NC STATE UNIVERSITY

Quantitative Methods for Portfolio Optimizations and Trading Strategies

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Outline

Component Selection
- Data Extraction
- Data Exploration and Analysis

Optimization of Portfolio
- Markowitz Portfolio Theory
- Lagrange Method

Variance Estimation
- Static Model
- Dynamic Model

Performance Evaluation
- Performance Metrics
- Comparison of Portfolios

Component Selection

- Stocks with good fundamentals
- Stocks in different industries
- Stocks with low correlation

Data Exploration

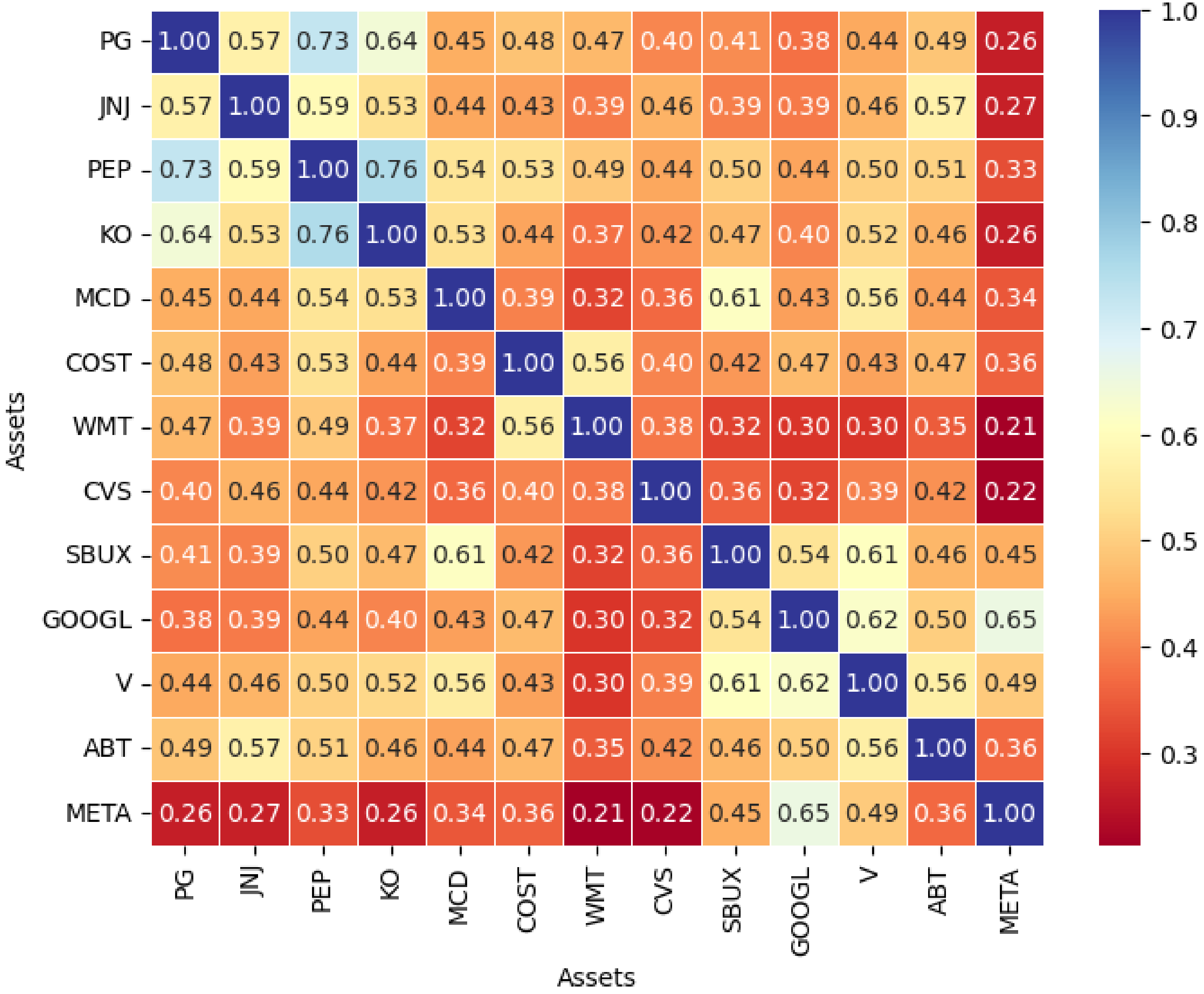
- Derived from BridgeWater, extract 13 components
- Exclude large Funds i.e. IVV: iShares S&P500, IEMG
- Use 2018-01-01 to 2022-12-31 as in-sample period to calculate weights
- Use 2023-01-01 to 2023-11-22 as out-of-sample period to test performance
- Benchmark: S&P500 and BridgeWater holdings

Component Selection

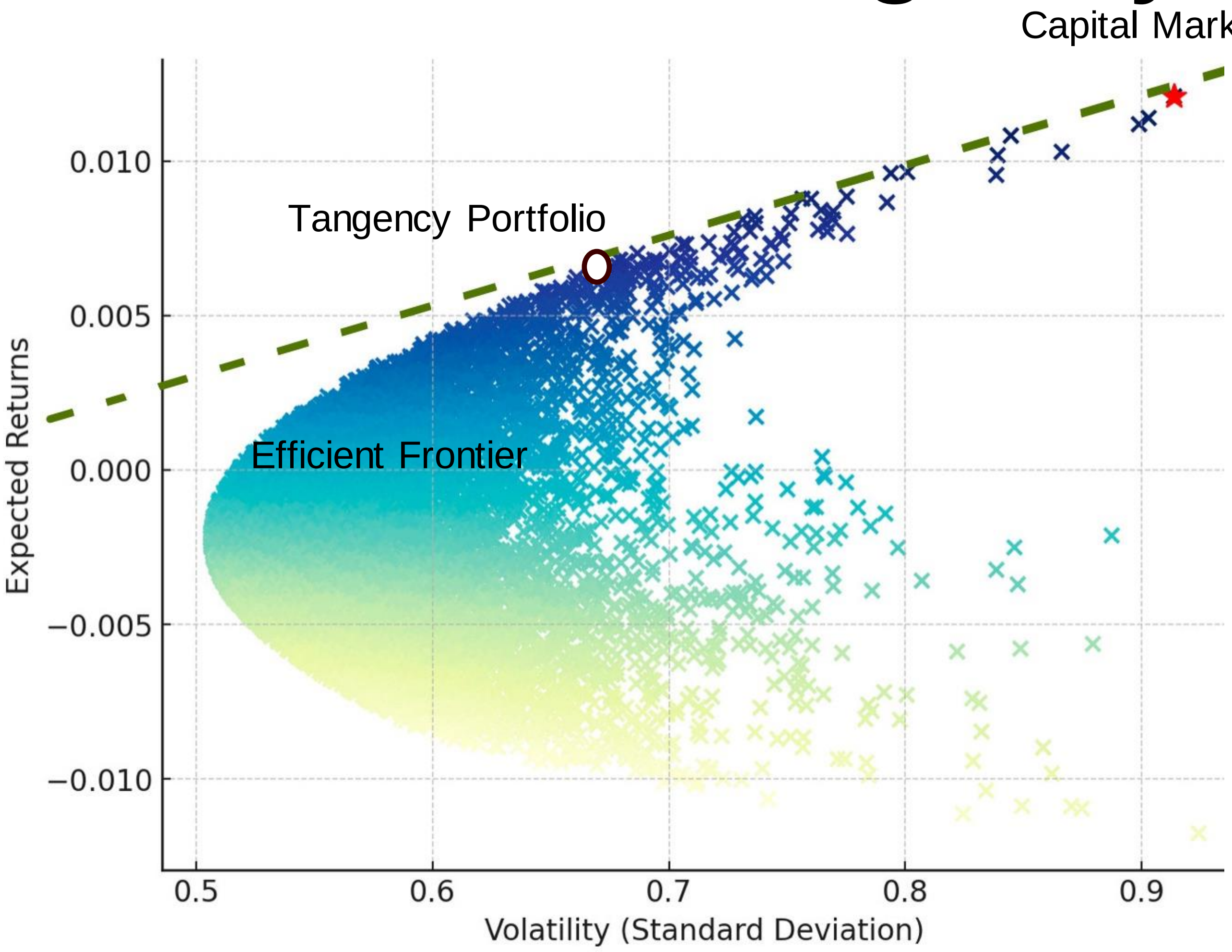
- PG: Procter & Gamble
- JNJ: Johnson and Johnson
- PEP: Pepsi
- KO: Coca-Cola inc.
- MCD: McDonalds Corp.
- META: Meta
- CVS: CVS Health Corporation

- COST: Costco
- WMT: Walmart
- SBUX: Starbucks
- GOOGL: Google
- V: Visa inc.
- ABT: Abbott Laboratories

Coefficient Matrix Heatmap



Tangency Portfolio



- Minimize Nonsystematic-Risk under given expected return
- Eliminate Nonsystematic-Risk by Diversification
- Optimal risk-return balance

Tangency weight calculation

$$\max_{\mathbf{t}} \frac{\mathbf{t}'\mu - r_f}{(\mathbf{t}'\Sigma\mathbf{t})^{\frac{1}{2}}} = \frac{\mu_{p,t} - r_f}{\sigma_{p,t}} \text{ s.t. } \mathbf{t}'\mathbf{1} = 1$$

Mathematical approach used to solve this optimization problem

t : Tangency portfolio weight

rf : risk-free rate

∑ : Components covariance

µ : Components expected return

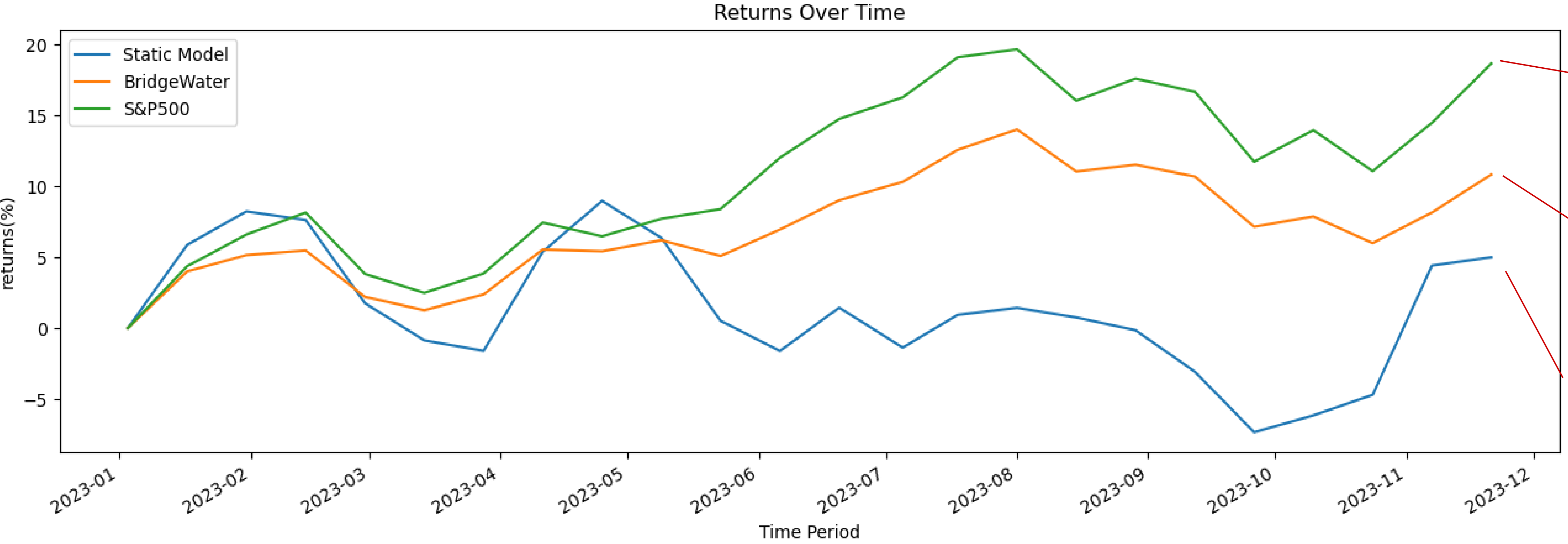
Estimation of expected return & covariance

$$\mathbf{t} = \frac{\Sigma^{-1}(\mu - r_f \cdot \mathbf{1})}{\mathbf{1}'\Sigma^{-1}(\mu - r_f \cdot \mathbf{1})}$$

Σ : Components covariance μ : Components expected return

- Static model: Assume expected returns and variance are static
- Calculate covariance matrix and expected return using historical returns

Static Model Return

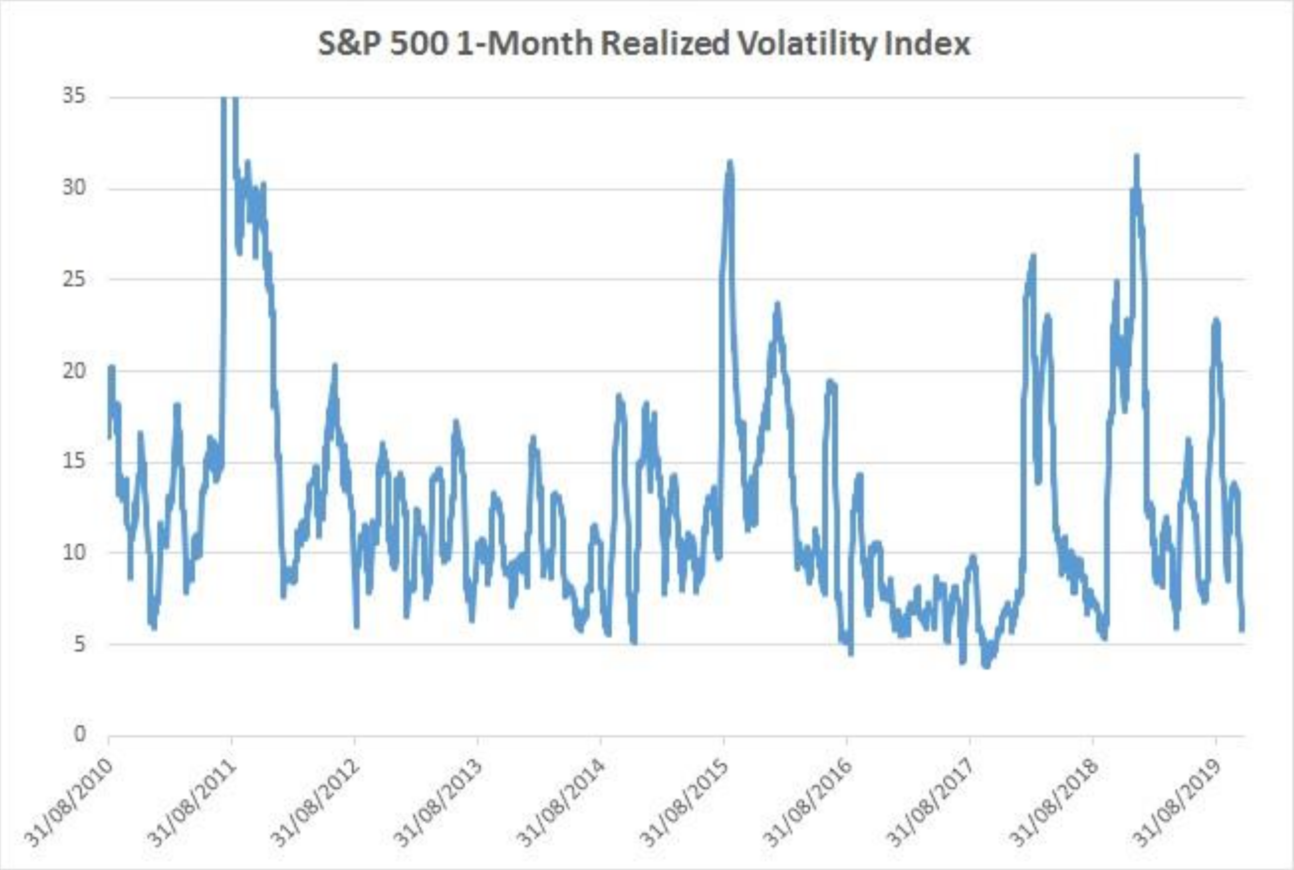


S&P500: 18.67%

BridgeWater: 10.84%

Static Model: 4.99%

Imperfection of Static model



- Variance and return are not static but dynamic
- Motivation to use dynamic model to capture this pattern

GARCH Model - Introduction

- **G** — Generalized
- **AR** — Auto Regressive
- **C** — Conditional
- **H** — Heteroskedasticity

GARCH Model - Introduction

- A complete GARCH model is divided into three components:
  - a mean model, e.g., a constant mean or an ARX;
  - a volatility process, e.g., a GARCH or an EGARCH process;
  - a distribution for the standardized residuals, e.g., Normal distribution, t-distribution

GARCH

The simplist GARCH model would be like this:

$$
\begin{aligned}
r_t &= \mu + \epsilon_t \\
\epsilon_t &= \sigma_t e_t \\
\sigma_t^2 &= \omega + \alpha \epsilon_{t-1}^2 + \beta \sigma_{t-1}^2 \\
e_t &\sim N(0, 1)
\end{aligned}
$$

- ω (omega): It represents the constant term, which is the unconditional variance of the return series.
- α (alpha): It measures the persistence of volatility.
- β (beta): It measures the speed of mean reversion of volatility.

GJR-GARCH

GLR-GARCG Includes one lag of an asymmetric shock:

$$r_t = \mu + \epsilon_t$$

$$\epsilon_t = \sigma_t e_t$$

$$\sigma_t^2 = \omega + \alpha\epsilon_{t-1}^2 + \gamma\epsilon_{t-1}^2 I_{[\epsilon_{t-1}<0]} + \beta\sigma_{t-1}^2$$

$$e_t \sim N(0,1)$$

- ω (omega): It represents the constant term, which is the unconditional variance of the return series.
- α (alpha): It measures the persistence of volatility.
- β (beta): It measures the speed of mean reversion of volatility.
- γ (gamma): It captures the asymmetric effect.

GARCH vs. GJR-GARCH

GARCH

Assumes symmetry in the impact of shocks

GJR-GARCH

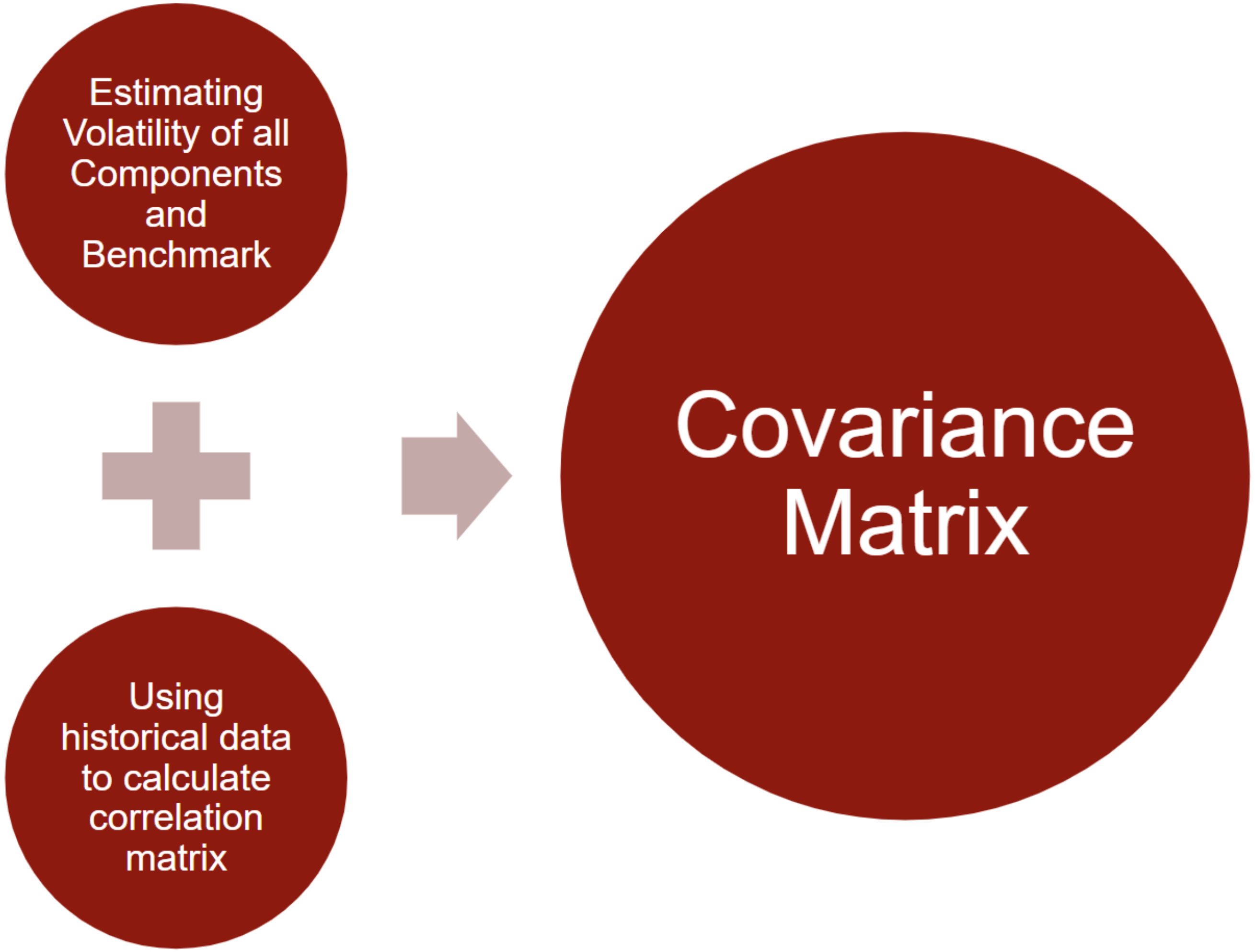
Leverage effect (asymmetric shocks)

Allows for positive and negative impacts

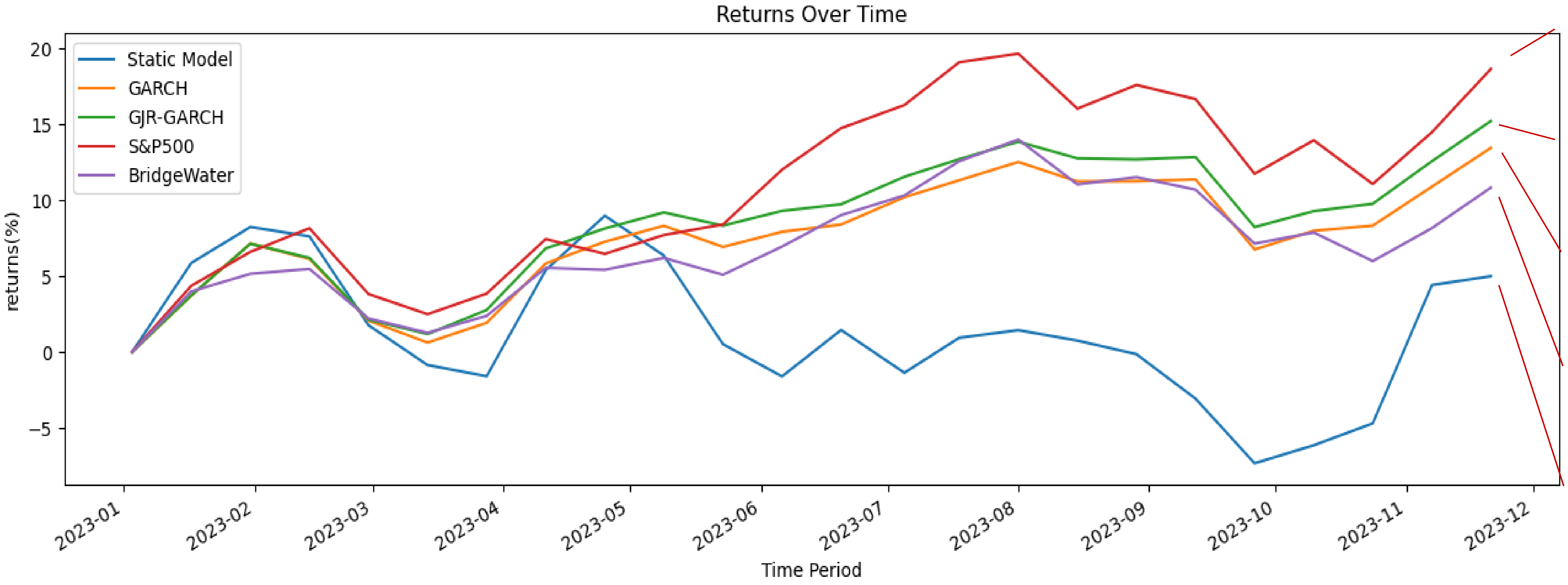
Components weights

- Use Beta to estimate expected return
- Use historical data to fit GARCH and GJR-GARCH model
- Use fitted model to predict future variance of components
- Estimated covariance matrix and estimated returns
- Weights are recalculated every two weeks

Components weights



Static & Dynamic Model Return



S&P500: 18.67%

GJR-GARCH: 15.23%

GARCH: 13.46%

BridgeWater: 10.84%

Static Model: 4.99%

Performance Metric

	GARCH Adjusted	GJR-GARCH Adjusted	Static Portfolio	BridgeWater	S&P500
Return	13.46%	15.23%	4.99%	10.84%	18.67%
Volatility	0.095	0.093	0.176	0.086	0.114
Sharpe Ratio	1.205	1.416	0.169	1.024	1.46
Information Ratio	0.275	0.470	-0.331	x	x

Future Work

- Add Trading Costs and Slippage
- Add conditional number for detection
- Add subjective views to adjust expected return and covariance matrix
- Implement Black-Litterman model

Thank You

Q&A