Final Project

FRE 6711
Quantitative Portfolio Management

Professor: Papa Momar Ndiaye

Wan-Yu Shih, N13829281;
Yingjing He, N15907671;
Tze-Cheng Wang, N10150465;
Ching-Che Chiang, N10781302

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Goal:

Our project is to build a Global Macro Investment strategy for the time period 2007-2015. Based on different combinations of trend estimators, we use minimizing portfolio variance method, or Markowitz Optimization, to optimize our portfolios. In this case, we use the Covariance Matrixes and the Expected Returns according to long-term and short-term historical data to build our strategies. Moreover, we build our strategies based on the change of the market environment to see the behavior of the optimal portfolios with different trend estimators. As a result, during different time periods, we will perform a list of Key Indicators to test the efficiency of our portfolios. Then we will change the target return to test the sensitivity of our portfolios and provide a conclusion.

Details:

For short-term estimators, we use 60 days of observation to calculate the expected daily returns and covariance matrixes under 13 assets over the rolling time period. We also choose 120 days of observation to calculate the corresponding long-term estimators. Therefore, we can use four sets of trend estimators, (R60, C60), (R120, C120), (R60, C120) and (R120, C60), to optimize our portfolios.

Based on those estimators with different lengths, we optimize our portfolios to get ample weight sets for long-term and short-term time periods. That is, we will rebalance on every chosen time period. For the chosen time periods, we opt 5 trading days for a short-term time period and 20 trading days for a long-term time period. In other words, we will rebalance our portfolio weekly or monthly. Although trend estimators can test the change of the market environment, we use VIX, which is the volatility of SPY, to be another indicator to check the stability of the Market.

In order to see the impact of different trend estimators, we calculate the risk indicators, corresponding to four strategies, on each asset and our optimal portfolios separately. Ultimately, through analyzing the return and risk among four strategies, we give the recommending strategy in different time period.

Section 1. Investment Universe

Overview:

- Download data of the selected set of ETFs from Yahoo Finance.
- Select time period from 01/01/2007 to 03/01/2015.

Selected Assets:

Index	Symbol	Name	Fund Type
1	FXE	CurrencyShares Euro Trust	Commodity Based ETF
2	EWJ	iShares MSCI Japan Index Fund	Global Equity ETF
3	GLD	SPDR Gold Shares	Commodity Based ETF
4	QQQ	PowerShares NASDAQ-100 Trust	US Equity ETF
5	SPY	SPDR S&P 500	US Equity ETF
6	SHV	iShares Short Treasury Bond Fund	US Fixed Income ETF
7	DBA	PowerShares DB Agriculture Fund	Commodity Based ETF
8	USO	United States Oil Fund LP	Commodity Based ETF
9	XBI	SPDR S&P Biotech	US Equity ETF
10	ILF	iShares Latin America 40 Index Fund	Global Equity ETF
11	GAF	SPDR S&P Emerging Middle East & Africa	Global Equity ETF
12	EPP	iShares MSCI Pacific Ex-Japan Index Fund	Global Equity ETF
13	FEZ	SPDR DJ EURO STOXX 50	Global Equity ETF

Details:

In order to make estimators complete, we use 07/12/2006-03/01/2015 data set, which 120 days more than required days, to calculate daily log returns, rolling expected returns and rolling covariance matrixes. And we truncate the missing data into time period: 3/26/2007-02/27/2015. For the initial data, there are three assets SHV, DBA and GAF, which have no complete data. SHV has missing data from 7/12/2006-1/10/2007. DBA has missing data from 7/12/2006-1/4/2007. And GAF has missing data from 7/12/2006-3/22/2007. Since the missing data are very little, the truncated data, 3/26/2007-02/27/2015, would not have big impact on our optimal portfolios.

Furthermore, in order to ease the impact of stock split and dividends, we use adjusted close price of ETFs to be our data set. We also download VIX as an indicator of the change of the Market environment.

Section 2. Investment Strategies

Overview:

- Calculate daily log returns for given data set.
- Calculate the annually expected log returns and covariance matrixes for short-term, 60 days, and for long-term, 120 days.
- Implement Markowitz optimization with four combinations of trend estimators to get weighted sets indicated above (R60, C120), (R120, C120), (R120, C60), and (R60, C60).

Assumption:

We do neglect transaction cost and do not consider SHV as a Riskless Security.

Market indicator:

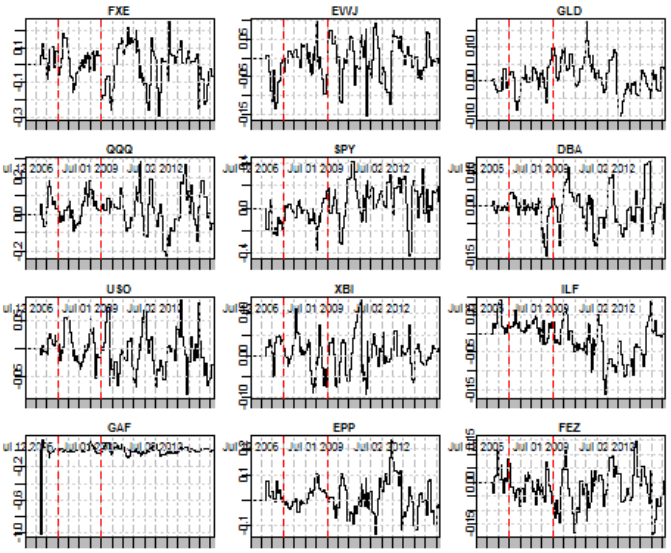
As our previous explanation, we choose VIX index to be an indicator of the change of market environment. When VIX is greater than 25, we consider the Market is turbulence. Although we do not test whether VIX get into bubble or not, we can see the Market gets into an unstable situation. Then we rebalanced our portfolio weekly. Otherwise, when VIX is smaller than 25, the Market is relatively stable. We adjust the portfolio monthly.

Under the constraint, we build long-term and short-term portfolios, using a combination of estimators, to see the behavior of the strategies during different historical periods, which are before the 2008 crisis, during the 2008 crisis and after the crisis.

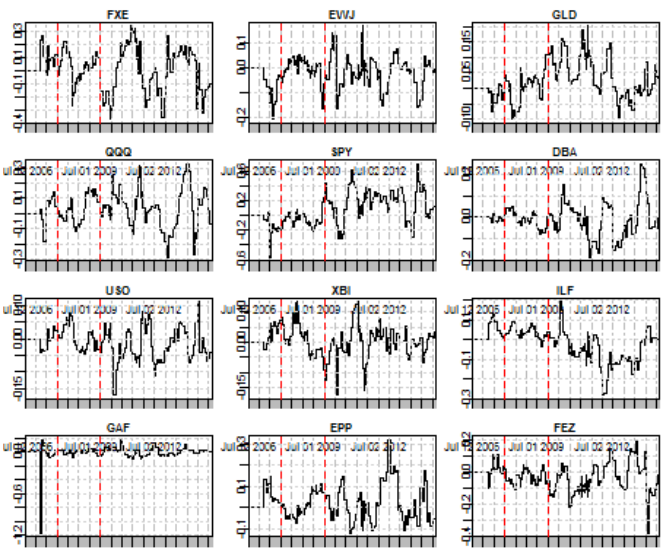
Report:

For four optimal portfolios, we get four corresponding weighted sets with 13 assets. For each strategy, we can plot the behaviors of each asset in the corresponding portfolio. We take the weights set with trend estimators (R60, C120), (R120, C120), (R120, C60) and (R60, C60) in the following graphs. The red dashes indicate the time period during the 2008 crisis.

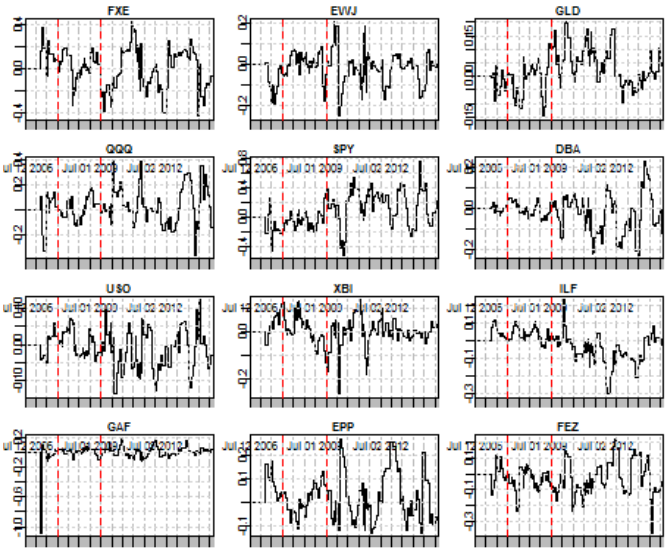
(R60, C120)



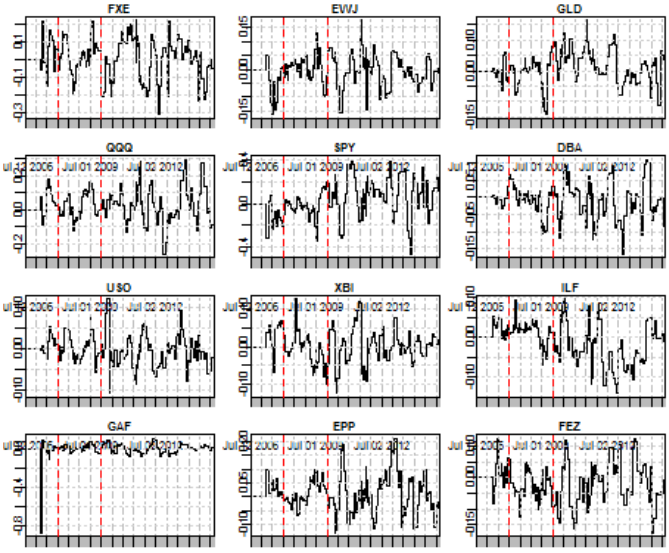
(R120, C120)



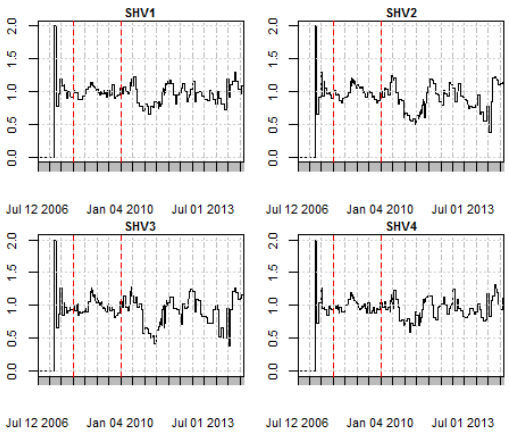
(R120, C60)



(R60, C60)



SHV



Comments:

- Under the four optimal portfolios, the behaviors of 13 assets do not have significant changes in each corresponding assets.
- Although we do not consider SHV as a riskless security, the weight of SHV is higher than the rest of assets. In general, the range of SHV lies between 0.5 and 1.5; however, most weights of other assets are less than 1. Specifically, some are between -0.2 and 0.2 and some are between -0.1 and 0.15.
- Although we indicate the time period of 2008 crisis, it is hard to see any trend in the strategically behaviors of 13 assets. Furthermore, more estimators need to be taken into consideration and the risk indicators should be calculated in separated time periods.

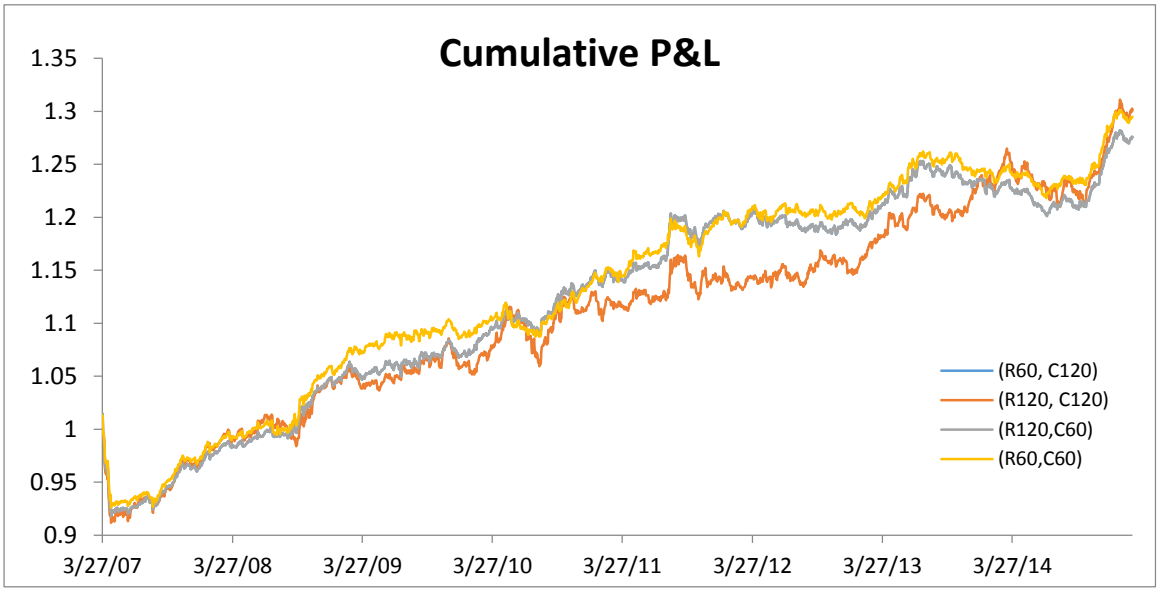
Section 3. Performance and Risk Reporting for comparing Strategies

Overview:

- Calculate the Key Indicators list of four optimal strategies over the whole and separated time periods.
- Calculate and plot the corresponding cumulated P&L or Return for each optimal portfolios in three time periods, which are "Before the 2008 crisis" (2007/3/27-2007/12/31), "During the 2008 crisis" (2008/1/1-2009/12/31), and "After the crisis" (2010/1/1-2005/3/1).
- Plot the distribution of daily log Returns on the optimal portfolios.
- Compare with the benchmark, SPY, to see the performance of our optimal portfolios.

Summary of the Key Indicators:

- **Overall Cumulative P&L:**

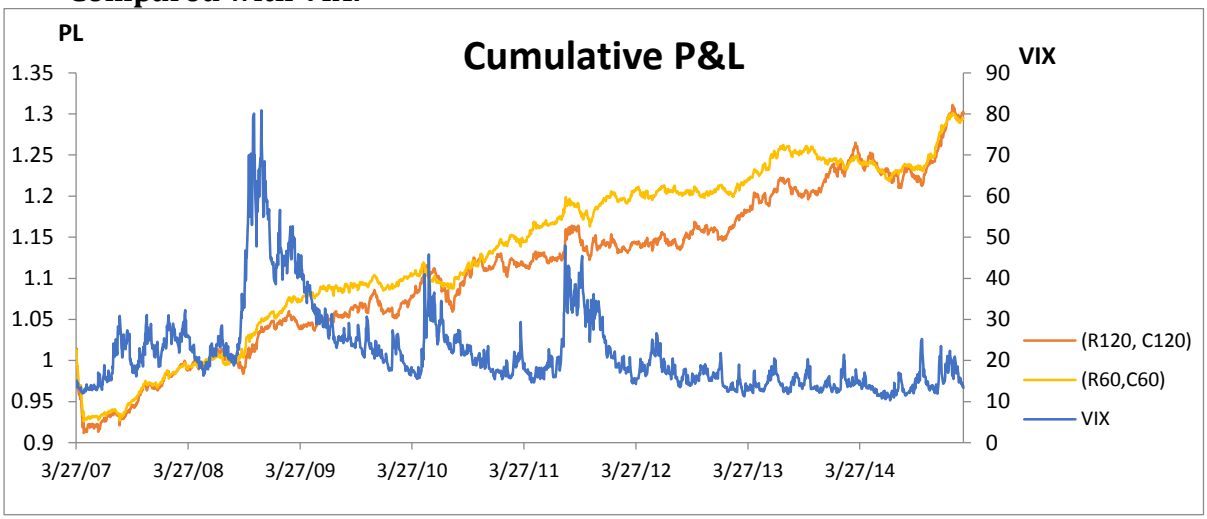


The above plot is the cumulative P&L, which comes from four different strategies, (R_{60}, C_{60}), (R_{120}, C_{120}), (R_{60}, C_{120}) and (R_{120}, C_{60}). We compared the performance of three strategies before, during and after the crisis.

First of all, if we combined the plot of cumulative P&L from three strategies, we could find out that cumulative P&L of (R_{60}, C_{120}) and (R_{120}, C_{60}) are almost the same. Consequently, we focus on the differences among (R_{60}, C_{60}), (R_{120}, C_{120}) and (R_{120}, C_{60}).

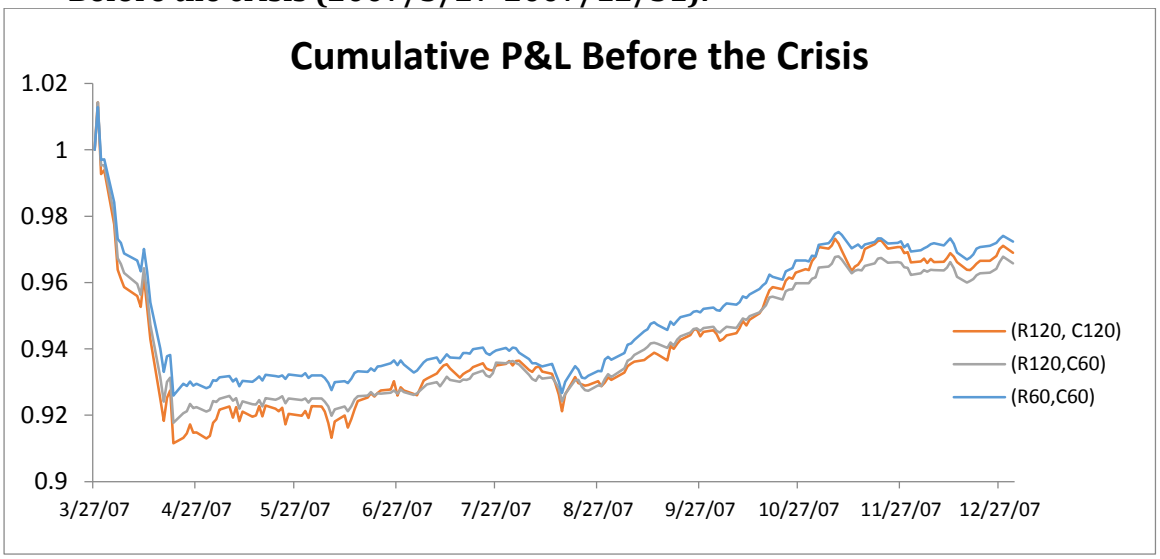
Secondly, the performance of (R_{120}, C_{60}) is usually between (R_{60}, C_{60}) and (R_{120}, C_{120}) most of the time. Nevertheless, (R_{120}, C_{60}) underperformed in the long run, especially after the crisis.

- **Compared with VIX:**



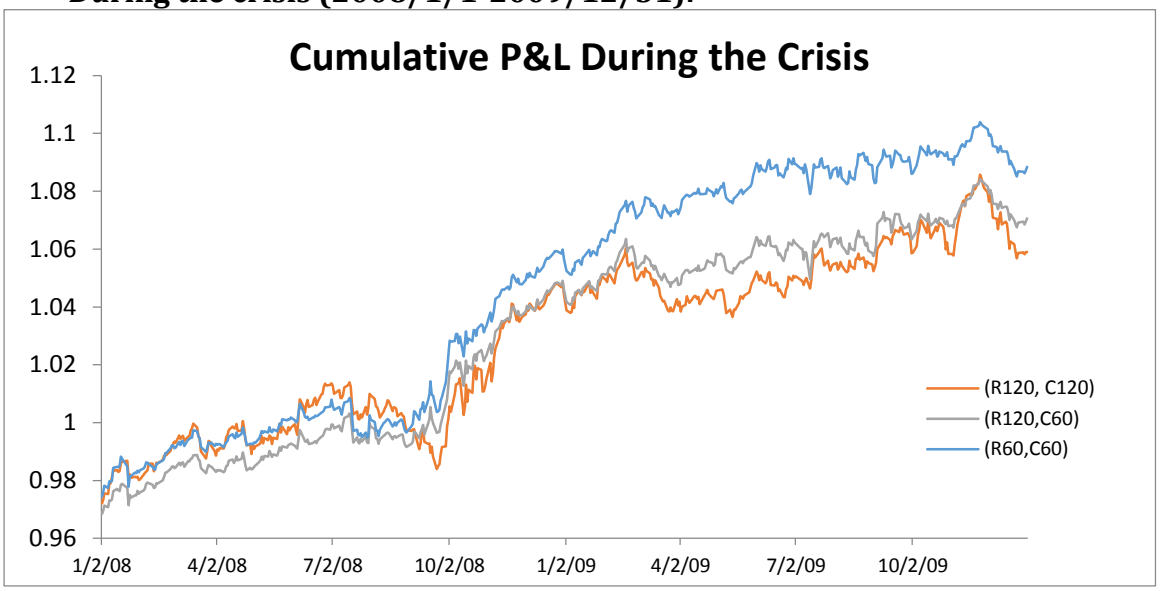
When comparing our results with VIX, an indicator of market condition, we could easily find out that if VIX increases rapidly, our optimal portfolio will begin losing money. For instance, March 2008, March 2010 and August 2011 are the periods that VIX increases dramatically. However, if the market seems to have specific movement, either in bull market or bear market, our cumulative PL of the portfolio will take profit.

- **Before the crisis (2007/3/27-2007/12/31):**



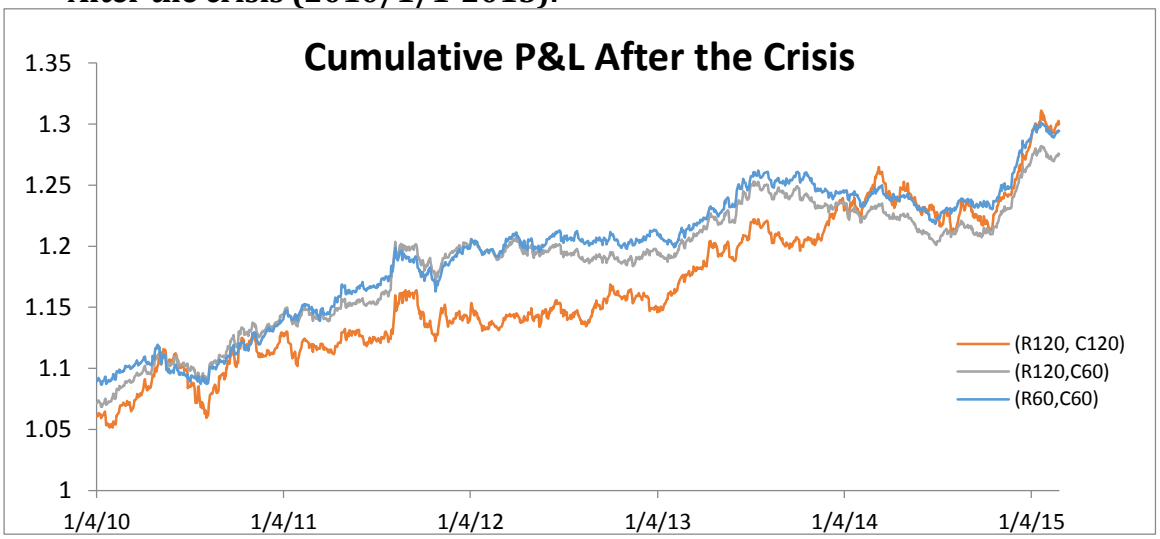
According to the above plot, we could easily see that (R_{60}, C_{60}) outperformed both other two strategies during this period, even though all of the strategies were losing money before the crisis. The reason why (R_{60}, C_{60}) experienced less loss is that market condition changed rapidly and, hence, the relative short-term expected return and covariance might be closer to the real one. Consequently, (R_{60}, C_{60}) is the best strategy before the financial crisis.

- **During the crisis (2008/1/1-2009/12/31):**



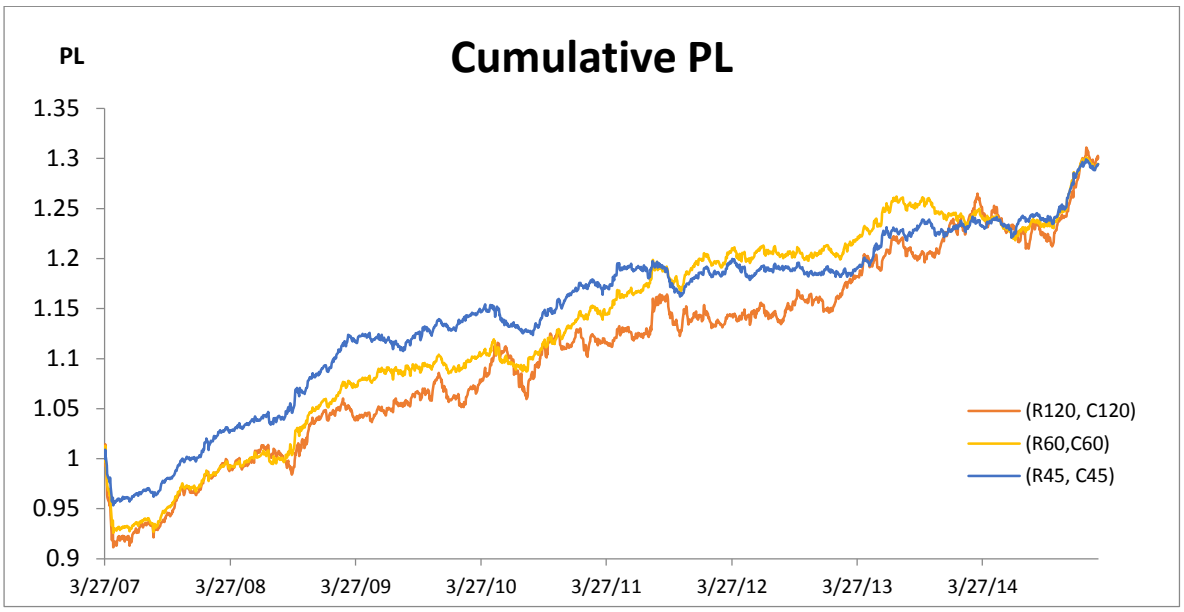
From the above plot, we could observe that (R_{120}, C_{120}) outperformed before July 2008; nevertheless, (R_{60}, C_{60}) started to gain money around August 2008 but (R_{120}, C_{120}) began losing money at that time. In the meantime, VIX started to surge from 20 to 80 at August 2008. Short-term estimators can adapt to fit the market condition well. After October 2008, the cumulative PL of (R_{60}, C_{60}) is higher than other strategies.

- **After the crisis (2010/1/1-2015):**



Observing from the above plot, we found out that (R_{120}, C_{120}) loses more money than any other strategies during 2010. This means that (R_{120}, C_{120}) has higher volatility at that time. (R_{120}, C_{120}) underperformed between 2011 and 2014; however, (R_{120}, C_{120}) gains more money during 2014.

- **Long-term v.s. short-term estimators**



In order to distinguish the difference between long-term and short-term strategy, we insert the strategy, (R_{45}, C_{45}), into the above plot. It is obvious that the cumulative PL of (R_{45}, C_{45}) between 2007 and 2011 is the highest and the drawdown is the lowest. Nonetheless, after 2011, (R_{45}, C_{45}) started losing its advantages and (R_{120}, C_{120}) stands out in the end.

The Distribution of Daily Returns:

- **Overall Results:**

Strategy	(R60, C120)	(R120, C120)	(R120, C60)	(R60, C60)
Daily Mean Geometric Return	0.0122%	0.0132%	0.0126%	0.0129%
Daily Min Return	-1.88%	-2.14%	-1.98%	-1.57%
Daily Max Return	1.44%	1.50%	1.31%	1.29%
Max Drawdown	9.53%	10.13%	10.14%	8.59%
Volatility	3.15%	4.19%	4.27%	3.07%
Sharpe Ratio	-0.2038	-0.1555	-0.1533	-0.2086
Sortino Ratio	0.0863	0.0706	0.0659	0.0947
Skewness	-1.06	-0.76	-0.76	-0.81
Kurtosis	13.09	6.81	5.02	8.15
Modified VaR	-0.32%	-0.44%	-0.46%	-0.32%
CVaR	-0.83%	-0.94%	-0.90%	-0.72%

According to the above results, (R_{120}, C_{120}) had the highest daily maximum return and lowest daily minimum return among other strategies. This indicates that (R_{120}, C_{120}) must have higher volatility. Also, (R_{120}, C_{120}) have largest conditional VaR, and a modified VaR, which is larger than (R_{60}, C_{60}). On the other hand, all of the strategies are negatively skewed, and this reveals that we have a greater chance of extremely negative returns. Since all of the excess kurtosis are all positive, the distributions have fatter tails than normal distribution and are more peaked.

Furthermore, the volatility of the portfolio is extremely low, and this results from our highly diversified portfolio, each ETF representing the risk from different countries.

Lastly, since the cumulative PL of (R_{60}, C_{120}) and (R_{120}, C_{60}) are exactly the same, the kurtosis of (R_{60}, C_{120}) is two times higher than that of (R_{120}, C_{60}). The reason is that the longer time for the estimator of covariance will result in weaker sensitivity. Thus, (R_{60}, C_{120}) will endure higher risk in the whole period.

Since it is hardly to pick the optimal strategy from the overall results, we divide our analysis into three periods, “Before the crisis”, “During the crisis”, and “After the crisis”.

- **Before the Crisis:**

Strategy	(R60, C120)	(R120, C120)	(R120, C60)	(R60, C60)
Daily Mean Geometric Return	-0.0142%	-0.0121%	-0.0128%	-0.0115%
Daily Min Return	-1.88%	-2.14%	-1.98%	-1.57%
Daily Max Return	1.44%	1.44%	1.31%	1.29%
Max Drawdown	9.53%	10.13%	10.14%	8.59%
Volatility	5.42%	6.36%	6.01%	4.86%
Sharpe Ratio	-0.8680	-0.7334	-0.7559	-0.9317
Sortino Ratio	-0.0466	-0.0333	-0.0377	-0.0426

Skewness	-2.20	-2.01	-2.02	-1.95
Kurtosis	11.89	9.25	8.80	10.10
Modified VaR	-0.68%	-0.80%	-0.76%	-0.60%
CVaR	-1.66%	-1.74%	-1.60%	-1.40%

All of the strategies have negative daily geometric returns and are negatively skewed. Short-term strategy (R_{60}, C_{60}) has higher daily return with lower volatility, maximum drawdown, and VaR among others. This means that (R_{60}, C_{60}) is the strategy with higher return but lower risk. Moreover, this period has higher conditional VaR that indicates the portfolio will incur large losses. Consequently, we suggest use (R_{60}, C_{60}) as our optimal strategy before the crisis.

- **During the Crisis:**

Strategy	(R60, C120)	(R120, C120)	(R120, C60)	(R60, C60)
Daily Mean Geometric Return	0.0204%	0.0176%	0.0150%	0.0223%
Daily Min Return	-0.85%	-1.25%	-1.27%	-0.80%
Daily Max Return	0.75%	0.75%	1.03%	0.73%
Max Drawdown	1.57%	2.96%	3.94%	1.70%
Volatility	2.88%	3.70%	3.96%	2.95%
Sharpe Ratio	-0.3783	-0.3103	-0.2853	-0.3667
Sortino Ratio	0.1682	0.1101	0.0864	0.1809
Skewness	-0.28	-0.36	-0.39	-0.29
Kurtosis	2.23	1.77	1.84	1.68
Modified VaR	-0.29%	-0.38%	-0.41%	-0.29%
CVaR	-0.45%	-0.58%	-0.63%	-0.44%

During the financial crisis, though we have positive daily geometric return, the distribution of log return is negatively skewed with negative excess kurtosis, which means that the distribution has a thinner tail and a large probability of losing money. However, Sortino ratio is the highest among all the other period and the volatility is smaller than the before crisis period. In this period, according to the conditional VaR and the modified VaR, long-term strategy seems to have higher risk than short-term strategy. Hence, we prefer to choose (R_{60}, C_{60}) as our optimal portfolio.

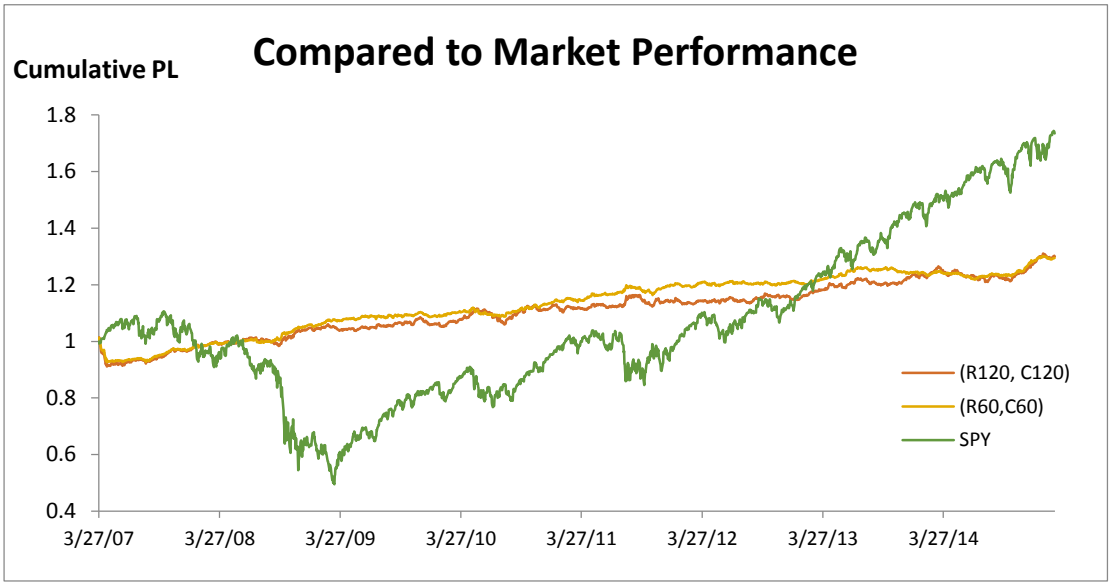
- **After the Crisis:**

Strategy	(R60, C120)	(R120, C120)	(R120, C60)	(R60, C60)
Daily Mean Geometric Return	0.0135%	0.0158%	0.0159%	0.0134%
Daily Min Return	-0.63%	-1.19%	-1.14%	-0.75%
Daily Max Return	1.17%	1.50%	1.13%	0.92%
Max Drawdown	4.15%	5.05%	6.75%	3.49%
Volatility	2.79%	3.98%	4.08%	2.77%
Sharpe Ratio	-0.0183	-0.0207	-0.0207	-0.0180
Sortino Ratio	0.1195	0.0949	0.0915	0.1167
Skewness	0.37	0.05	-0.19	0.13
Kurtosis	2.40	1.98	1.59	1.50
Modified VaR	-0.25%	-0.38%	-0.41%	-0.26%
CVaR	-0.32%	-0.55%	-0.61%	-0.36%

During this period, (R_{120}, C_{120}) and (R_{120}, C_{60}) have higher daily return with higher volatility and VaR. On the contrary, (R_{60}, C_{120}) and (R_{60}, C_{60}) have lower daily return with lower risk. Besides, all the excess kurtosis are negative, which reveals that the probability of extreme events is lower than normal distribution. After the crisis, we recommend (R_{120}, C_{120}) as optimal strategy. Though it is not the lowest risk among others, (R_{120}, C_{120}) gain more money and the risk is acceptable as well since it is lower than "During the crisis" and "Before the crisis".

Comparison with the Market:

In order to benchmark our strategies to market, we take SPY to represent S&P 500 Index.



Strategy	SPY (Market)	(R60, C120)	(R120, C120)	(R120, C60)	(R60, C60)
Daily Mean Geometric Return	0.0275%	0.0122%	0.0132%	0.0126%	0.0129%
Daily Min Return	-9.84%	-1.88%	-2.14%	-1.98%	-1.57%
Daily Max Return	14.52%	1.44%	1.50%	1.31%	1.29%
Max Drawdown	55.19%	9.53%	10.13%	10.14%	8.59%
Volatility	22.17%	3.15%	4.19%	4.27%	3.07%
Sharpe Ratio	-0.0276	-0.2038	-0.1555	-0.1533	-0.2086
Sortino Ratio	0.0377	0.0863	0.0706	0.0659	0.0947
Skewness	0.24	-1.06	-0.76	-0.76	-0.81
Kurtosis	13.37	13.09	6.81	5.02	8.15
Modified VaR	-1.79%	-0.32%	-0.44%	-0.46%	-0.32%
CVaR	-1.79%	-0.83%	-0.94%	-0.90%	-0.72%

- First of all, from the cumulative PL, market performance is more volatile than our portfolio. That is, our portfolio is more stable but with lower profit in the long run.
- Even though the daily geometric return of our portfolio is about half of the market performance, the maximum drawdown and volatility is only 1/5 of the SPY. Therefore, the Sortino ratio of our portfolio can be as much as 2.5 times that of SPY.
- Moreover, when it comes to the distribution of the daily return, the kurtosis of our portfolio is smaller, which reveals that we have a thinner tail than SPY. Hence, we will have lower chance to the extreme events.
- In our optimization process, we minimized the variance and, hence, lost the excessive return. Meanwhile, since our portfolio is globally diversified, we can reduce the idiosyncratic risk effectively.

Section 4. Summary and Comments

- Markowitz optimization method indicates that higher volatility would cause lower weighted to the individual ETF and the reverse is also true. For instance, SHV has relatively low volatility (less than 1%), so it obtains relatively great amount of weight in the portfolio.
- According to our result, we suggest to use short-term strategy (R_{60}, C_{60}) before the crisis, because this strategy has higher daily geometric mean with lower maximum drawdown and volatility.
- During the crisis, short-term strategy has not only the highest daily return but also the smallest conditional VaR and modified VaR. As a consequence, we should consider the short-term strategy during the crisis.
- Lastly, we recommend implement long-term strategy (R_{120}, C_{120}) after the crisis for the sake of the higher daily geometric mean. Even though it has higher volatility, the statistics is not far from the short-term strategy (R_{60}, C_{60}).
- In a nutshell, it seems that our optimal portfolio can't be better than the market performance in the long run. However, our optimal portfolio endure less risk than the market during the whole period of 2007 to 2015. In the short term, optimal portfolio is less volatile than the SPY, especially during the financial crisis in 2008.

Appendix I –Results for ETFs

Index	FXE	EWJ	GLD	QQQ	SPY	SHV	DBA	USO	XBI	ILF	GAF	EPP	FEZ
Daily Mean Geometric Return	-0.007%	-0.003%	0.028%	0.048%	0.028%	0.004%	-0.004%	-0.052%	0.077%	0.004%	0.018%	0.018%	-0.002%
Daily Min Return	-3.07%	-10.41%	-8.78%	-8.96%	-9.84%	-0.36%	-8.61%	-10.68%	-10.10%	-19.47%	-13.62%	-11.22%	-11.43%
Daily Max Return	3.67%	15.82%	11.29%	12.16%	14.52%	0.32%	7.97%	9.60%	13.26%	26.25%	18.20%	16.59%	17.53%
Max Drawdown	29.56%	52.55%	40.52%	53.40%	55.19%	0.36%	48.88%	85.90%	37.59%	67.48%	55.98%	66.01%	64.21%
Volatility	10.35%	23.97%	20.59%	22.58%	22.17%	0.43%	20.55%	34.11%	28.22%	37.44 %	31.55%	30.69%	32.53%
Sharpe Ratio	-0.063	-0.025	-0.029	-0.026	-0.028	-1.363	-0.030	-0.017	-0.027	-0.013	-0.019	-0.017	-0.017
Sortino Ratio	-0.009	0.008	0.040	0.059	0.038	0.205	0.005	-0.018	0.076	0.020	0.027	0.027	0.013
Skewness	0.05	0.50	-0.11	0.11	0.24	-0.36	-0.23	-0.12	0.06	0.41	0.23	0.29	0.24
Kurtosis	2.30	12.28	6.18	7.59	13.37	34.93	4.70	2.73	3.30	14.52	9.18	9.14	6.91
Modified VaR	-1.04%	-1.89%	-1.98%	-2.03%	-1.79%	-0.02%	-2.09%	-3.53%	-2.69%	-2.89%	-2.74%	-2.63%	-2.93%
CVaR	-1.48%	-1.89%	-3.26%	-2.74%	-1.79%	-0.02%	-3.55%	-5.36%	-3.99%	-2.89%	-2.78%	-2.63%	-3.62%