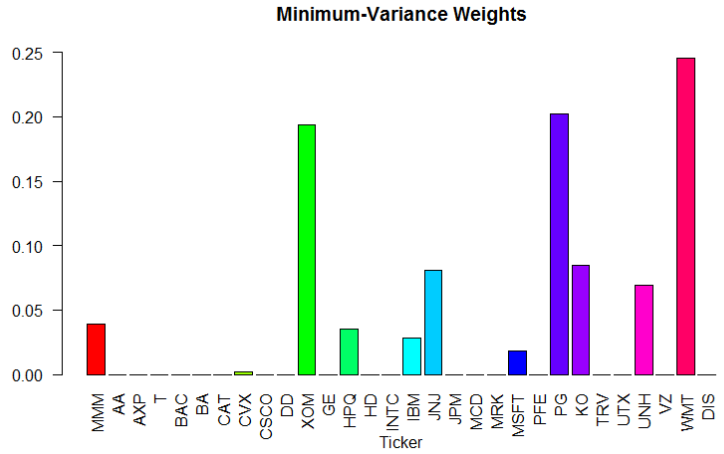
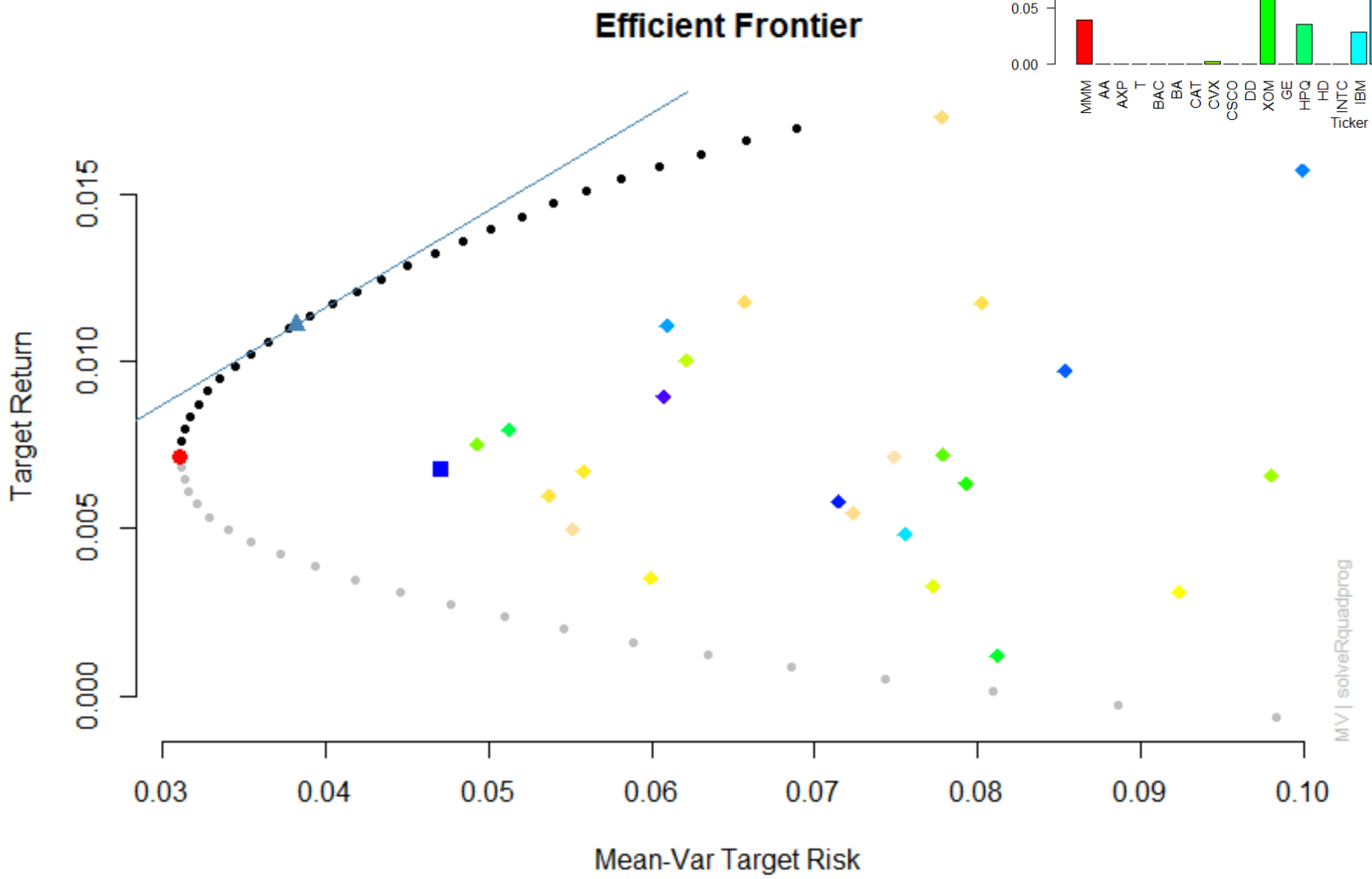
# RISK-STABLE PORTFOLIO OPTIMIZATION

Performance and Evaluation

Cody Pedro

# What?


Minimum-Variance Weights
0.25
0.20
0.15
0.10
0.05
0.00
MMM
AA
AXP
T
BAC
BA
CAT
CVX
CSCO
DD
XOM
GE
HPQ
HD
INTC
IBM
JNJ
JPM
MCD
MRK
MSFT
PFE
PG
KO
TRV
UTX
UNH
VZ
WMT
DIS
Ticker


Efficient Frontier
Target Return
0.000
0.005
0.010
0.015
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.10
Mean-Var Target Risk
MV | solveRquadprog

# Risk Stable Portfolio

- Target the maximum return for a given level of risk

Advantages

- Risk exposure is constant
- It is unambiguously passive
- Clients know for certain they are not being overexposed to a particular asset or risk and that their risk will not change under different market conditions

# Asset Classes

- Equities
- Fixed Income
  - Corporate Bonds
  - US Bonds
- Real Estate
- Commodities
  - Gold, Silver

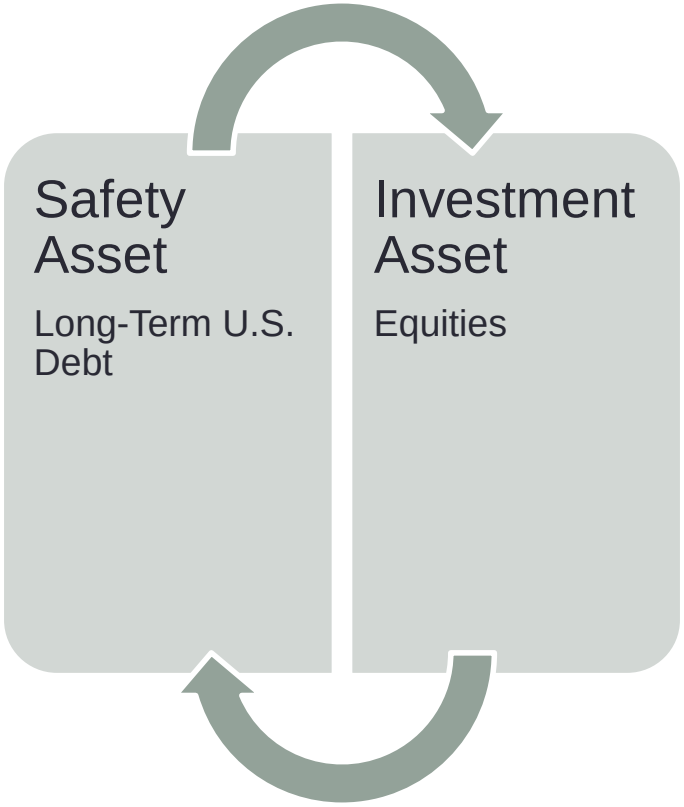
Asset: property owned by a person or company, regarded as having value and available to meet debts, commitments, or legacies

- e.g. Assets have a positive expected value

# Asset Class Correlations

| | SPY | TLT | LQD | SCHH | IAU | SLV |
|---|---|---|---|---|---|---|
| SPY | 1.00 | -0.59 | -0.11 | 0.81 | 0.06 | 0.21 |
| TLT | -0.59 | 1.00 | 0.67 | -0.37 | 0.09 | -0.08 |
| LQD | -0.11 | 0.67 | 1.00 | 0.11 | 0.21 | 0.10 |
| SCHH | 0.81 | -0.37 | 0.11 | 1.00 | 0.06 | 0.18 |
| IAU | 0.06 | 0.09 | 0.21 | 0.06 | 1.00 | 0.81 |
| SLV | 0.21 | -0.08 | 0.10 | 0.18 | 0.81 | 1.00 |

# Capital Flows

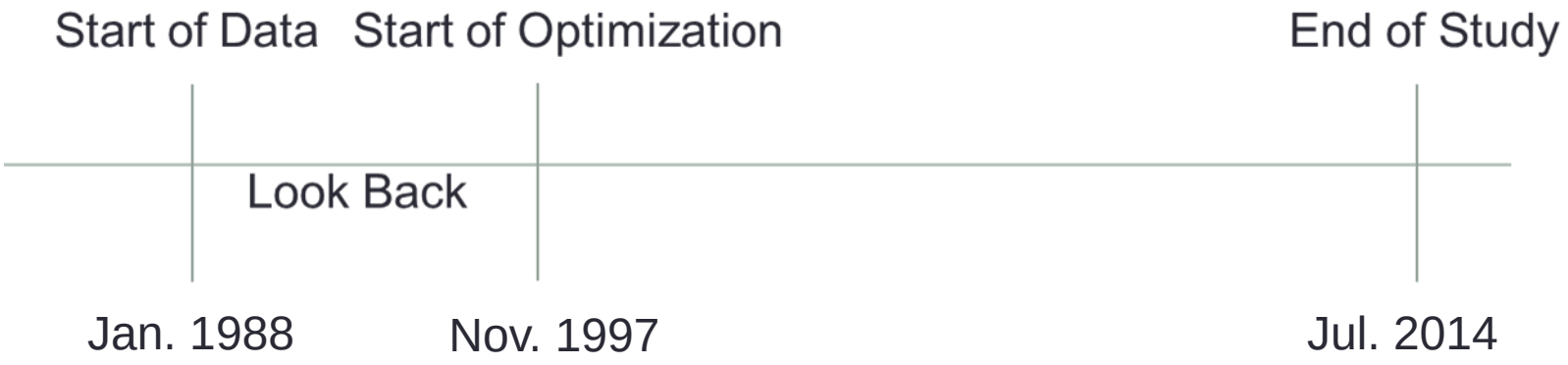



Less Risk

More Risk

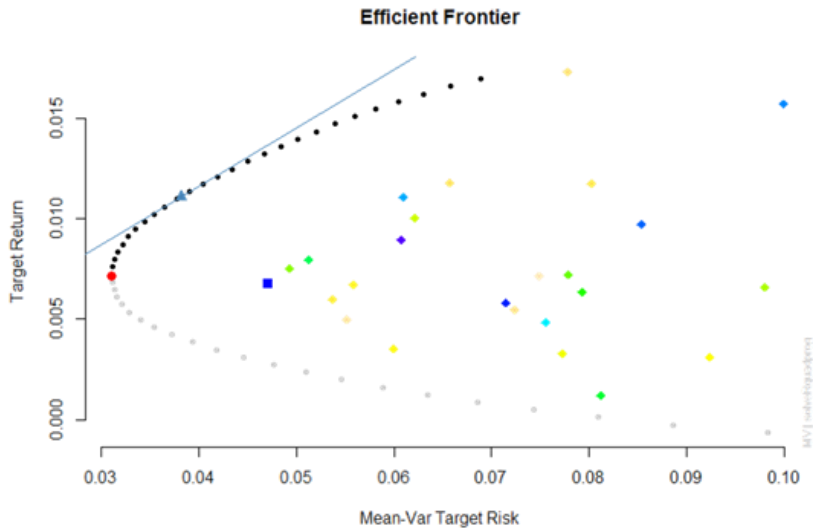
# Methodology Part I

- Use the previous 2500 daily observations to estimate the GARCH(1,1) model
- Then use the one step ahead forecast of the GARCH(1,1) model to estimate the portfolio CVaR for each weight combination in 1% increments
- Re-optimize and rebalance every 60 days (Aprox. 1 quarter)



# Methodology Part II

- Bound the weights for each asset between 10% and 90%
- Choose from just two assets; VUSTX & The S&P 500
  - 81 possible weight combinations
  - VUSTX is a Vanguard mutual fund that tracks Long-Term Government Debt

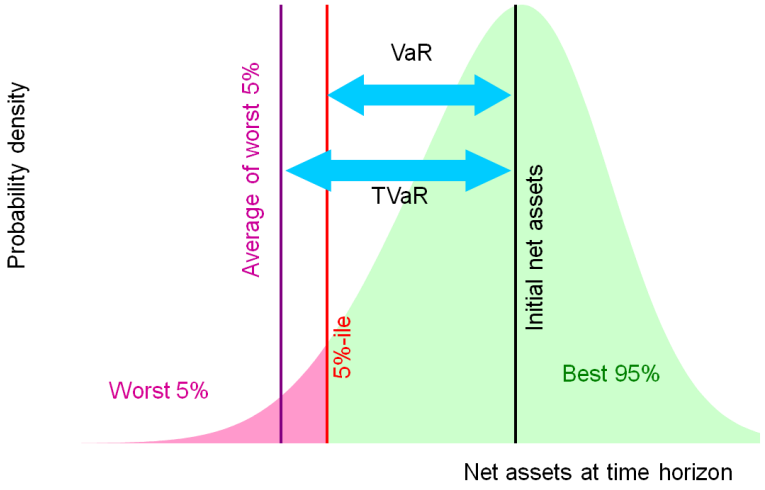


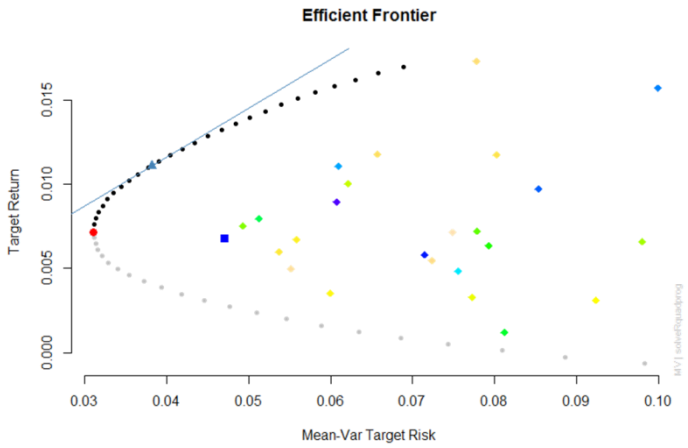
# Methodology Part III

- Further bound the equity weight to be greater than the GMC (Global-Minimum CVaR) Portfolio to ensure the portfolio is on the efficient frontier
- Choose the portfolio within the weight bounds that most closely matches the desired CVaR, which is 1.0%
- If all portfolios are above the target risk than weight into cash until the target risk is achieved

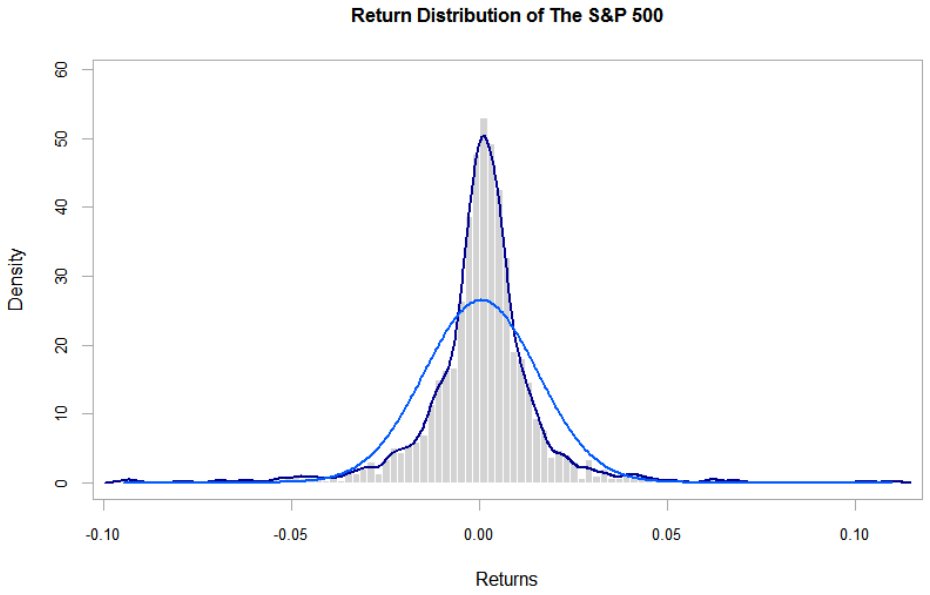
# Why CVaR?

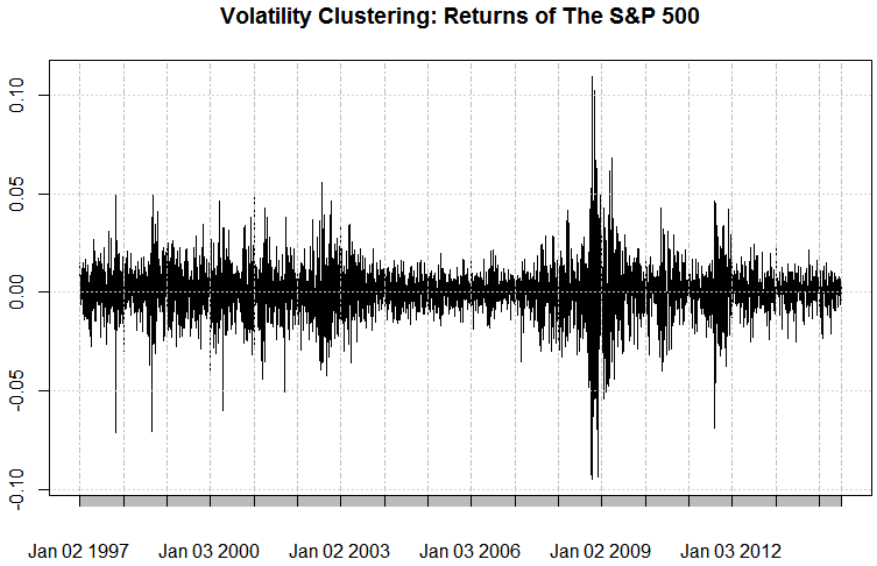
- Better estimate of risk than volatility
- Coherent Risk Measure
  - Normalized
  - Monotonicity
  - Sub-additivity
  - Positive Homogeneity
  - Translation Invariance



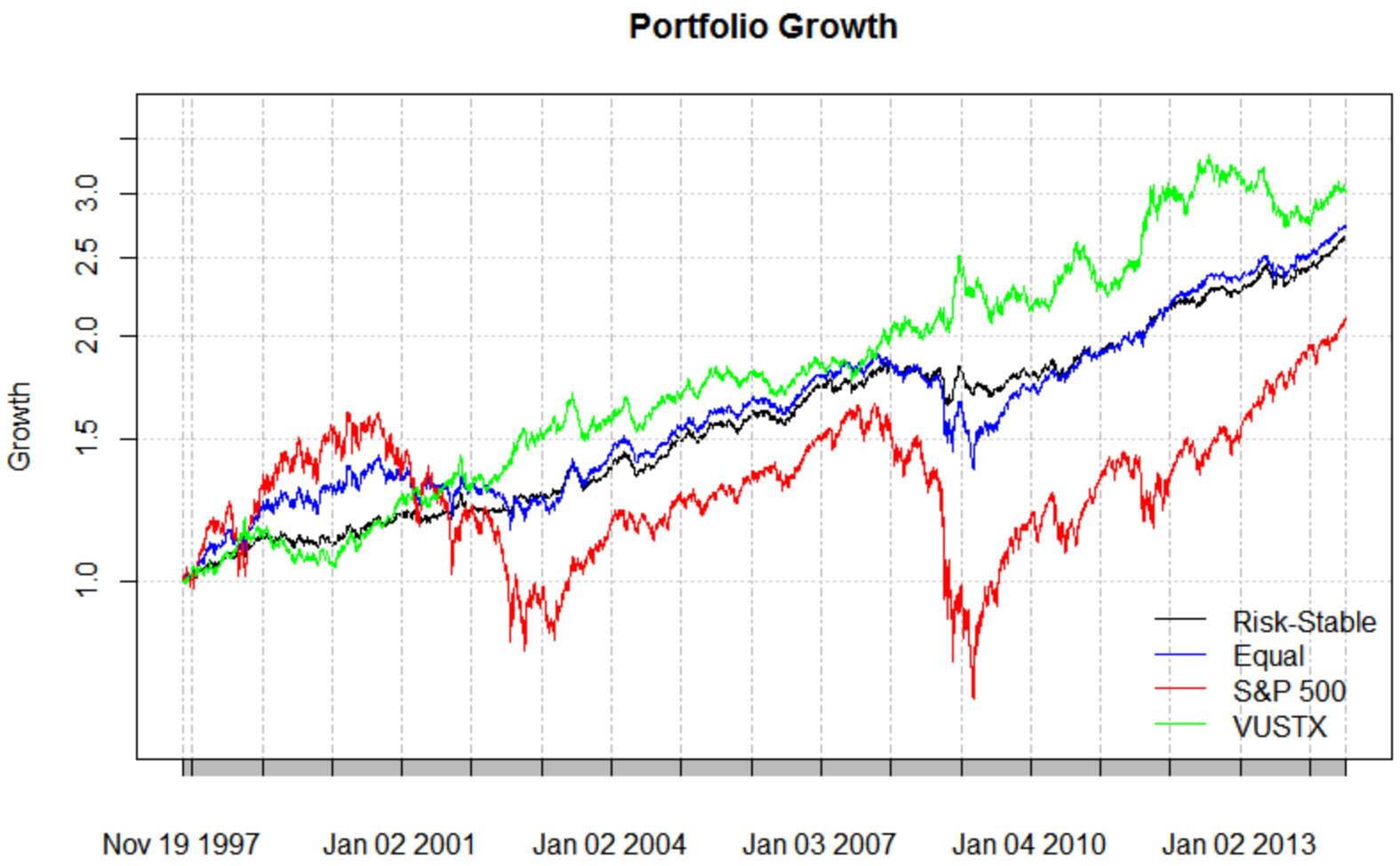



# Why GARCH(1,1)?

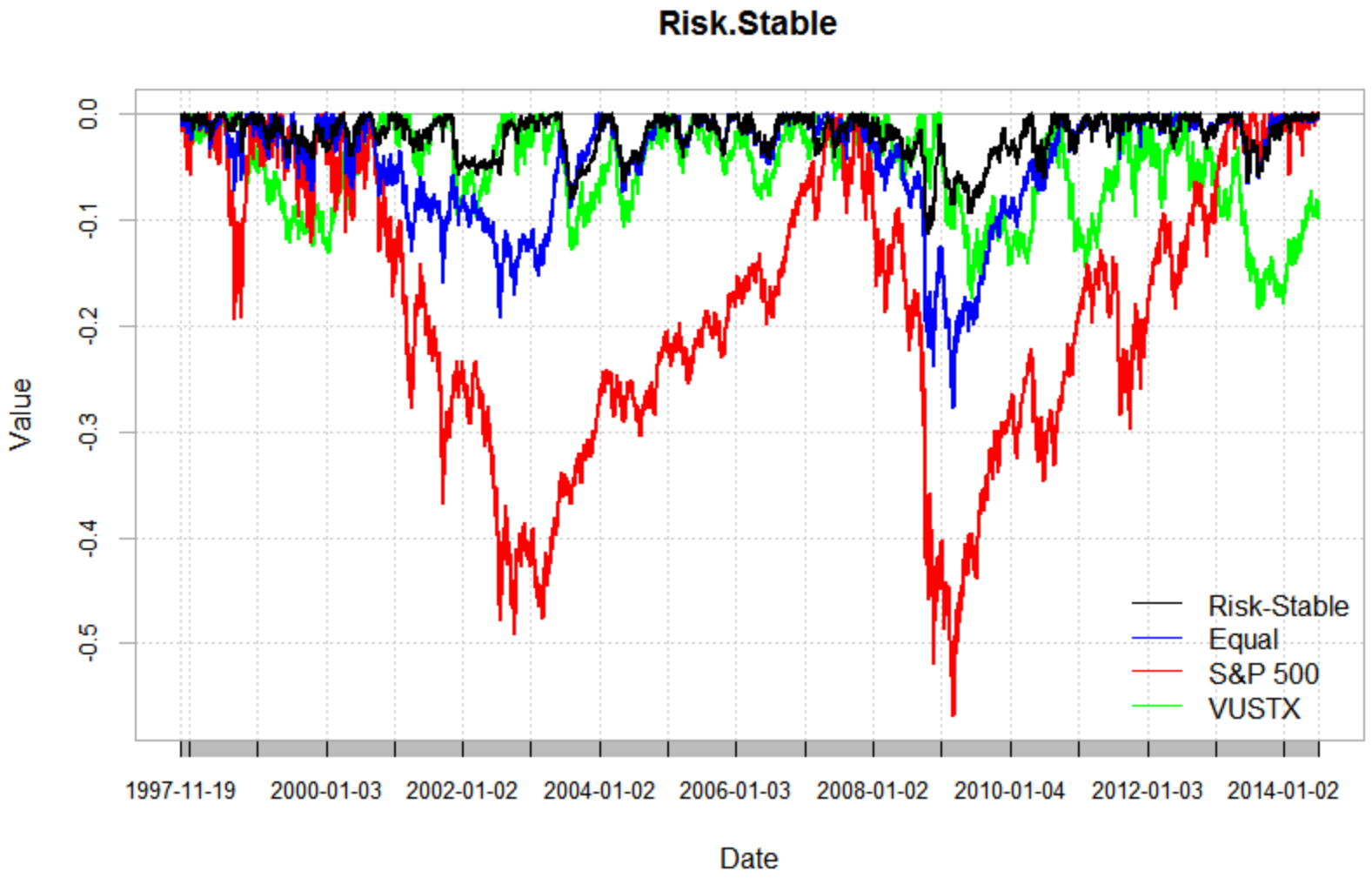

Return Distribution of The S&P 500
Density
0
10
20
30
40
50
60
-0.10
-0.05
0.00
0.05
0.10
Returns


Volatility Clustering: Returns of The S&P 500
0.10
0.05
0.00
-0.05
-0.10
Jan 02 1997
Jan 03 2000
Jan 02 2003
Jan 03 2006
Jan 02 2009
Jan 03 2012

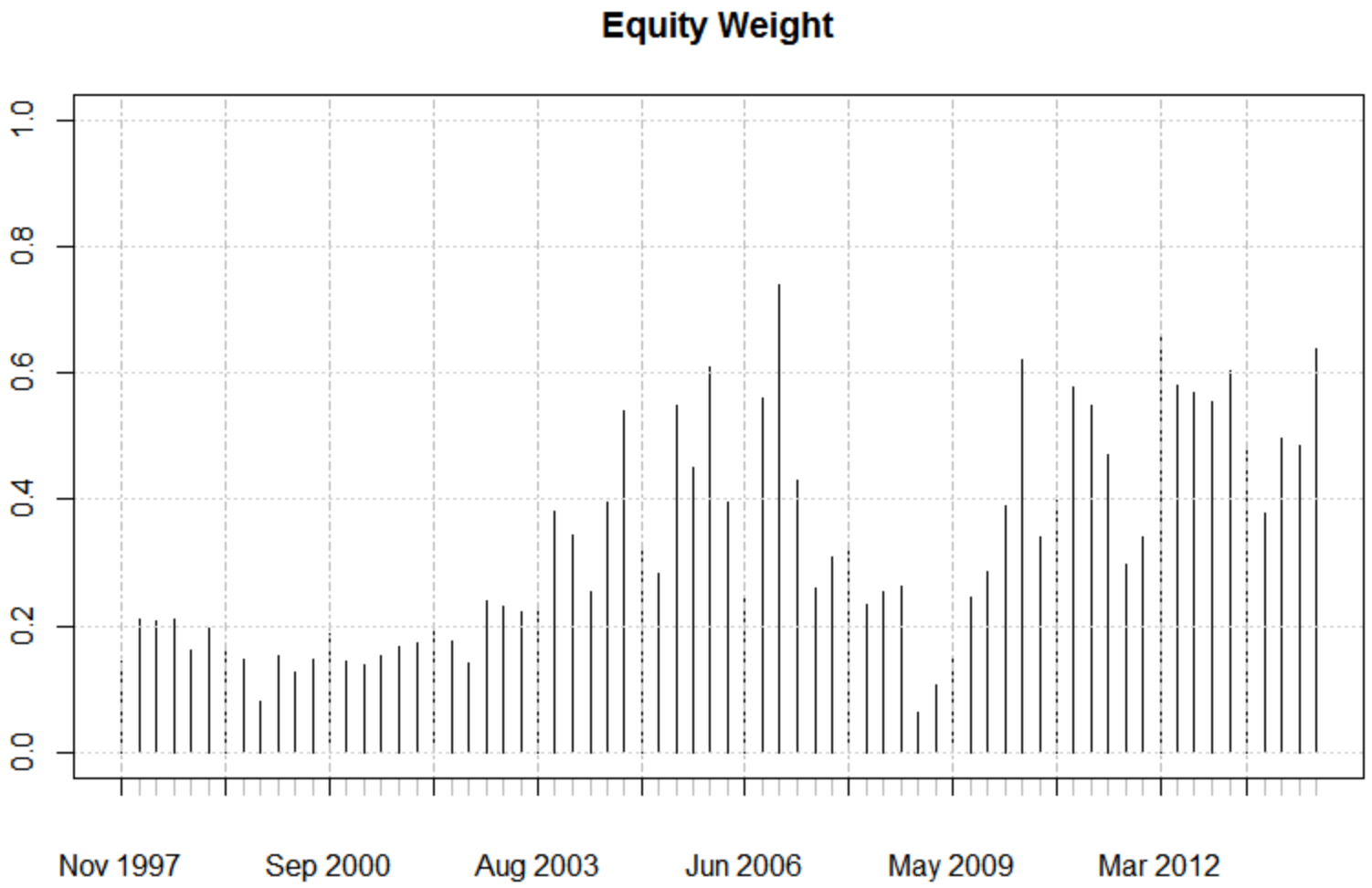
# Growth


Portfolio Growth
Growth
1.0
1.5
2.0
2.5
3.0
Risk-Stable
Equal
S&P 500
VUSTX
Nov 19 1997
Jan 02 2001
Jan 02 2004
Jan 03 2007
Jan 04 2010
Jan 02 2013

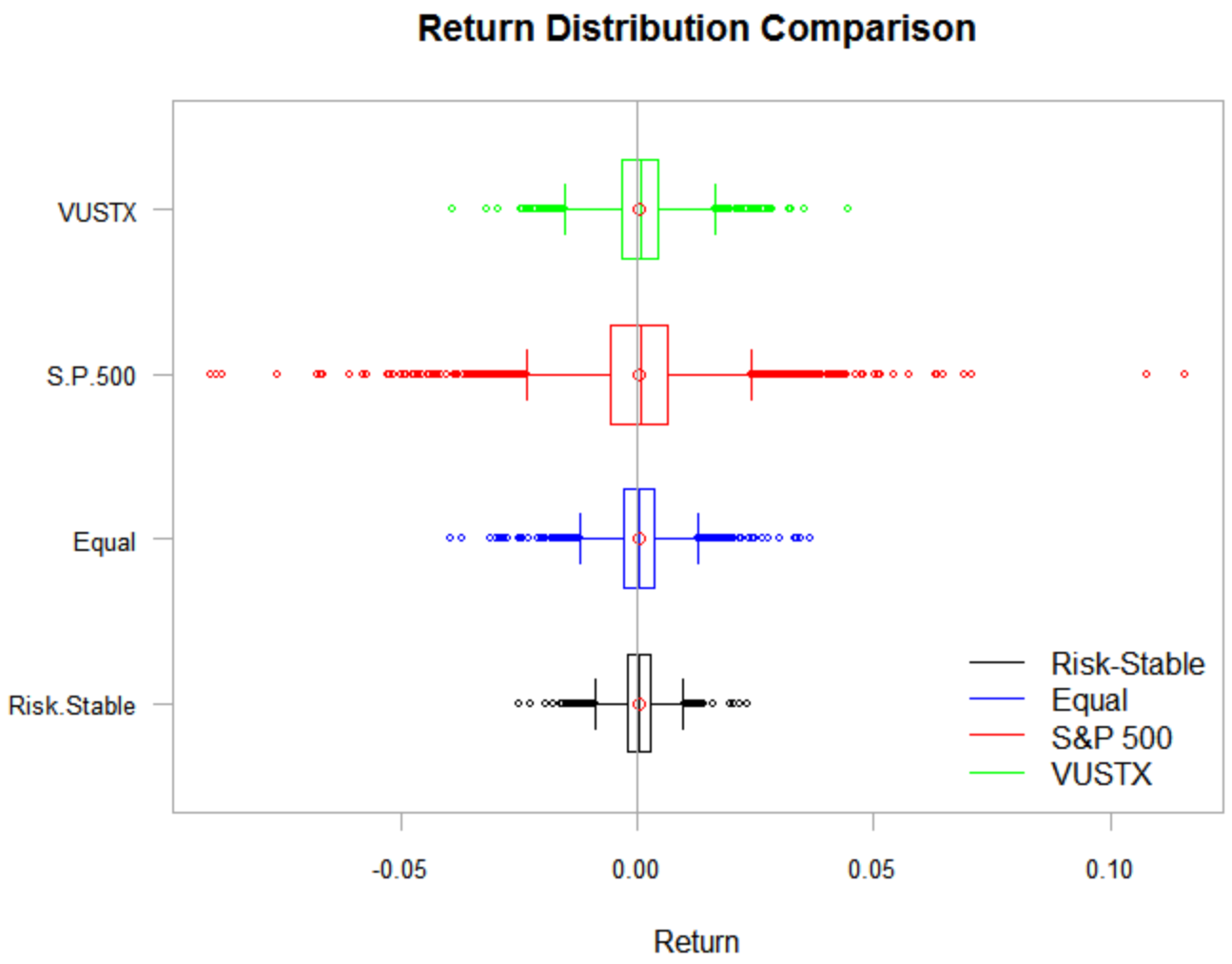
# Drawdowns


Risk.Stable
Value
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
1997-11-19
2000-01-03
2002-01-02
2004-01-02
2006-01-03
2008-01-02
2010-01-04
2012-01-03
2014-01-02
Date
Risk-Stable
Equal
S&P 500
VUSTX

# Weights


Equity Weight
1.0
0.8
0.6
0.4
0.2
0.0
Nov 1997
Sep 2000
Aug 2003
Jun 2006
May 2009
Mar 2012

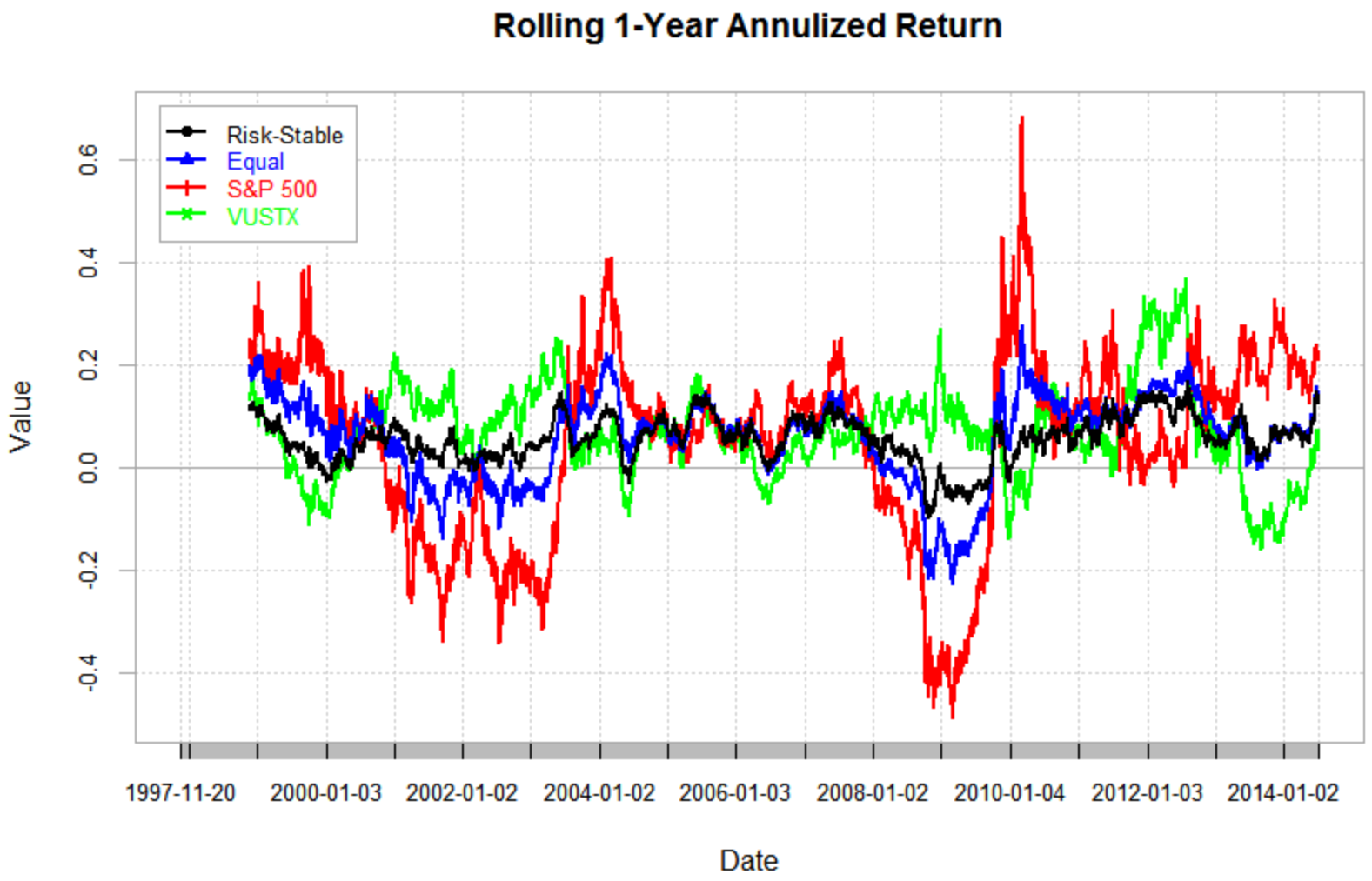
# Box Plots


Return Distribution Comparison
VUSTX
S.P.500
Equal
Risk.Stable
-0.05
0.00
0.05
0.10
Return
Risk-Stable
Equal
S&P 500
VUSTX

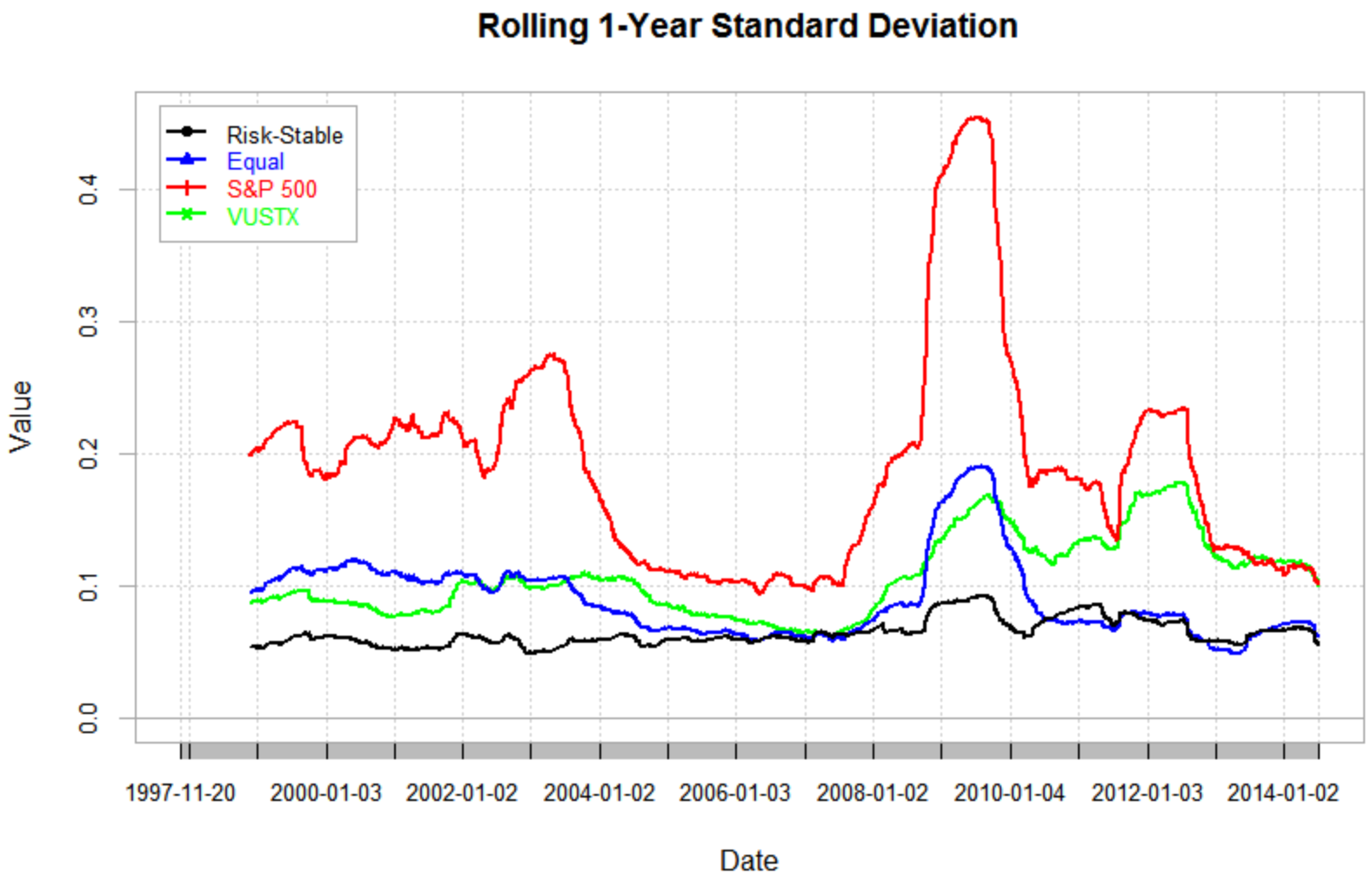
# Portfolio Statistics

| | Risk Stable | Equal | S&P 500 | VUSTX |
|---|---|---|---|---|
| nobs | 4181 | 4181 | 4181 | 4181 |
| | | | | |
| Minimum | -2.53 | -3.98 | -9.04 | -3.94 |
| Maximum | 2.32 | 3.65 | 11.58 | 4.47 |
| 1. Quartile | -0.20 | -0.29 | -0.57 | -0.36 |
| 3. Quartile | 0.27 | 0.34 | 0.62 | 0.44 |
| Mean | 0.02 | 0.03 | 0.03 | 0.03 |
| Median | 0.02 | 0.03 | 0.07 | 0.07 |
| Variance | 0.00 | 0.00 | 0.02 | 0.00 |
| Stdev | 0.40 | 0.59 | 1.29 | 0.69 |
| Skewness | -.167 | -.031 | -.018 | 0.01 |
| Kurtosis | 2.21 | 3.84 | 7.56 | 2.00 |
| | | | | |
| Growth of $1 | $2.65 | $2.73 | $2.09 | $3.03 |
| Annualized Return | 6.05 | 6.24 | 4.55 | 6.91 |
| Annualized Standard Deviation | 6.39 | 9.37 | 20.40 | 10.90 |
| Annualized Sharpe Ratio | 0.95 | 0.67 | 0.22 | 0.63 |
| Omega (L = 0%) | 1.17 | 1.13 | 1.06 | 1.12 |
| | | | | |
| Downside Deviation (0%) | 0.28 | 0.41 | 0.91 | 0.47 |
| Maximum Drawdown | 11.29 | 27.70 | 56.78 | 18.42 |
| Historical ES (95%) | -0.90 | -1.31 | -3.02 | -1.50 |
| Modified ES (95%) | -0.97 | -1.41 | -2.87 | -1.54 |

# Rolling Return

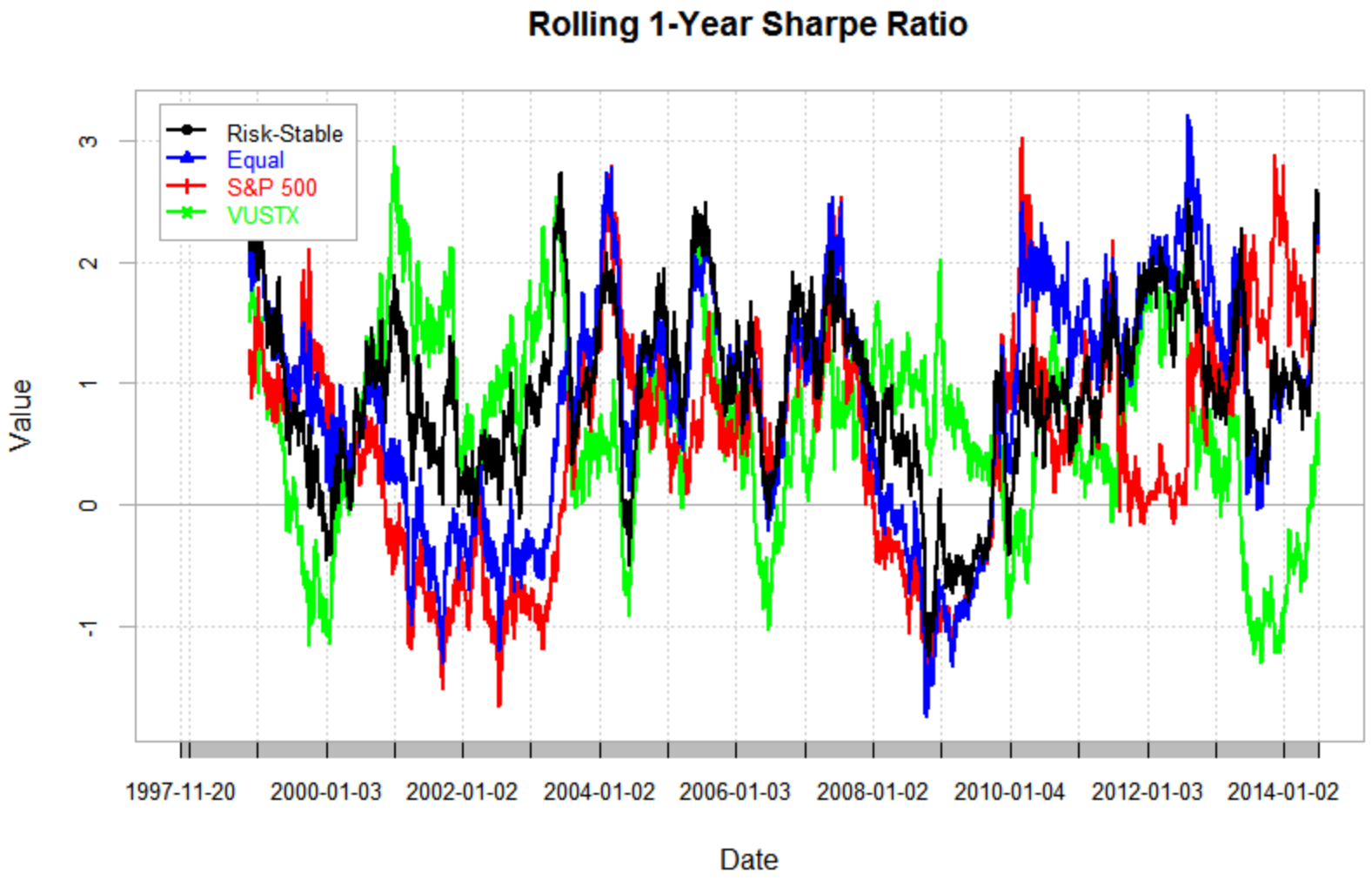


# Rolling Volatility



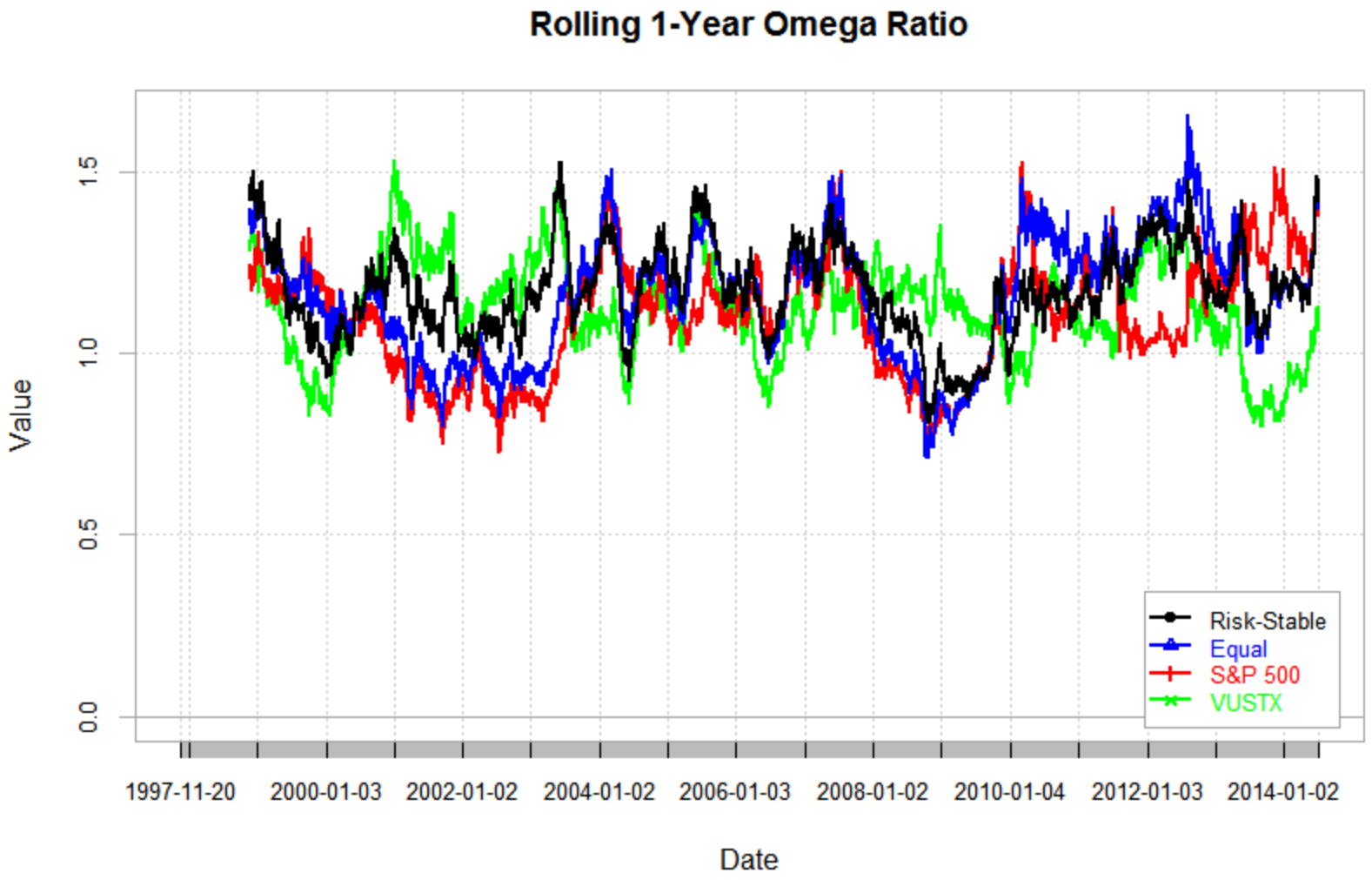
# Rolling Sharpe

$$S = \frac{E[R_a - R_b]}{\sigma}$$



# Rolling Omega

$$\Omega(r) = \frac{\int_r^{\infty}(1 - F(x))\,dx}{\int_{-\infty}^{r} F(x)dx}$$



# Proof of Concept

- Can be generalized to N assets, but the computational requirement grows exponentially
- Risk-stable portfolios can be actively managed within risk targets by maximizing the portfolio return for the given level of targeted risk

Advantages:

- GARCH Model accounts for volatility clustering
- CVaR estimates are a more mathematically correct definition of risk
- Historical analysis shows outperformance
- The portfolio risk can be actively managed

# Portfolio Framework

1. Set the risk target band
2. Set the level of acceptable risk deviation
3. Choose and rank the assets
4. Use the ranking function to score the portfolios
5. Let the algorithm determine the proper weighting within the risk bands that maximizes the portfolio score
6. Repeat periodically

# Code

- Github
  - Title: Risk Stable Portfolio Optimization.R
  - URL: https://github.com/codypedro/MarketAnalysis