

# Recession Resistant Portfolio Picking Strategies

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# Motivations and Aims

- Our Investment goal: mitigate losses
- Emphasize the “resistance” of the stock’s performance to extreme bear markets
- Explore the spaces of “recession resistant” stocks
- Build a portfolio of stocks meeting this criteria
- See how resistant portfolios measure up to typical portfolios during bull and bear markets

# Stock Metrics and the Sharpe Ratio




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# Key Metrics

- Excess Returns
- Askhi
- Bidlo
- Price/Askhi
- Volume
- Shares Outstanding
- Volume/Sout
- EPS (Earnings per Share)
- ROE (Return on Equity)
- Dividend-adjusted PEG (Price to Earnings and Growth)
- D/E (Debt to Equity)

# Sharpe Ratio

- Core Portfolio Weighting and Evaluation Metric
- Ratio of Excess Returns to Risk
- Max. Sharpe should approach max. Signal-Noise ratio
- Flawed metric, but common in practice!
- Not used for prediction or modelling


$$\text{Sharpe Ratio Formula} = \frac{\text{Return of Portfolio} - \text{Risk Free Rate}}{\text{Standard Deviation of Portfolio's Excess Return}}$$

# Sharpe Ratio Algorithm

- Optimization Problem
- Matrix multiply the inverse covariance matrix with excess returns vector
- Need lots of return data points
- Finds max weights of *historical data*
- Short-sale assumption

$$S = \frac{\mathbb{E}[r_p] - \mathbb{E}[r_f]}{\sigma_p} = \frac{w^T [r_p - r_f]}{(w^T \Sigma w)^{1/2}}$$

$$\text{find } w \text{ s.t. } \frac{\partial S}{\partial w} = 0$$

Sharpe Ratio will  
balance high returns  
with high diversity!

# Data Preprocessing and Exploration

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# Data Preprocessing

- Daily data for S&P 500 stocks was acquired from two sources.
  - UPenn Wharton Research Data Services
  - Alphavantage API
- Quarterly data from [stockpup.com](https://stockpup.com)

# UPENN Preprocessing

- Daily metrics for 386 stocks from 2007-2019
- Data for 2019 became available to the Finance Department in the first week of March 2020

	date	symbol	name	bidlo	askhi	price	vol	ret	sout	open
0	2019-01-02	ORCL	ORACLE CORP	44.45	45.340	45.22	14320441.0	0.00155	3588919.0	44.48
1	2019-01-03	ORCL	ORACLE CORP	44.41	45.500	44.78	19868713.0	-0.00973	3588919.0	44.75
2	2019-01-04	ORCL	ORACLE CORP	45.25	46.950	46.71	20983953.0	0.0431	3588919.0	45.37
3	2019-01-07	ORCL	ORACLE CORP	46.47	48.105	47.45	17967907.0	0.015842	3588919.0	46.93
4	2019-01-08	ORCL	ORACLE CORP	47.20	48.360	47.88	16255688.0	0.009062	3588919.0	47.93


	date	2019-01-02	2019-01-03	2019-01-04	2019-01-07	2019-01-08	2019-01-09	2019-01-10	2019-01-11	2019-01-14	2019-01-15	...	2019-12-17	2019-12-18	2019-12-19
ORCL_ORACLE CORP	44.45	44.41000	45.2500	46.47000	47.20000	46.61000	46.88	47.3700	47.62	47.41000	...	52.83	52.95000	53.04000	
MSFT_MICROSOFT CORP	98.94	97.20000	98.9300	100.98000	101.71340	103.24450	102.38	101.6400	101.26	101.88000	...	154.45	154.17999	153.75000	
TROW_T ROWE PRICE GROUP INC	90.22	88.58000	89.2100	91.14000	91.43000	91.51000	91.40	89.5400	89.23	91.06500	...	122.74	121.91000	121.93000	
HON_HONEYWELL INTERNATIONAL INC	129.50	129.07001	132.0475	133.14999	134.32001	135.06641	134.67	136.4100	135.98	136.53999	...	175.81	174.41000	174.49001	
ADM_ARCHER DANIELS MIDLAND CO	40.53	40.40000	41.0900	41.47000	42.03000	42.70000	42.78	42.8764	42.68	42.89500	...	46.17	44.87000	45.28000	

5 rows × 252 columns

# Alphavantage Preprocessing

- Source for 2020 data
- Data from this source was more limited, we could only acquire Price, Volume and Returns data

	date	AAPL_open	AAPL_high	AAPL_low	AAPL_close	AAPL_volume	AAPL_return
0	2020-03-23	228.080	228.4997	213.68	215.25	31202470.0	-0.056252
1	2020-03-20	247.180	251.8300	228.00	229.24	100423346.0	-0.072579
2	2020-03-19	247.385	252.8400	242.61	244.78	67964255.0	-0.010530
3	2020-03-18	239.770	250.0000	237.12	246.67	75058406.0	0.028778
4	2020-03-17	247.510	257.6100	238.40	252.86	81013965.0	0.021615



	A	AAL	AAP	AAPL	ABC	ABMD	ABT	ACN	ADBE
2020-03-20	66.46	10.38	75.03	229.24	80.61	130.51	68.00	149.94	295.34
2020-03-19	65.76	10.29	85.97	244.78	86.00	140.51	74.50	158.50	307.51
2020-03-18	68.87	11.65	88.74	246.67	84.97	146.55	79.26	151.15	294.61
2020-03-17	70.44	15.58	100.25	252.86	89.50	145.25	79.49	157.71	311.81
2020-03-16	64.13	15.92	95.25	242.21	80.50	142.44	73.66	152.54	286.03
...	...	...	...	...	...	...	...	...	...
2007-01-08	33.97	57.93	35.14	85.47	46.45	14.11	50.08	37.21	40.45
2007-01-05	34.09	58.29	35.02	85.05	45.73	14.14	49.90	36.68	40.62
2007-01-04	34.41	58.84	35.81	85.66	46.29	14.35	49.90	37.20	40.82
2007-01-03	34.30	56.30	35.58	83.80	46.11	14.05	48.97	36.38	39.92
2006-12-29	34.85	53.85	35.56	84.84	44.96	14.10	48.71	36.93	41.12

# Stockpup Preprocessing

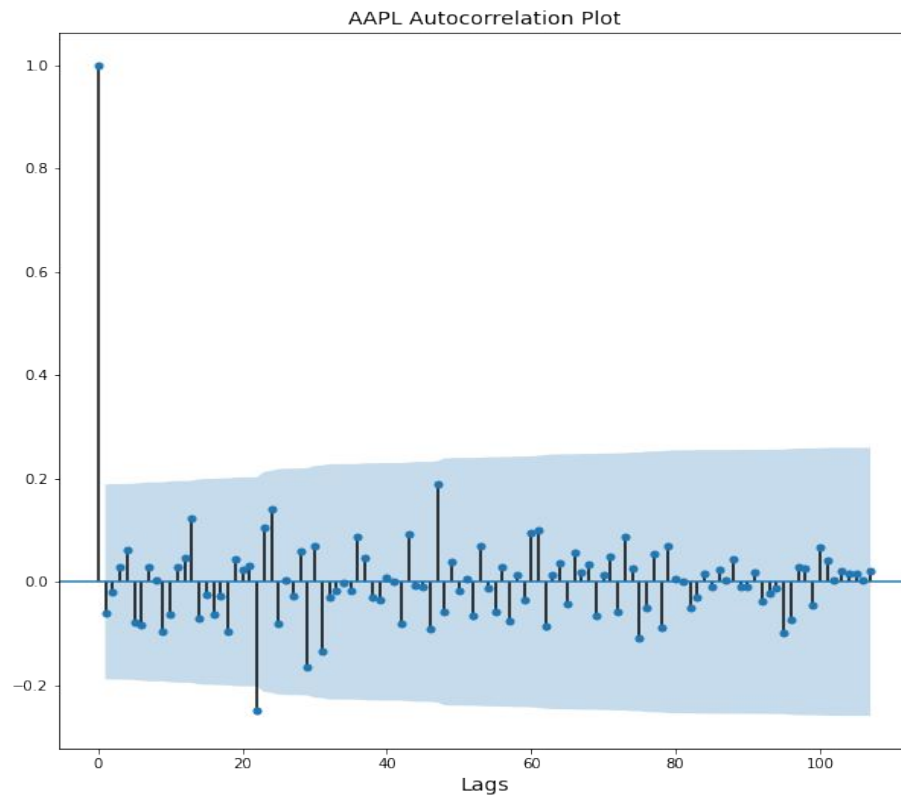
- Most stock had at least one irregularity
- Many quarter report dates did not match quarter end dates
- Multiple reports in one quarter

# Data Exploration: Sharpe Ratio Assumptions

- Can't have the following
  - Autocorrelation
  - Heteroskedasticity
  - Serious departure from normality
- Easiest way to check is visually
- Z-test for inference on proportion ( $n = 100$ )
- Null:  $\geq 10\%$  of our stocks violate assumption
- Alternative:  $< 10\%$  proportion violate assumption
- 386 stocks, 108 observations

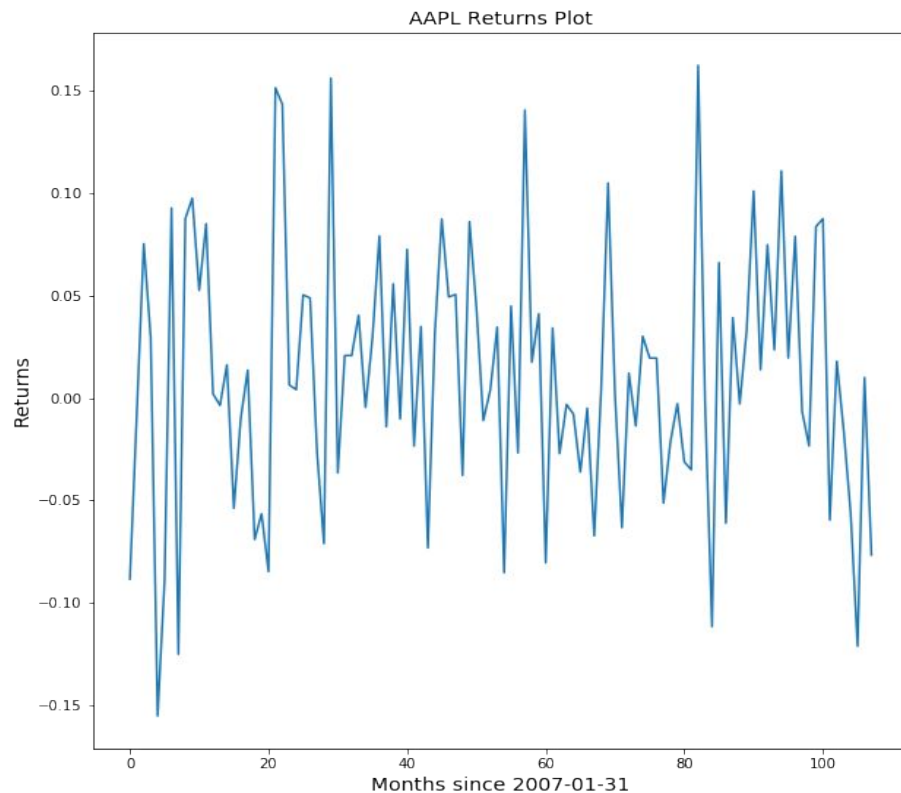
# Autocorrelation

- Blue area = 95% Confidence Interval
- If number of correlated Lags  $\geq 4$ , judged to be autocorrelated
- Only one autocorrelated stock
- $z = -9.05$ ,  $p \approx 0$
- Reject null hypothesis



# Heteroskedasticity

- Looking for cone or hourglass shape
- 3 stocks judged to be heteroskedastic
- $z = -4.1$ ,  $p = 0.0002$
- Reject null hypothesis



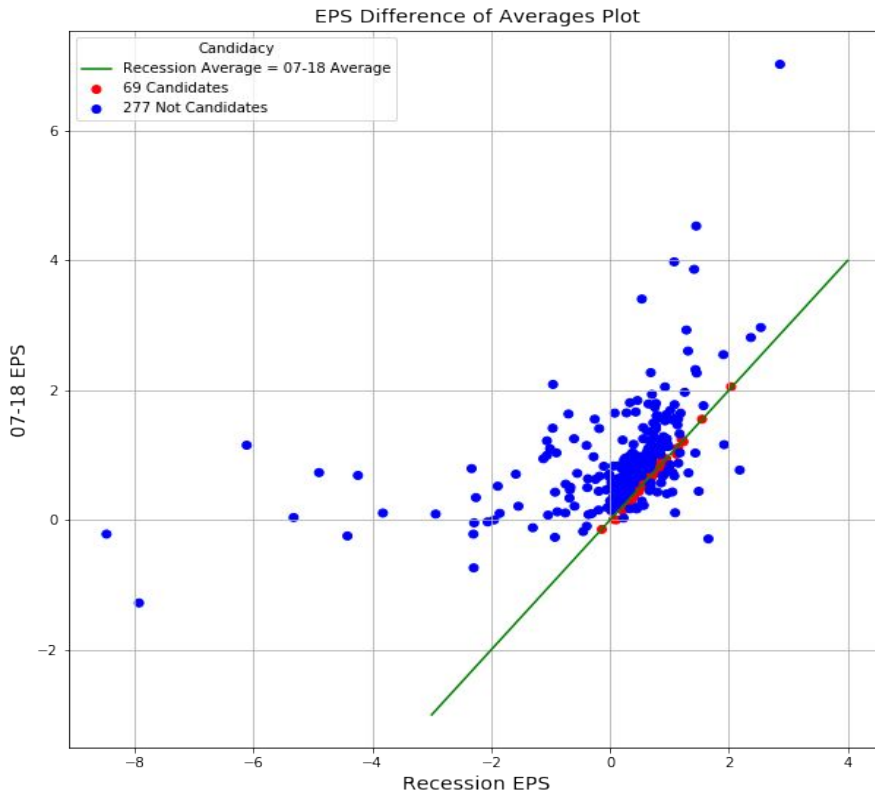
# “Rough” Normality of Returns

- Hardest assumption to test
- More important when sampling a single portfolio
- Every QQ plot had heavy tail
- Shapiro-Wilk test with relaxed threshold ( $p < 0.001$ )
- Still too many stocks reject normality
- Not confident enough to make 10% assumption
- Further inquiry is needed into the effect on results



# Recession Resistance: Quarterly Metric

- Units are in dollars
- 20/80 split between Candidates and Not Candidates

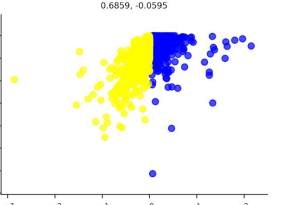
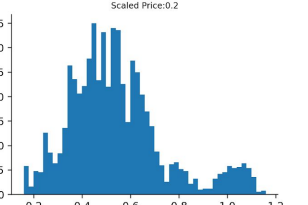
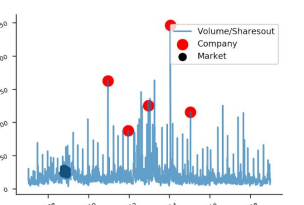
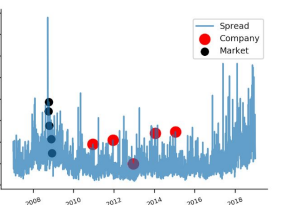
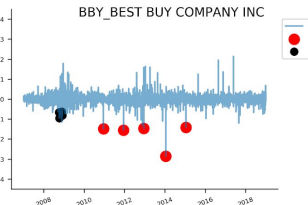
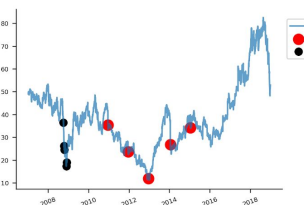
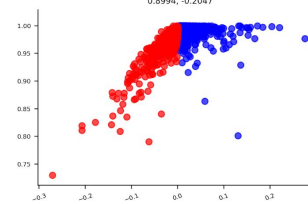
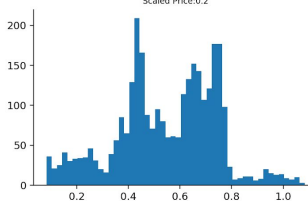
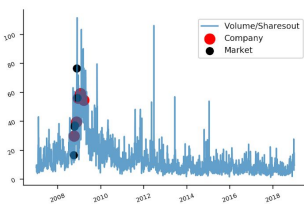
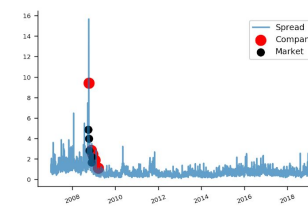
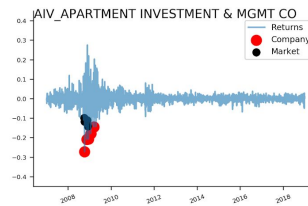
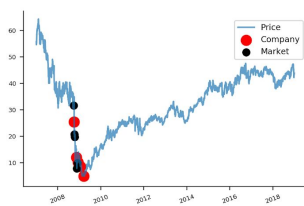


# Daily Exploration

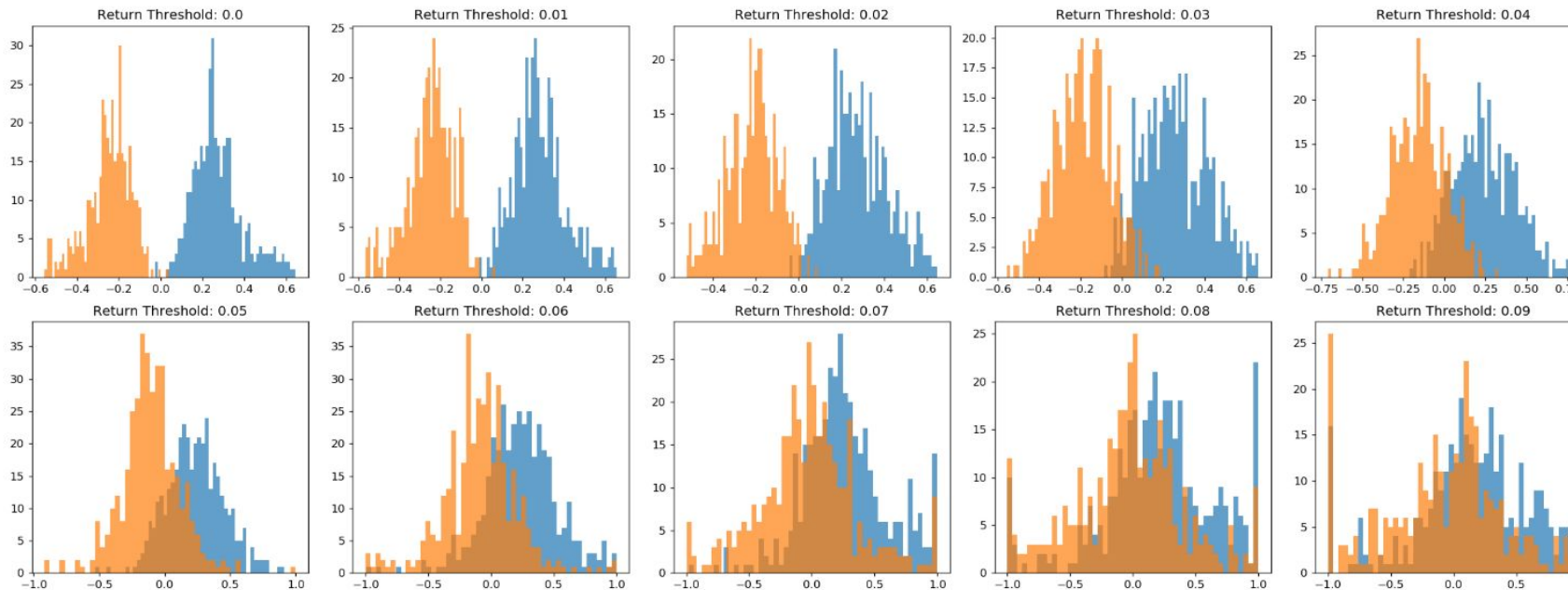
- Is there a useful metric to estimate the return the future return?
  - Design a metric such as Price/Askhi or Volume/Sharesout that could serve as leading indicators for the return of a stock the next day or the day after
- How did each security perform against the overall market during the 2007-2009 bear market?
  - Did their worst trading days occur during the decline from 9/2008-12/2008?
- How did returns correlate with new metrics?

# Visualization Portfolio

- What hypothesis can we infer from a visual representation of select metrics?



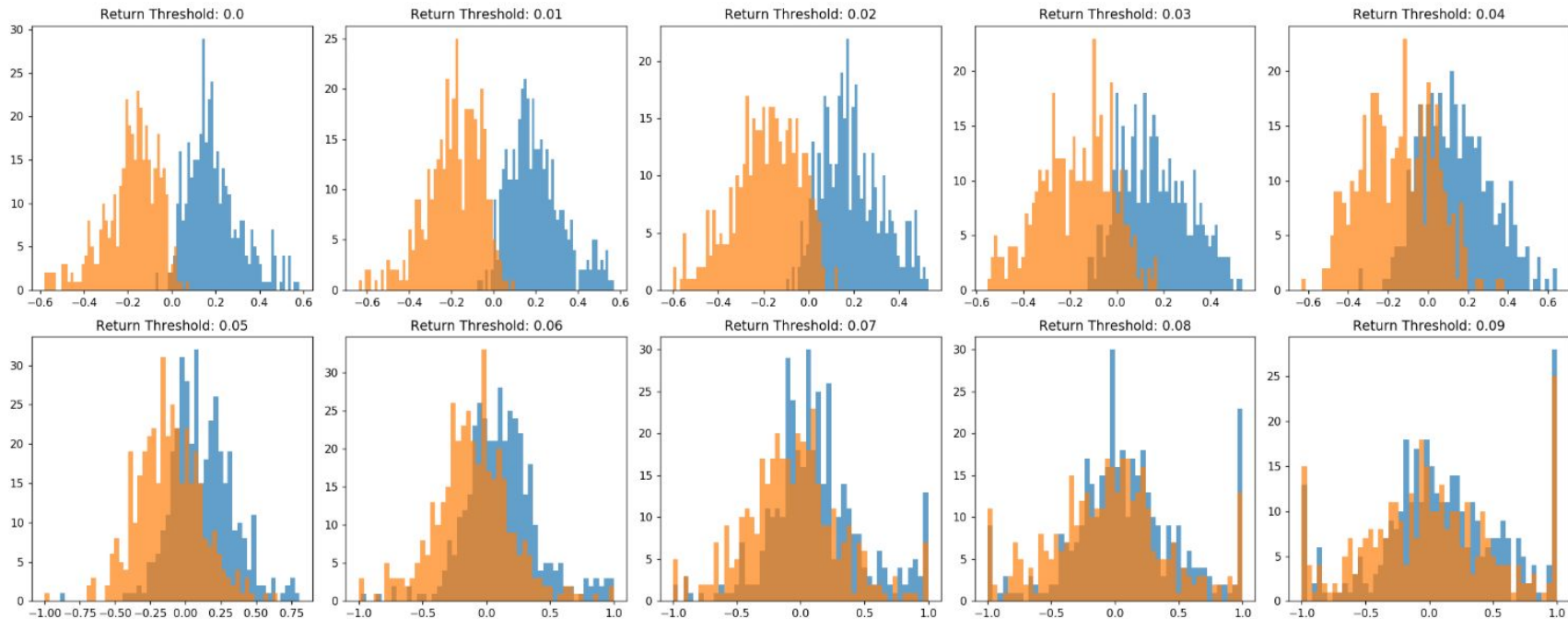
# 1 Day Leading (VS/Sout)



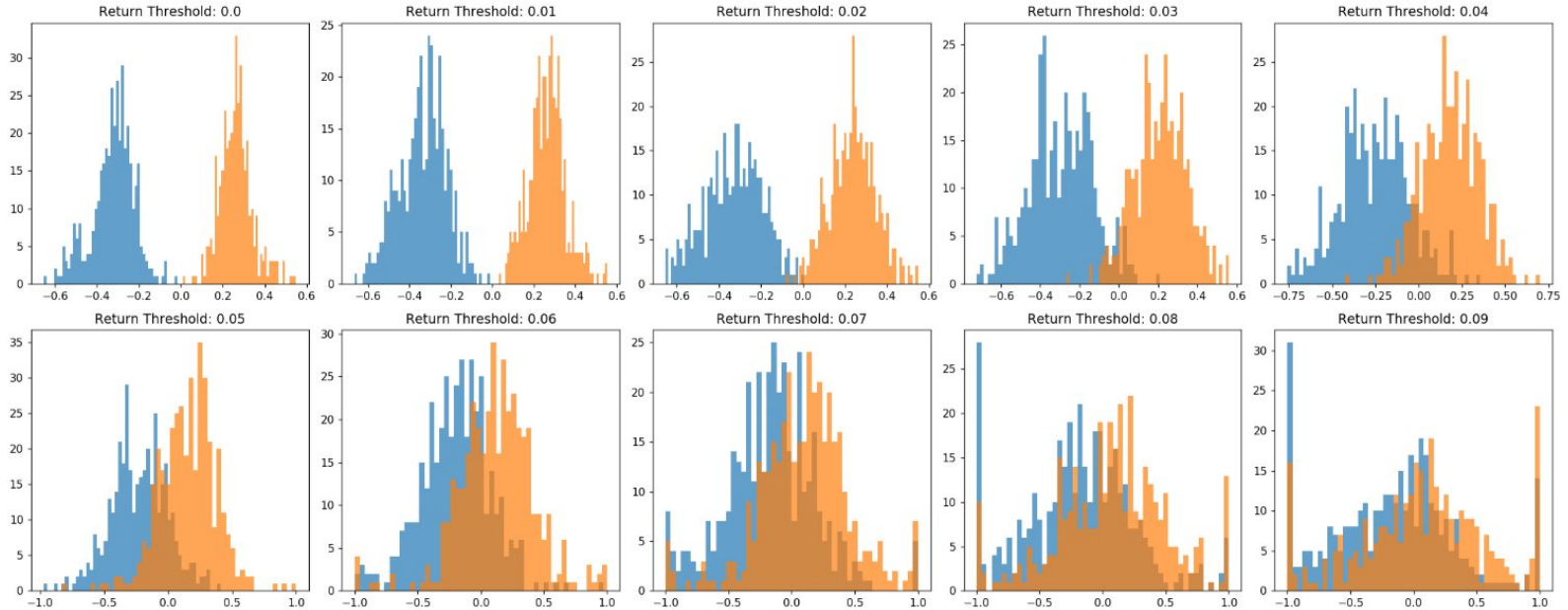
Volume/ShareOut

- (GDP/Market Cap)
- Does a high stock "GDP" signal a sign to dump in the future?

# 5 Day Leading (VS/Sout)

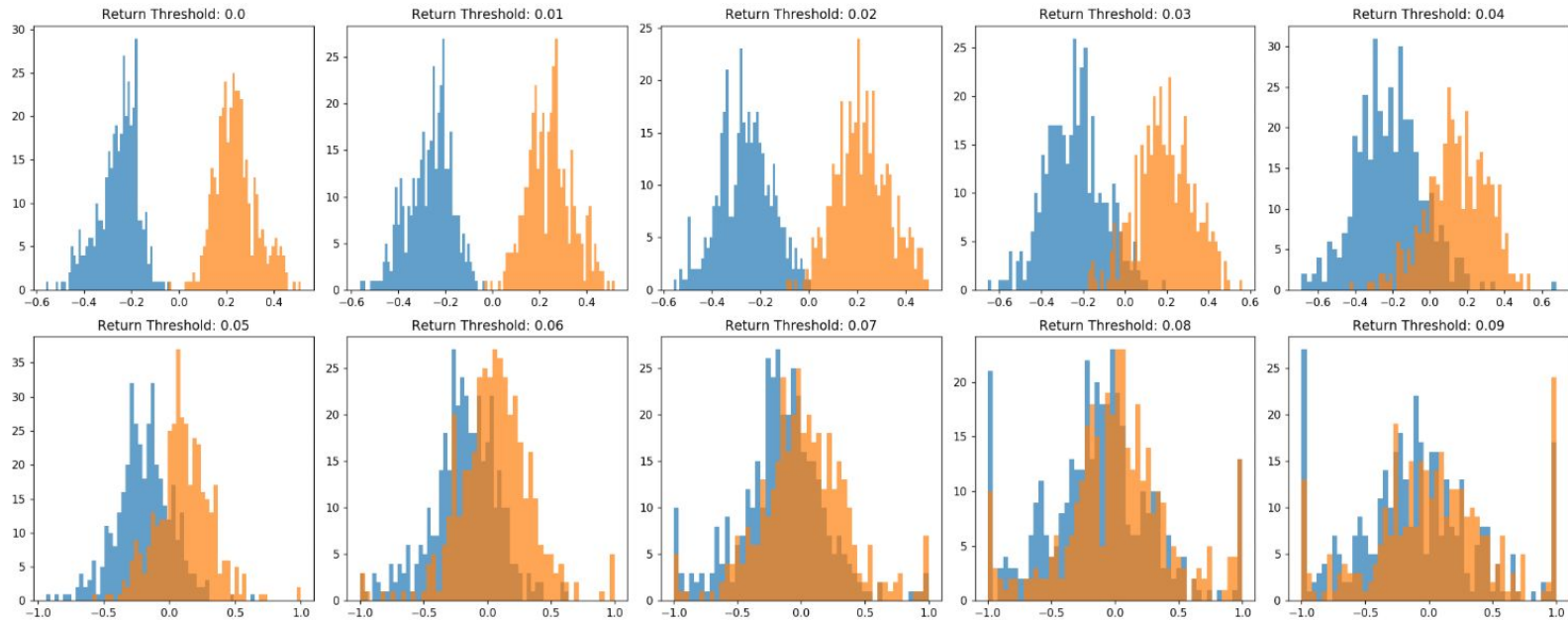


# 1 Day Leading (P/Ah)



- Price/Askhi
  - Does a discount signal a drop in the returns 1 or 5 days later?

# 5 Day Leading (P/Ah)



- Correlation histograms look very similar to 1 Day leading which indicates noise

# Experiment 1

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# Experiment 1

- Control Portfolio 1: Random Sampling of 25 stocks from quarterly “Not Candidate” pool of recession resistant stocks
- Control Portfolio 2: Random Sampling of 25 stocks from all stocks in the data set
- Alternative Portfolio: Random Sampling of 25 stocks from quarterly “Candidate” pool of recession resistant stocks
- Hypothesis 1: The average Alternative portfolio will outperform the Control on 2019 data
- Hypothesis 2: The average Alternative portfolio will outperform the Control on Great Recession data (Q3 2008-Q2 2009)

# Exp. 1: Benchmark

- Control 1 is in line with traditional statistical testing (treatment vs. no treatment)
- Control 2 is a better comparison against the broader market
- Three Treatments: EPS, ROE, Dividend-adjusted PEG
- Treatment used to determine “recession resistant”

# Exp. 1: Methodology

- 1000 i.i.d samples of 25 stock portfolios
- 108 observations of monthly returns data (2010-2018)
- Optimal weights from Sharpe Algorithm
- Returns/Risk/Sharpe calculated on testing set
- Inference on difference between means of Sharpe ratios

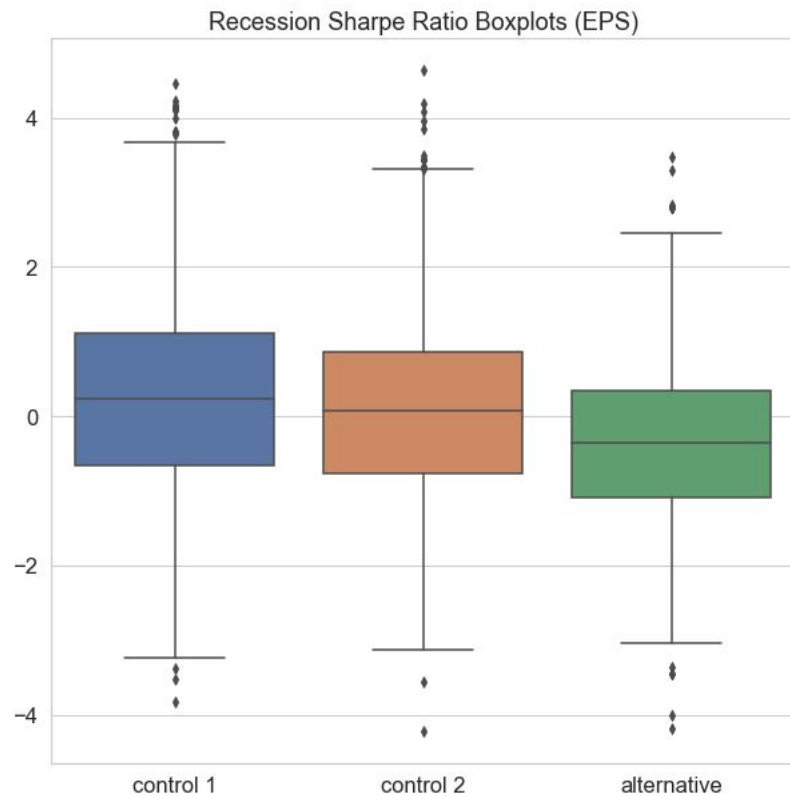
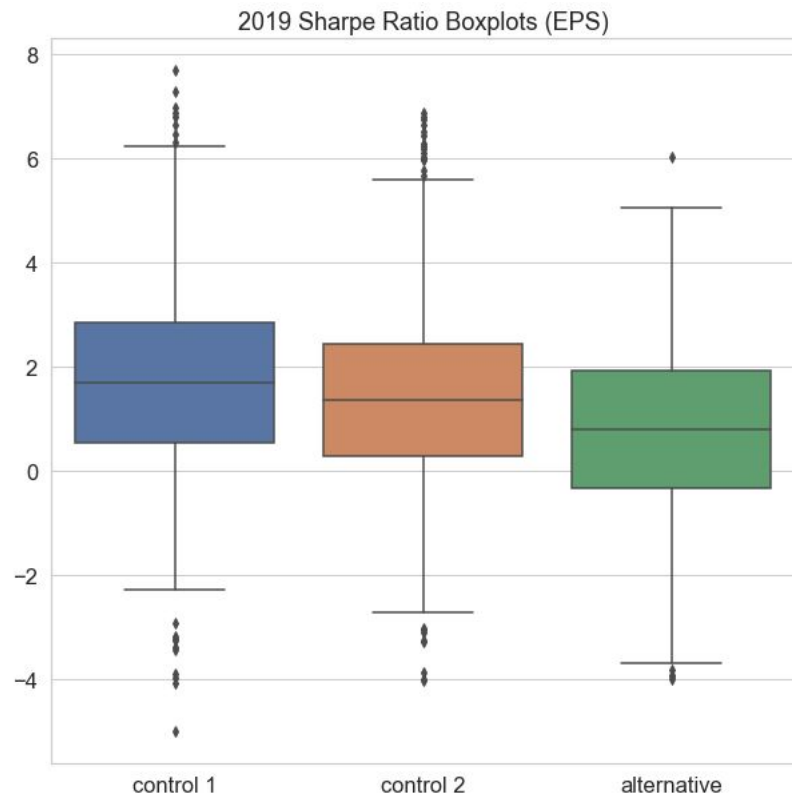
# Exp. 1: Formal Hypotheses

- Null and alternative hypotheses for hypotheses 1 and 2
- Alternative ~ Control 1, Alternative ~ Control 2
- One-sided z-test, alpha = 0.05, 95% confidence intervals

$$H_0^1 : \mu_{alt} \leq \mu_{ctl1} \quad H_A^1 : \mu_{alt} > \mu_{ctl1}$$

$$H_0^2 : \mu_{alt} \leq \mu_{ctl2} \quad H_A^2 : \mu_{alt} > \mu_{ctl2}$$

# Exp. 1 Treatment: EPS



# Exp. 1 Treatment: EPS

## Hypothesis 1 (2019 data)

### Alternative~Control 1 Test:

2 Sample Z-test produced  $z = -11.47$ ,  $p = 1$   
95% Confidence Interval:  $(-1.009714, \text{infinity})$

Conclusion: Failure to reject null hypothesis.

### Alternative~Control 2 Test:

2 Sample Z-test produced  $z = -7.52$ ,  $p = 1$   
95% Confidence Interval:  $(-0.696713, \text{infinity})$

Conclusion: Failure to reject null hypothesis.

## Hypothesis 2 (Recession data)

### Alternative~Control 1 Test:

2 Sample Z-test produced  $z = -11.59$ ,  $p = 1$   
95% Confidence Interval:  $(-0.710668, \text{infinity})$

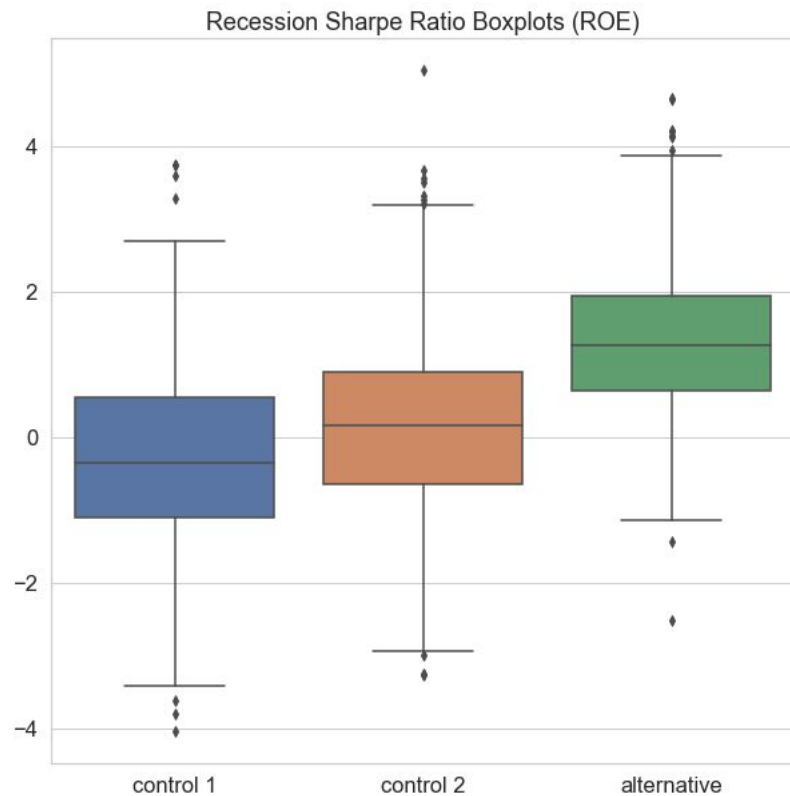
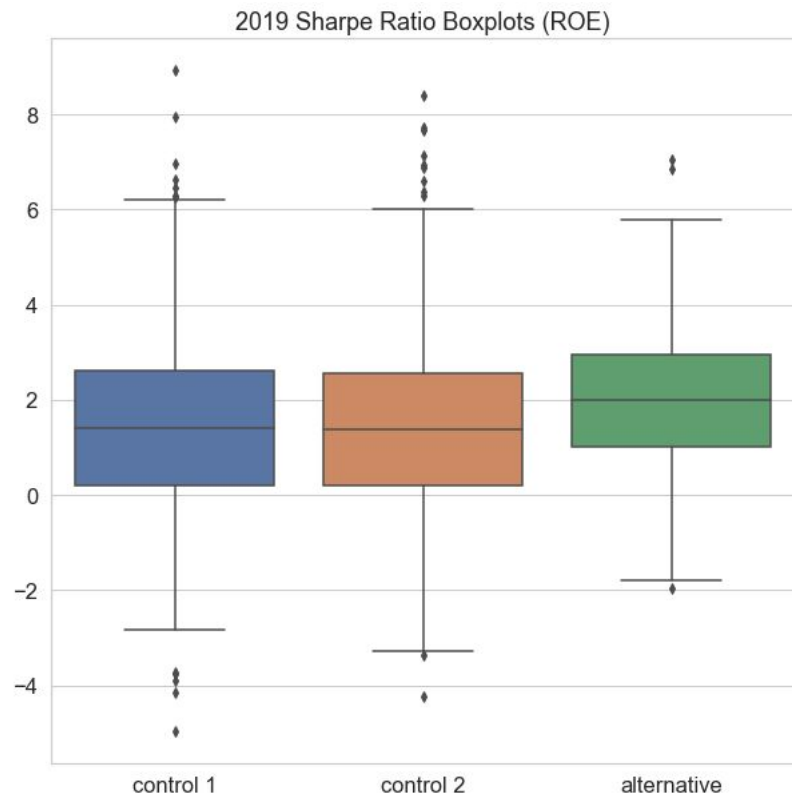
Conclusion: Failure to reject null hypothesis.

### Alternative~Control 2 Test:

2 Sample Z-test produced  $z = -8.93$ ,  $p = 1$   
95% Confidence Interval:  $(-0.554440, \text{infinity})$

Conclusion: Failure to reject null hypothesis.

# Exp. 1 Treatment: ROE



# Exp. 1 Treatment: ROE

## Hypothesis 1 (2019 data)

### Alternative~Control 1 Test:

2 Sample Z-test produced  $z = 9.06$ ,  $p = 0$   
95% Confidence Interval: (0.532210, infinity)

Conclusion: Reject null hypothesis.

### Alternative~Control 2 Test:

2 Sample Z-test produced  $z = 8.18$ ,  $p = 0$   
95% Confidence Interval: (0.474724, infinity)

Conclusion: Reject null hypothesis.

## Hypothesis 2 (Recession data)

### Alternative~Control 1 Test:

2 Sample Z-test produced  $z = 33.00$ ,  $p = 0$   
95% Confidence Interval: (1.529901, infinity)

Conclusion: Reject null hypothesis.

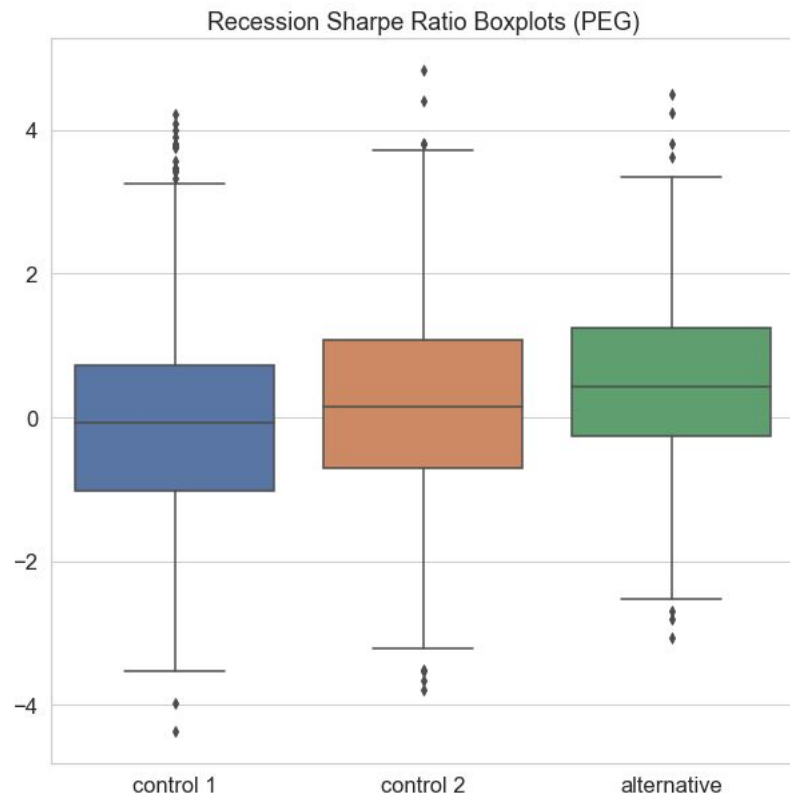
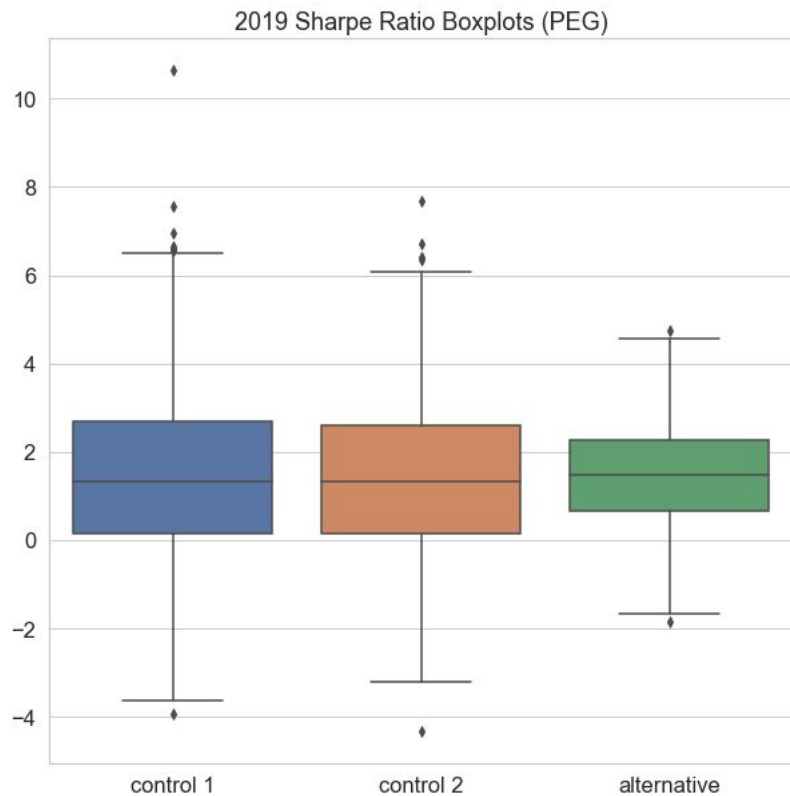
### Alternative~Control 2 Test:

2 Sample Z-test produced  $z = 24.49$ ,  $p = 0$   
95% Confidence Interval: (1.094825, infinity)

Conclusion: Reject null hypothesis.



# Exp. 1 Treatment: PEG



# Exp. 1 Treatment: PEG

## Hypothesis 1 (2019 data)

### Alternative~Control 1 Test:

2 Sample Z-test produced  $z = 0.33$ ,  $p = 0.37$ .  
95% Confidence Interval:  $(-0.092774, \text{infinity})$

Conclusion: Failure to reject null hypothesis.

### Alternative~Control 2 Test:

2 Sample Z-test produced  $z = 0.94$ ,  $p = 0.17$ .  
95% Confidence Interval:  $(-0.046517, \text{infinity})$

Conclusion: Failure to reject null hypothesis.

## Hypothesis 2 (Recession data)

### Alternative~Control 1 Test:

2 Sample Z-test produced  $z = 10.02$ ,  $p = 0$   
95% Confidence Interval:  $(0.467000, \text{infinity})$

Conclusion: Reject null hypothesis.

### Alternative~Control 2 Test:

2 Sample Z-test produced  $z = 5.40$ ,  $p = 0$   
95% Confidence Interval:  $(0.206303, \text{infinity})$

Conclusion: Reject null hypothesis.

ROE and PEG are  
treatments worth  
further investigation!

# Experiment 2

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# Experiment 2

- **Statement 1:** The Alternative Portfolio will yield a positive return in 2019 and will outperform Control Portfolio 1 and Control Portfolio 2 on each of the 5 worst S&P 500 return dates in 2019 and each of the 5 worst return dates of 2020.
- **Statement 2:** The Alternative Portfolio will outperform Control Portfolio 1 and Control Portfolio 2 in 2019 and in 2020.
- 10,000 bootstraps per hypothesis
  - Each Alt, Ctl1, Ctl2 portfolio contained 25 randomly selected shares
- A one sided z-test was tested on each hypothesis
- Alpha = 0.05

# Statement 1: Alternative & Control Portfolio Criteria

- Alternative:
  - None of the 5 worst trading days (by daily return) from 2007-2018 coincided with any of the 5 worst trading days of the S&P 500 from 2007-2018
- Control 1:
  - The stock did not meet the Alternative criteria but still traded in the S&P 500
- Control 2:
  - The stock traded in the S&P 500

Statement 1: The Alternative Portfolio will yield a positive return in 2019 and will outperform Control Portfolio 1 and Control Portfolio 2 on each of the 5 worst S&P 500 return dates in 2019 and each of the 5 worst return dates of 2020.

Hypothesis 3

$$H_0 : \mu_{alt} = 0 \quad H_A : \mu_{alt} > 0$$

Hypothesis 4a

*For each Date in the 5 Worst Dates of 2019*

$$H_0^1 : \mu_{alt} = \mu_{ctl1} \quad H_A^1 : \mu_{alt} > \mu_{ctl1}$$

$$H_0^2 : \mu_{alt} = \mu_{ctl2} \quad H_A^2 : \mu_{alt} > \mu_{ctl2}$$

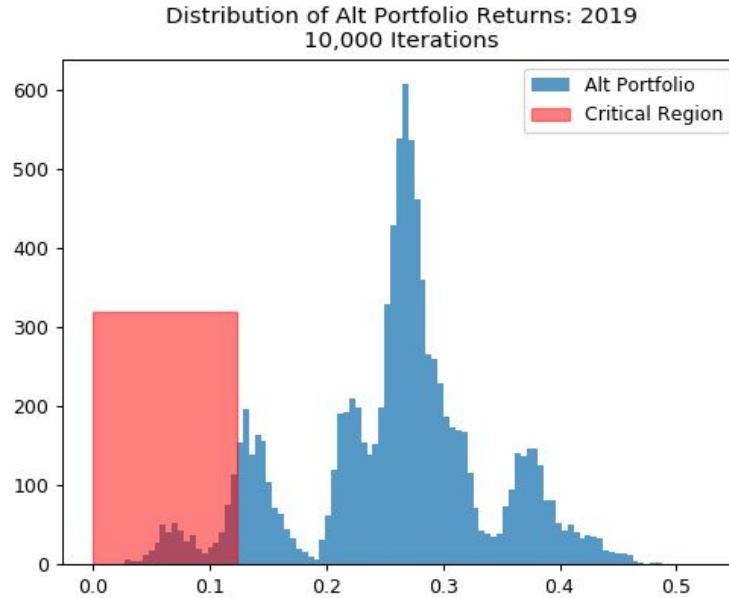
Hypothesis 4b

*For each Date in the 5 Worst Dates of 2020*

$$H_0^1 : \mu_{alt} = \mu_{ctl1} \quad H_A^1 : \mu_{alt} > \mu_{ctl1}$$

$$H_0^2 : \mu_{alt} = \mu_{ctl2} \quad H_A^1 : \mu_{alt} > \mu_{ctl2}$$

# Hypothesis 3 Results

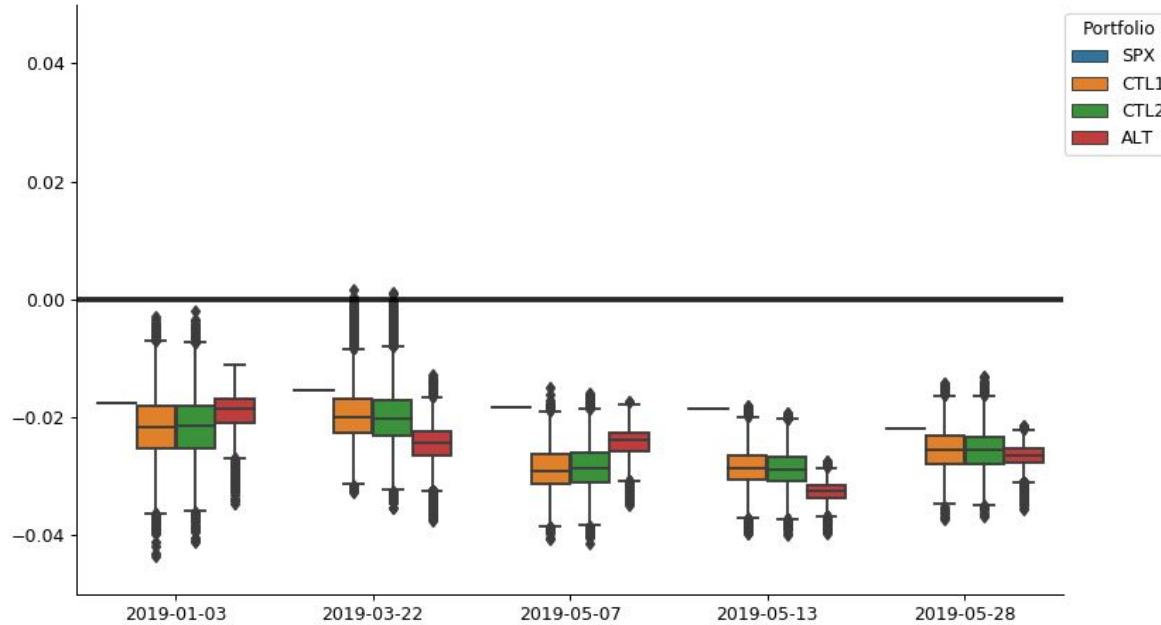


X Bar Alt	Lower	Upper	P-Value	Hypothesis Result
0.259152	0.123751	0.394553	0	Reject Null



# Hypothesis 4a Results

Distribution of Alt and Control Portfolio Returns:  
5 Worst S&P500 Dates 2019  
10,000 Iterations



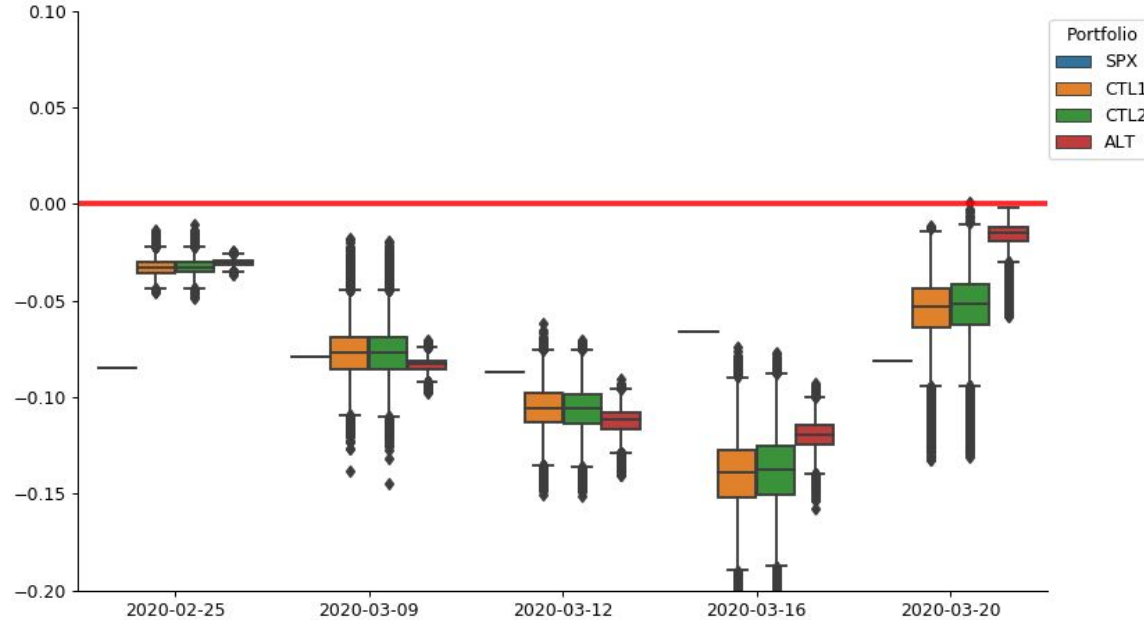
# Hypothesis 4a Results

Check Date	X Bar Alt	Lower 1	Upper 1	P-Value 1	Hypothesis Result (against Ctl1)
1/3/2019	-0.0191	-0.0294	-0.0088	0.3390	Accept
3/22/2019	-0.0251	-0.0357	-0.0145	0.8097	Accept
8/5/2019	-0.0243	-0.0314	-0.0172	0.1473	Accept
8/14/2019	-0.0328	-0.0389	-0.0268	0.8789	Accept
8/23/2019	-0.0268	-0.0332	-0.0203	0.6287	Accept

Check Date	X Bar Alt	Lower 2	Upper 2	P-Value 2	Hypothesis Result (against Ctl2)
1/3/2019	-0.0191	-0.02927	-0.00897	0.343899	Accept
3/22/2019	-0.0251	-0.03589	-0.01433	0.793564	Accept
8/5/2019	-0.0243	-0.03145	-0.01713	0.166157	Accept
8/14/2019	-0.0328	-0.03886	-0.02677	0.862956	Accept
8/23/2019	-0.0268	-0.03315	-0.02039	0.622217	Accept

# Hypothesis 4b Results

Distribution of Alt and Control Portfolio Returns:  
5 Worst S&P500 Dates 2020  
10,000 Iterations



# Hypothesis 4b Results

Check Date	X Bar Alt	Lower 1	Upper 1	P-Value 1	Hypothesis Result (against Ctl1)
2/25/2020	-0.0302	-0.0379	-0.0224	0.2907	Accept
3/9/2020	-0.0831	-0.1069	-0.0593	0.6725	Accept
3/12/2020	-0.1129	-0.1366	-0.0893	0.6778	Accept
3/16/2020	-0.1197	-0.1596	-0.0798	0.1886	Accept
3/20/2020	-0.0192	-0.0561	0.0176	0.0486	Reject

Check Date	X Bar Alt	Lower 2	Upper 2	P-Value 2	Hypothesis Result (against Ctl2)
2/25/2020	-0.0302	-0.03793	-0.02239	0.308574	Accept
3/9/2020	-0.0831	-0.10718	-0.05901	0.669281	Accept
3/12/2020	-0.1129	-0.1365	-0.08939	0.674088	Accept
3/16/2020	-0.1197	-0.15923	-0.08018	0.206702	Accept
3/20/2020	-0.0192	-0.0569	0.018425	0.063688	Accept

Statement 2: The Alternative Portfolio will outperform Control Portfolio 1 and Control Portfolio 2 in 2019 and in 2020.

Hypothesis 5a

Hypothesis 5b  
(Same as 5a, but  
for 2020)

Hypothesis 6a

Hypothesis 6b  
(Same as 6a, but  
for 2020)

*For each Threshold in the Return Thresholds*

$$H_0^1 : \mu_{alt} = \mu_{ctl1} \quad H_A^1 : \mu_{alt} > \mu_{ctl1}$$

$$H_0^2 : \mu_{alt} = \mu_{ctl2} \quad H_A^2 : \mu_{alt} > \mu_{ctl2}$$

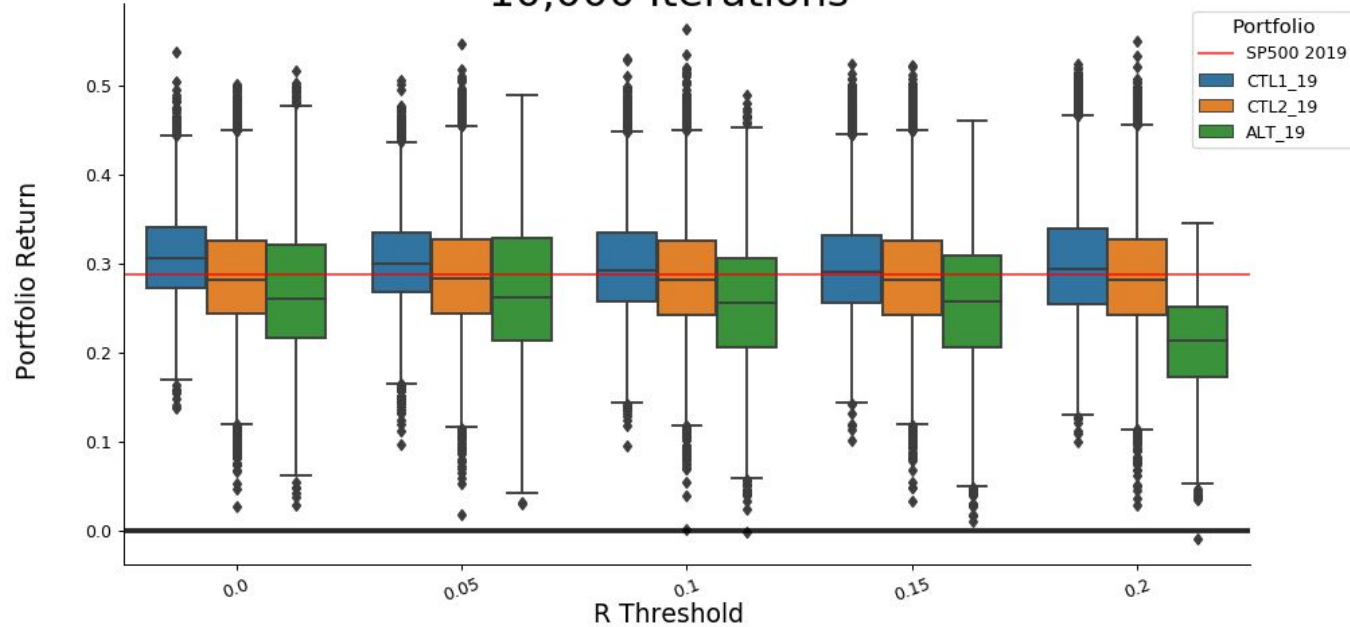
*For each Threshold in the Return Thresholds*

$$H_0^1 : \mu_{alt} = \mu_{ctl1} \quad H_A^1 : \mu_{alt} > \mu_{ctl1}$$

$$H_0^2 : \mu_{alt} = \mu_{ctl2} \quad H_A^2 : \mu_{alt} > \mu_{ctl2}$$

# Hypothesis 5a Results

Alternative vs. Control Portfolios 2019  
10,000 Iterations

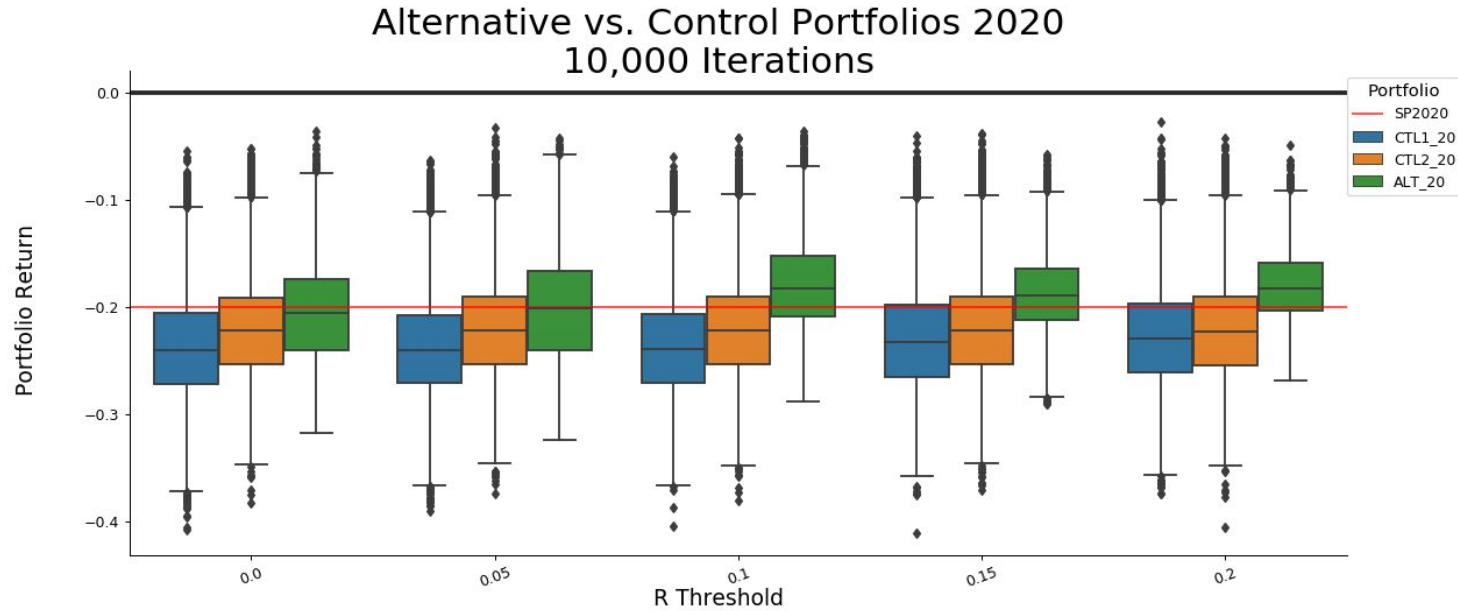


# Hypothesis 5a Results

Returns Threshold	X Bar Alt	Lower 1	Upper 1	P-Value 1	Hypothesis Result (against Ctl1)
0.0	0.2715	0.1163	0.426613	0.650469	Accept
0.05	0.2722	0.113749	0.430597	0.621812	Accept
0.10	0.2561	0.097353	0.414886	0.677422	Accept
0.15	0.2567	0.09905	0.41425	0.668998	Accept
0.20	0.2093	0.067387	0.351165	0.859842	Accept

Returns Threshold	X Bar Alt	Lower 2	Upper 2	P-Value 2	Hypothesis Result (against Ctl2)
0.0	0.2715	0.098538	0.444375	0.560774	Accept
0.05	0.2722	0.096414	0.447933	0.561629	Accept
0.10	0.2561	0.090635	0.421604	0.621661	Accept
0.15	0.2567	0.090687	0.422614	0.62134	Accept
0.20	0.2093	0.062263	0.356289	0.810406	Accept

# Hypothesis 5b Results



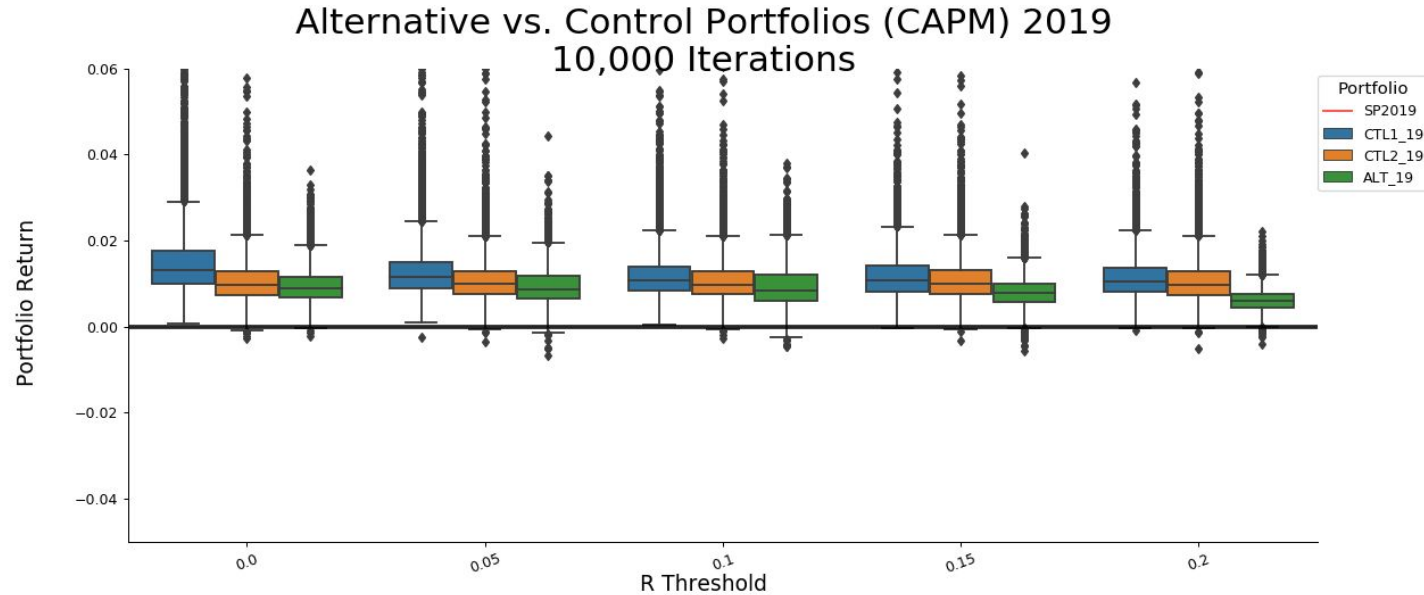


# Hypothesis 5b Results

Returns Threshold	X Bar Alt	Lower 1	Upper 1	P-Value 1	Hypothesis Result (against Ctl1)
0.0	-0.20499	-0.3240	-0.0859	0.3394	Accept
0.05	-0.20125	-0.3200	-0.0825	0.3194	Accept
0.10	-0.17963	-0.2862	-0.0730	0.1948	Accept
0.15	-0.18738	-0.2901	-0.0847	0.2554	Accept
0.20	-0.1804	-0.2790	-0.0818	0.2260	Accept

Returns Threshold	X Bar Alt	Lower 2	Upper 2	P-Value 2	Hypothesis Result (against Ctl2)
0.0	-0.20499	-0.3162	-0.0938	0.4149	Accept
0.05	-0.20125	-0.3145	-0.0880	0.3970	Accept
0.10	-0.17963	-0.2849	-0.0744	0.2669	Accept
0.15	-0.18738	-0.2857	-0.0891	0.2989	Accept
0.20	-0.1804	-0.2774	-0.0834	0.2531	Accept

# Hypothesis 6a Results



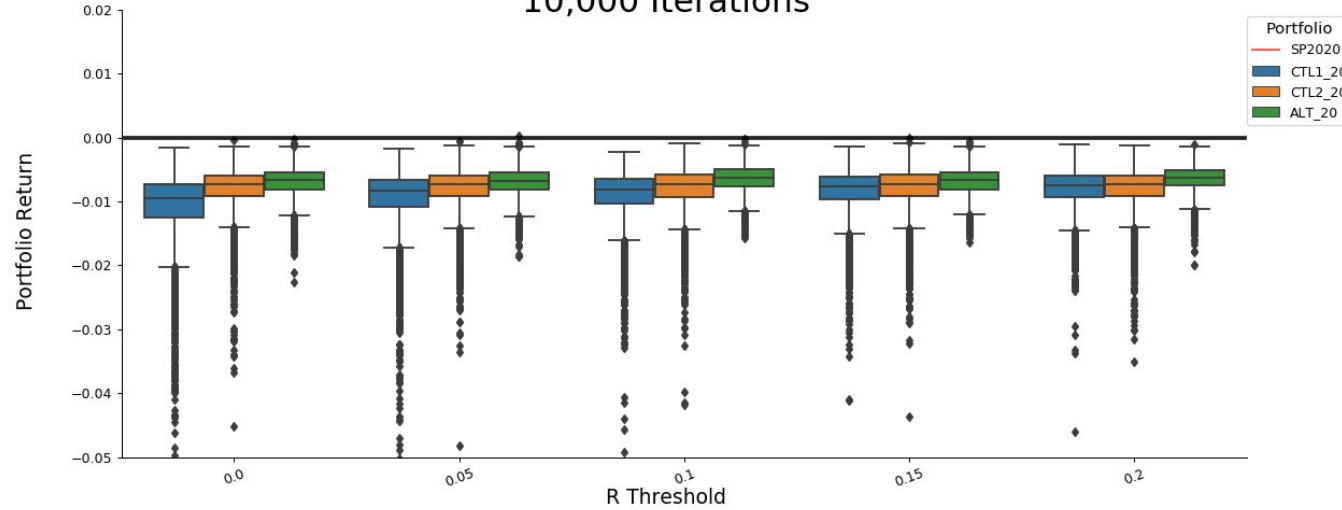
# Hypothesis 6a Results

Returns Threshold	X Bar Alt	Lower 1	Upper 1	P-Value 1	Hypothesis Result (against Ctl1)
0.0	0.0095	-0.1037	0.1226	0.5285	Accept
0.05	0.0094	-0.0160	0.0349	0.5900	Accept
0.10	0.0093	-0.0045	0.0232	0.6190	Accept
0.15	0.0079	-0.0073	0.0232	0.6612	Accept
0.20	0.0061	-0.0038	0.0159	0.8155	Accept

Returns Threshold	X Bar Alt	Lower 2	Upper 2	P-Value 2	Hypothesis Result (against Ctl2)
0.0	0.0095	-0.1745	0.1935	0.4994	Accept
0.05	0.0094	-0.0073	0.0262	0.5445	Accept
0.10	0.0093	-0.0019	0.0206	0.5785	Accept
0.15	0.0079	-0.0734	0.0893	0.5272	Accept
0.20	0.0061	-0.0069	0.0190	0.7231	Accept

# Hypothesis 6b Results

Alternative vs. Control Portfolios 2020 (CAPM)  
10,000 Iterations



# Hypothesis 6b Results

Returns Threshold	X Bar Alt	Lower 1	Upper 1	P-Value 1	Hypothesis Result (against Ctl1)
0.0	-0.0069	-0.0194	0.0055	0.3087	Accept
0.05	-0.0069	-0.0149	0.0010	0.3178	Accept
0.10	-0.0064	-0.0130	0.0002	0.2766	Accept
0.15	-0.0068	-0.0131	-0.0006	0.3538	Accept
0.20	-0.0064	-0.0129	0.0001	0.3460	Accept

Returns Threshold	X Bar Alt	Lower 2	Upper 2	P-Value 2	Hypothesis Result (against Ctl2)
0.0	-0.0069	-0.0134	-0.0005	0.4094	Accept
0.05	-0.0069	-0.0140	0.0001	0.4147	Accept
0.10	-0.0064	-0.0183	0.0055	0.4257	Accept
0.15	-0.0068	-0.0127	-0.0009	0.3916	Accept
0.20	-0.0064	-0.0123	-0.0005	0.3436	Accept

# Conclusions

- ROE and PEG portfolios performed very well (Experiment 1)
- Using the return threshold as a heuristic is a good start (Experiment 2) to estimate stocks eligible for alternative portfolios
- Other metrics need to be built into the alternative portfolio criteria
  - Apply moving average analysis and D/E ratio to future models
- We can use stocks from other exchanges to perform “Completely Randomized Design” multifactor experiments