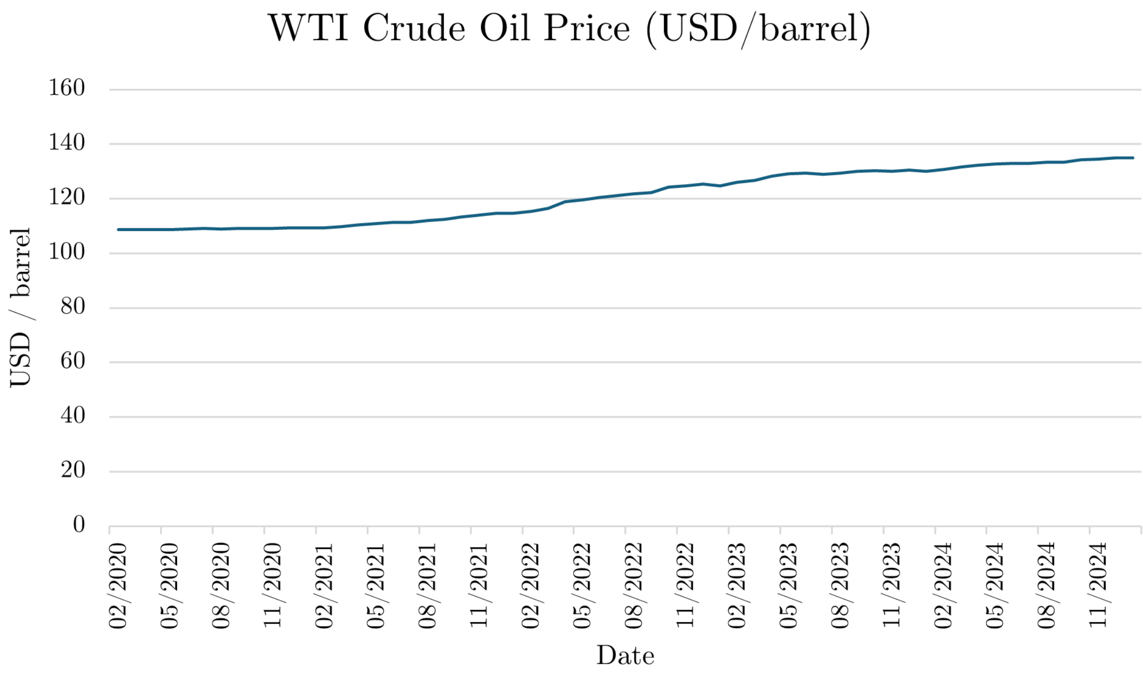


Figure 4: Crude Oil Prices (USD per barrel)

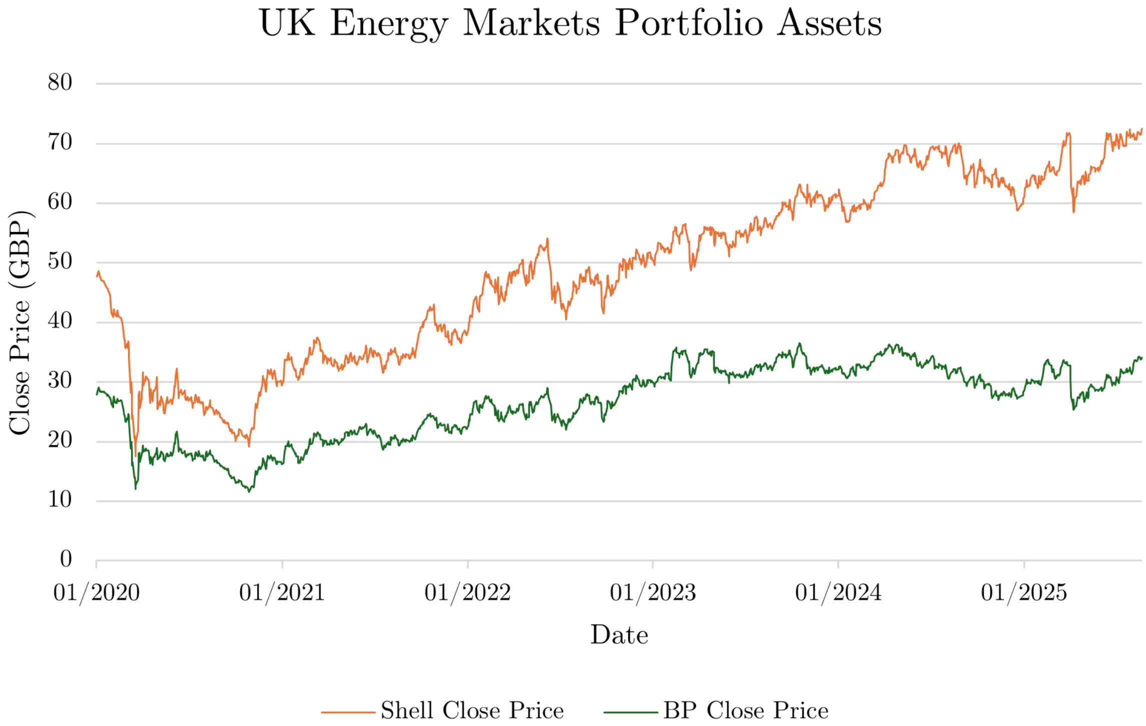


Figure 5: UK Energy Market Portfolio Assets (BP and Shell)

- $C_t$ = Crude oil price at time $t$ (USD per barrel)
- $P_{i,t}$ = Energy sector stock price of asset $i$ (BP, Shell) at time $t$ (GBP)

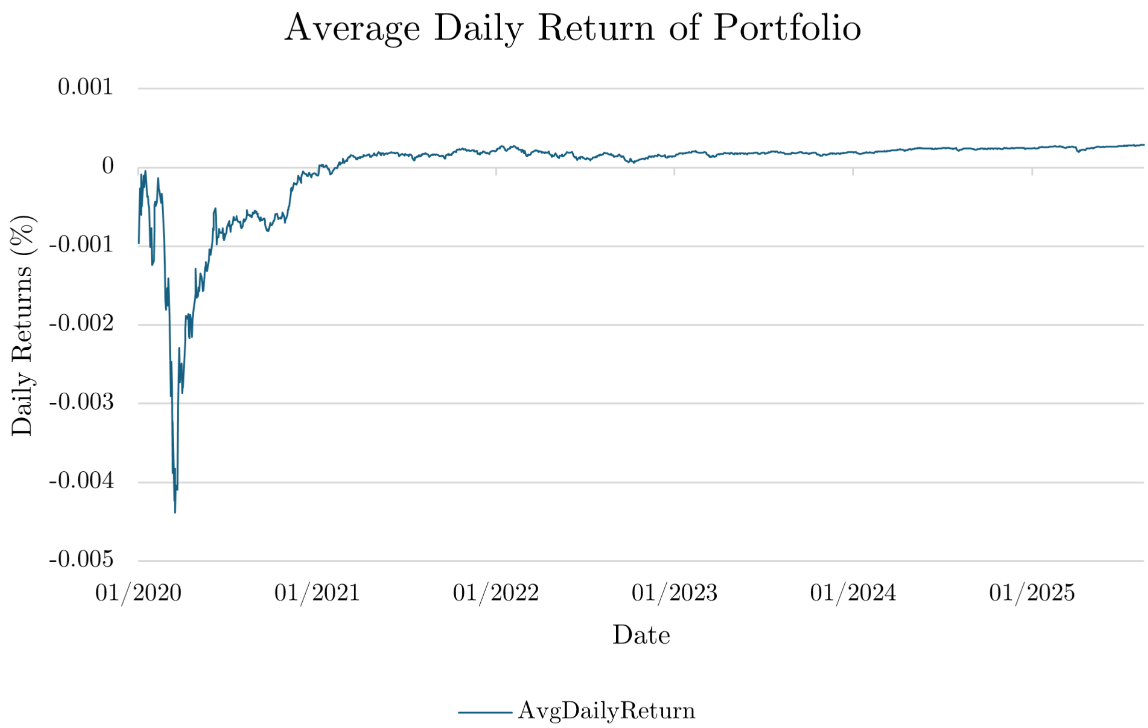


Figure 6: Average Daily Portfolio Returns

- $R_{p,t}$ = Portfolio average daily return at time $t$ (%)

Period Covered: February 2020 – January 2025

## 5.2 High-Level Observations

- BP and Shell's stock prices move almost identically, reflecting strong correlation with crude oil prices.
- During shocks (Feb–Mar 2020), both stocks plummeted sharply (BP: £30 → £11, Shell: £50 → £11) despite crude oil prices being initially stagnant, showing sensitivity to market sentiment.

## 5.3 Impact on Portfolio Returns

- Portfolio returns drop sharply during energy market shocks but stabilise when markets settle.
- After early shocks, as crude oil prices increase, BP and Shell rise along a similar gradient.
- Portfolio returns gradually track energy market recovery, though the slope is slightly flatter due to diversification across other assets.

### 5.4 Patterns and Takeaways

- Sudden shocks in energy stocks cause large negative portfolio returns even if crude oil prices are stable.
- Sustained increases in crude oil prices drive energy stock performance and portfolio returns over time.
- Energy exposure in the portfolio captures commodity uptrends while smoothing volatility from diversification.
- The slope of portfolio returns is slightly flatter than crude oil price trends, showing the cushioning effect of other portfolio assets.

# 6 Market Indices, Risk, and Portfolio Dynamics

## 6.1 Data Visualisations

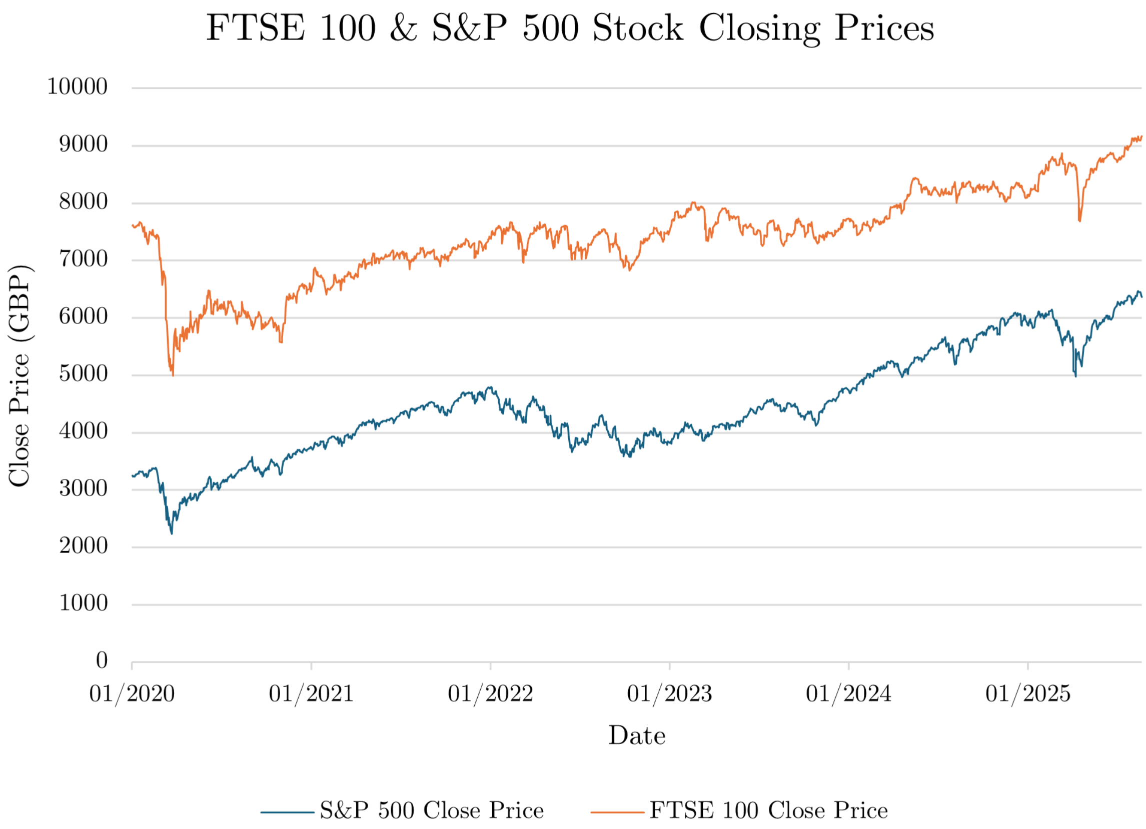


Figure 7: FTSE 100 & S&P 500 Stock Closing Prices

- $F_t$ = FTSE 100 closing price at time $t$ (GBP)
- $S_t$ = S&P 500 closing price at time $t$ (USD)

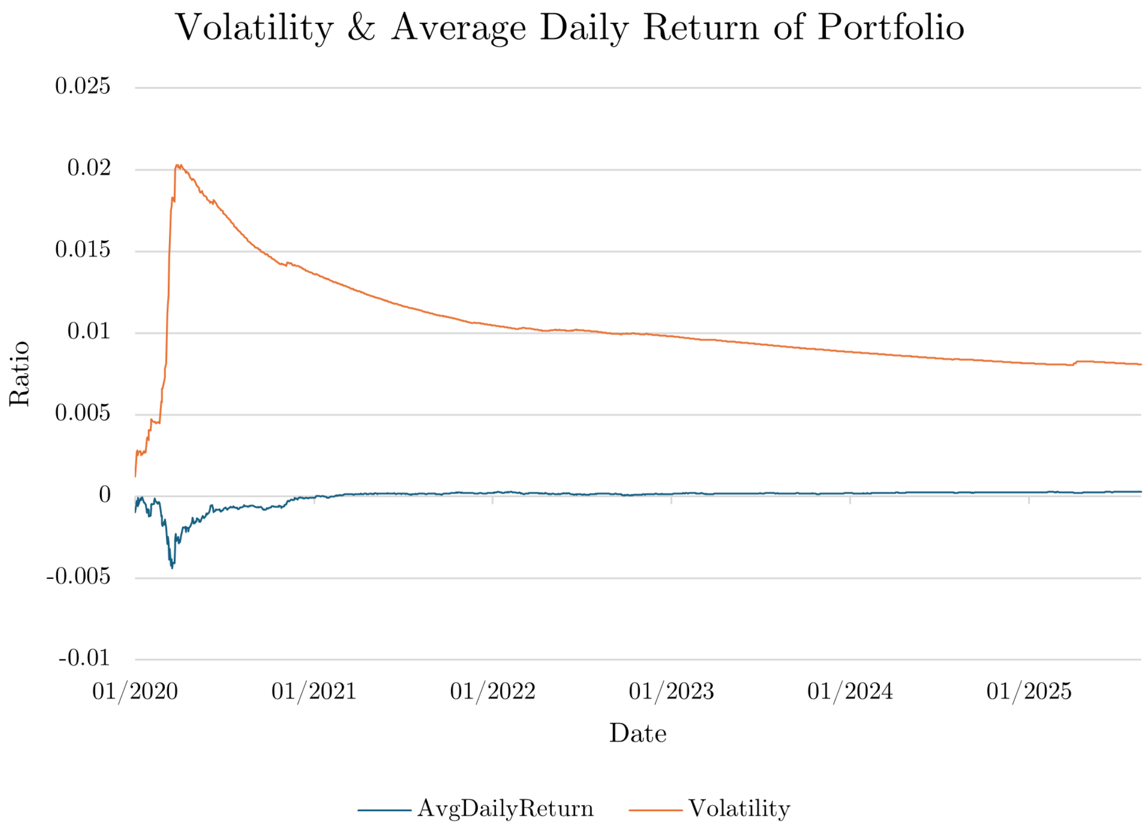


Figure 8: Volatility & Average Daily Return of Portfolio

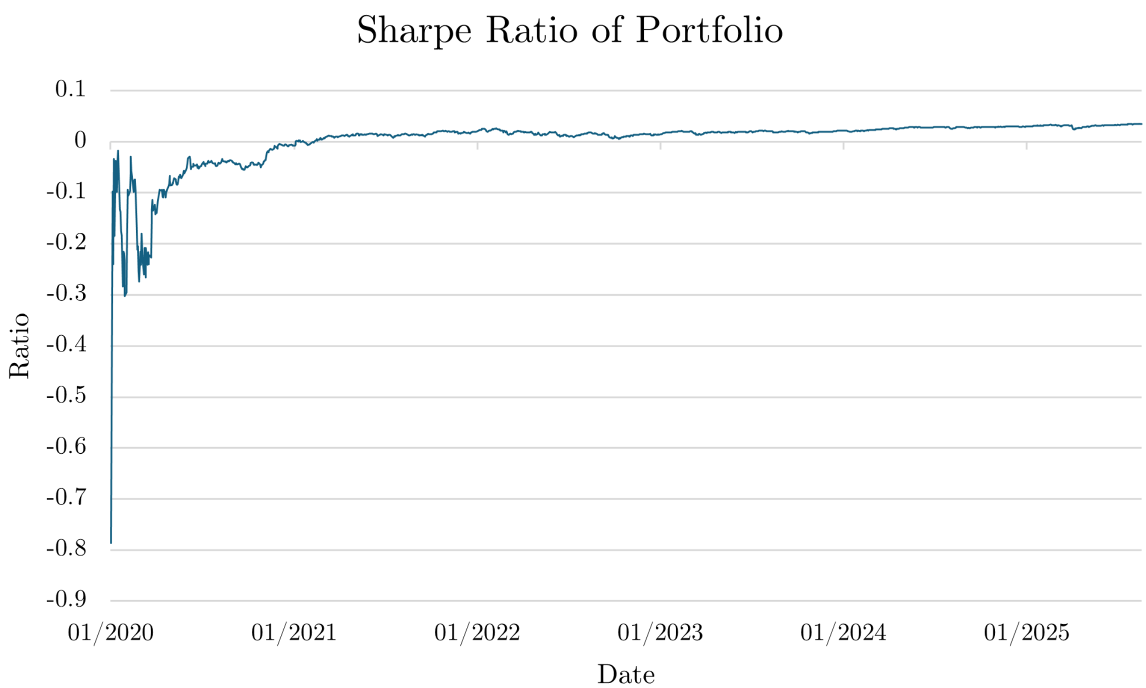


Figure 9: Sharpe Ratio of Portfolio

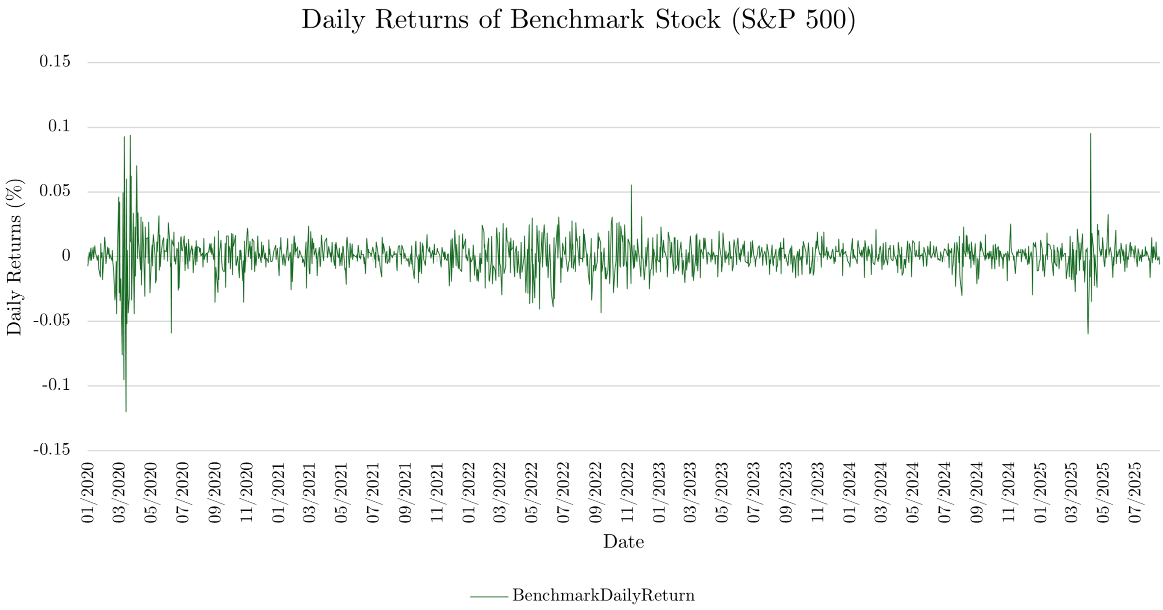


Figure 10: Daily Returns of Benchmark Stock (S%P 500)

- $R_{p,t}$ = Portfolio average daily return at time $t$ (%)
- $\sigma_{p,t}$ = Portfolio volatility at time $t$ (%)
- $\text{CumulativeReturn}_{p,t}$ = Portfolio cumulative return at time $t$ (%)
- $\text{Sharpe}_{p,t}$ = Portfolio Sharpe ratio at time $t$
- $\text{BenchmarkDailyReturn}_t$ = Daily return of S&P 500 at time $t$ (%)

Period Covered: January 2020 – January 2025

### 6.2 Formulae

Portfolio Volatility and Sharpe Ratio

Portfolio volatility measures the standard deviation of portfolio returns, accounting for asset correlations:

$$\sigma_p = \sqrt{\sum_{i=1}^{n} w_i^2 \sigma_i^2 + \sum_{i=1}^{n} \sum_{\substack{j=1 \\ j \neq i}}^{n} w_i w_j \sigma_i \sigma_j \rho_{ij}}$$

where:

- $w_i$ = weight of asset $i$ in the portfolio
- $\sigma_i$ = standard deviation of daily returns of asset $i$
- $\rho_{ij}$ = correlation coefficient between assets $i$ and $j$

The portfolio Sharpe ratio measures risk-adjusted returns:

$$\text{Sharpe}_p = \frac{\overline{R}_p - R_f}{\sigma_p}$$

where:

- $\overline{R}_p$ = average daily portfolio return
- $R_f$ = daily risk-free rate (e.g., 10-Year UK gilt yield converted to daily)
- $\sigma_p$ = portfolio volatility

### 6.3 High-Level Observations

- Portfolio performance mirrors indices closely, especially S&P 500 (40% weighting) and FTSE 100 (10% weighting).
- Cumulative portfolio returns often move more like the S&P 500, meaning global equity markets carried the portfolio when UK equities underperformed.
- Volatility spikes only during sharp market crashes (e.g., Mar 2020, early 2025), while long bull runs reduce volatility steadily.
- Benchmark daily returns (S&P 500) show strong amplitude swings during crises but flatten during stable growth periods.

### 6.4 Impact on Portfolio Returns

- Average daily returns trend upward when indices trend upward, but remain flat during sideways market conditions.
- Portfolio's resilience in 2022–2023 downturn came from heavy S&P 500 exposure, offsetting FTSE 100 weakness.
- Cumulative returns are the best proxy for overall market-driven performance.

### 6.5 Patterns and Takeaways

- Crisis = Spike in Volatility + Daily Returns Swings: 2020 crash and 2025 mini-crash produced sudden volatility spikes and large benchmark swings.
- Stable Growth = Falling Volatility: Long bull runs (2021–2022, 2024) steadily decreased volatility, with portfolio returns rising smoothly.
- Sharpe Ratio Dynamics: Portfolio Sharpe ratio is lowest during volatility spikes and increases gradually as volatility declines; these factors are highly correlated.

# 7 UK Macroeconomic Indicators

## 7.1 Data Visualisations

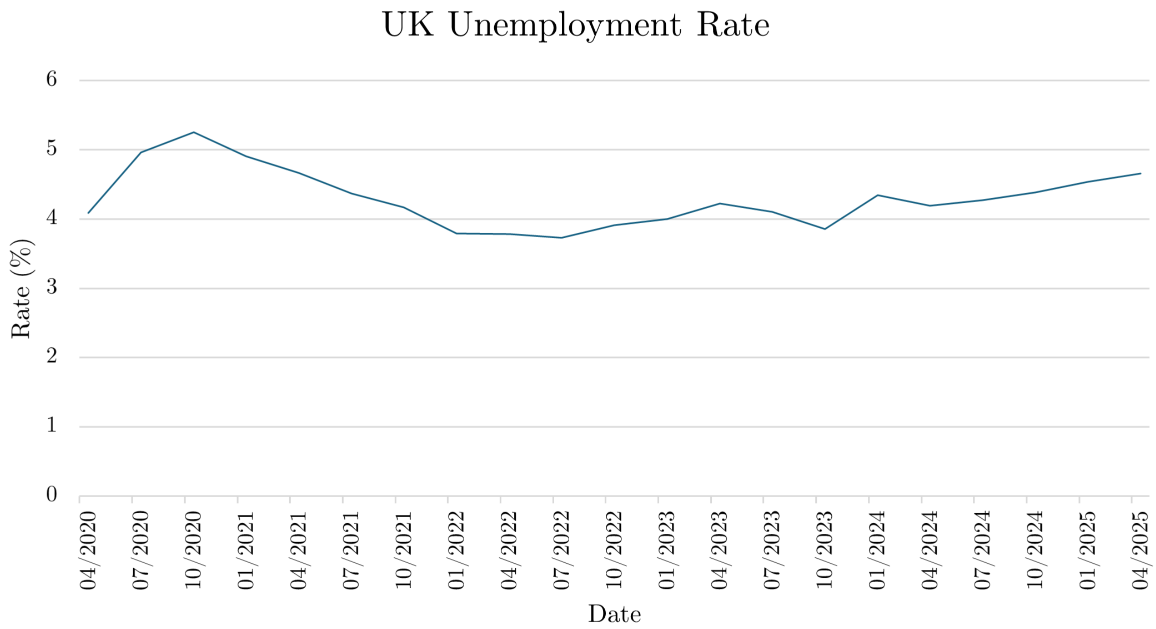


Figure 11: UK Unemployment Rate

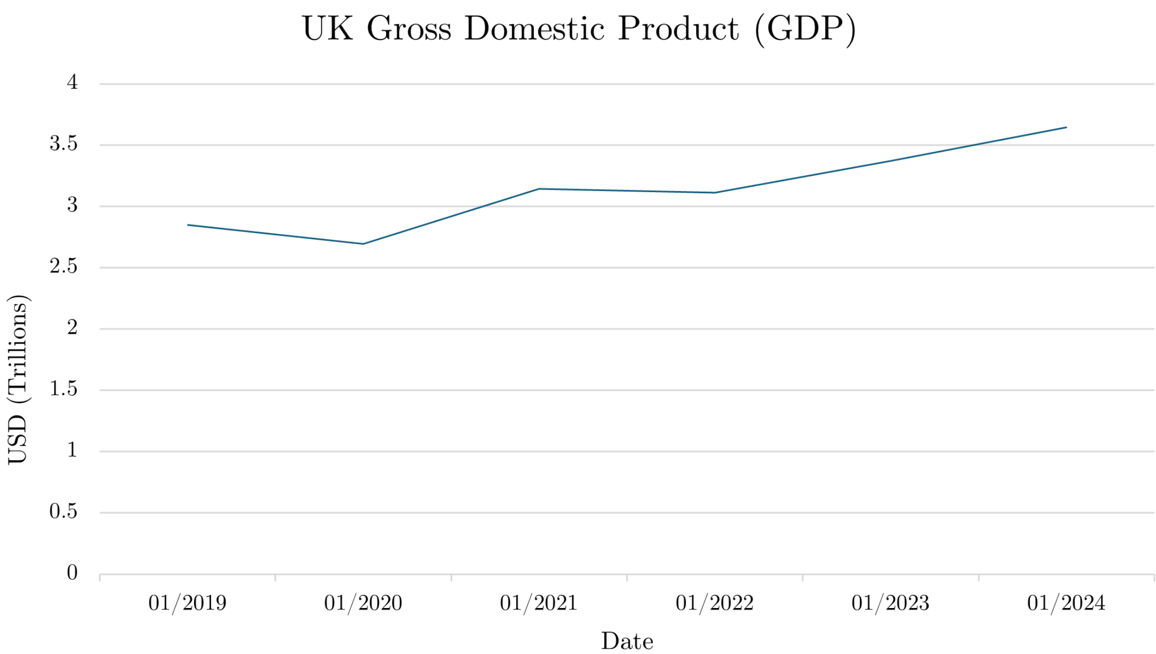


Figure 12: UK Gross Domestic Product (GDP)

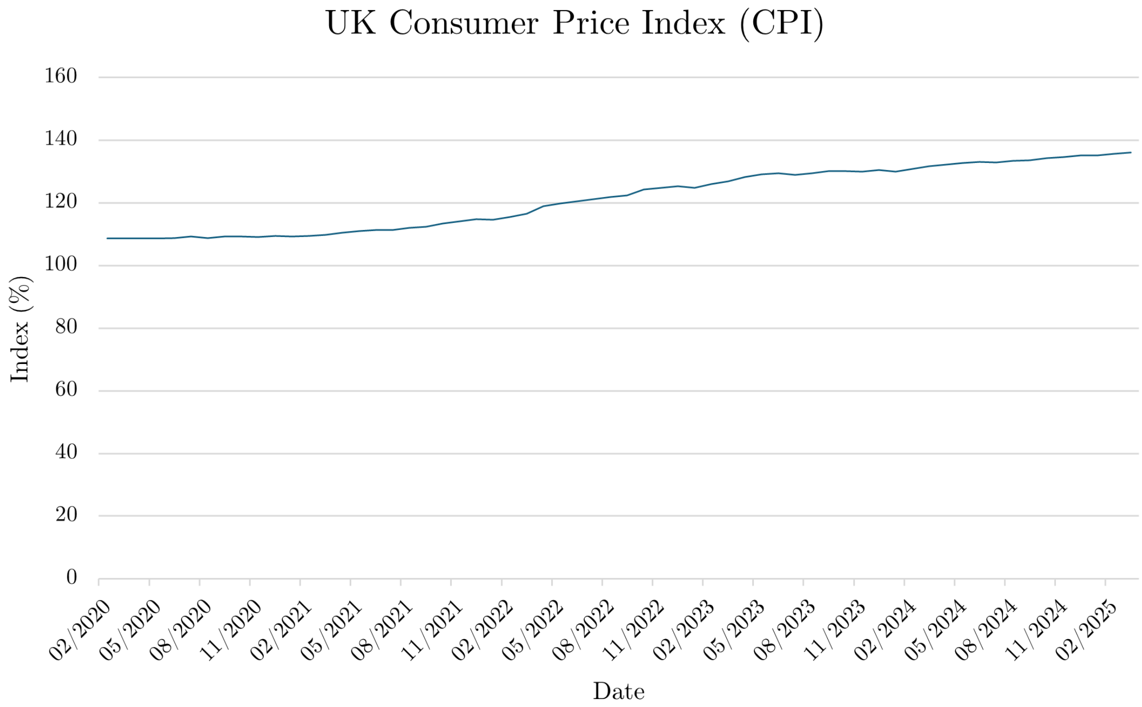


Figure 13: UK Consumer Price Index (CPI)

Period Covered: January 2019 – January 2024

- $U_t$ = UK unemployment rate at time $t$ (%)
- $GDP_t$ = UK GDP growth at time $t$ (%)
- $CPI_t$ = Consumer Price Index at time $t$

### 7.2 High-Level Observations

- Early Recovery (2020–2021): unemployment fell before GDP growth picked up, showing a lag between labour market recovery and output growth.
- Classic Link (2021–mid 2022): falling unemployment aligned with GDP expansion, reflecting expected macroeconomic behaviour.
- Breakdowns (late 2023 onwards): unemployment rose while GDP continued increasing, suggesting other factors (inflationary growth, fiscal stimulus, productivity shocks) influenced output.
- CPI consistently rose, indicating background inflation pressures but not directly explaining portfolio dynamics.

### 7.3 Patterns and Takeaways

- The unemployment–GDP relationship in the UK is non-linear and state-dependent: classical theory holds in some periods, while structural factors dominate in others.

- Inflationary trends provide context for cost pressures and potential monetary policy responses.
- Portfolio exposure to macro-sensitive sectors (e.g., financials, energy) may react differently depending on the phase of the unemployment–GDP cycle.

# 8 Portfolio Simulation Scenario: Rising UK Interest Rates

## 8.1 Data Visualisations

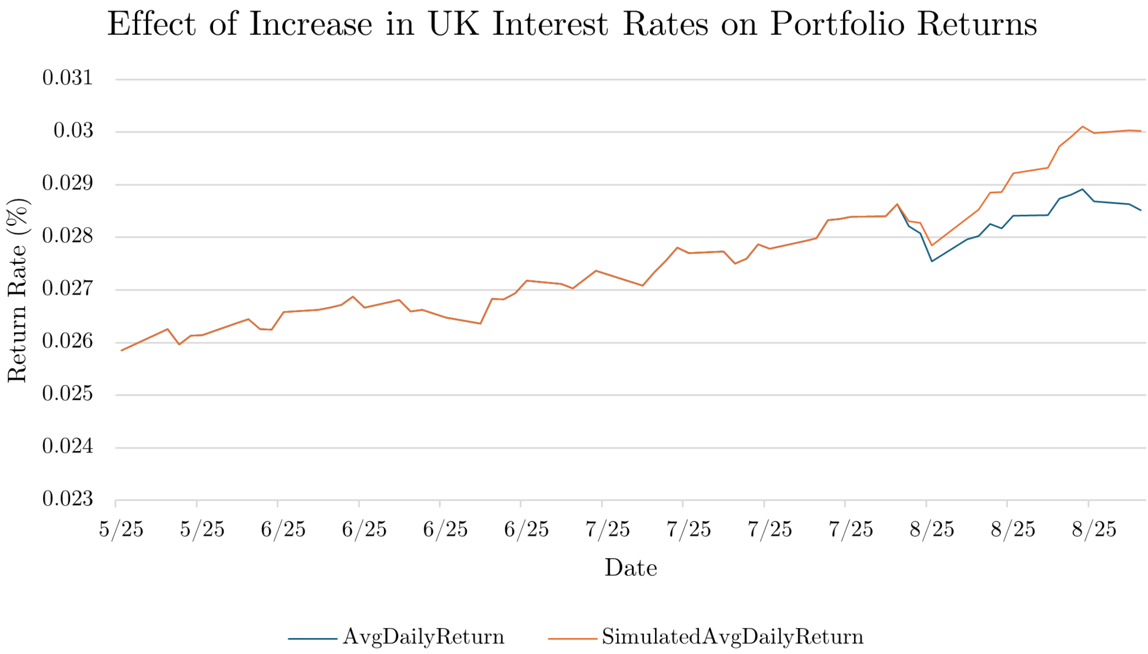


Figure 14: Effect of Increase of UK Interest Rates on Portfolio Returns

Period Covered: May 2025 – August 2025

Justification for Simulated Portfolio Returns under Rising UK Interest Rates

*Since approximately 30% of the portfolio is exposed to the UK financial sector (Barclays & HSBC), interest rate dynamics, captured by the 10-year UK government bond yield, are a major driver of returns.*

## 8.2 Observed Relationships

Bond Yields and Bank Performance

- Higher 10-year yields: market expects tighter policy and higher interest margins, resulting in stronger financial sector performance (Barclays, HSBC).
- Lower or sharply falling yields: signal weaker growth or potential rate cuts, leading to weaker bank performance and negative portfolio impact.

Gradual vs. Rapid Rate Changes

- Gradual increases in yields (e.g., Feb–Aug 2024: 3.9% → 4.2%) supported steady cumulative returns and strong Barclays performance.
- Sudden spikes or drops created uncertainty, causing financial stocks to underperform and the portfolio to experience short-term dips.

Portfolio Sensitivity

- Barclays and HSBC react similarly, though Barclays tends to outperform in recovery phases.
- Broader portfolio diversification (S&P 500, FTSE 100, energy) smooths volatility but does not fully offset shocks.

CPI Considerations

- CPI rises steadily regardless of short-term yield shocks.
- Inflation only affects financial markets via long-term interest rate expectations, not immediate fluctuations.

### 8.3 Patterns and Takeaways

- Positive scenario: slow, steady rate increases lead to stable growth for banks and the financial sector.
- Negative scenario: sharp yield shocks (up or down) cause volatility, stagnation, or short-term losses.
- Portfolio impact: returns move with interest rate trends but are muted due to diversification.

### 8.4 Investment Recommendation

- Favour UK financials (Barclays, HSBC) when yields increase gradually, this environment boosts interest margins and supports sector growth.
- Reduce exposure if yields rise too sharply, shocks undermine financial stability and trigger market uncertainty.
- Maintain diversification with non-financial assets to smooth volatility, while recognising that yield shocks will still affect short-term performance.

## 9 Financial Analysis

Rising UK interest rates generally improve profitability for banks, as higher yields increase net interest margins. Gradual and predictable rate increases are more favourable, producing stable portfolio returns, whereas sudden spikes or drops introduce short-term volatility.

Energy market shocks, particularly fluctuations in crude oil prices, can indirectly influence financial markets through inflationary pressures and CPI trends, which in turn affect monetary policy decisions.

Portfolio diversification across financials, energy, and global indices helps mitigate risk, but it cannot fully eliminate sensitivity to macroeconomic shocks.

Correlation analysis indicates that financial stocks respond strongly to bond yield movements, while energy stocks tend to track commodity prices, highlighting the sector-specific drivers of portfolio performance.

## 10 Conclusion

Steady increases in UK interest rates provide favourable conditions for investing in the financial sector, particularly in Barclays and HSBC. Portfolio performance is most stable when interest rate changes are gradual and predictable, while sudden macroeconomic shocks can cause temporary setbacks.

Diversification across sectors and international indices helps smooth portfolio volatility but requires careful monitoring of macroeconomic and commodity indicators.

Future work could involve stress testing under extreme interest rate scenarios, scenario modelling for energy market shocks, and incorporating machine learning forecasts to improve predictive portfolio management.

## 11 References


- Yahoo Finance API. Financial market data for UK and global equities, 2020–2025. `https://finance.yahoo.com/`.
- Federal Reserve Economic Data (FRED) API. US and UK macroeconomic indicators, including interest rates and GDP. `https://fred.stlouisfed.org/`.
- World Bank API. Global economic and commodity data, including CPI, GDP, and oil prices. `https://data.worldbank.org/`.