

PORTFOLIO THEORY & APPLICATION FINAL PROJECT

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Portfolio

GOALS/OBJECTIVES

- To explain the construction of a factor-based model allocation in a long/short Global Macro Strategy with a target beta
- To evaluate the sensitivity to variations of beta & its sensitivity to the length of the estimators for covariance matrix & expected returns under different market scenarios
- To explain any peculiar or new measures encountered or noted in this project



Where is the Data & What is the Coding Language?

- Python 3.8 via Google Collab
- Appendix A contains snapshot of data via Yahoo Finance
- Appendix B contains snapshot of Fama French Factor Data
https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html. The T-bill return is the simple daily rate that in the month compounds to 1-month T-Bill rate from Ibbotson and Associates Inc.
- Time period 2007-03-01 to 2020-10-29 was used in project analysis (this date range was selected based on maximum data available for Fama-French).



Methodology



How the project was approached?

1. Downloaded Tickers and factors for Fama French Model
2. For each Regime (pre-crisis , during-crisis, post-crisis)
 - a. Selected a look-back period (Long-150; Medium-90; Short-40)
 - b. Running multiple regression for calculating “Factor Beta” for each ticker
 - c. Using the Beta calculated for each factor, Expected Returns are projected
 - d. With the help of Expected Returns, Expected Covariance is calculated
 - e. Using Expected Returns and Expected Covariance from the Factor Model , optimized portfolio weights are calculated.
 - f. We compute actual returns of the constructed portfolio.
 - g. The Portfolio weights are rebalanced each week.
 - h. go back to step f until the end of regime
3. The above process is again performed without dividing into different regimes.
4. Performances of both the strategies are compared.

For all our charts, analysis, we go by the question to assume our Initial Investment to be \$100



Sensitivities and Conditions to test

Pre-Crisis:	Look Back Period	Choice of Betas
start date: 2007-03-01	Long= 150	-1
end date: 2007-12-31	days	0.5
During Crisis:	Medium= 90	1
start date: 2008-01-01	days	Short= 40
end date: 2009-06-30	days	
Post Crisis:		
start date: 2009-07-01		
end date: 2020-10-29		
Whole Period:		



Computation Engine

Computation Engine to test various strategies

```
""" Implementing the strategy computation engine for testing for a whole regime"""

def Strategy_Implementation(all_data, Industry_ETF, start_date, end_date,
                            Beta_tar, LB_period_ret, LB_period_cov):
    Portfolio_daily_ret = []

    # Selection of the Regime
    regime_data = all_data[start_date:end_date]

    for idx in range(0, len(regime_data), 5):

        # Record the returns & Cov matrix for the sample factor Model
        sample_ret = factor_modelling(regime_data, Industry_ETF, idx, LB_period_ret)
        sample_retcov = factor_modelling(regime_data, Industry_ETF, idx, LB_period_cov)
        if len(sample_retcov) <= 1:
            break
        else:
            sample_cov = sample_retcov.cov().to_numpy()

        # Average Return of tickers
        sample_mu = pd.DataFrame()
        for tickers in Industry_ETF:
            sample_mu.loc['mu', tickers] = sample_ret[tickers].mean()
        n = len(sample_mu.T)
        sample_mu = np.array(sample_mu).reshape((n, 1))

        # Computing the Initial Weights at the start of trading
        if idx == 0:
            W = Port_firstAllocation(sample_mu, sample_cov)
        else:
            Beta_arr = betavalue(all_data, Industry_ETF, LB_period_ret, start_date)
            W = Port_Rebal(Beta_arr, Beta_tar, W, sample_mu, sample_cov)

        # Computing daily returns until next rebalancing
        Lookback_db = regime_data.iloc[idx:LB_period_ret+idx,:12]
        Lookforward_db = regime_data.iloc[LB_period_ret+idx+1:,:12]
        for i in range(min(5, len(Lookforward_db))):
            ret_sum = 0
            for j in range(len(sample_mu)):
                ret_sum += Lookforward_db.iloc[i, j] * W[j]
            Portfolio_daily_ret.append(ret_sum)

    return Portfolio_daily_ret
```

Selecting the Regime

Computing Expected Return and Covariance on basis of different Lookback-Periods

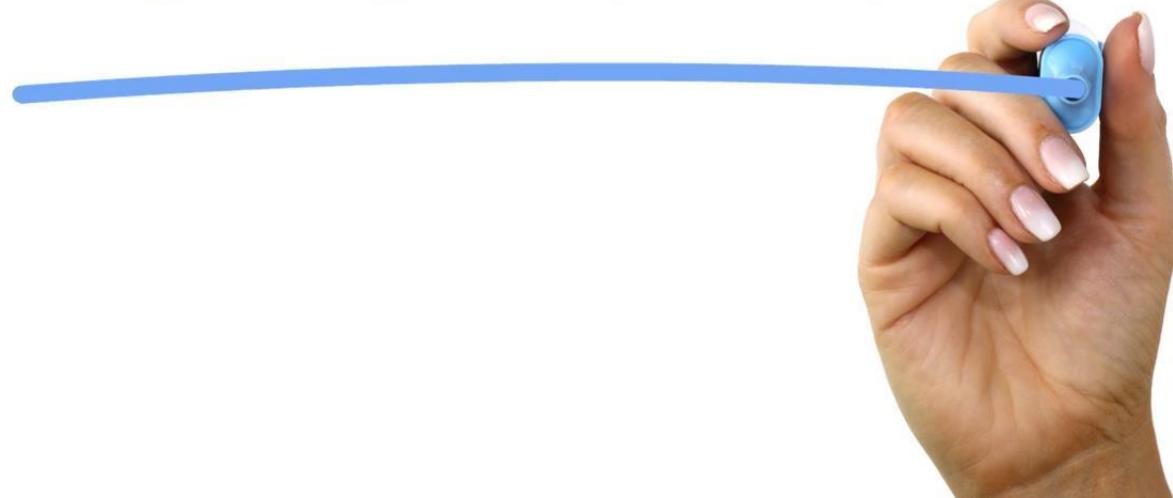
Computing Portfolio Weights based on Expected Returns & Cov computed from the Factor Model

Finally, getting the Portfolio Returns based on actual returns on the tickers (Appropriate for Backtesting)



Results

RESULTS



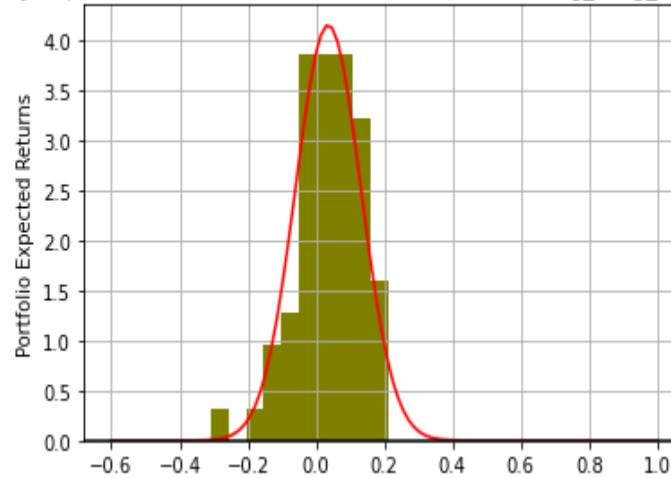
Sample Regressing Results of Fama French On Investment Universe

	Intercept	mkt_excess	SMB	HML
FXE	0.000534087	0.0865196	0.0727694	0.0618646
EWJ	-0.0016506	0.927243	0.191589	0.441996
GLD	-0.000671666	0.659711	0.755133	0.123242
QQQ	-0.000495695	1.16483	-0.446576	-1.18846
SPY	3.72906e-05	0.996709	-0.159382	-0.10298
SHV	-1.63508e-05	-0.00228066	-0.0218232	0.031939
DBA	-0.00262622	0.457863	-1.21729	-0.338934
USO	-0.000399911	0.32028	0.840297	0.142097
XBI	0.000829236	0.942752	0.478712	-1.50357
ILF	0.00125682	1.8826	0.310258	0.317336
EPP	0.000897721	1.55746	0.761746	0.738257
FEZ	0.00094388	1.33595	0.145606	0.218354

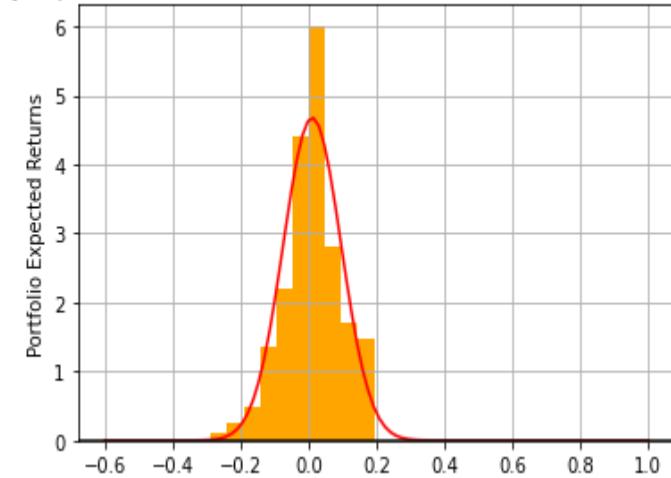


Pre Crisis (Probability Density Function -PDF)

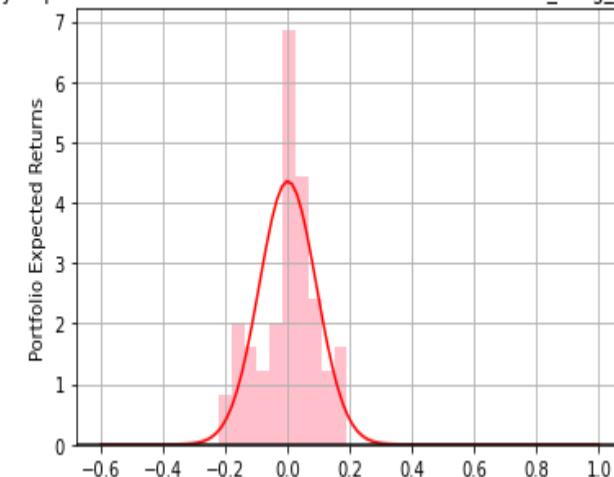
Probability Expected Returns for Given Beta Value = 1.0 Long_Long_Before1 the Crisis



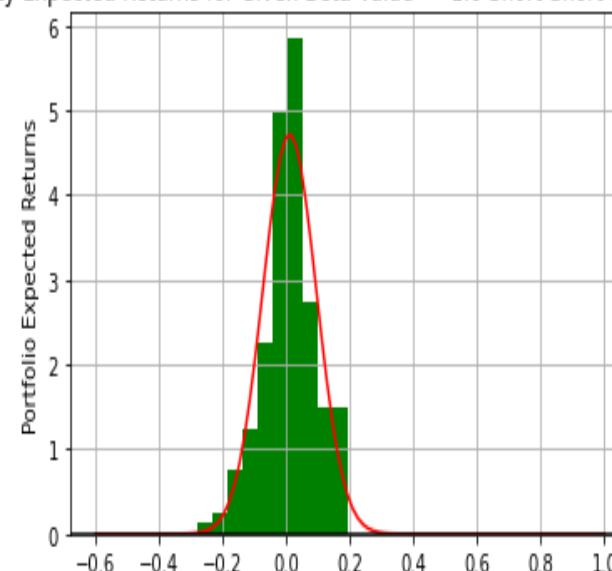
Probability Expected Returns for Given Beta Value = 0.5 Short-Short-Before3 the Crisis



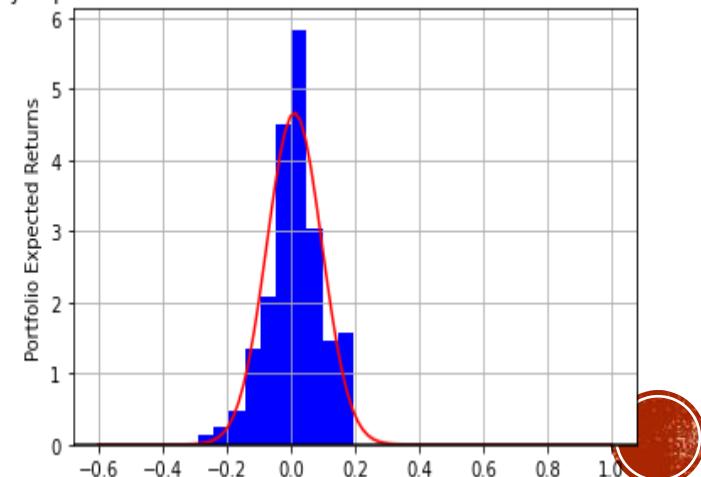
Probability Expected Returns for Given Beta Value = 1.0 Medium_Long_Before1 the Crisis



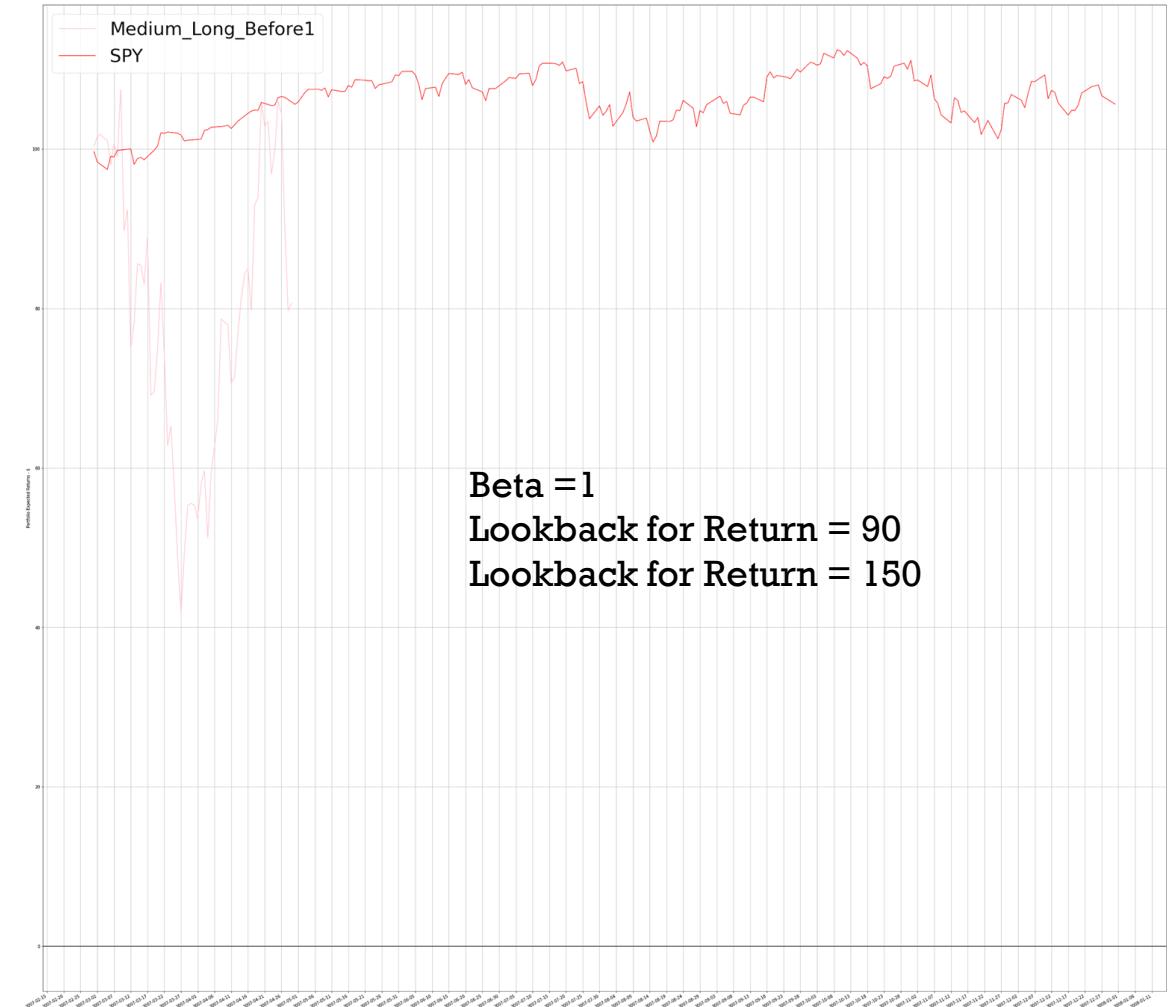
Probability Expected Returns for Given Beta Value = -1.0 Short-Short-Before2 the Crisis



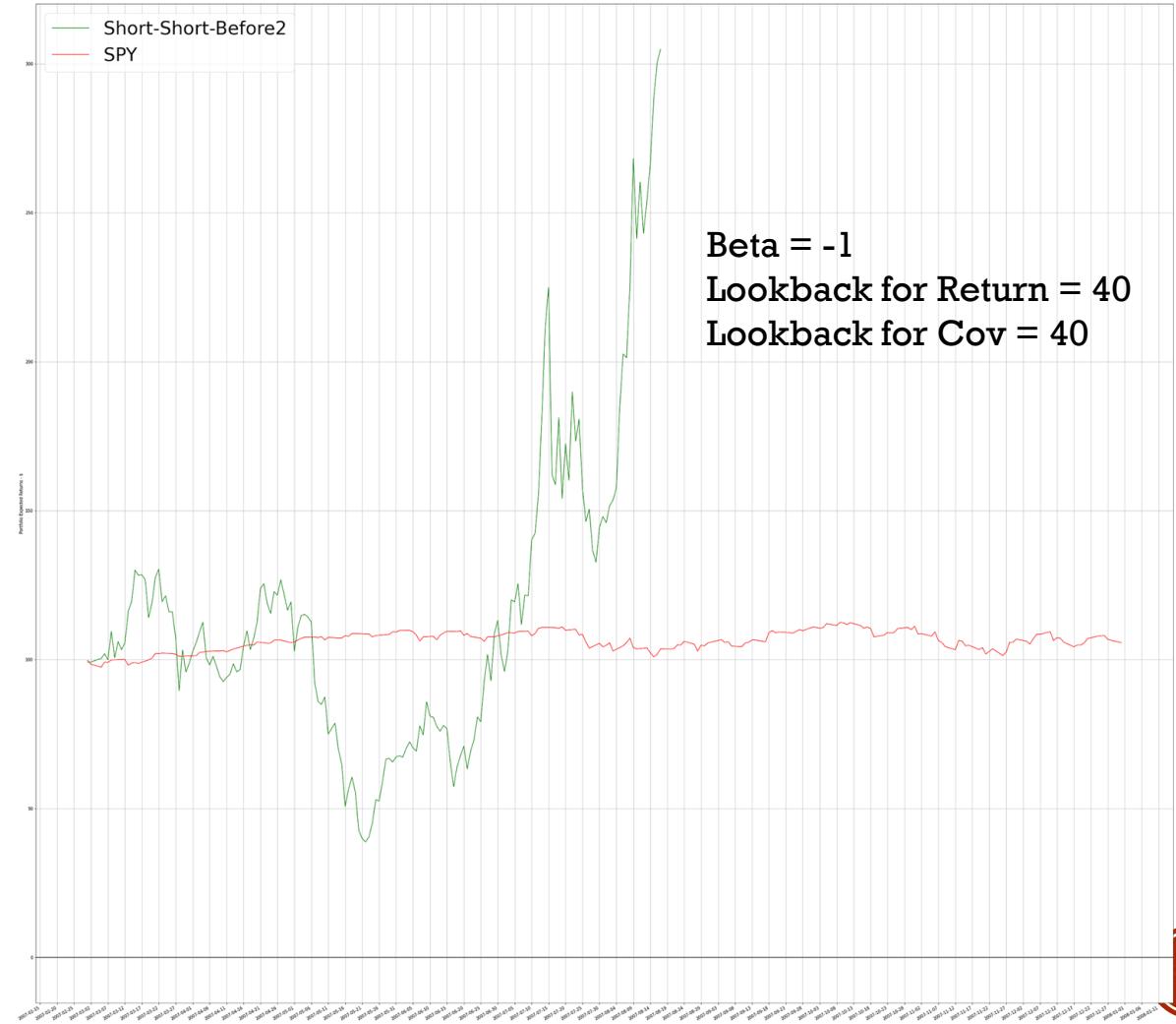
Probability Expected Returns for Given Beta Value = 1.0 Short-Short-Before1 the Crisis



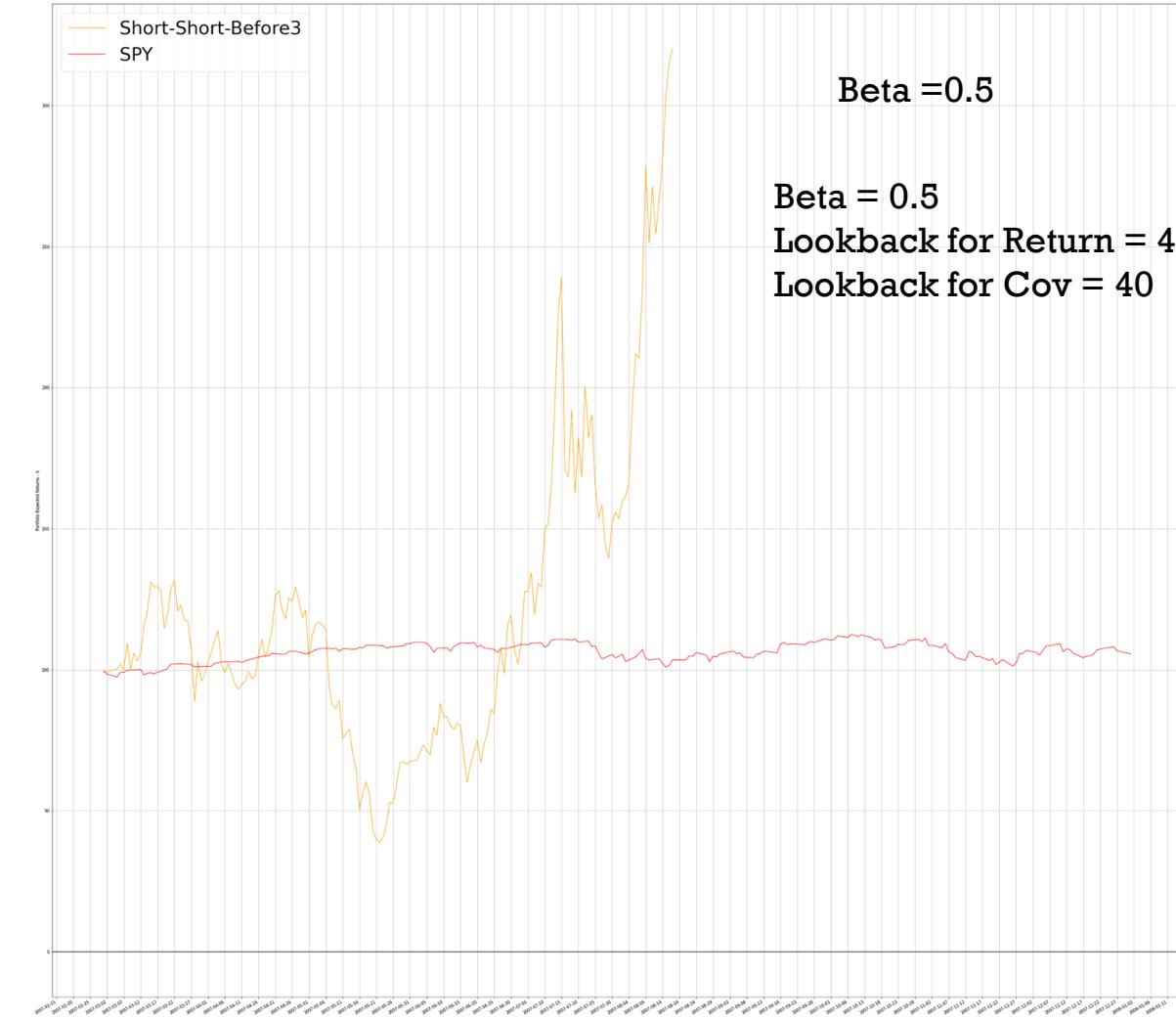
Pre Crisis (Cumulative Returns)



Pre Crisis (Cumulative Returns)



Pre Crisis (Cumulative Returns)



Pre Crisis

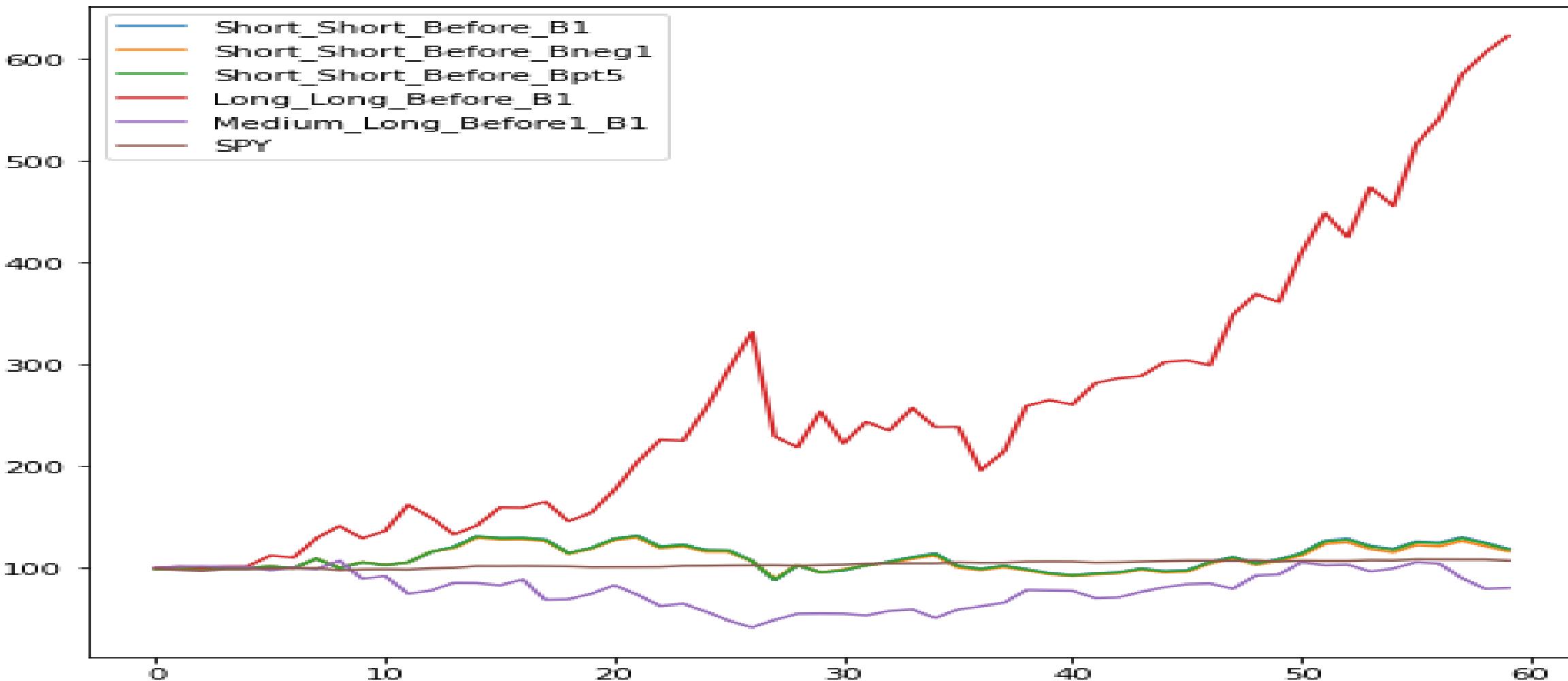
▶ Results_pre

◀

	Short_Short_Before1	Short_Short_Before2	Short_Short_Before3	Long_Long_Before1	Medium_Long_Before1	SPY
Daily Mean Arithmetic Return	0.010704	0.010221	0.010583	0.035724	0.000735	0.000313
Min Return	-0.289973	-0.279651	-0.287393	-0.308610	-0.222320	-0.029634
Cumulated Return	2.252176	2.048478	2.200764	5.231338	-0.193386	0.056610
Max 10 Days Drawdown	0.705791	0.702730	0.705208	0.408859	0.610793	0.099246
Volatility	1.357262	1.340490	1.352662	1.530798	1.460303	0.164065
Sharpe Ratio	0.906136	0.845893	0.891451	0.360148	-0.034425	0.291368
Skewness	-0.364914	-0.330129	-0.356993	-0.816789	-0.305153	-0.294724
Kurtosis	0.625714	0.583711	0.613654	1.545373	-0.047136	0.868914
Modified VAR	-0.151900	-0.149672	-0.151300	-0.194972	-0.152650	-0.017381
CVAR	-0.001385	-0.001017	-0.001295	-0.025213	0.009291	0.000813



Conclusion- Before Crisis Graphically



Conclusion - Pre Crisis

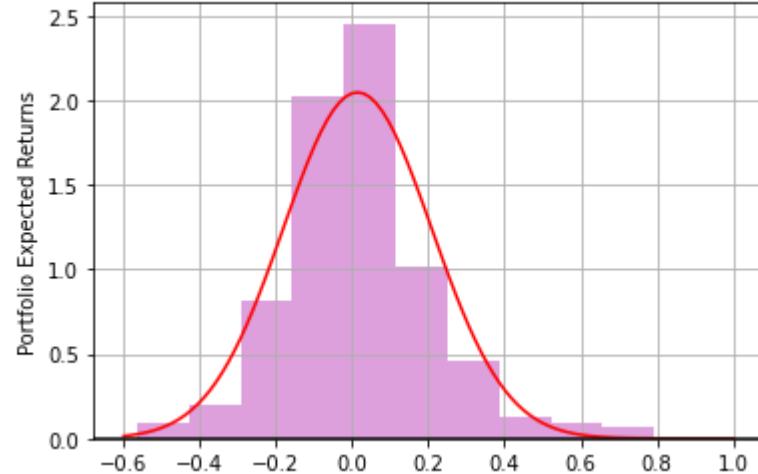
Long Long Before 1 with target Beta = 1 we noted for LBP (Look Back Period) return= 150 days , LBP cov= 150

- By referring to the table in **Slide 14**, it was noted that Long Long Before 1 has the greatest daily mean arithmetic return, cumulative returns & volatility than the market (SPY)
- The maximum 10 days drawdown for this strategy was the lowest in comparison to the other strategies. However, Medium Long Before 1 had the lowest Sharpe Ratio, whilst Short Short Before 1 had the highest Sharpe Ratio in comparison to the market (SPY)
- By referring to **Slide 10**, it was noted that Long Long Before 1 fits the cumulative best in comparison to the other strategies and had the least outliers as well.
- Although, there is similarity in the expected returns for the strategies when compared to the SPY, one should note that this similarity is due to small differences between each strategy in the expected returns

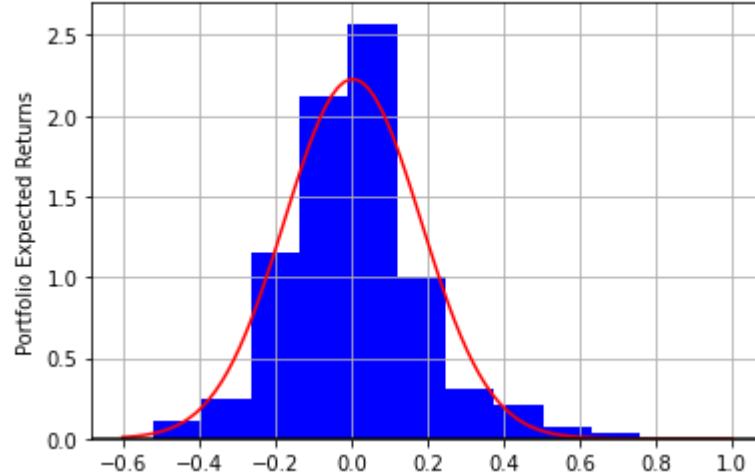


During Crisis (PDF)

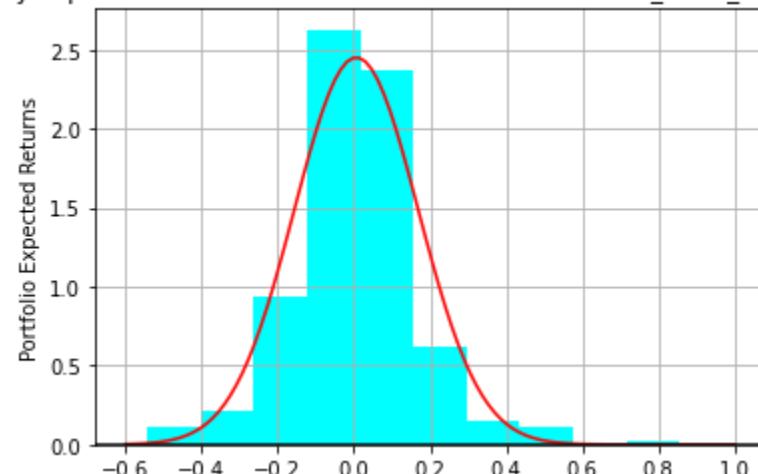
Probability Expected Returns for Given Beta Value = -1.0 Long_Long_During1 the Crisis



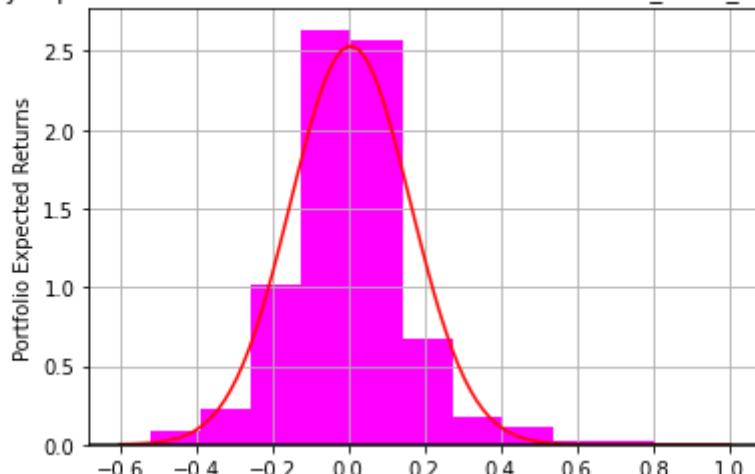
Probability Expected Returns for Given Beta Value = 1.0 Medium_Long_During1 the Crisis



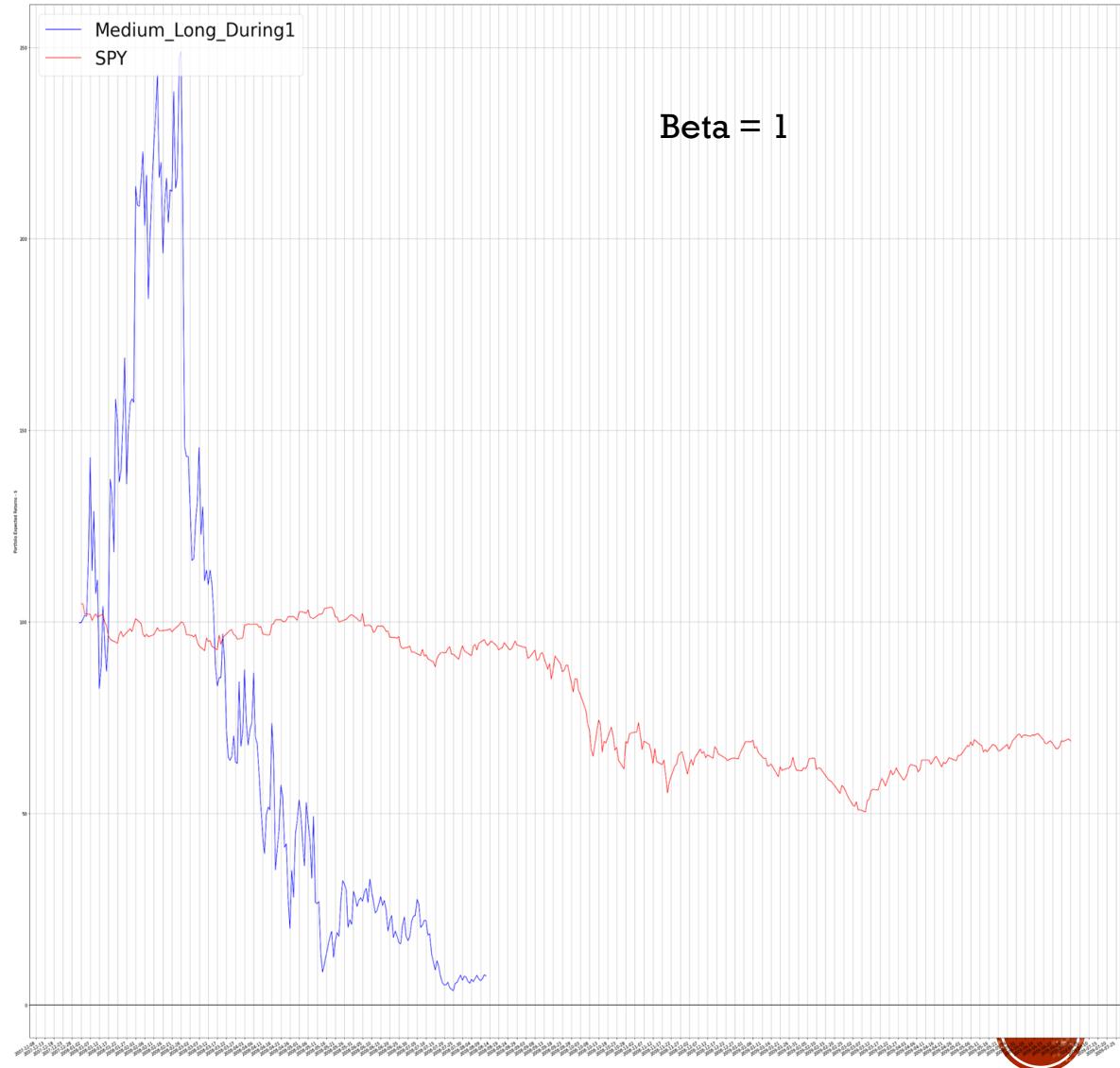
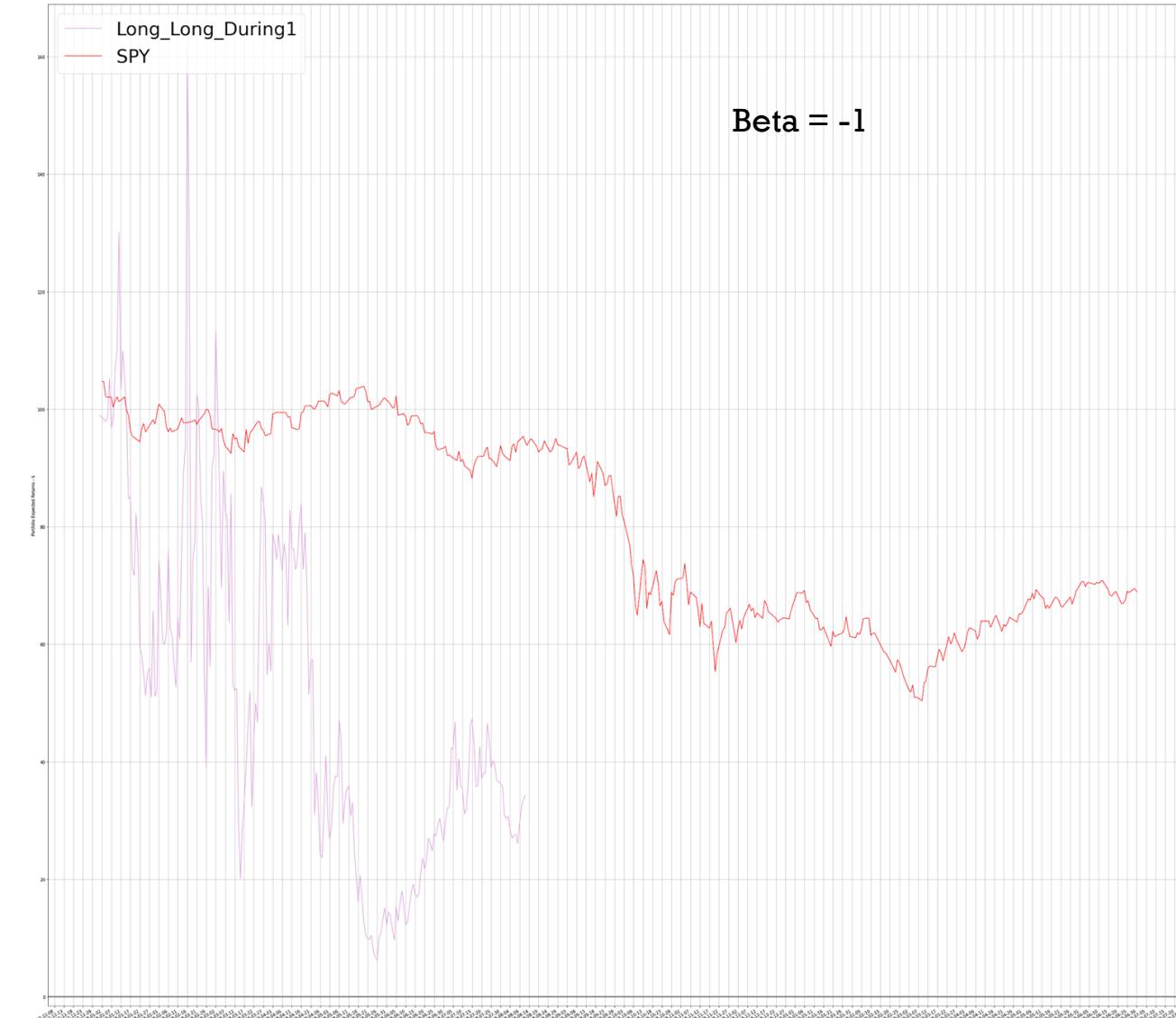
Probability Expected Returns for Given Beta Value = 1.0 Short_Short_During1 the Crisis



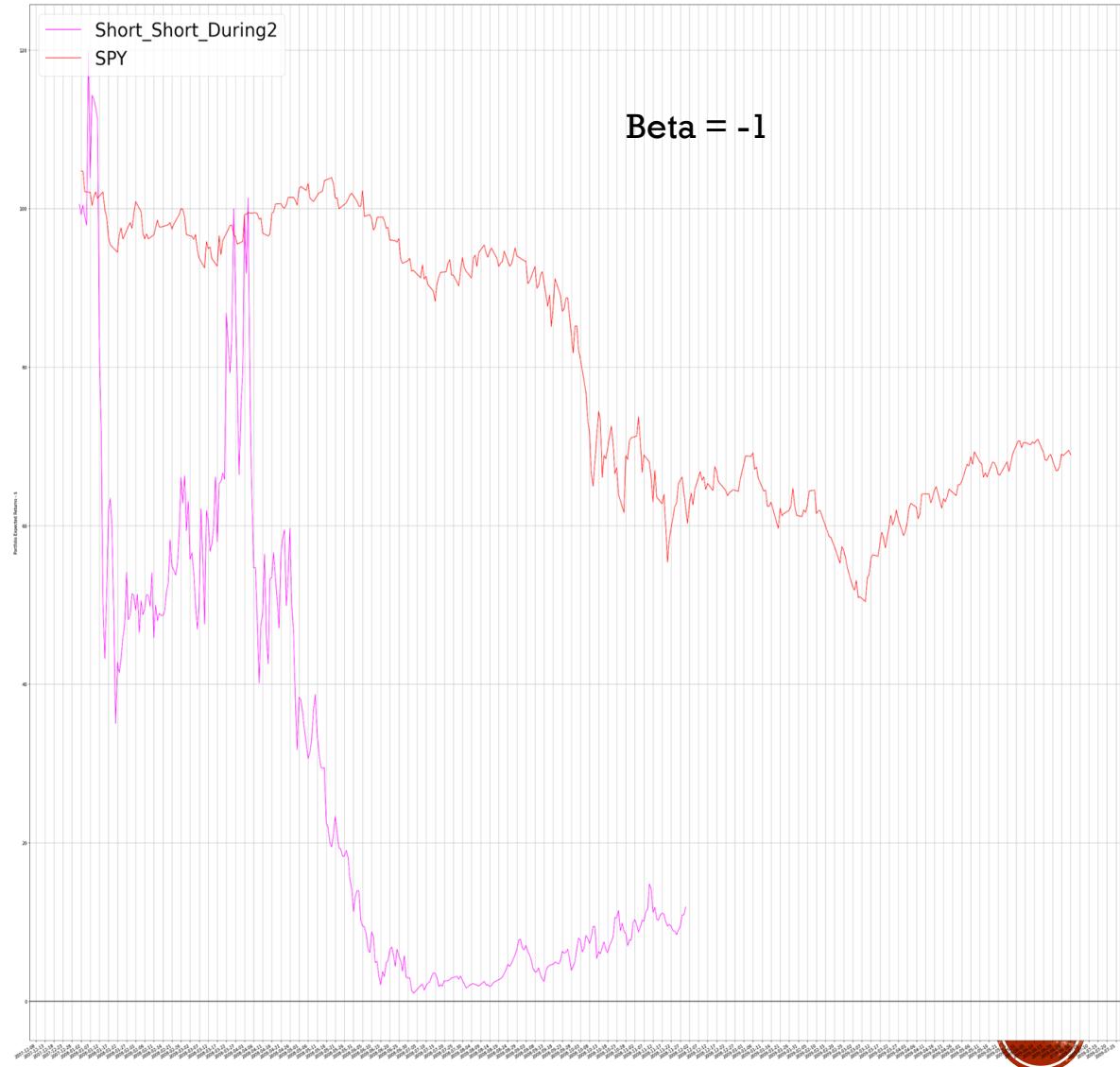
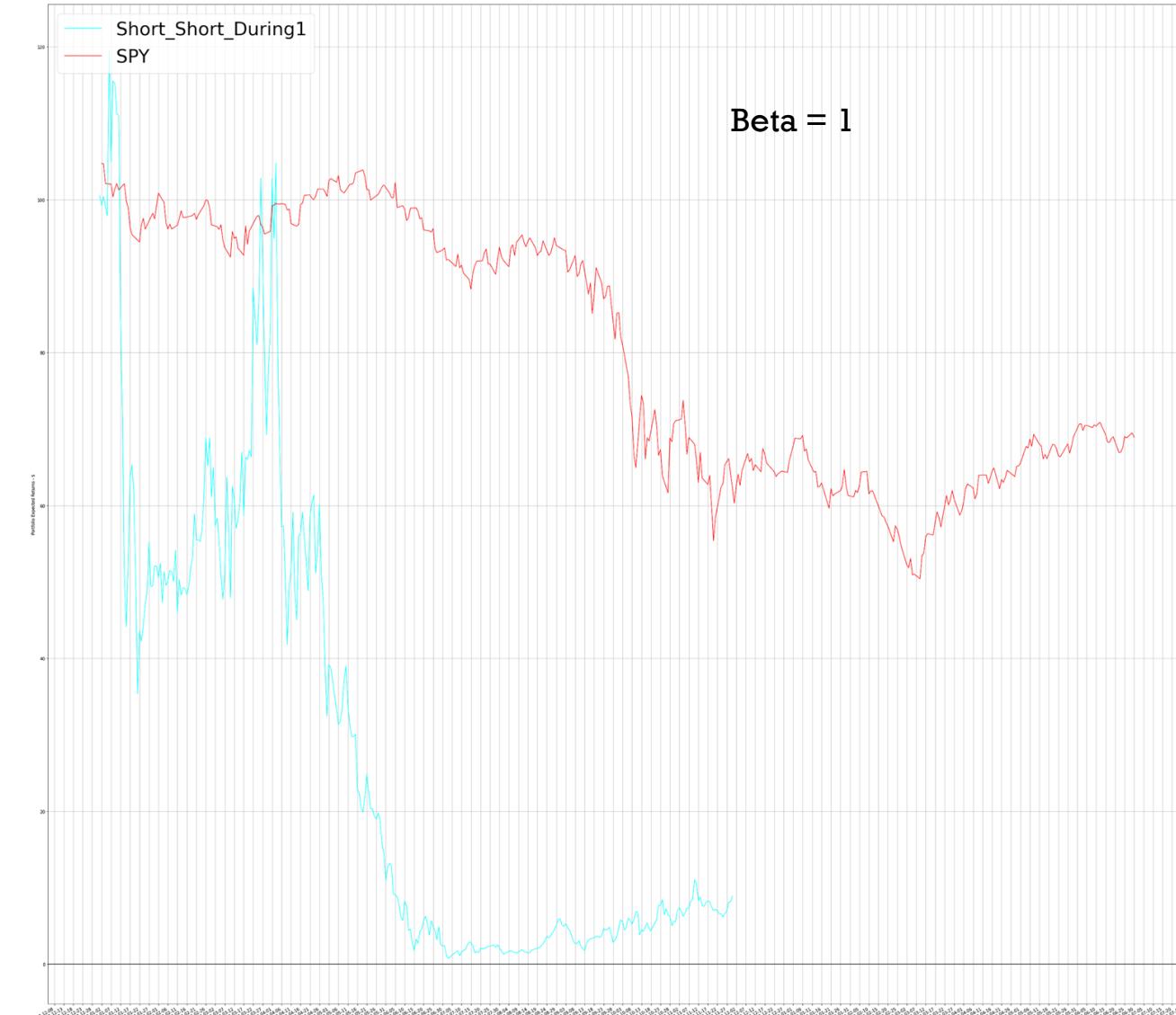
Probability Expected Returns for Given Beta Value = -1.0 Short_Short_During2 the Crisis



During Crisis (Cumulative Returns)



During Crisis (Cumulative Returns)



During Crisis



Results_dur

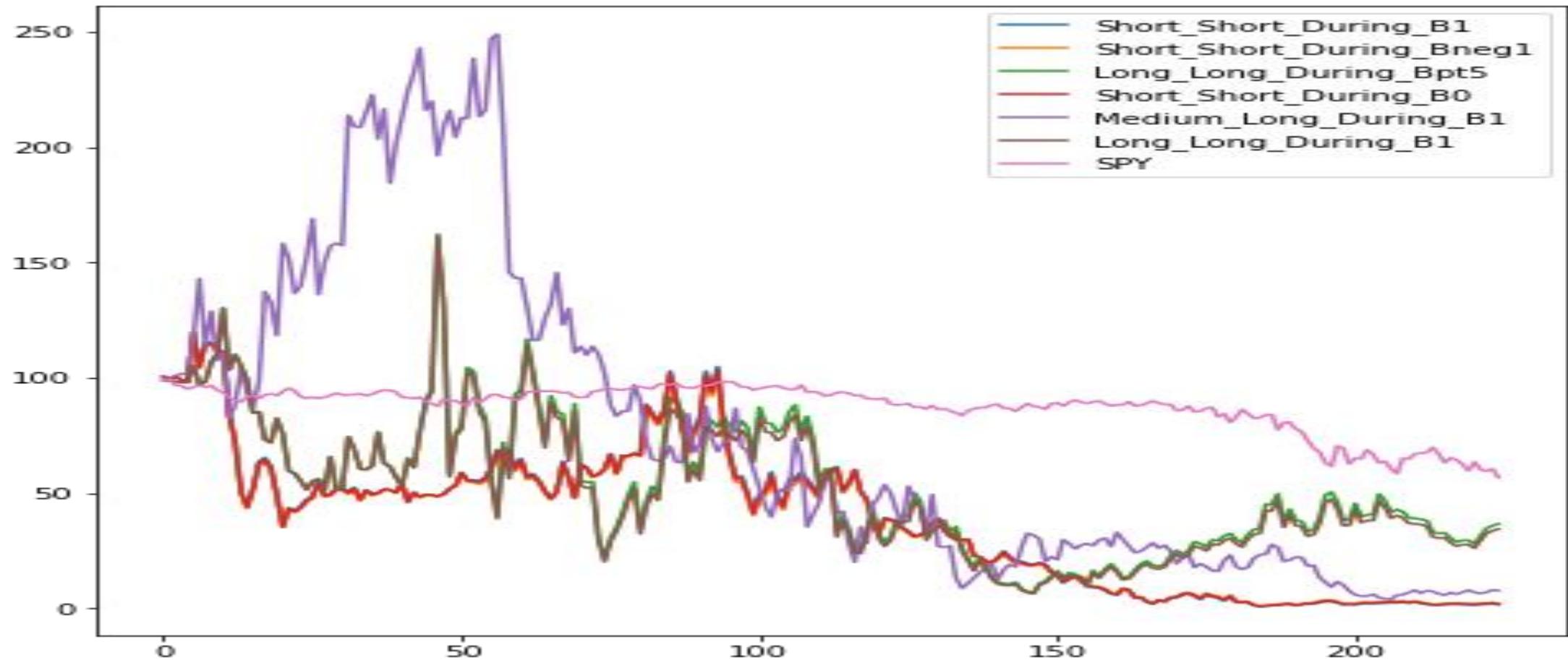


Short_Short_During1 Short_Short_During2 Long_Long_During1 Medium_Long_During1 SPY

Daily Mean Arithmetic Return	0.006163	0.006121	0.013673	0.004453	-0.000832
Min Return	-0.542925	-0.520209	-0.565524	-0.519405	-0.098448
Cumulated Return	-0.911160	-0.881158	-0.657161	-0.923501	-0.347699
Max 10 Days Drawdown	0.993733	0.991686	0.961456	0.984862	0.518737
Volatility	2.578637	2.494300	3.089909	2.839143	0.388927
Sharpe Ratio	-0.353350	-0.353269	-0.212680	-0.325275	-0.893996
Skewness	0.510985	0.496090	0.722107	0.628179	0.468615
Kurtosis	3.358140	3.102764	2.125785	2.036596	5.577625
Modified VAR	-0.274418	-0.265603	-0.335116	-0.299808	-0.039628
CVAR	0.011542	0.011005	0.007542	0.015041	0.003503



Conclusion- During Crisis Graphically



Conclusion - During Crisis

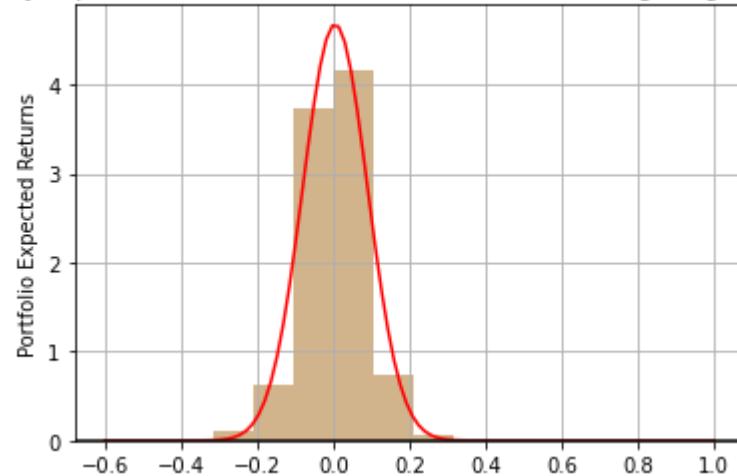
Long Long During1 with target Beta = -1 we noted for LBP return= 150 days , LBP cov= 150 Days

- By referring to the table in **Slide 19**, it was noted that Long Long During1 has the greatest daily mean arithmetic return & volatility than the market (SPY)
- However, the maximum 10 days drawdown for this strategy was the lowest in comparison to the other strategies
- By referring to **Slide 16**, it is noted that Short Short During 2 fits the cumulative distribution best in comparison to the other strategies and had the least outliers as well.
- By considering each plot in **Slide 17 & Slide 18**, it is noted that the Long Long During 1 strategy outperformed the market in comparison to the other strategies

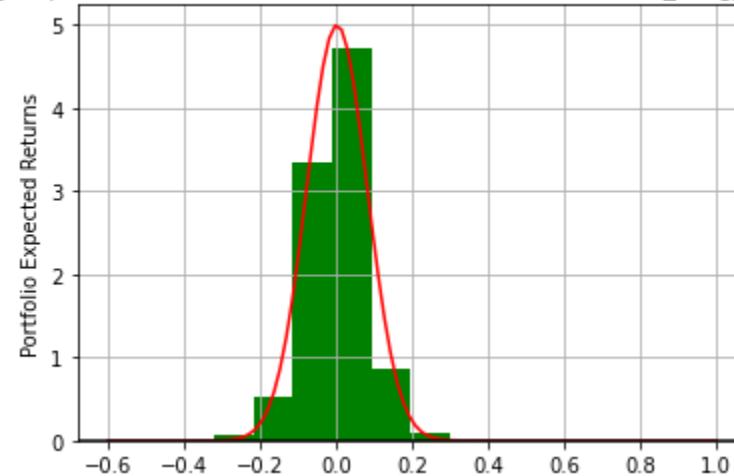


Post Crisis (PDF)

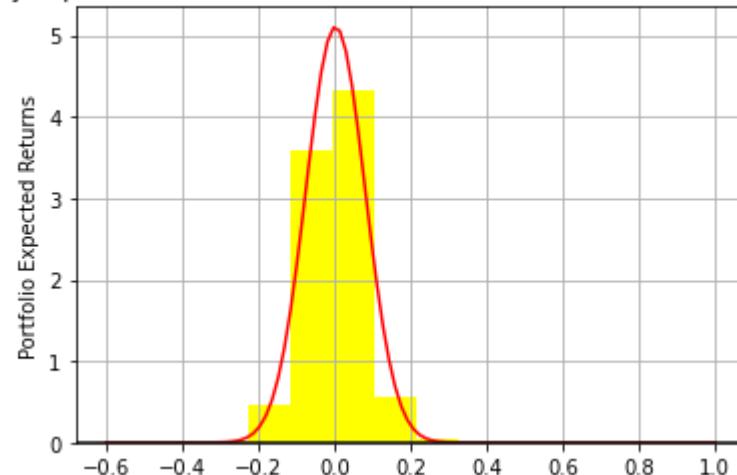
Probability Expected Returns for Given Beta Value = 1.0 Long-Long-After the Crisis



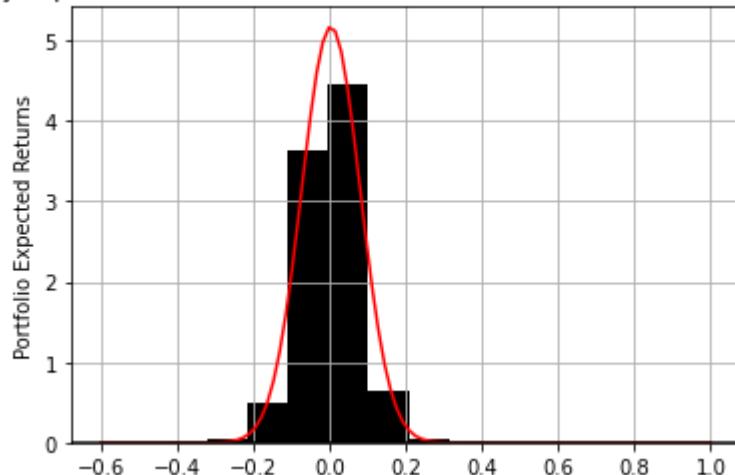
Probability Expected Returns for Given Beta Value = 1.0 Medium_Long_After1 the Crisis



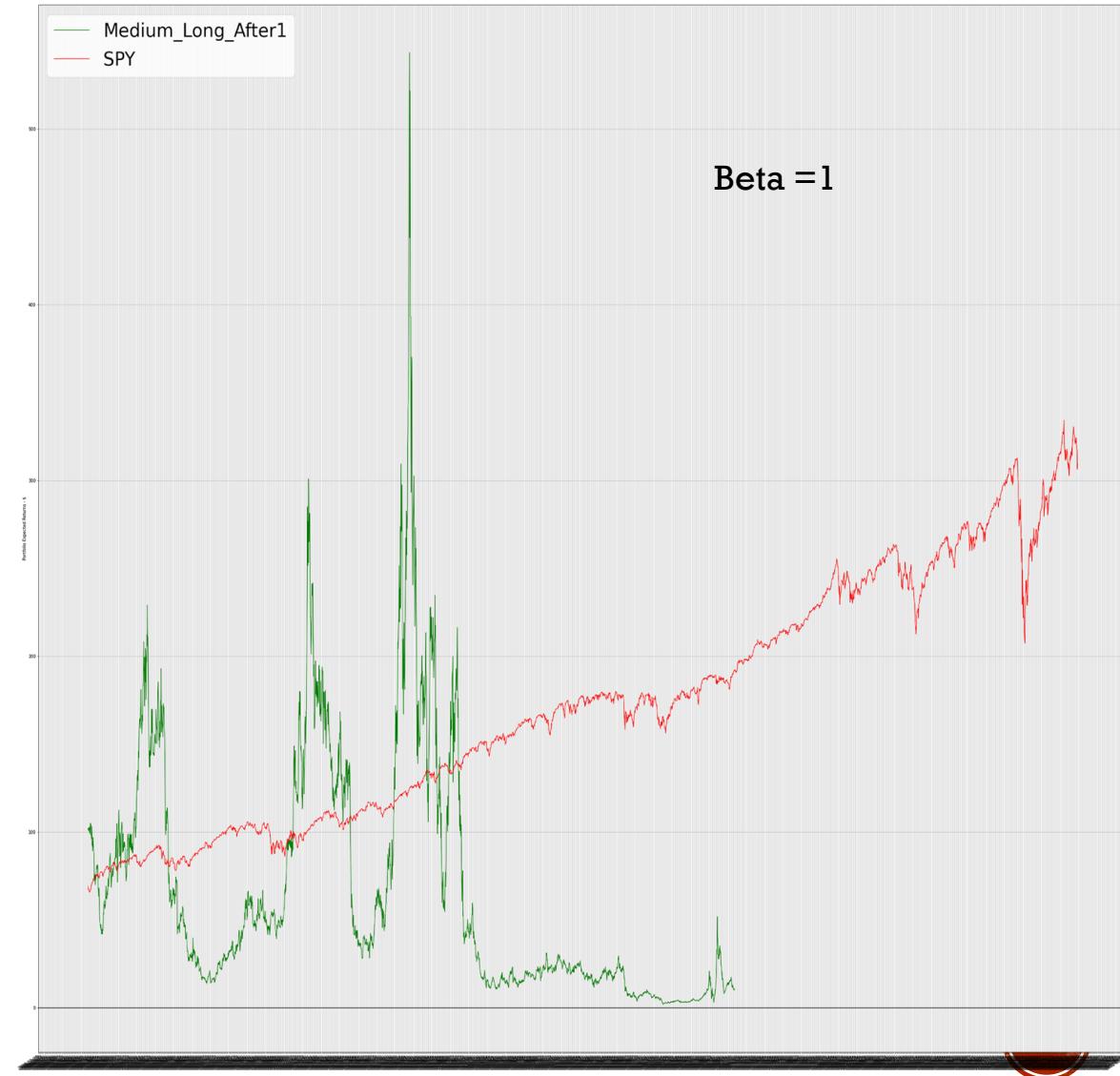
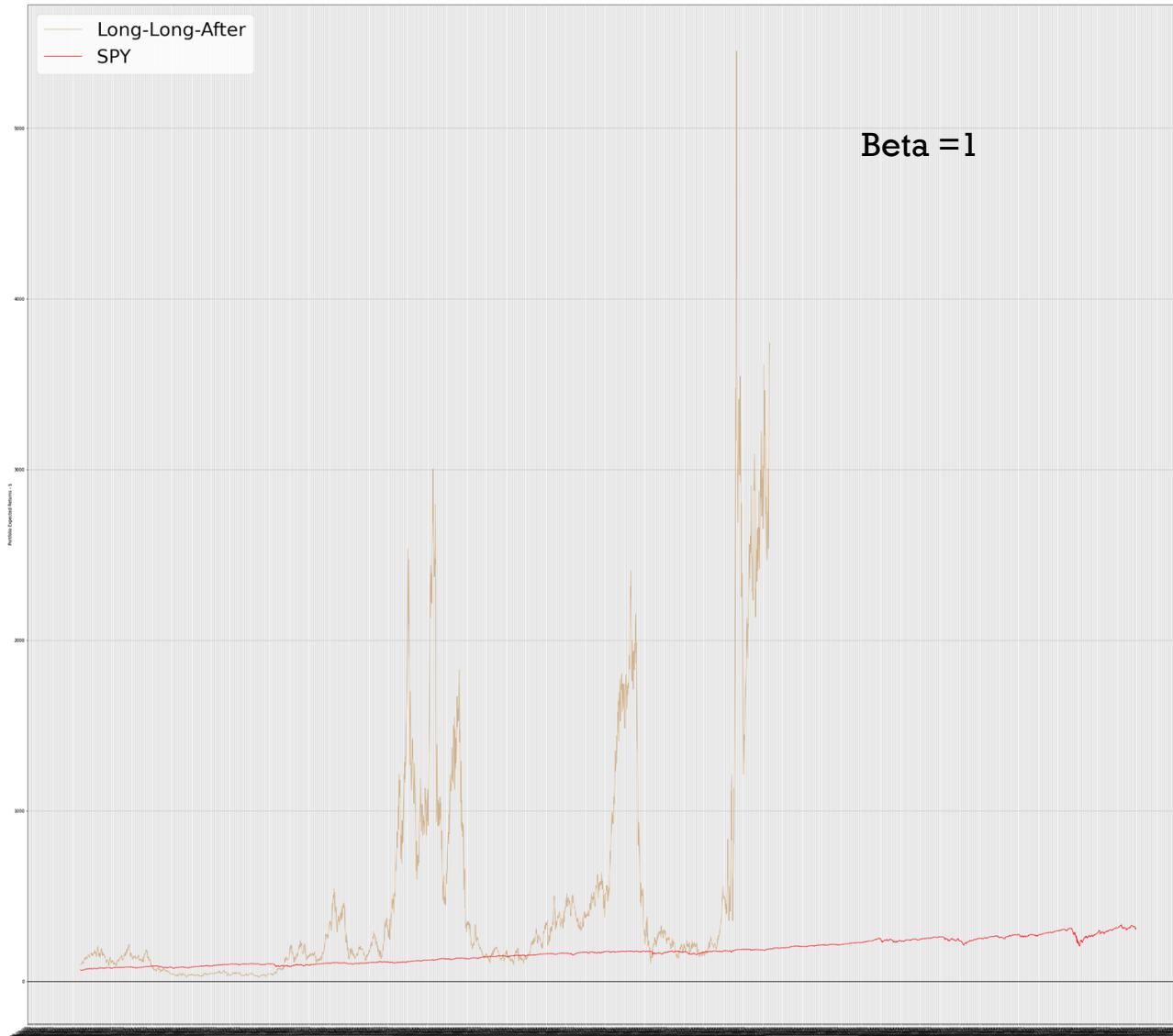
Probability Expected Returns for Given Beta Value = 1.0 Short-Short-After1 the Crisis



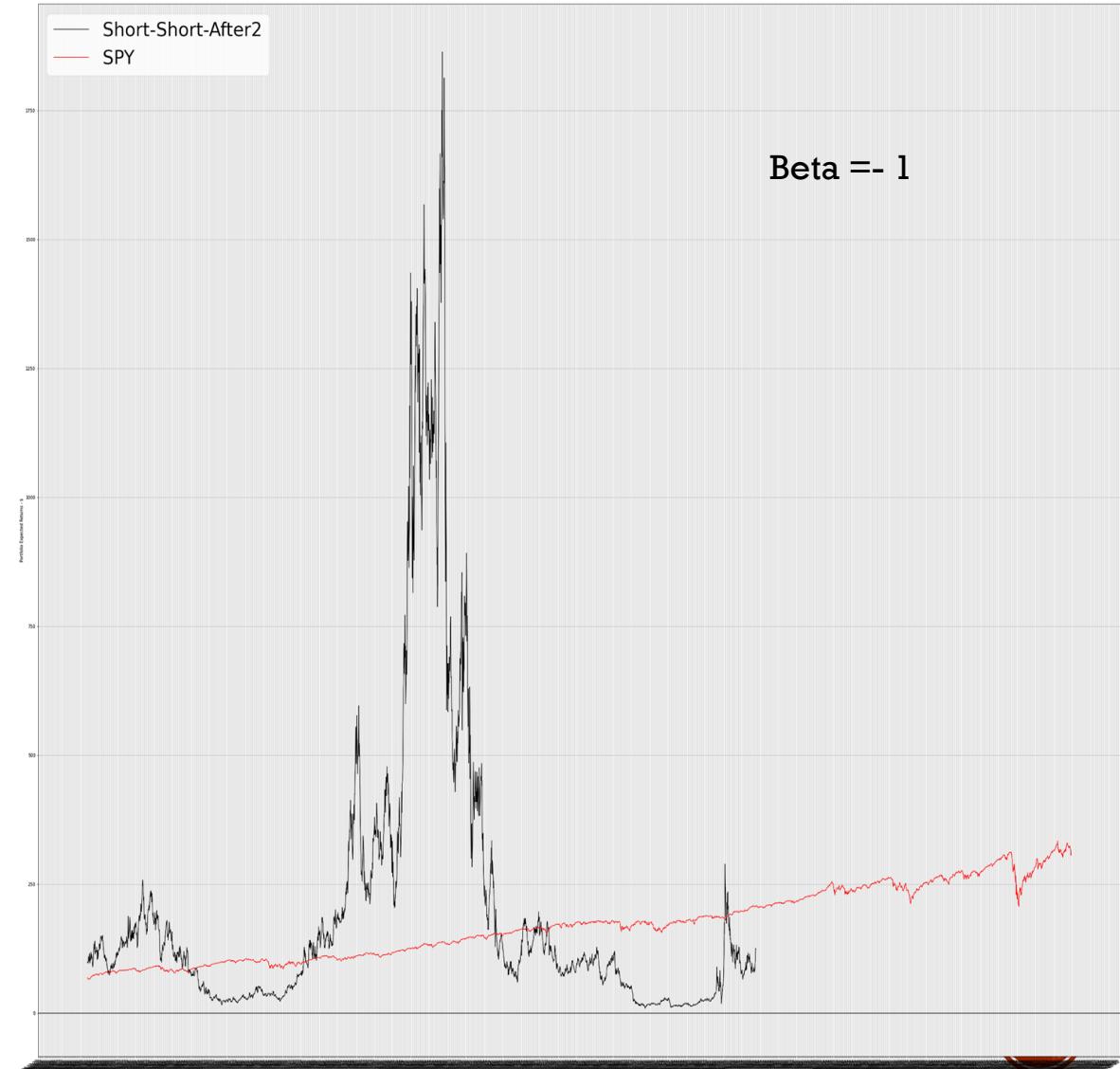
Probability Expected Returns for Given Beta Value = -1.0 Short-Short-After2 the Crisis



Post Crisis (Cumulative Returns)



Post Crisis (Cumulative Returns)



Post Crisis



Results_post

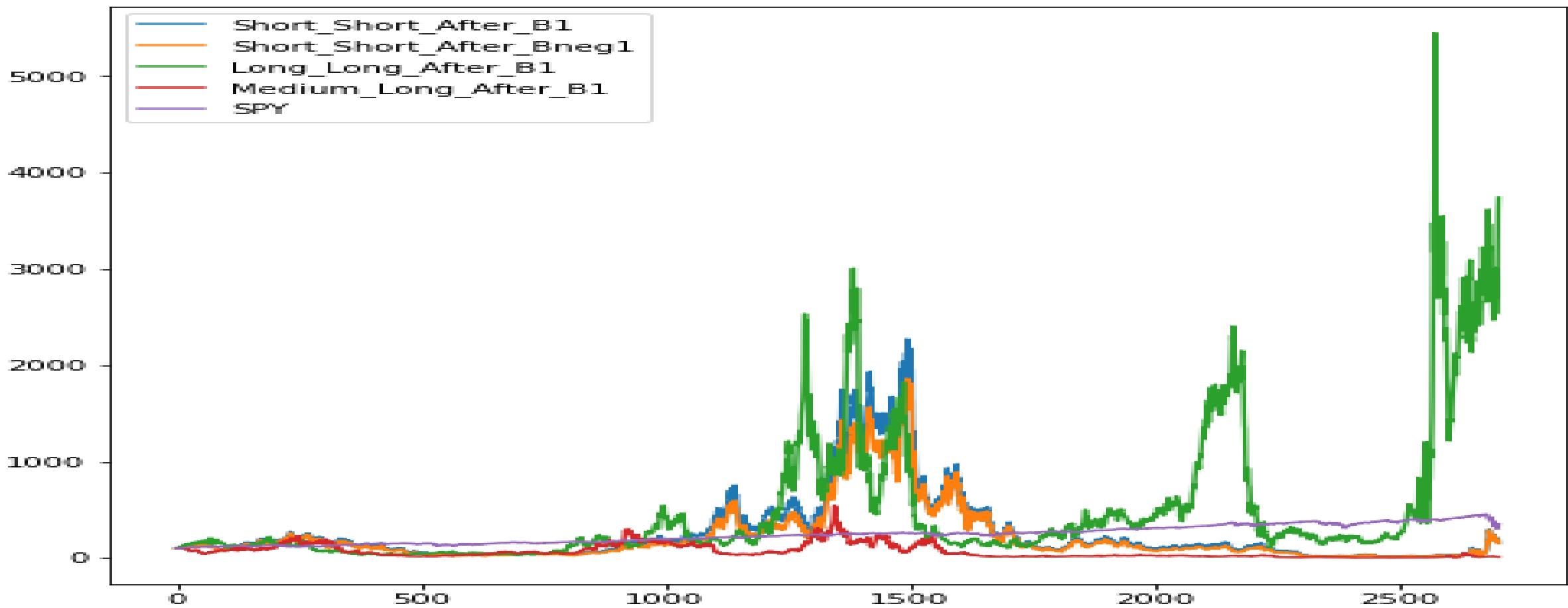


Short_Short_After1 Short_Short_After2 Long_Long_After1 Medium_Long_After1 SPY

Daily Mean Arithmetic Return	0.003141	0.003050	0.004991	0.002384	0.000586
Min Return	-0.445387	-0.430346	-0.420700	-0.424678	-0.109424
Cumulated Return	0.272633	0.242390	36.396660	-0.896973	3.491285
Max 10 Days Drawdown	0.995161	0.994827	0.967049	0.996302	0.337173
Volatility	1.235165	1.219577	1.348246	1.262233	0.172109
Sharpe Ratio	0.220726	0.198750	26.995571	-0.710624	20.285288
Skewness	0.321345	0.334476	0.216569	0.117547	-0.605672
Kurtosis	5.044665	4.719193	3.847562	4.249057	12.987066
Modified VAR	-0.131634	-0.129922	-0.145249	-0.133693	-0.018490
CVAR	0.005340	0.005324	0.004266	0.006283	0.000596



Conclusion- After Crisis Graphically



Conclusion - Post Crisis

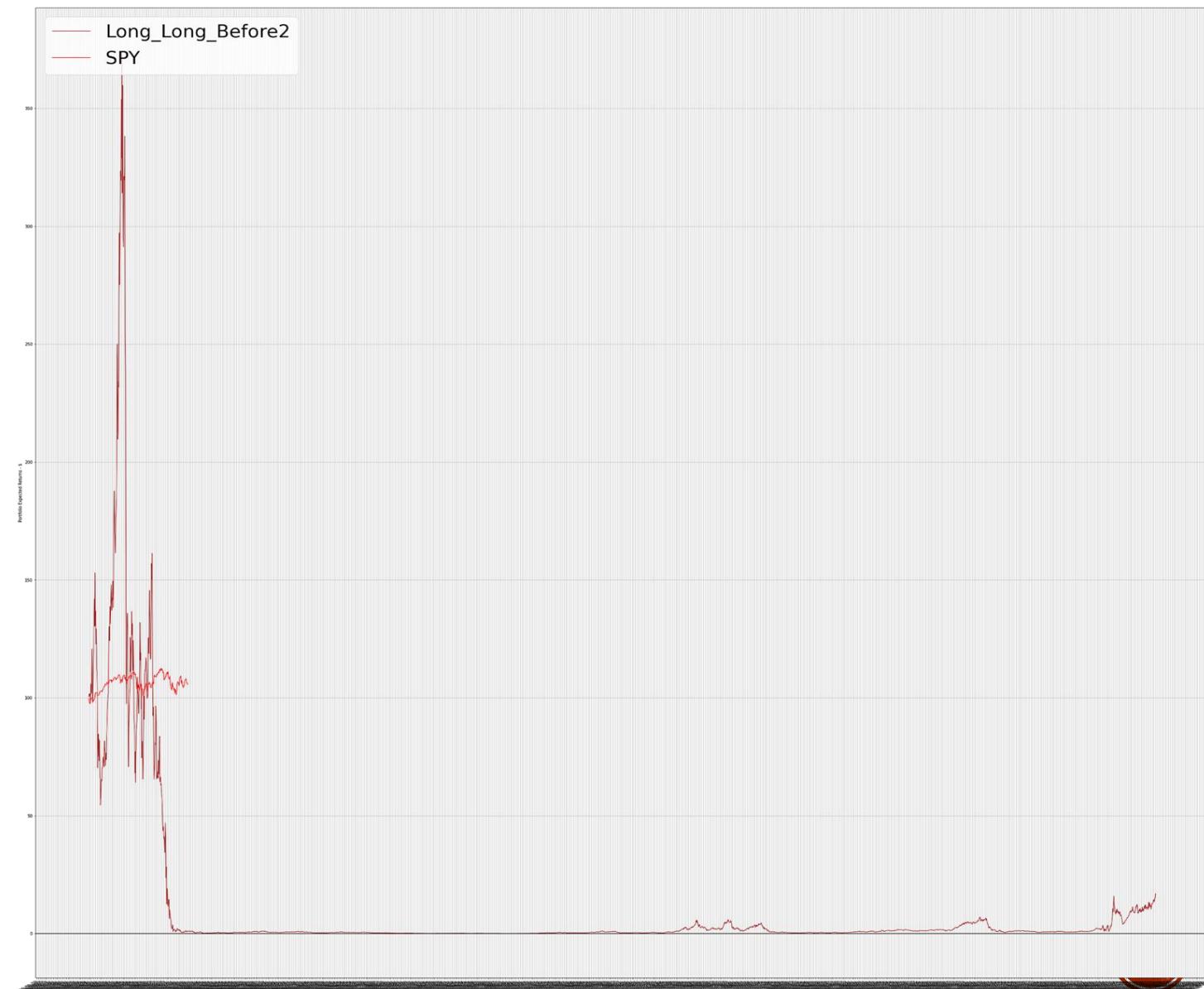
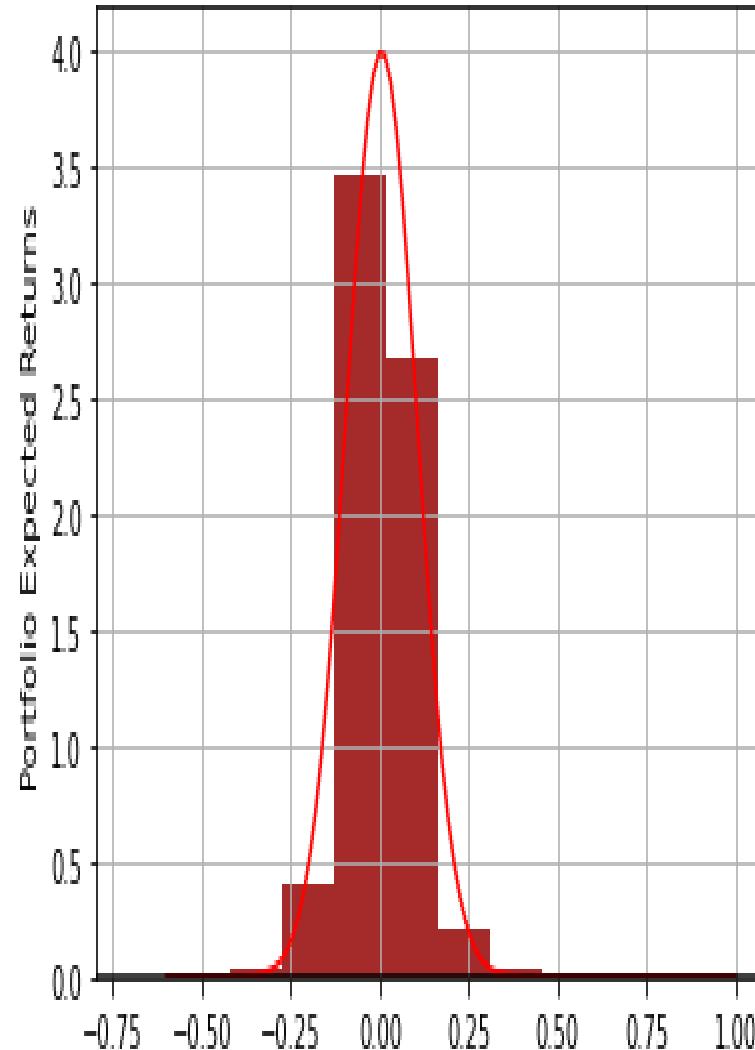
Long Long After1 with target Beta = 1 we noted for LBP return= 150 days , LBP cov= 150

- By referring to the table in **Slide 24**, it was noted that Long Long After1 has the greatest daily mean arithmetic return, cumulative return & volatility than the market (SPY)
- However, the maximum 10 days drawdown for this strategy was the lowest in comparison to the other strategies, but this measure was greater than the market (SPY)
- By referring to **Slide 21**, it is noted that Long Long After fits the cumulative distribution best in comparison to the other strategies and had the least outliers as well.



Whole L.B.P. Return = Long , L.B.P. Cov=Long, Beta= 1.0

Probability Expected Returns for Given Beta Value = 1.0 Long_Long_Before2 the Crisis



Whole Period



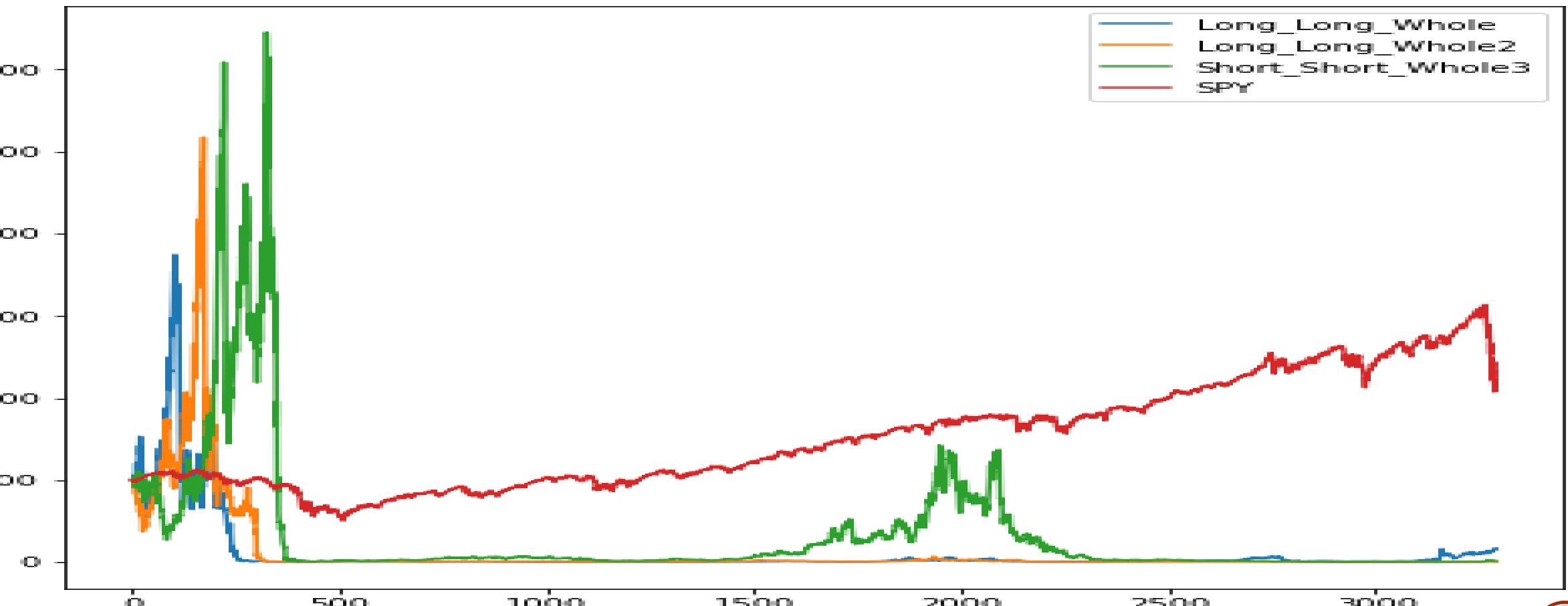
Results_Whole



Long_Long_Whole_B1 Long_Long_Whole2_Bneg1 Short_Short_Whole3_B2 SPY

Daily Mean Arithmetic Return	0.004593	0.002605	0.003571	4.138948e-04
Min Return	-0.710832	-0.828079	-0.866221	-1.094236e-01
Cumulated Return	-0.834129	-0.998932	-0.984451	2.095517e+00
Max 10 Days Drawdown	0.999818	0.999970	0.999924	5.518944e-01
Volatility	1.577607	1.475690	1.500437	2.068225e-01
Sharpe Ratio	-0.633871	-0.677649	-0.666472	2.771915e+07
Skewness	0.229715	-0.048348	0.162343	-4.818637e-02
Kurtosis	7.161316	8.622325	9.712243	1.490518e+01
Modified VAR	-0.168711	-0.156120	-0.159661	-2.192958e-02
CVAR	0.006239	0.007528	0.006731	1.006186e-03

Conclusion- Whole Period Graphically



Conclusion - Overall

Long Long Whole with target Beta = 1 we noted for LBP return= 150 days , LBP cov= 150

- By referring to the table in **Slide 27**, it was noted that Long Long Whole has the greatest daily mean arithmetic return & volatility than the market (SPY), but lower cumulative returns in comparison to the market (SPY)
- However, the maximum 10 days drawdown for this strategy was greater in comparison to the market and was smaller for the Sharpe ratio in comparison to the market
- By referring to **Slide 26**, it is noted that Long Long Whole portfolio closely fits the cumulative distribution with very few outliers



Q&A



Appendices



Appendix A - Dataset 1

	FXE	EWJ	GLD	...	SMB	HML	RF
Date							
2007-03-01	-0.003332	-0.004742	-0.009928	...	-0.0012	0.0016	0.00019
2007-03-02	0.000682	-0.016338	-0.032057	...	-0.0063	0.0022	0.00019
2007-03-05	-0.007576	-0.014533	-0.012243	...	-0.0068	-0.0030	0.00019
2007-03-06	0.002672	0.023877	0.019387	...	0.0064	-0.0001	0.00019
2007-03-07	0.004416	-0.002058	0.002338	...	-0.0011	0.0008	0.00019
...
2020-10-23	0.003327	0.000506	-0.001062	...	0.0043	0.0004	0.00000
2020-10-26	-0.004481	-0.009612	-0.000504	...	-0.0027	-0.0040	0.00000
2020-10-27	0.000180	0.003576	0.002632	...	-0.0004	-0.0238	0.00000
2020-10-28	-0.005490	-0.013573	-0.016143	...	0.0006	0.0055	0.00000
2020-10-29	-0.005882	0.007568	-0.004145	...	0.0016	0.0023	0.00000

[3443 rows x 16 columns]



Appendix B - Dataset 2

Date	Mkt-RF	SMB	HML	RF
19260701	0.1	-0.24	-0.28	0.009
19260702	0.45	-0.32	-0.08	0.009
19260706	0.17	0.27	-0.35	0.009
19260707	0.09	-0.59	0.03	0.009
19260708	0.21	-0.36	0.15	0.009
19260709	-0.71	0.44	0.56	0.009
19260710	0.62	-0.5	-0.15	0.009
19260712	0.04	0.03	0.54	0.009
19260713	0.48	-0.26	-0.23	0.009
19260714	0.04	0.09	-0.48	0.009
19260715	-0.43	0.54	-0.3	0.009
19260716	0.53	0.01	-0.57	0.009
19260717	0.34	0.43	-0.63	0.009
19260719	-0.01	0.01	-0.49	0.009
19260720	-0.57	-0.23	0.16	0.009
19260721	-0.6	0.21	0.31	0.009
19260722	-0.73	-0.3	-0.17	0.009
19260723	-0.02	0.08	0.06	0.009
19260724	-0.14	0.44	-0.06	0.009
19260726	0.53	-0.38	-0.25	0.009

