Extensions to Multivariate CAViaR
A More Insightful Approach to Risk Modeling

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Roadmap

- Background: Summarize M.S. thesis
- Describe extensions and get feedback:
    - Extension 1: Improve forecast from thesis
    - Extension 2: Combine predictions between models
    - Extension 3: Build predictive algorithm, from PCA

Executive Summary

- ▶ I developed a new risk prediction model that is easy to interpret but needs help with predictive accuracy.
- ▶ I also developed two potentially novel but unproven extensions based on this model that may need a better application.

Background: What to forecast?

- What should we predict in equity returns?
- The S&P 500 (largest 500 U.S. stocks) earned ~6.8% pre-tax, post-inflation from 1871-2020
  - Includes world wars, great depression, stagflation
  - "In the long run we are all dead"
- Short-term gyrations drive long-term performance

Background: How to forecast?

- ▶ Fully generative vs. fully nonparametric
  - ▶ Fully generative (RiskMetrics)
  - ▶ Fully nonparametric (historical simulation)

Generative model   CAViaR   Fully nonparametric approach

Pros: Flexible
Cons: Assumes too much

Pros: Easy to interpret
Cons: Inflexible, "fights last war"

Background: Value-at-Risk

- 1% VaR of -$10MM = lose $10MM+ 1 out of 100 days
  - Boils risk into "one number"
  - Commonly used by financial regulators

Background: What is CAViaR?

- CAViaR = conditional autoregressive value at risk
  - Developed by Engle and Manganelli in 2004
- Directly predicts α % quantile
  - Balances between too little and too much
- Statistically robust
  - Builds upon rich methodology literature

Background: Potential Issues with CAViaR?

- How to incorporate information from other stocks?
- How can we have clear, explainable results?

Background: Proposed Extensions as "Multivariate CAViaR"

- ▶ Include meaningful ETFs (exchange traded funds)
  - ▶ ETFs avoid issues like bankruptcy & mergers
- ▶ I used mostly sector ETFs (utilities, industrial, energy, etc.)
- ▶ I used SPY (S&P 500 ETF) as a response

Background: Proposed Extensions as "Multivariate CAViaR"

- ▶ Idea: Combine ETFs into principal components at forecast origin (diffusion indices, or DIs)
    - ▶ Builds upon the diffusion index literature from Stock and Watson in 2002
- ▶ Add nonlinear autoregressive (AR) terms from SPY into model
- ▶ 4 configurations of univariate model
- ▶ 4 configurations of multivariate model

Background: Fitting Process

- Take 5 years of SPY returns
  - ~3 years: Training set
  - ~1 year: Validation set
  - ~1 year: Test set
- Choose number of DIs & AR lags on validation set
- Evaluate performance of 1%, 5%, and 10% VaR
- Evaluate in 2008, 2010, 2014, and 2016

Background: Results

- Results from 2008 were poor
- Results were comparable in 2010, 2014, and 2016

Extension 1

- ▶ How to improve this forecast?
- ▶ One idea: Include MA terms in MV CAViaR
    - ▶ Pro: Likely dramatically improves accuracy
    - ▶ Con: Harder to interpret model
    - ▶ Cons: Harder to fit model

Extension 2: Motivation

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Extension 2: Motivation

Extension 2: A Tale of Two Approaches

1. "Rational" forecast
   - Day of week, weather, time, etc.
2. "Irrational" forecast
   - Anchor to recent behavior

Extension 2: Application to Earlier Work

- When multivariate CAViaR dominates, we're in a "rational" state
- Otherwise, in a "irrational" state
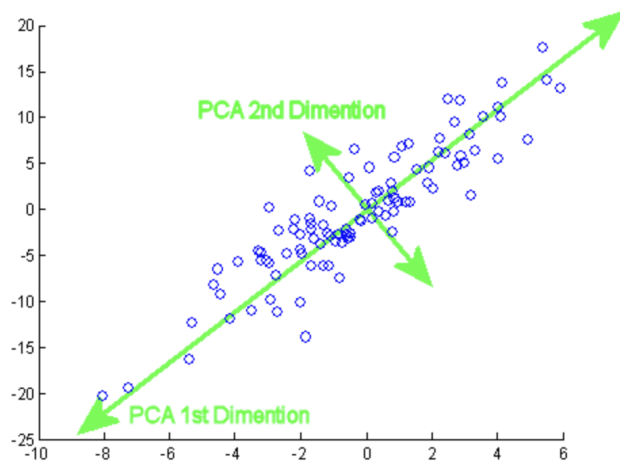- Find posterior probability of latent state using Hidden Markov Model – Some details omitted (see appendix)

Extension 2: Application to Earlier Work

- ▶ Results are not overly promising, but may require another dataset
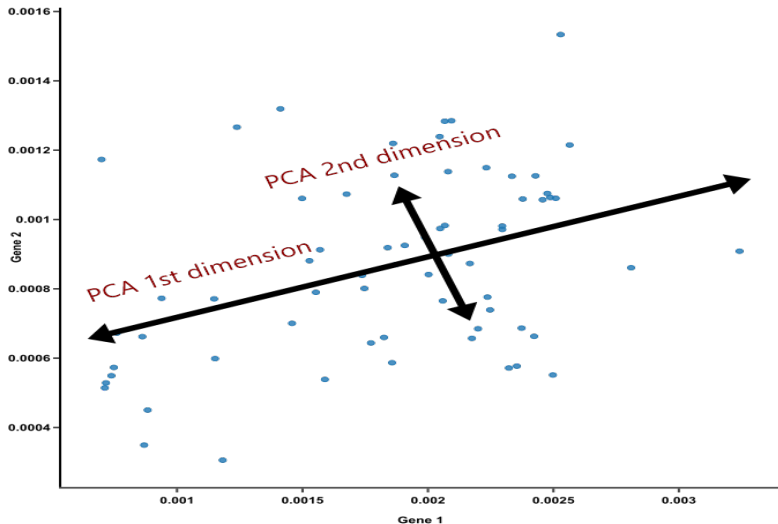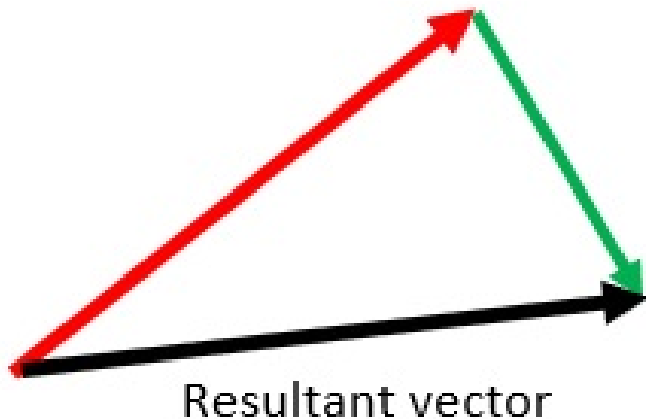
Extension 3: Motivation from PCA

Extension 3: Motivation from PCA

Tip of red vector to the tail of the green vector.

Resultant vector

Extension 3: Procedure

- Compute the resultant for t points and m vectors
- Measure the angle between resultants; 90 degrees implies "orthogonal"
- Results are promising

Appendix