# FFAENGINE

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# PROJECT OVERVIEW

A quick recap into the project goals

# INTENDED GOALS

- Create a factor-based allocation model leveraging a long/short strategy
- Evaluate its sensitivity to various parameters
- Highlight the importance of historical data structure and sudden shifts in the market

# THE ENGINE

- Called the **FFAEngine**
- Leverages the *Fama French 3-Factor* asset pricing model

# THE MATHEMATICAL STRUCTURE

The foundation and concepts

# THE FAMA FRENCH 3 FACTOR MODEL

## BUILT ON TOP OF THE CAPM

$$\rho_i = \rho_0 + \beta_i^s(\rho_m - \rho_0)$$

$$\beta_i^s = \frac{cov(R_i, R_m)}{\sigma_m^2}$$

## ADDS MORE DESCRIPTORS

$$\rho_i = \rho_0 + \beta_i^s(\rho_m - \rho_0) + \beta_i^{smb}\rho_{smb} + \beta_i^{hml}\rho_{hml} + \alpha_i$$

# THE OPTIMIZATION PROBLEM

## MAXIMIZE RETURNS WHILE MINIMIZING RISK

$$\max_{w \in \mathbb{R}^n} \quad \rho^T \omega - \lambda(\omega - \omega_p)^T \Sigma(\omega - \omega_p)$$

$$\text{s.t.} \quad \sum_{i=1}^{n} \beta_i^m \omega_i = \beta_T^m$$

$$\sum_{i=1}^{n} \omega_i = 1$$

$$-2 \leq \omega_i \leq 2$$

# SUB-PERIOD DIVISION

## TOTAL TIME PERIOD

March 1st 2007 – June 30th 2021

**Pre-Crisis**
- March 1st 2007
- December 31st 2007

**In-Crisis**
- January 1st 2008
- June 30th 2009

**Post-Crisis**
- July 1st 2009
- June 30th 2021

# TERM STRUCTURE

# NOTATION

$$S_{\rho_L}^{\Sigma_L}\left(\beta_T^m\right)$$

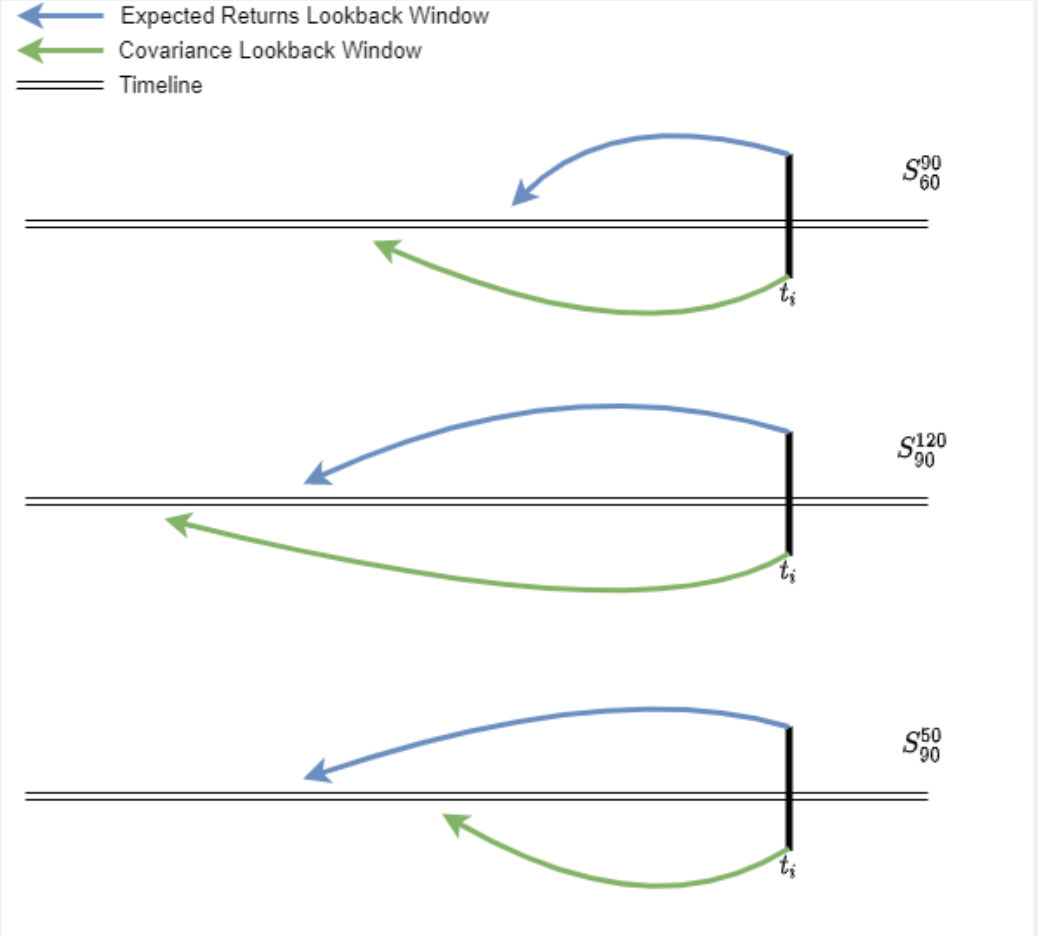



Figure 1.3: Abstract overview of how the term structure features will work to parse historical data

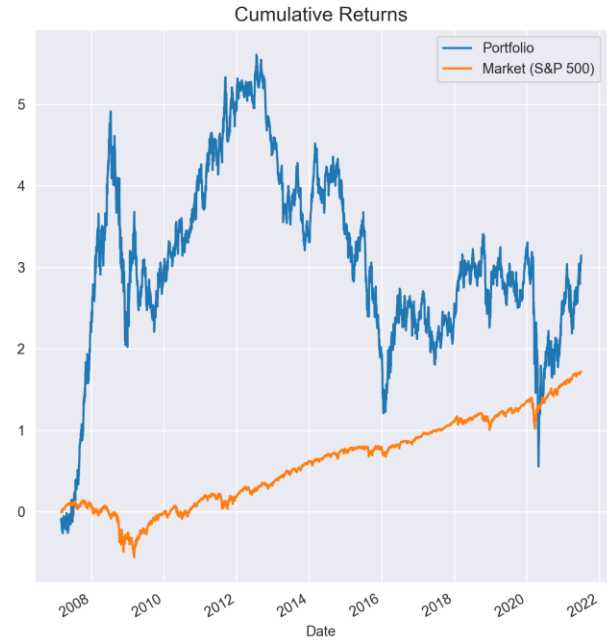
# OBSERVATIONS AND ANALYSIS

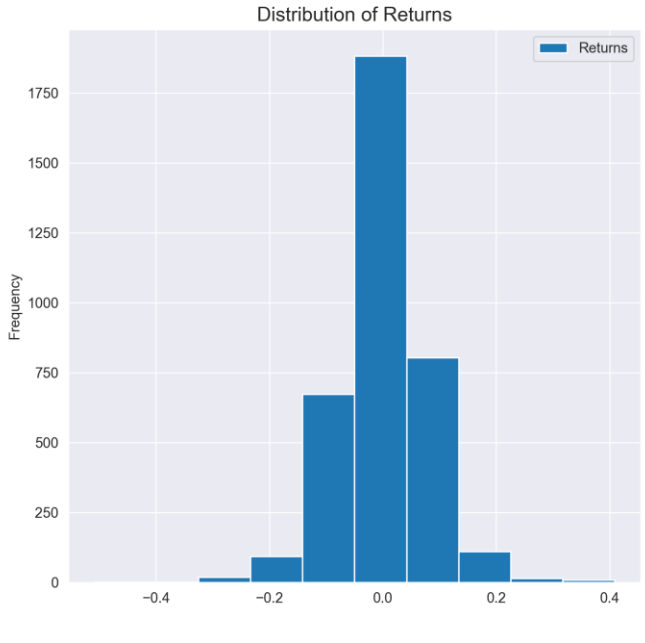
Reports and Highlights

# IMPACT FROM THE TARGET BETA

$$S_{90}^{120}\left(-0.5\right)$$

| Performance | Pre-Crisis |
|---|---|
| PnL | $72.1052 |
| Daily Mean | 0.217849 |
| Volatility | 0.0766214 |
| Sharpe Ratio | 0.0113728 |
| VaR 95% | -0.115074 |



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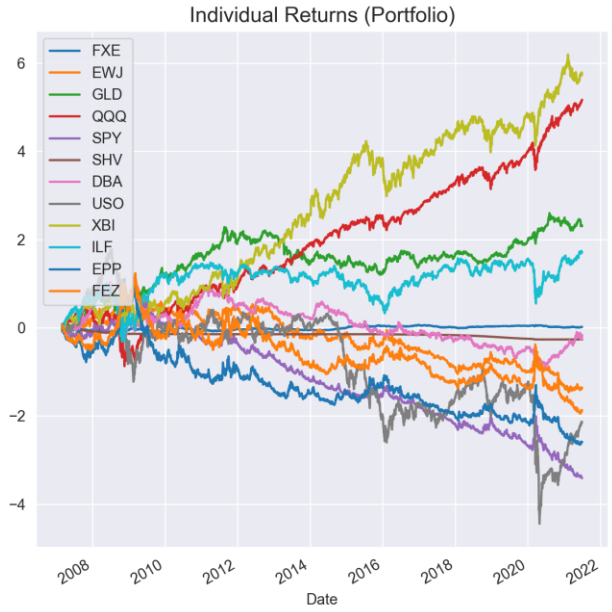


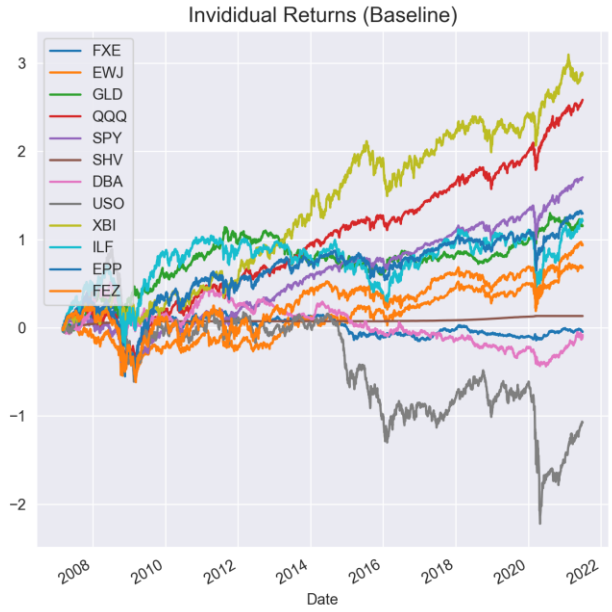

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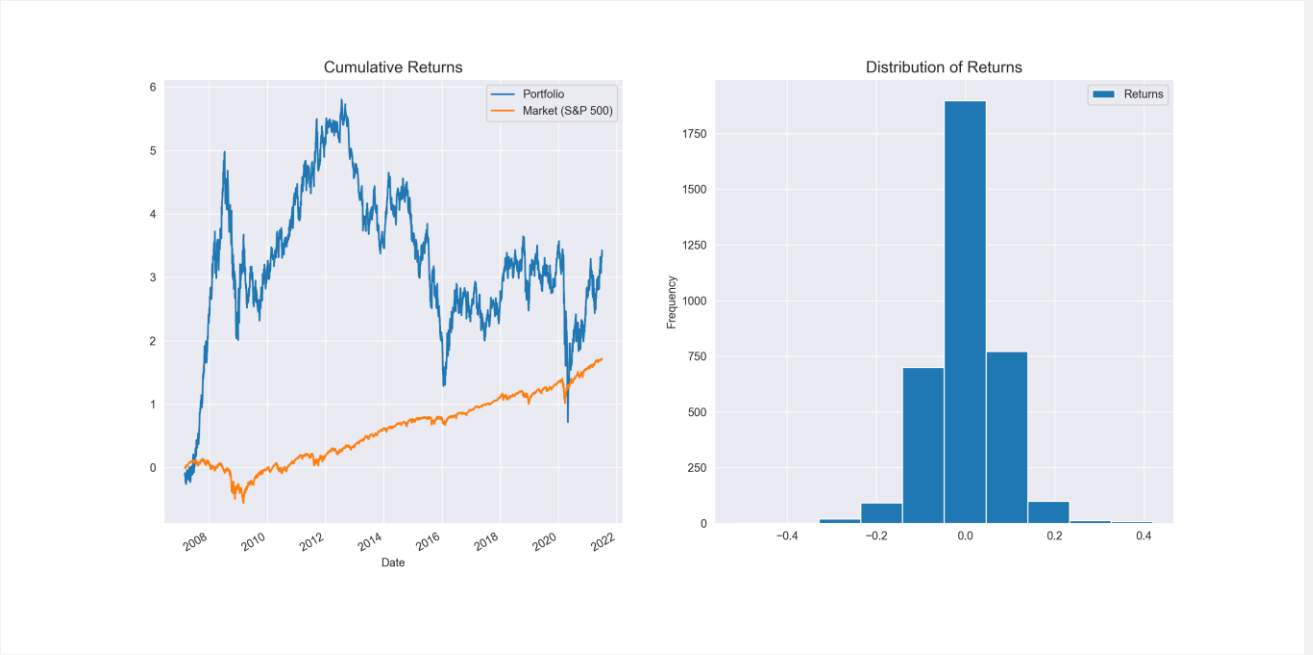

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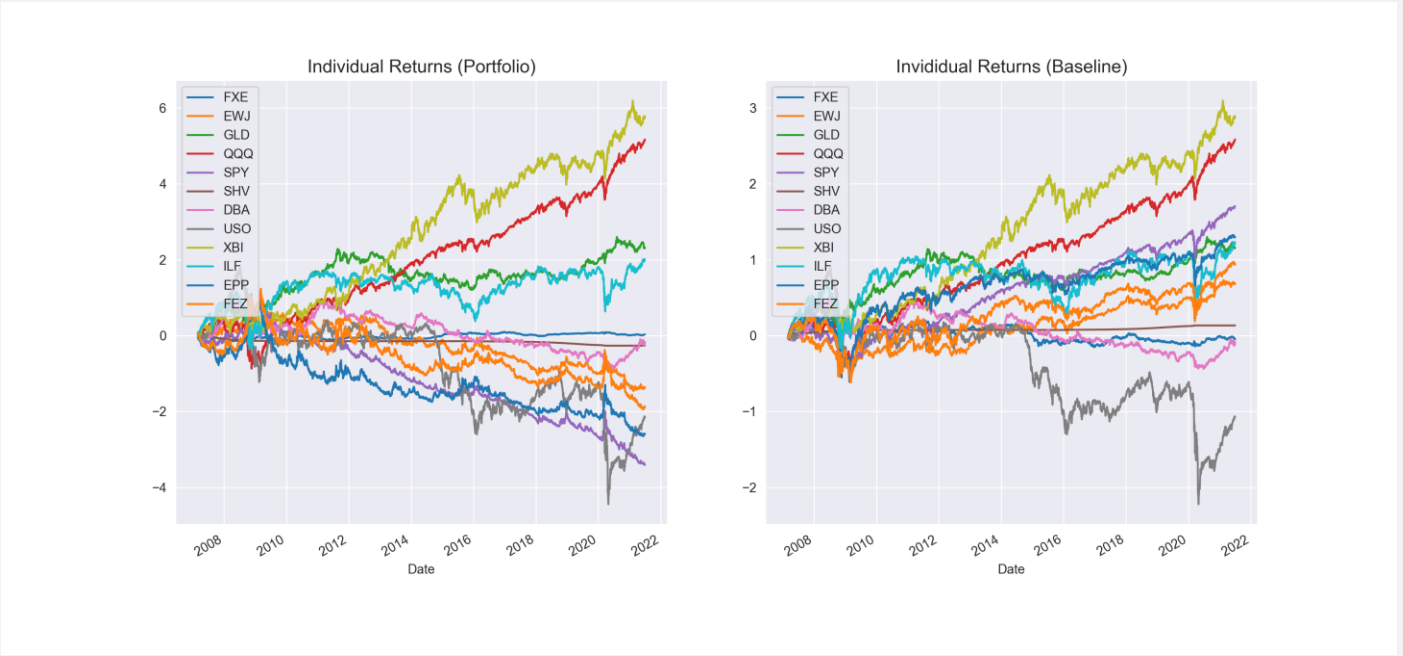

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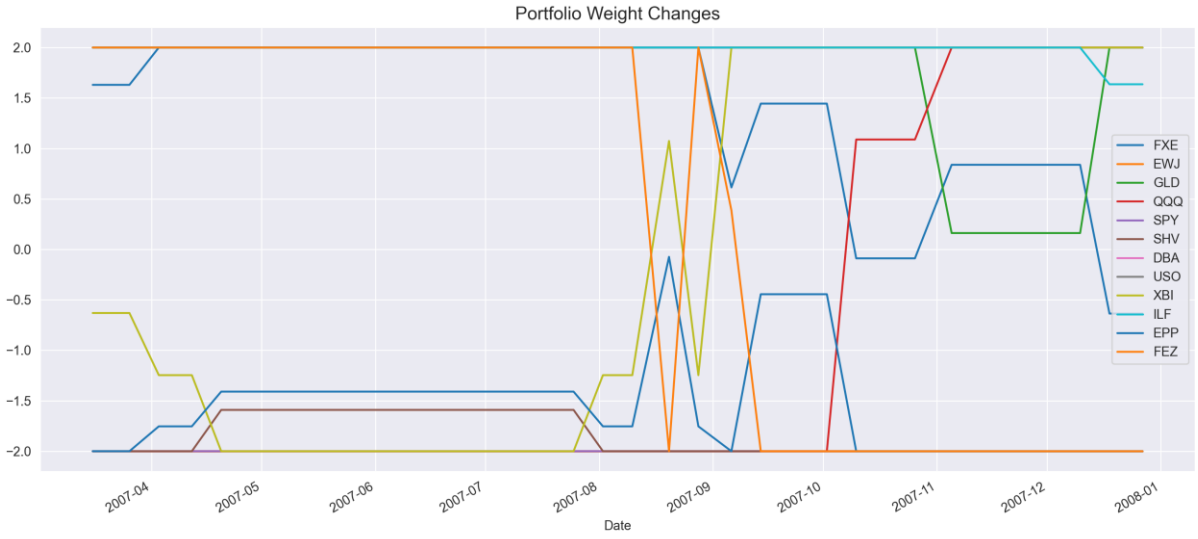

$$S_{90}^{120}\ (1)$$

| Performance | Post-Crisis |
|---|---|
| PnL | -$197.539 |
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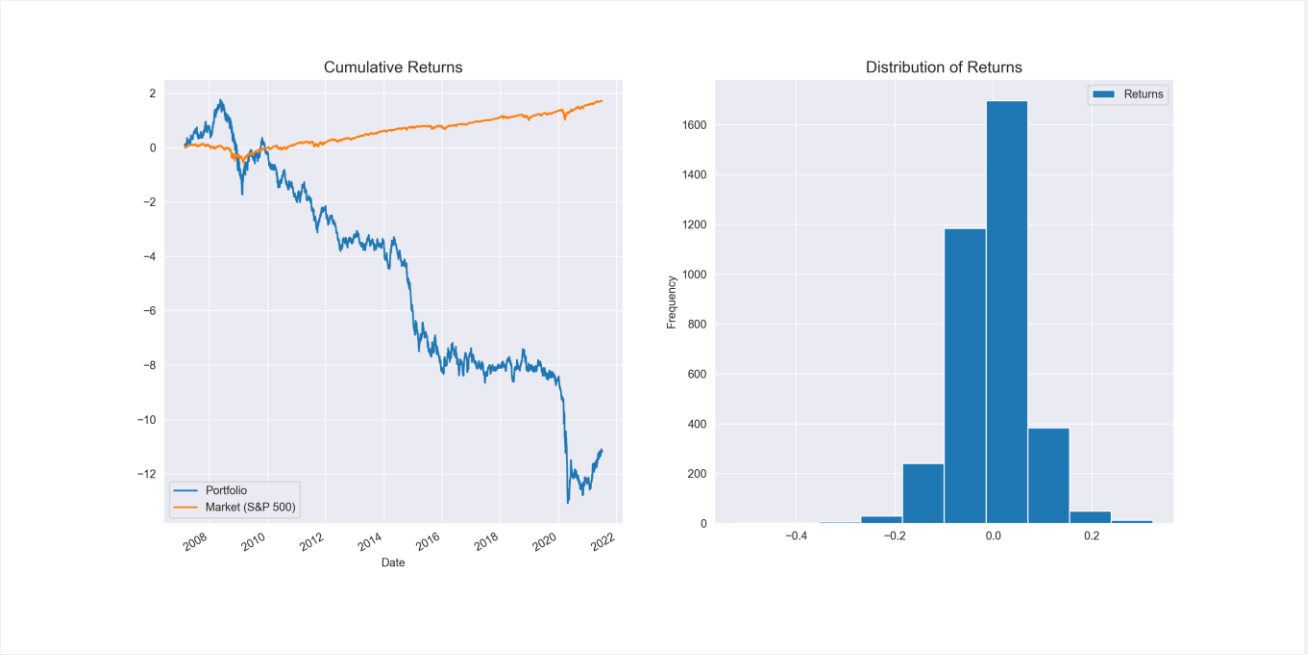

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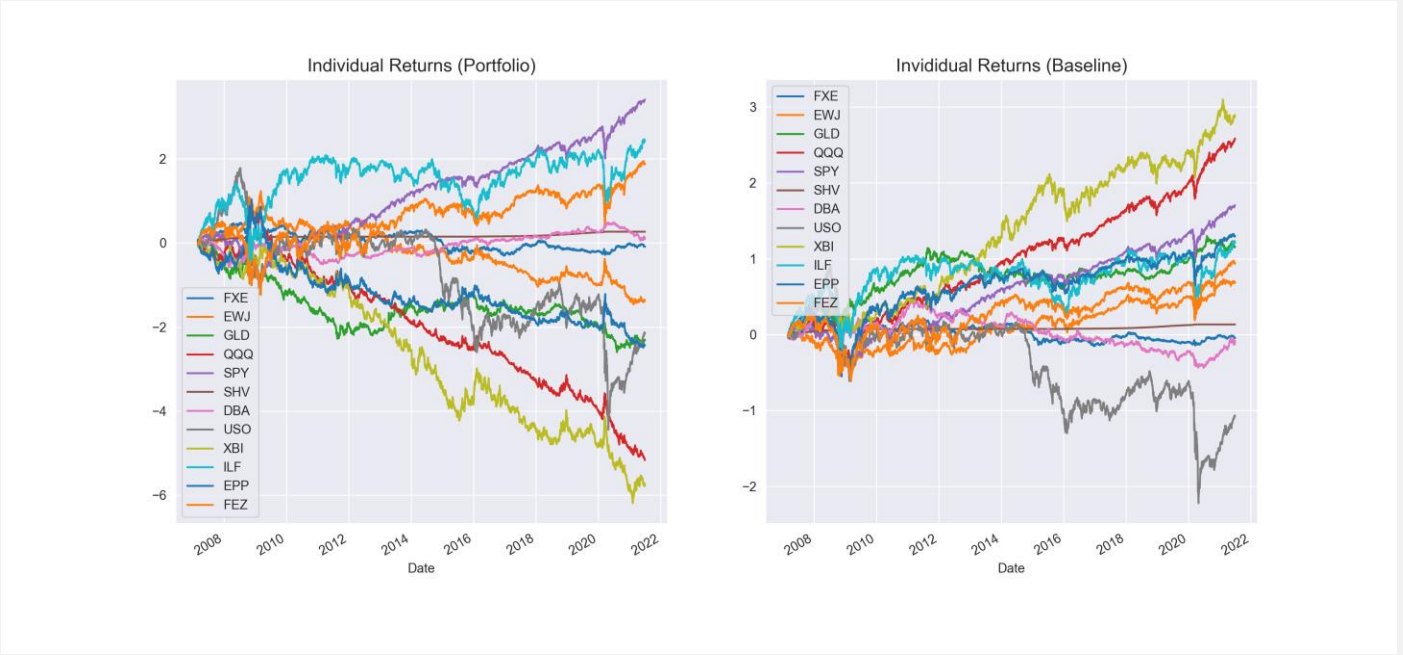

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# IMPACT FROM THE TERM STRUCTURE

$$S_{40}^{240}\,(0.5)$$

| Performance | Pre-Crisis |
|---|---|
| PnL | -$8.37556 |
| Daily Mean | 0.0216064 |
| Volatility | 0.0766831 |
| Sharpe Ratio | 0.00112705 |
| VaR 95% | -0.12165 |

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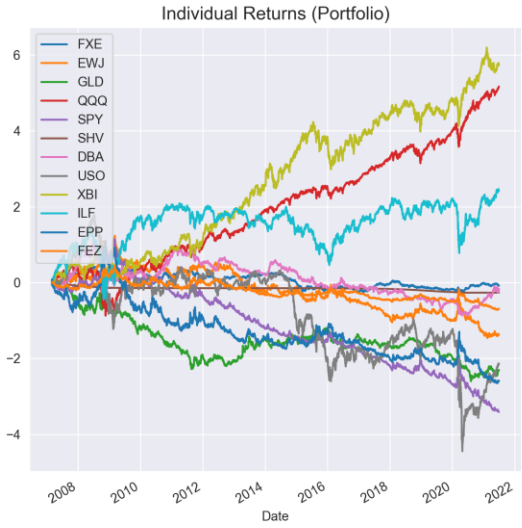


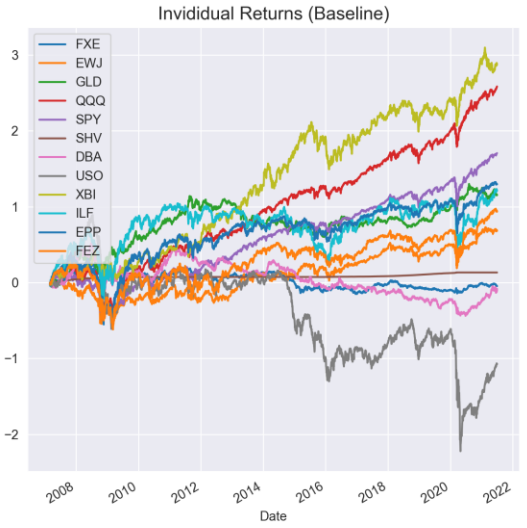

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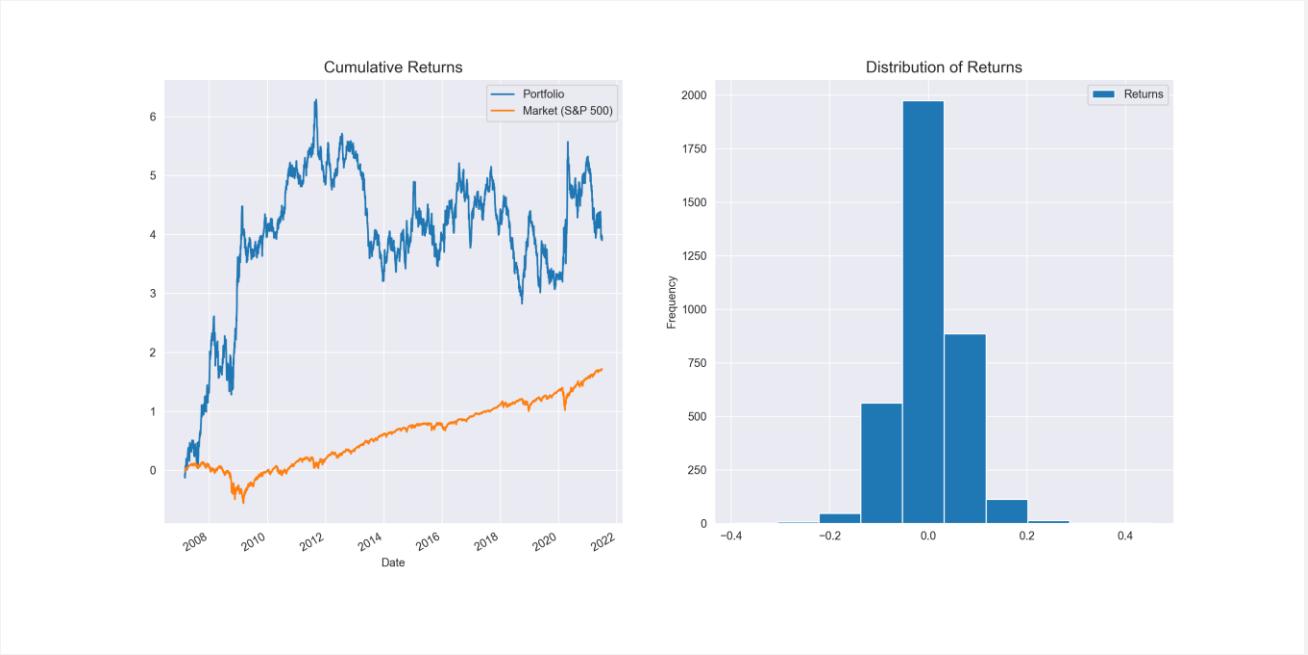
$$S_{200}^{40}\,(0.5)$$

| Performance | In-Crisis |
|---|---|
| PnL | $897.99 |
| Daily Mean | 0.274116 |
| Volatility | 0.0640025 |
| Sharpe Ratio | 0.0171316 |
| VaR 95% | -0.0995051 |



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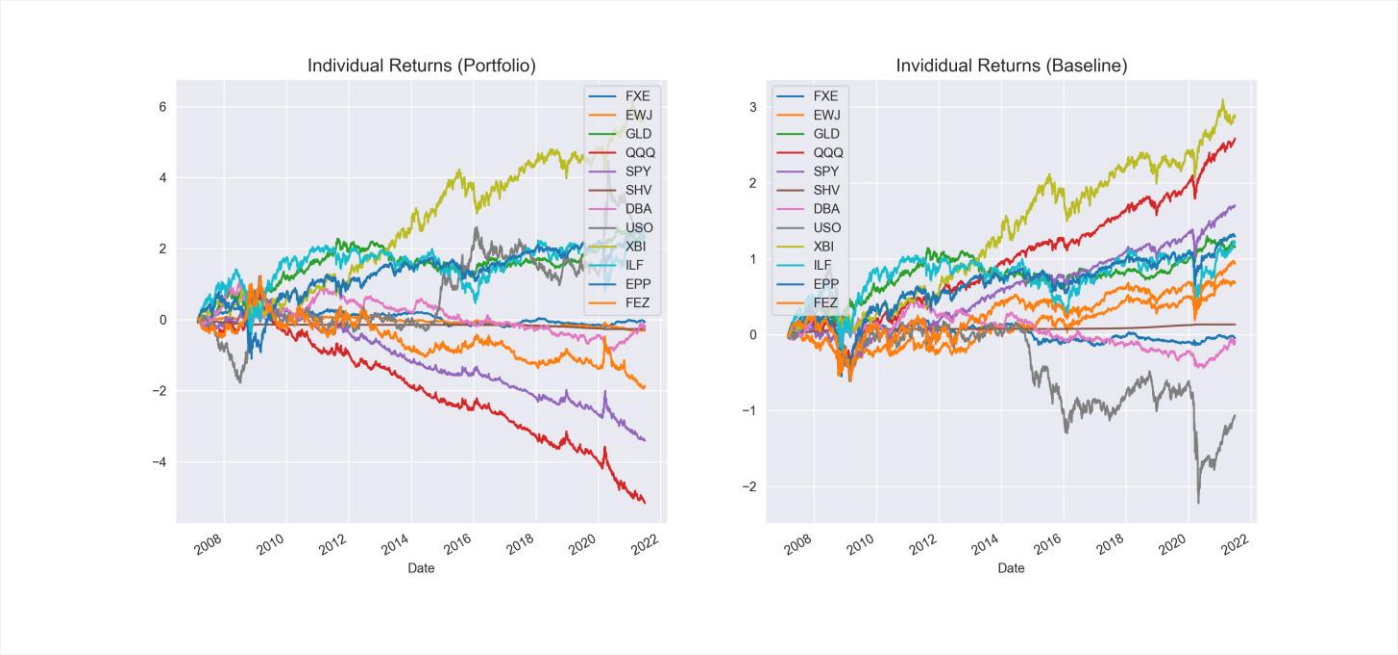

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# THE ENGINE

The Nuances

# INFRASTRUCTURE

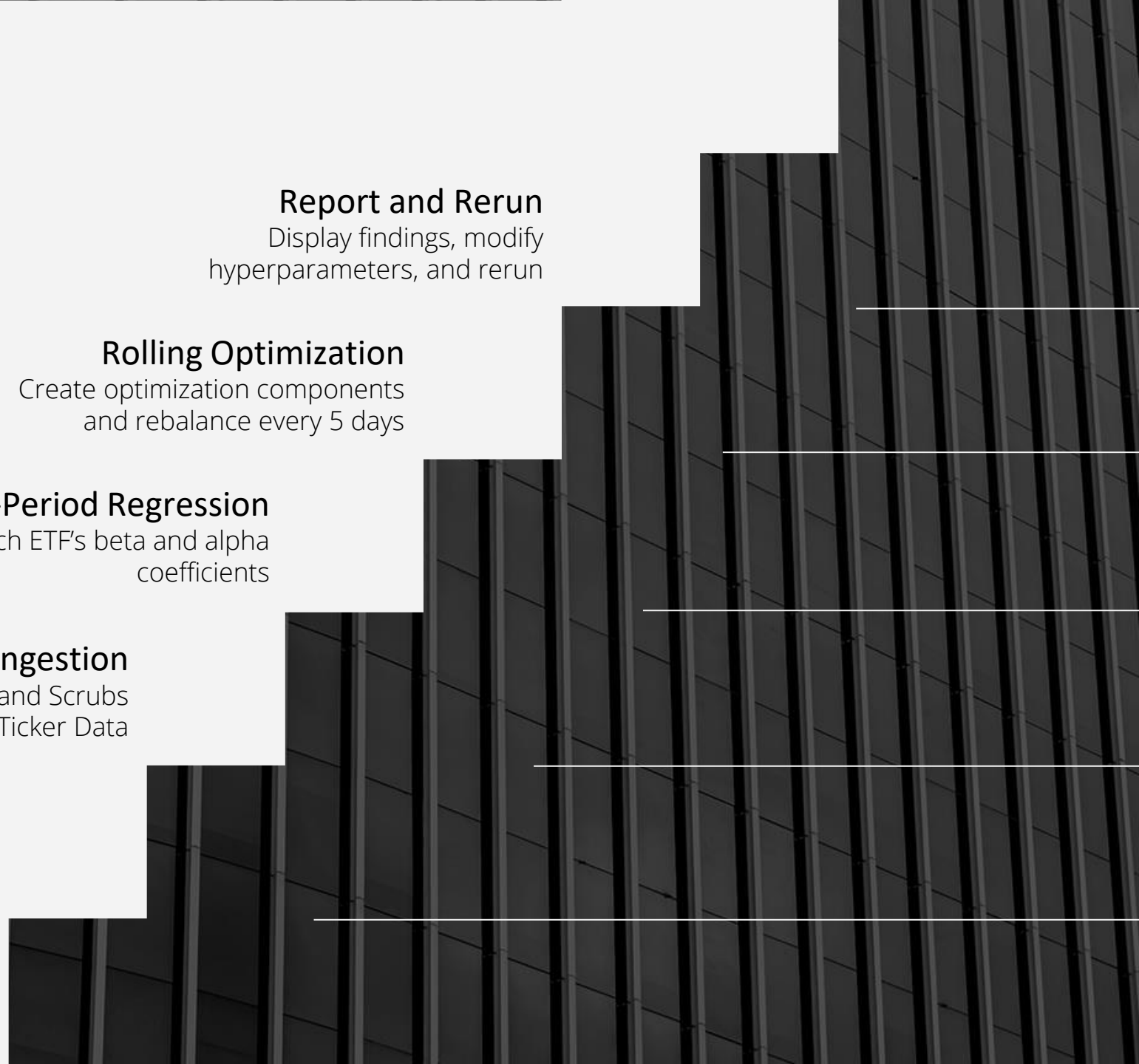
**Report and Rerun**
Display findings, modify hyperparameters, and rerun

**Rolling Optimization**
Create optimization components and rebalance every 5 days

**Sub-Period Regression**
Collect each ETF's beta and alpha coefficients

**Ingestion**
Aggregates and Scrubs Ticker Data

**Foundation**
NumPy, Pandas, CVXPY



# FINAL REMARKS

Thoughts and Feedback

# SENSITIVITY PARAMETERS

- $\beta_T < 0.5$ worked best
  - Is $\beta_T < 0$ smart in real world?
- Term structures with large window for expected returns provided better calculation of beta coefficients during linear regression
- Look for conditions where portfolio weight rebalancing is not too drastic

# SUB-PERIODS ARE EQUALLY IMPORTANT

- In-Crisis period back-testing performed best
  - Important due to project dates (2007 – 2021)
  - Head of crisis began roughly in 2008
- Close to current time period = Larger historical window
  - Engine requires more drastic shifts in market to smooth volatility of allocation

# IMPROVEMENTS TO ENGINE

- Data quality
  - Normalization
- Data quantity
  - Longer historical windows
  - More years prior to crisis
- Feature to apply dual optimization of both term structures
  - Create optimal window based on sub-period

# THANK YOU