University of Zurich[UZH]

# Final Project of Digital Tools for Finance

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# Introduction

- Our project is a replication of paper:
  - Anderson E W, Cheng A R. Robust bayesian portfolio choices[J]. The Review of Financial Studies, 2016, 29(5): 1330-1375.
- Replicate the robust Bayesian model and compare its performance.
  - with equally weighted model and standard Markowitz model on SP 500 daily stock return from 2005 to 2020

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# Literature Review

- Modern Portfolio Theory
- Resampling
- ‘Robust Bayesian Portfolio Choices’
- ‘Incorporating estimation errors into portfolio selection: Robust portfolio construction’
- ‘Robust Asset Allocation’

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# Research Question

Can ‘Robust Bayesian Portfolio Choices’ yield superior returns in an environment of extreme financial markets?

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# Theoretical Framework

- Initialization
- Updating parameters in each t
- Updating probabilities for each model m in each t
- Allocate assets in each t

# Initialization

In period 1 we initialize mean, covariance and model- and scaling parameters.

$$\bar{\mu}_{t-1} = \frac{1}{n}\sum_{i=1}^{n}(\frac{1}{t-1}\sum_{s=1}^{t-1} R_{i,s})$$

$$\bar{\lambda}_{t-1} = \frac{1}{n}\sum_{i=1}^{n}(\frac{1}{t-2}\sum_{s=1}^{t-1}(R_{i,s} - \bar{\mu}_{i,t-1})^2)$$

$$\kappa_{t,t-1} = 1, \delta_{t,t-1} = 1, \tau = 4 \text{ and } \alpha = 1$$

# Updating parameters in each t

At each point in time the mean and covariance matrix for all existing previous models is updated, using the newly observed excess returns $R_t$.

$$\mu_{m,t} = \frac{\kappa_{m,t-1}\mu_{m,t-1} + R_t}{\kappa_{m,t}}$$

$$\Sigma_{m,t} = \frac{\delta_{m,t-1}\kappa_{m,t}\Sigma_{m,t-1} + \kappa_{m,t-1}(R_t - \mu_{m,t-1})(R_t - \mu_{m,t-1})'}{\delta_{m,t}\kappa_{m,t}}$$

With $\kappa_{m,t} = \kappa_{m,t-1} + 1$ and $\delta_{m,t} = \delta_{m,t-1} + 1$, which can be viewed as scaling parameters that define the weight put on more recent inputs.

# Updating probabilities for each model m in each t

$$P_t(m|F_t) = \frac{L(R_t|m, F_{t-1})P_t(m|F_{t-1})}{\sum_{m\in M_t} L(R_t|m, F_{t-1})P_t(m|F_{t-1})}$$

$$L(R_t|m, F_{t-1}) = \frac{\kappa_{m,t-1}^{n/2} \det(\Lambda_{m,t-1}^{\nu_{m,t-1}/2})\Gamma_n(\nu_{m,t-1}/2)}{\pi^{n/2}\kappa_{m,t}^{n/2} \det(\Lambda_{m,t}^{\nu_{m,t}/2})\Gamma_n(\nu_{m,t-1}/2)}$$

$$P_t(m|F_{t-1}) = \begin{cases} (1-\alpha)P_{t-1}(m|F_{t-1} + \alpha[\sum_{q=1}^{m}(\frac{1}{t-q+1})P_{t-1}(q|F_{t-1})]), \\ \alpha[\sum_{q=1}^{t-1}(\frac{1}{t-q+1})P_{t-1}(q|F_{t-1})], \end{cases}$$

# Allocate assets in each t

The optimal portfolio weights $\phi_t$ can be calculated as follows.

$$\phi_t = \frac{1}{\theta}\hat{\Sigma}_t^{-1}\hat{\mu}_t \quad \text{where}$$

$$\hat{\Sigma}_t = V(R_{t+1}|F_t) = \sum_{m \in M_t} (\bar{\Sigma}_{m,t} + \mu_{m,t}\mu'_{m,t})' P_t(m|F_t) - \hat{\mu}_t\hat{\mu}_t{}' \quad \text{with}$$

$$\bar{\Sigma}_{m,t} = V(R_{t+1}|m, F_t) = \left(\frac{1 + \kappa_{m,t}}{\kappa_{m,t}}\right)\Sigma_{m,t} \quad \text{and}$$

$$\hat{\mu}_t = E(R_{t+1}|F_t) = \sum_{m \in M_t} \mu_{m,t} P_t(m|F_t)$$

Next periods excess returns are observed based on the portfolio created in this instance.

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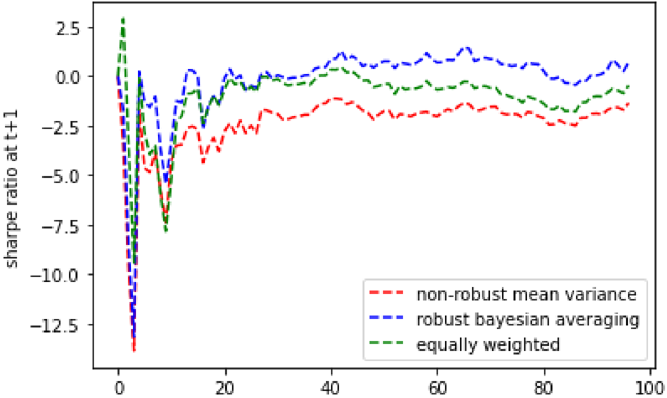
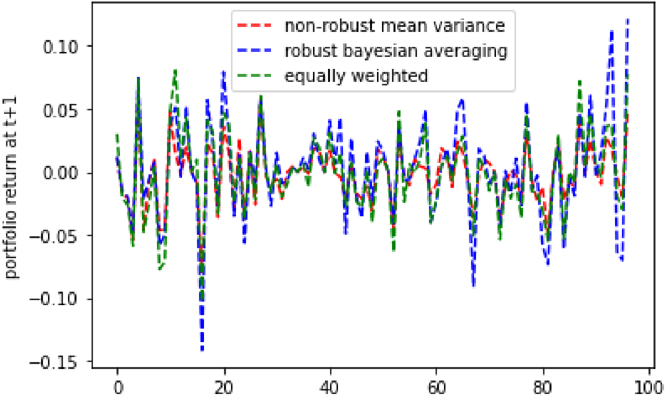
# Empirical Analysis Results



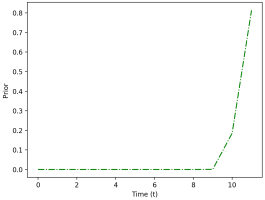

(sharpe-ratio at t+1 from October 2008 to March 2009)

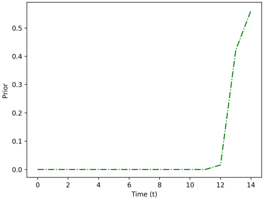
# Empirical Analysis Results

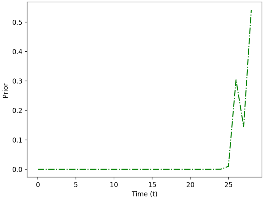



(portfolio return at t+1 from October 2008 to March 2009)

# Empirical Analysis Results



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# Conclusion

Our main finding is that, with a small portfolio (N=30) and large rolling window (T=100), the robust bayesian model outperforms the other two before 2012, and this outperforming effect vanishes after 2012 when the paper is submitted. Also, we finds an interesting phenonmenon: robust bayesian model dominates the other two regardless of portfolio size from 2008 September to 2009 March, which is the period of financial crisis. A possible explanation could be that during crisis period, investors put more weight on prior information. Since investors are more likely to sell a stock which has a negative return yesterday due to panic rather than rational analysis during crisis period, prior information plays a more important role.