



# Applying Functional Data Analysis to the Price Action of the Most Traded Stocks in the S&P 500 Index (EDA and Hypothesis testing)

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## 2 Exploratory data analysis

- Smoothed data visualisation (reminder)
- EDA

## 3 Hypothesis testing

- One-way ANOVA test
- Point-Wise two-sample Mean Tests
- Point-Wise two-sample Variance Tests

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# Introduction

## Purpose

In this presentation, we conduct an Exploratory Data Analysis (EDA) and Hypothesis Testing of smoothed intraday stock price data, within a Functional Data Analysis (FDA) framework for the most traded S&P 500 stocks.

## Objectives

- To visually and statistically explore differences in intraday price patterns between bull and bear market days;
- To evaluate centrality, variability, dispersion, covariance structure, and depth of smoothed stock curves;
- To test for statistically significant differences between bull and bear day intraday price dynamics.

## Approach

- **EDA includes:** Smoothed data visualization, central tendency and variability measures, functional principal component analysis (FPCA);
- **Hypothesis Testing includes:** Statistical comparison of bull versus bear day functional data characteristics.

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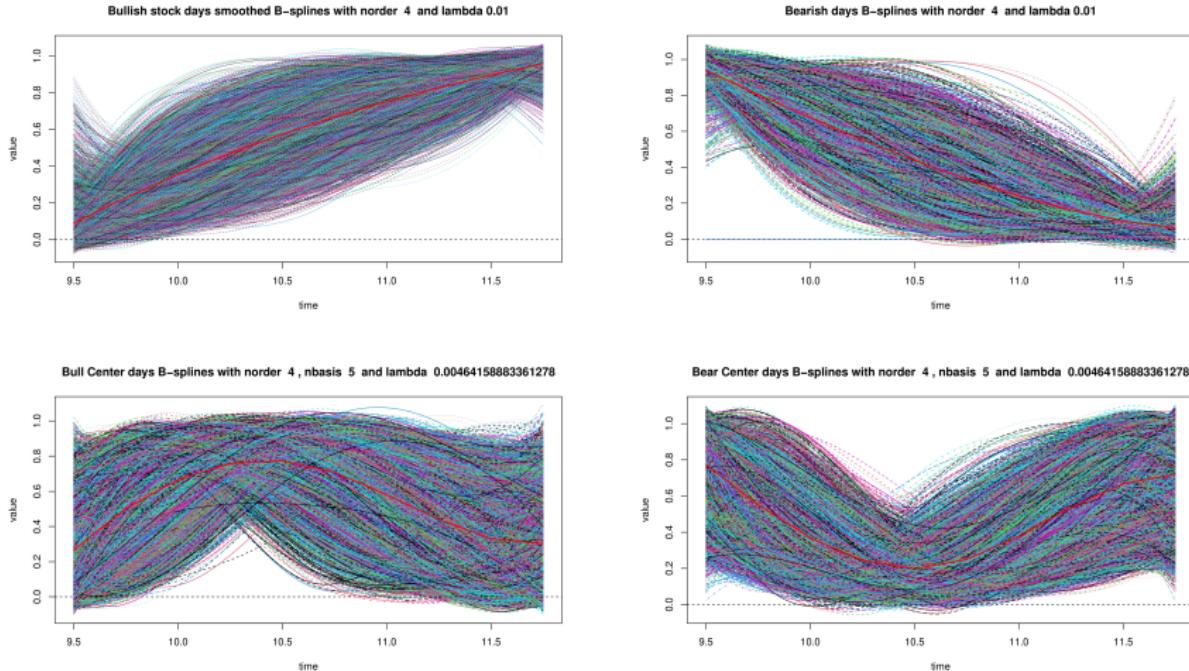
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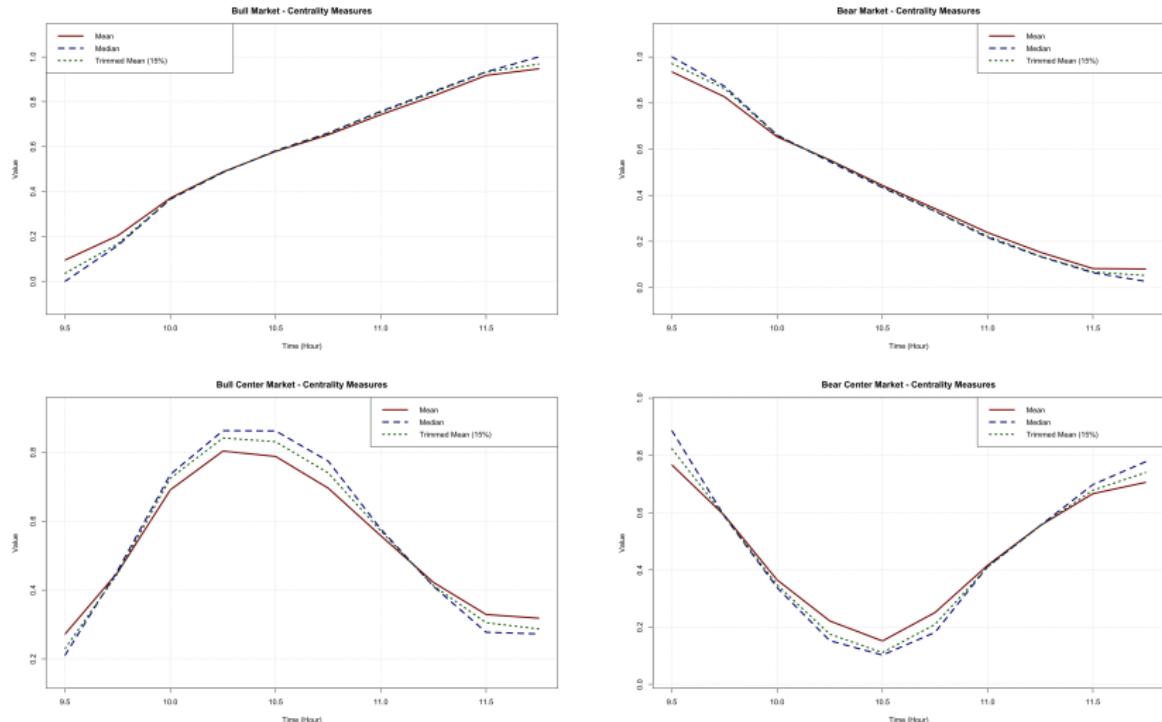
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# Smoothed data visualisation (reminder)



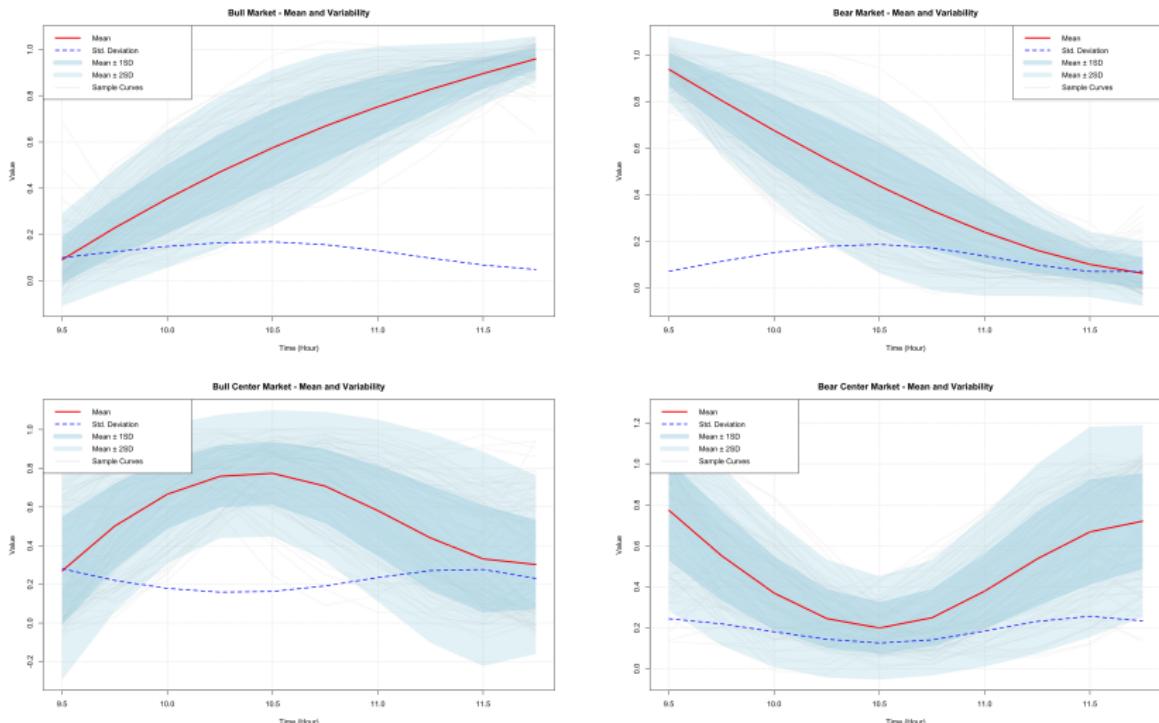
**Figure 1:** B-Spline smoothed stock data for Bull, Bear, Bull-center, Bear-center days  
Source: Made by author

# EDA: Centrality measures



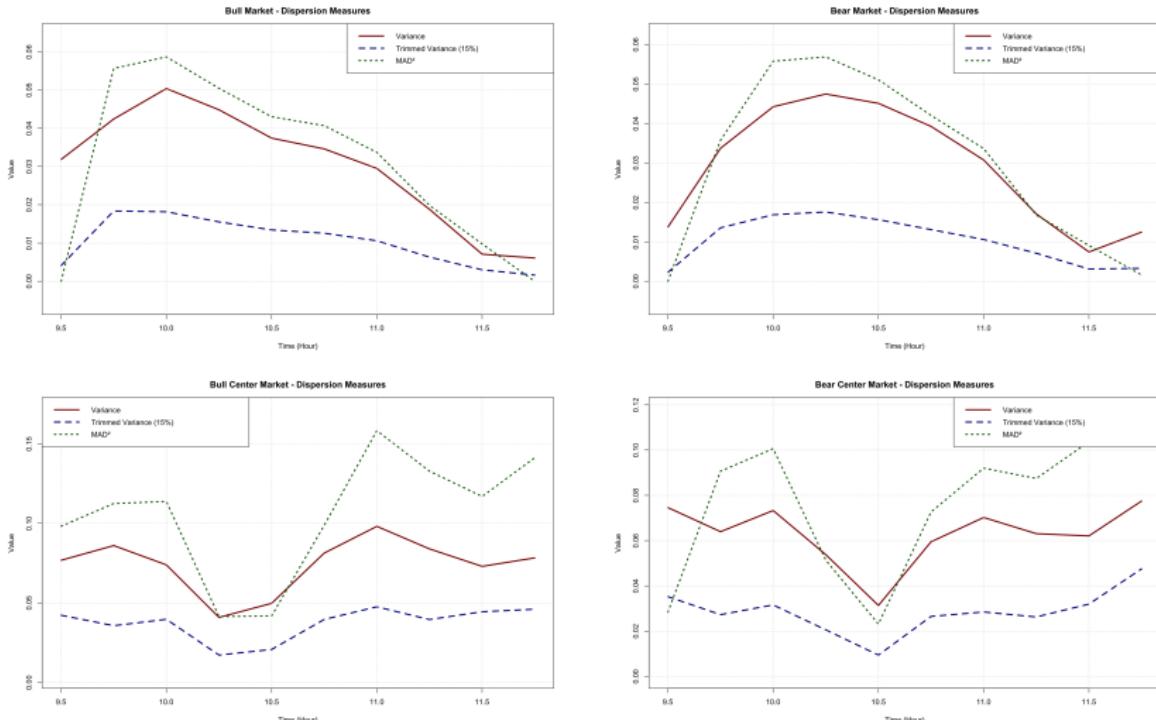
**Figure 2: Centrality measures for Bull, Bear, Bull-center, Bear-center days**  
Source: Made by author

# EDA: Variability measures



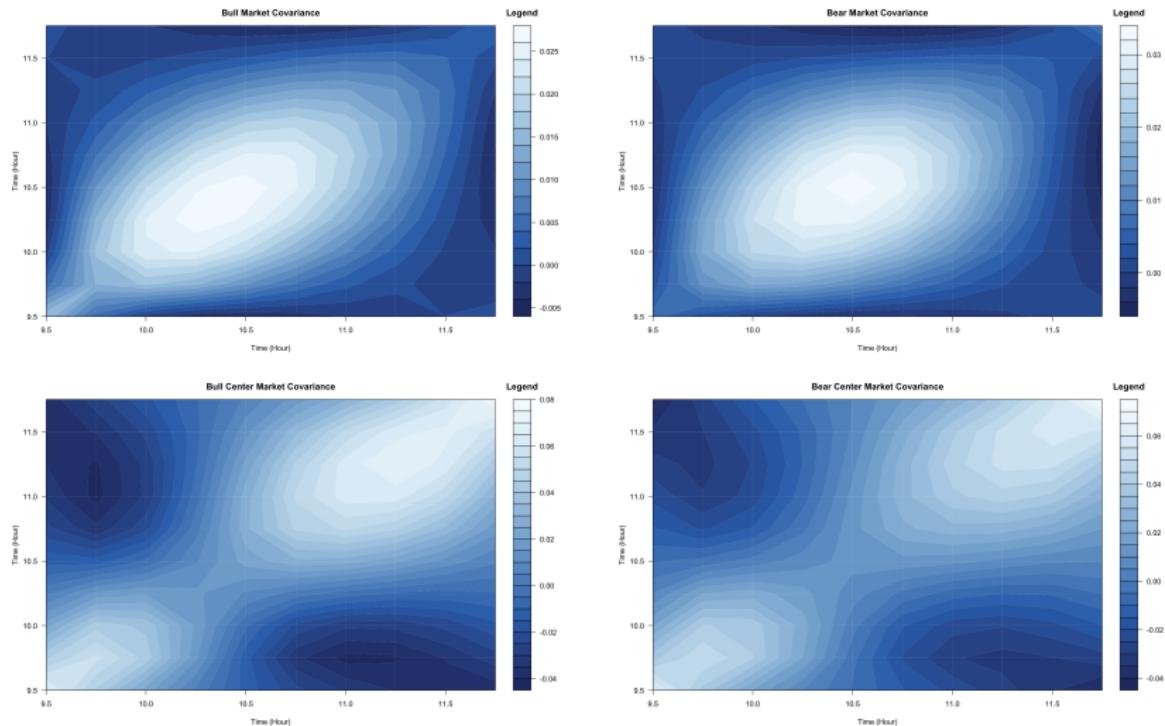
**Figure 3: Variability for Bull, Bear, Bull-center, Bear-center days**  
Source: Made by author

# EDA: Dispersion measures



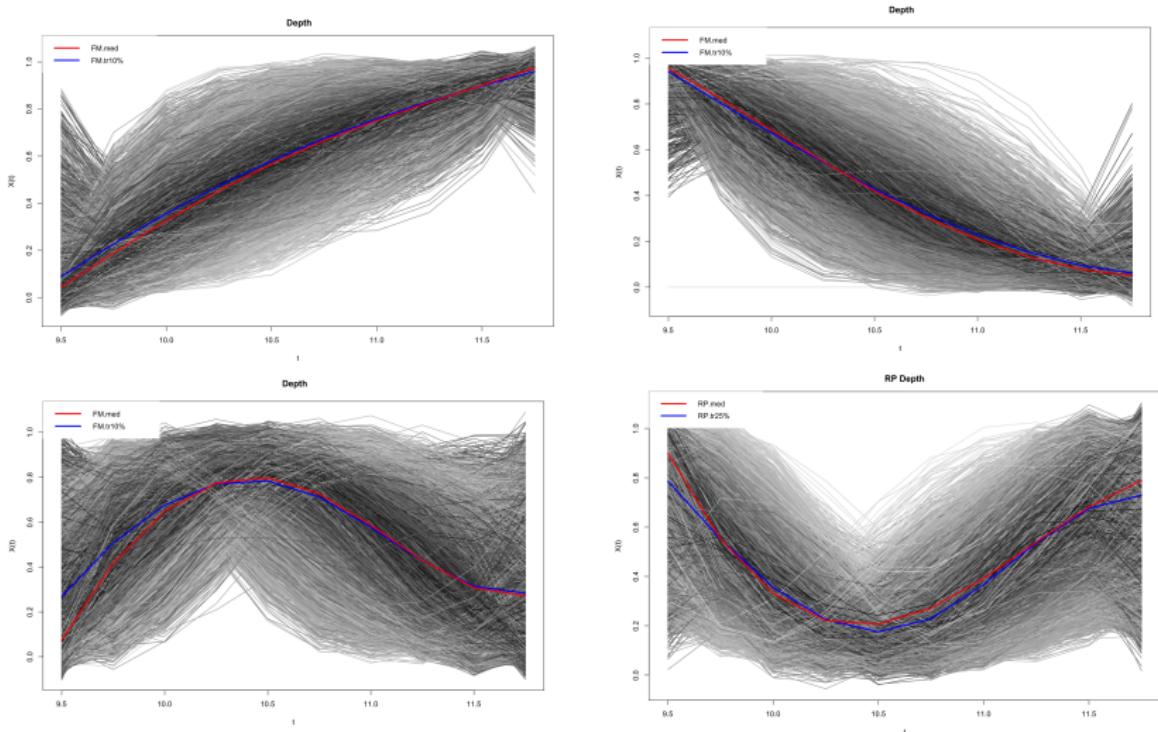
**Figure 4: Dispersion for Bull, Bear, Bull-center, Bear-center days**  
Source: Made by author

# EDA: Covariance surface



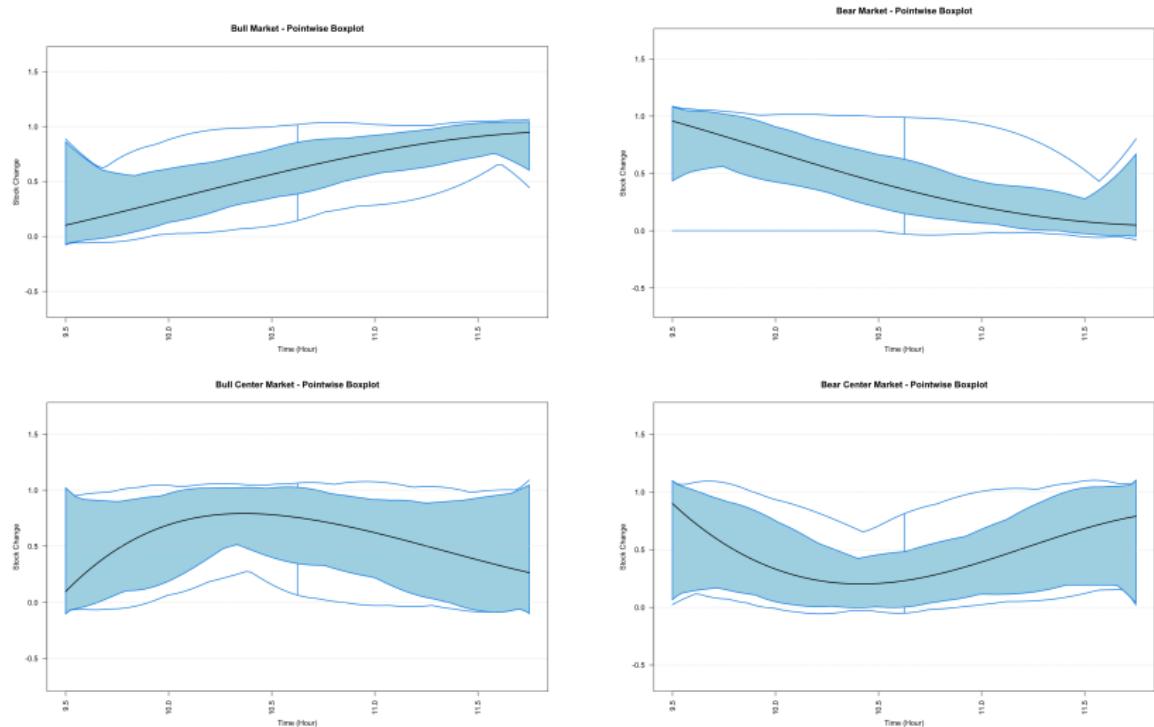
**Figure 5:** Covariance surface for Bull, Bear, Bull-center, Bear-center days  
Source: Made by author

# EDA: Depth



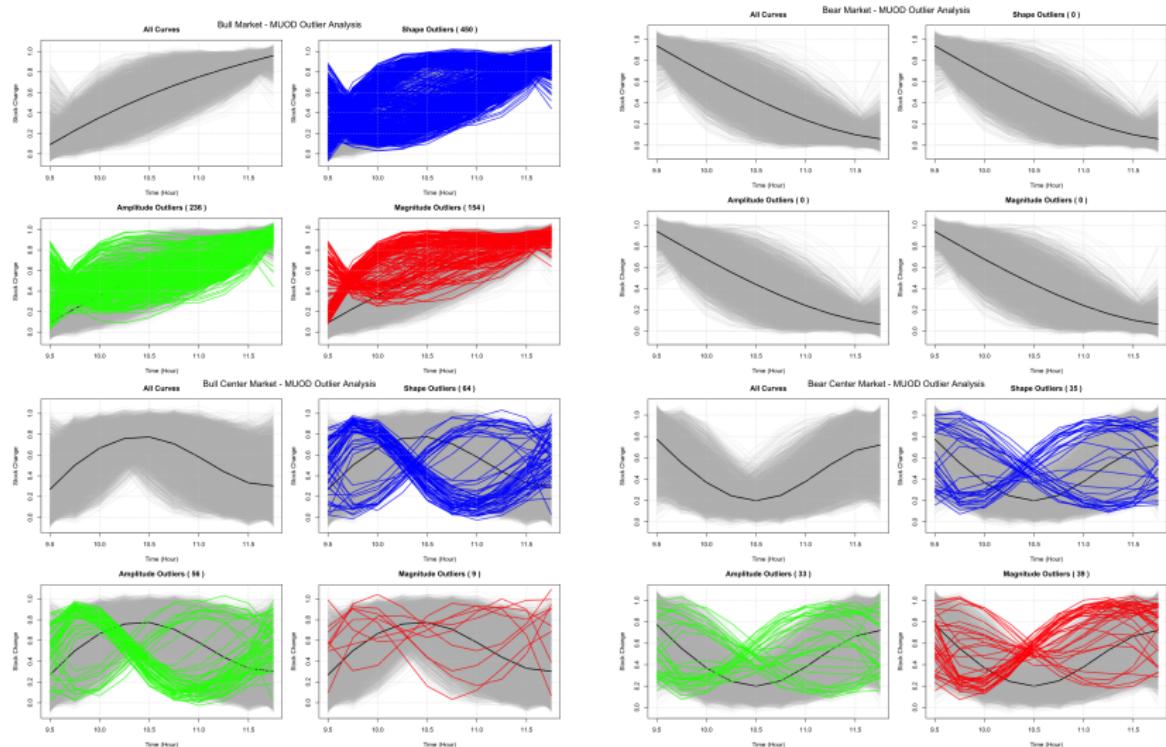
**Figure 6: Depth for Bull, Bear, Bull-center, Bear-center days**  
Source: Made by author

# EDA: Boxplots



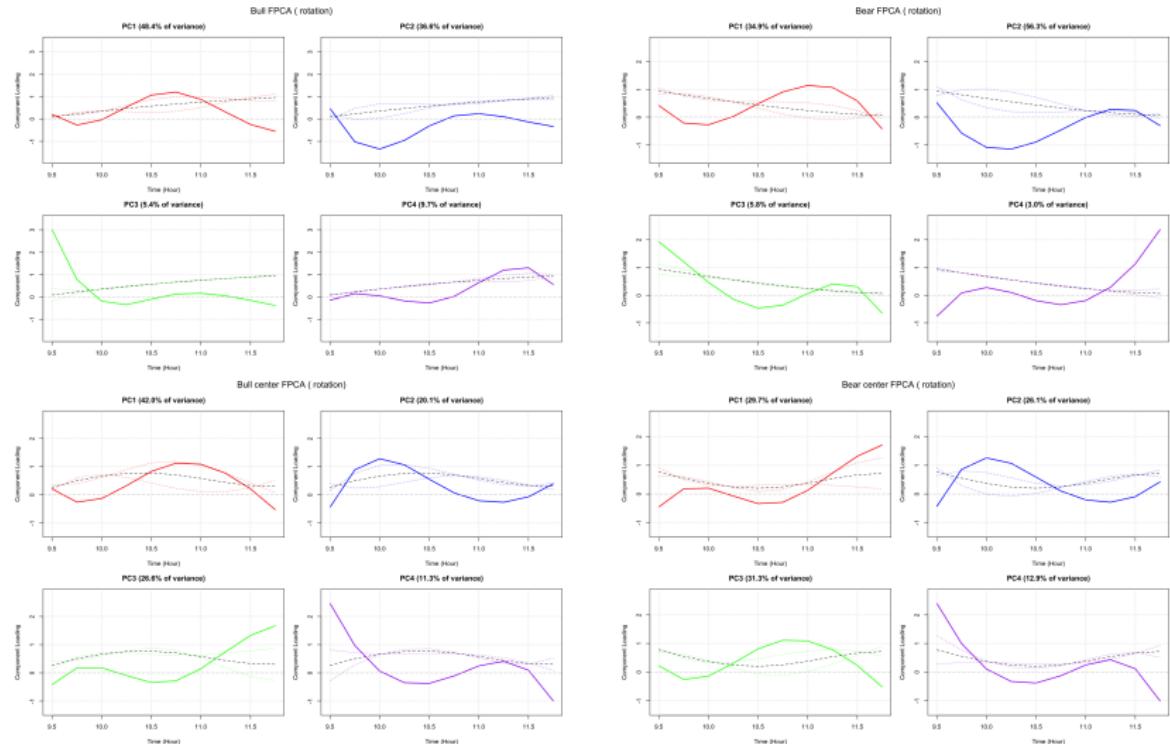
**Figure 7: Boxplots for Bull, Bear, Bull-center, Bear-center days**  
Source: Made by author

# EDA: MUOD outliers



**Figure 8: MUOD analysis for Bull, Bear, Bull-center, Bear-center days**  
Source: Made by author

# FPCA



**Figure 9: 4 PC functions for Bull, Bear, Bull-center, Bear-center days**  
Source: Made by author

## Key Insights

- Bear and Bear Center days show tighter, more synchronized intraday price paths.
- Stronger alignment of mean, median, and trimmed mean in Bear and Bear Center data.
- Bull and Bull Center days display greater variability and less collective synchronization.
- Covariance surfaces for Bear and Bear Center are predominantly diagonal, indicating smoother evolution.
- Bear and Bear Center curves have higher depth concentration, suggesting typical behavior dominates.
- FPCA shows that Bear and Bear Center days concentrate variance in fewer principal components, confirming stronger, more structured behavior compared to Bull and Bull Center days.
- MUOD detected no outliers in Bear days, while Bull and Bull Center showed some irregular patterns.

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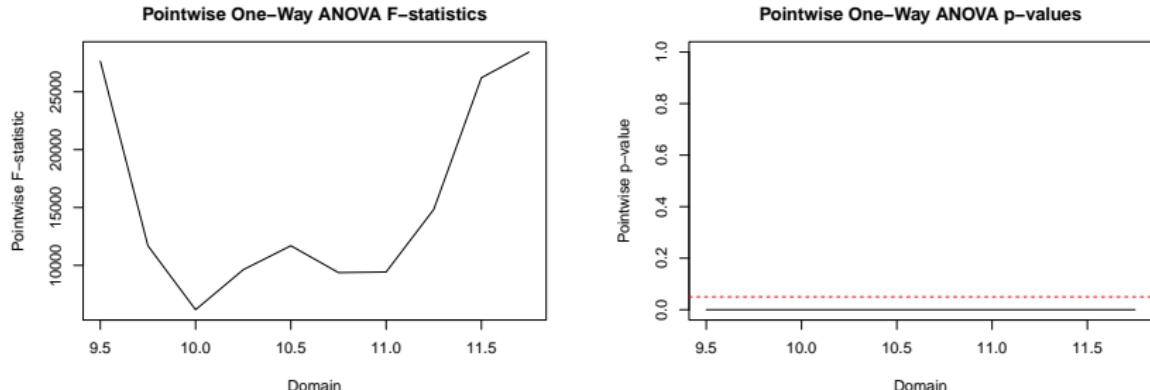
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# One-way ANOVA Tests



```
> print(anova_results_fd)
Analysis of Variance for Functional Data

L2N test - L2-norm-based test with naive method of estimation
Test statistic = 14849.13 p-value = 0
```

```
> print(anova_results_GPF)
Analysis of Variance for Functional Data

GPF test - globalizing the pointwise F-test
Test statistic = 15511.34 p-value = 0
```

**Figure 10:** One-way ANOVA global (L2-Norm) & point-wise test results  
Source: Made by author

# Point-wise Mean Tests

Pointwise Mean Difference Curves for All Group Pairs

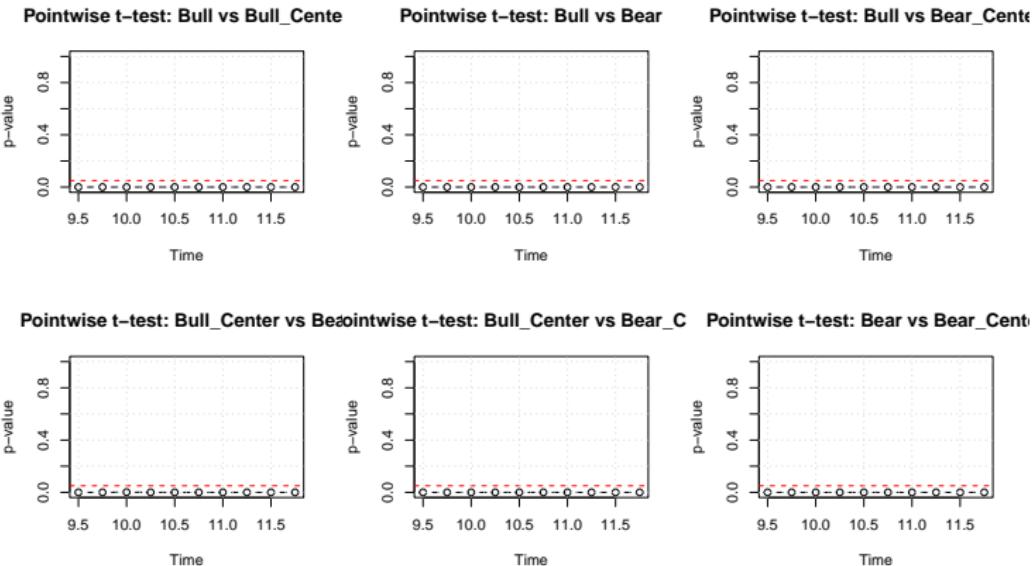
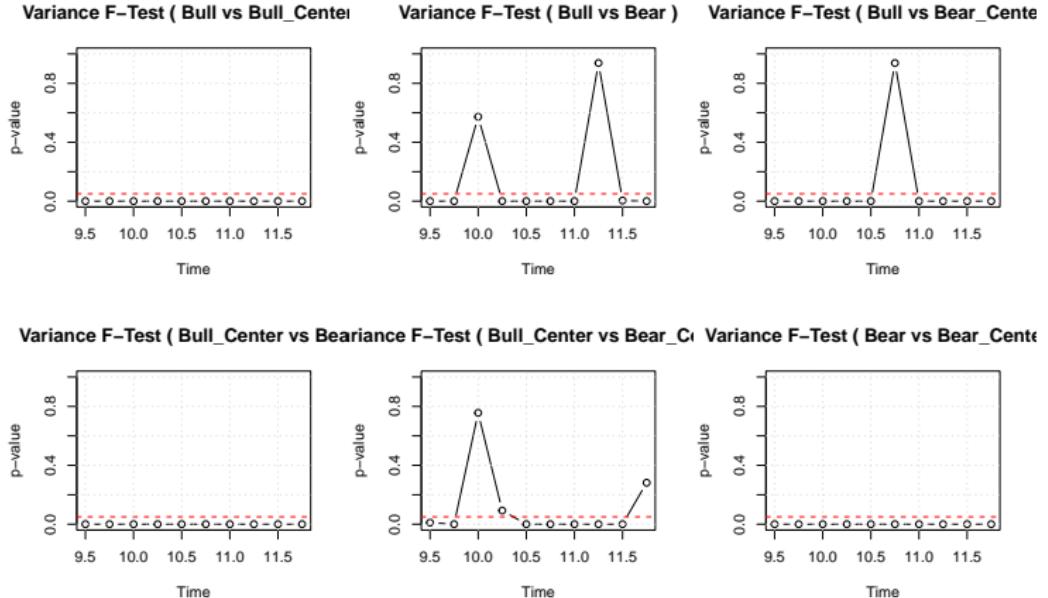


Figure 11: Point-wise mean difference tests for differing combinations of function groups

# Point-wise Variance Tests



**Figure 12:** Point-wise variance difference tests for differing combinations of function groups

Thank you for your attention