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Application of Three Commonly Used Portfolios in the Hong Kong Stock Market

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Abstract: This paper will use stocks in Hang Seng Index to figure out the construction of portfolios. In addition, Fama experiment would be used to eliminate the idiosyncratic risk and R language would be regarded as the tool to do onerous computation. And 9 stocks randomly selected plus one risk-free asset would be entailed to construct portfolios, and finally all the stocks without missing values would be entailed. This paper may shed light on investing combination of stocks of Hang Seng index or some others about how to assign the weight proportion to reach different purposes.

Keywords: Hang Seng Index, Portfolio, Mean-variance.

1. Introduction

Hong Kong, governed under "one country, two systems" framework, serves as a bridge connecting China and other countries. Both China and other countries benefit from this leading global financial and business center. Considering the prominent importance of Hong Kong to China, it is conspicuous that Hang Seng index are of great significance to Chinese economy. Thus, there is also plethora of research have done with regard to Hang Seng index. For example, studying the distribution and scaling of fluctuations for Hang Seng index in Hong Kong stock market [1], some price discovery on index, futures, and tracker fund [2], or some recent study on Hang Seng Index concerning the political unrest [3]. There is also study on how GARCH approach pricing Hang Seng Index options [4], some proves no relationship existing between expirations of Hang Seng Index derivatives and stock market volatility [5], some concerns the elements of the last two papers, which uses GARCH approach to forecast the volatility of Hang Seng Index [6]. As an important financial market, the Hongkong stock market suffered a decreasing trend in the past several years, thus, constructing certain portfolios by the well-known mean-variance to diminish the potential lose became an interesting issue.

Ever since the mean-variance model proposed by Markowitz in 1952, the attention on optimization of portfolios has been aroused. In recent years, there are some researches about high-dimensional minimum variance portfolio estimation [7], where estimators of minimum variance portfolio are proposed to adapt to stochastic volatility and market microstructure noise; higher order moments of the estimated tangency portfolio weights [8], where Monte Carlo experiment are used to compute the first four moments of estimated weights; and portfolio optimization for extreme risks with maximum diversification [9], which proves that diversification ratio (DR) outperforms four benchmark strategies, equally weighted portfolio, minimum variance portfolio, extreme risk index portfolio and

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most diversified portfolio; some specifically study the minimum variance portfolio in the field of econometrics [10].

The portfolio is of great importance for deducting idiosyncratic risk, the number of research in portfolio of Hong Kong stocks is limited in recent years, however. So, this paper aims at studying the portfolios in the stocks composing the index Hang Seng by making use of the data ranging from December 2009 to December 2021. And it preprocesses the data first, and then discussed the minimal number of stocks to get rid of the idiosyncratic risk by using the Fama experiment, which is 9. Next the assumption of normality and IID of randomly selected stocks would be checked to be feasible, followed by the construction of portfolios. Due to the huge amount of data, "optim" function will be used here to get the minimum variance portfolio and tangency portfolio in both 9-stock portfolio and 50-stock portfolio, with one more highest return portfolio in the former one. There's no doubt that when risk-free asset is included in any kind of portfolio, it would have the largest part in the portfolio. And in portfolios without the risk-free asset, MTR. Corp. Ltd has the maximum proportion in 9-stock minimum variance portfolio and tangency portfolio, while AAC. Technologies is the one in 50-stock minimum variance portfolio and Hengan. International in 50-stock tangency portfolio. In addition, Link.Real.Estate.Investment.Trust has the largest absolute value in the 9-stock highest return portfolio.

2. Method and Results

2.1. Data Preprocessing

The constituent stocks of the Hang Seng Index are collected from Yahoo Finance (https://finance.yahoo.com/) and the closing price data of them are converted into returns as function 1. The simple descriptive statistics of the samples are as Table 1, Table 2.

$$R_t = \frac{P_t}{P_{t-1}} - 1 \tag{1}$$

Table 1: Mean of 50 stocks.

	Tencent	ICBC	CCB	CMB	BOC
Mean	214.3	5.3	6.2	26.2	3.5
	PetroChina	CMCC	HSBC	BYD	China Life
Mean	6.9	74.7	66.9	61.7	22.6
	Sinopec	CNOOC	HKEX	BOCHK	HSB
Mean	5.5	12.2	216.7	26.1	139.8
	SHKP	COLI	MTR	CITIC	Resources Land
Mean	111.3	21.6	34.5	12.1	22.5
	Longfor	ANTA	CK.hutchison	Techtronic	Galaxy
Mean	18.7	36.0	73.4	40.7	37.4
	CLP	Mengniu	HK & China Gas	Henderson	Li Ning
Mean	71.9	20.7	10.2	31.6	16.2
	Shenzhou	Resources Beer	Link REIT	Sands China	CK Infrastructure
Mean	57.3	23.9	51.4	32.7	52.8
	CountryGarden	Geely Automobile	ENN	Unicom HK	Sunny Optical
Mean	6.1	9.5	56.7	9.9	58.9
	Power Assets	CSPC Pharmaceutical	Lenovo	New World	Sino bio-pharmaceutical
Mean	50.8	5.0	6.6	40.2	3.5
	Hang Lung	Xinyi Glass	Alibaba Health	Hengan international	AAC
Mean	22.4	8.0	6.0	67.1	49.8

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Table 2: Standard deviation of 50 stocks.

	Tencent	ICBC	CCB	CMB	BOC
Sd	173.7	0.7	0.8	14.0	0.6
	PetroChina	CMCC	HSBC	BYD	China Life
Sd	2.8	13.2	14.7	58.8	5.9
	Sinopec	CNOOC	HKEX	BOCHK	HSB
Sd	1.1	3.1	100.3	5.8	29.7
	SHKP	COLI	MTR	CITIC	Resources Land
Sd	12.5	4.5	8.5	3.5	7.4
	Longfor	ANTA	CK.hutchison	Techtronic	Galaxy
Sd	11.7	39.0	18.6	38.2	19.0
	CLP	Mengniu	HK & China Gas	Henderson	Li Ning
Sd	9.4	10.5	2.2	6.1	20.9
	Shenzhou	Resources Beer	Link REIT	Sands China	CK Infrastructure
Sd	48.9	16.9	20.3	11.5	12.2
	CountryGarden	Geely Automobile	ENN	Unicom HK	Sunny Optical
Sd	3.9	8.0	32.8	3.1	67.6
	Power Assets	CSPC Pharmaceutical	Lenovo	New World	Sino bio-pharmaceutical
Sd	7.6	3.2	2.2	6.8	2.7
	Hang Lung	Xinyi Glass	Alibaba Health	Hengan international	AAC
Sd	5.8	6.2	6.1	11.8	32.1

It's obvious that Tencent Holdings has both the largest mean and standard deviation, while Bank of China holds both the least. There are some stocks with mean exceeding 100 besides Tencent Holdings, Hong Kong Exchanges and Clearing, Hang Seng Bank and Sun Hung Kai Properties. Among them, the first two have a standard deviation larger than 100, which is extremely large, while the last two have a relatively large one compared with the rest. In addition to Bank of China, Sino Biopharmaceutical also has a mean lower than 5, and both of them are low in standard deviation as well.

2.2. Fama Experiment

By randomly adding one stock to a portfolio each time, the Fama experiment is replicated. After implementing 50 times, Figure 1, and Figure 2 could be obtained. From the Figure 1, the standard deviation of portfolio is decreasing and converges to the line of standard deviation equal to 0.5. In the Figure 2, the light grey stands for the idiosyncratic risk, while the dark grey represents the systematic risk. It's clear that the systematic risk almost remains the same while the idiosyncratic risk keeps reducing in a trend like that of Figure 1. Comparing two figures, it could be found that 9 would be an appropriate number of stocks in order to well diversify the idiosyncratic risk from a portfolio, where standard deviation almost reaches its lowest and idiosyncratic risk could be neglected.

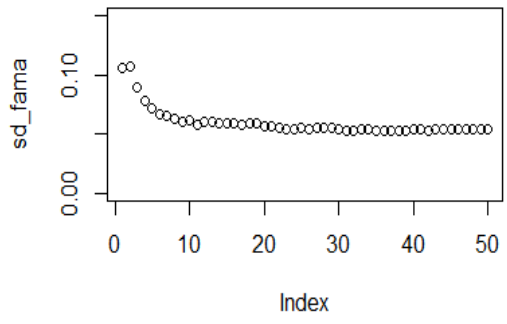

Figure 1: Standard deviation with increasing stocks in portfolio.

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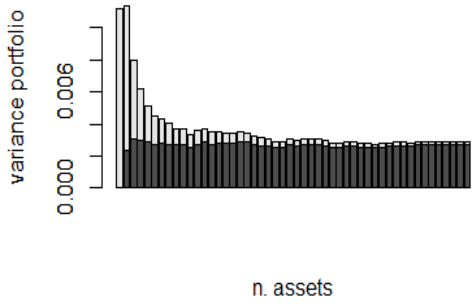

Figure 2: Distribution of idiosyncratic risk and system risk in total one.

Thus, 9 stocks would be randomly chosen to construct a portfolio in this paper. And they are China.Merchants.Bank.Co.Ltd, China.Unicom.Hong.Kong.Ltd, Tencent.Holdings.Ltd, Sands.China.Ltd, CK.Hutchison.Holdings.Ltd, Lenovo.Group.Ltd, BOC.Hong.Kong.Holdings.Ltd, MTR.Corp.Ltd, Link.Real.Estate.Investment.Trust, respectively.

2.3. Estimate Parameters and Check Assumptions

Then the underlying assumption of normality and IID would be checked. Before that, mean and standard deviation of each return should be worked out first. Intuitively comparing the plots of histogram and corresponding normal distribution, it can be figured out from Figure 3 that all of them fit not bad. Although some of them are not perfectly normally distributed after scrutinizing through QQplot as shown in Figure 4, a method comparing the quantiles of normal distribution and the test distribution, they could be assumed to be normal.

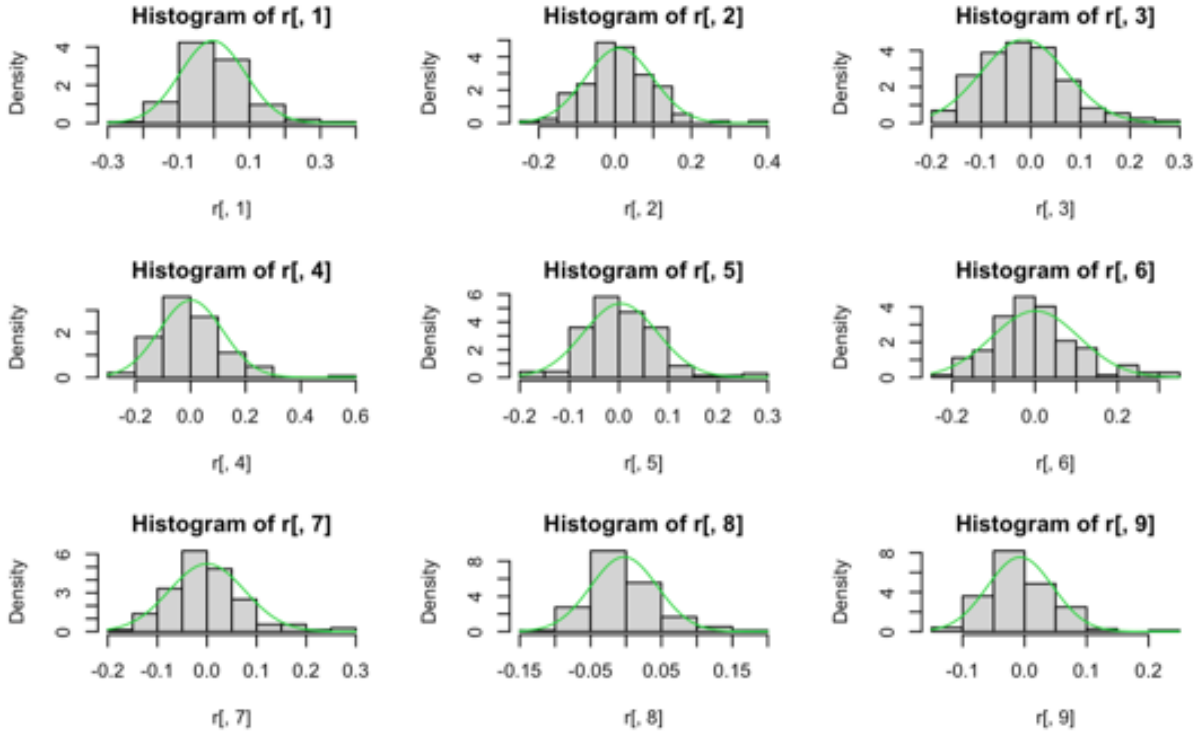

Figure 3: Histogram and normal curve of the 9 stocks.

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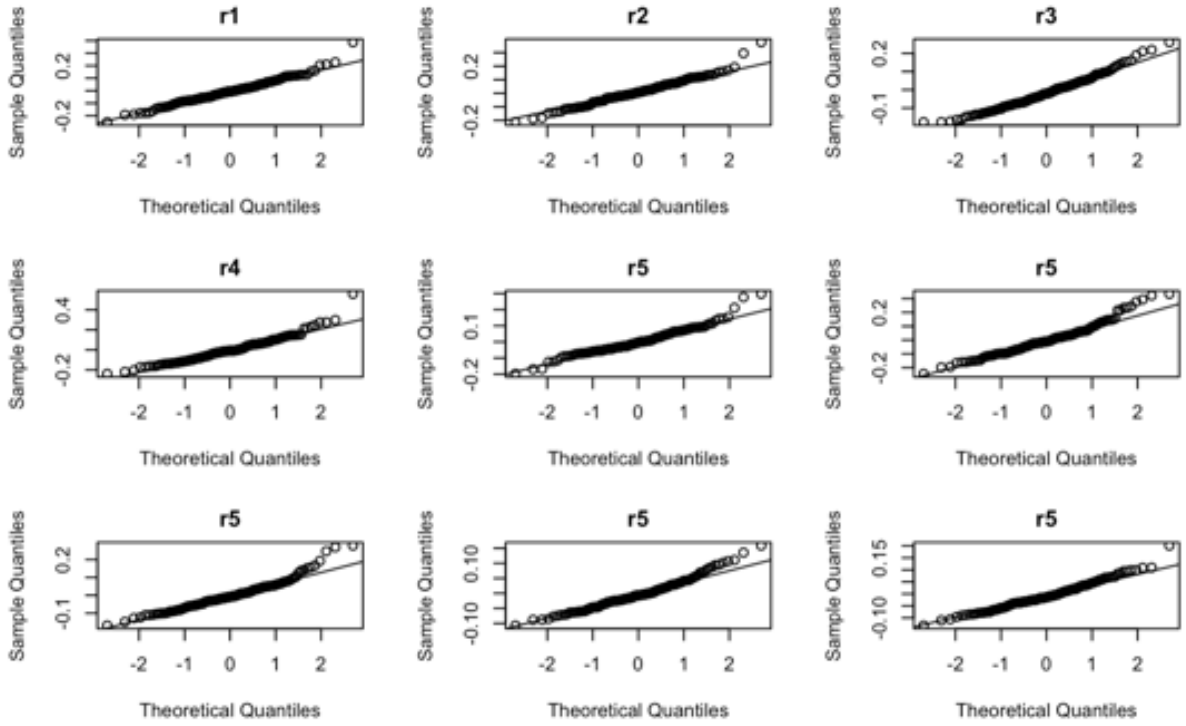

Figure 4: QQplot of the 9 assets.

Under normal assumption, IID would be checked by ACF. Showing in Figure 5, all roughly fit well except some with a few lags slightly exceeding the significance level. Generally speaking, the assumptions of normal distribution, independence and identical distribution are reasonable in the data.

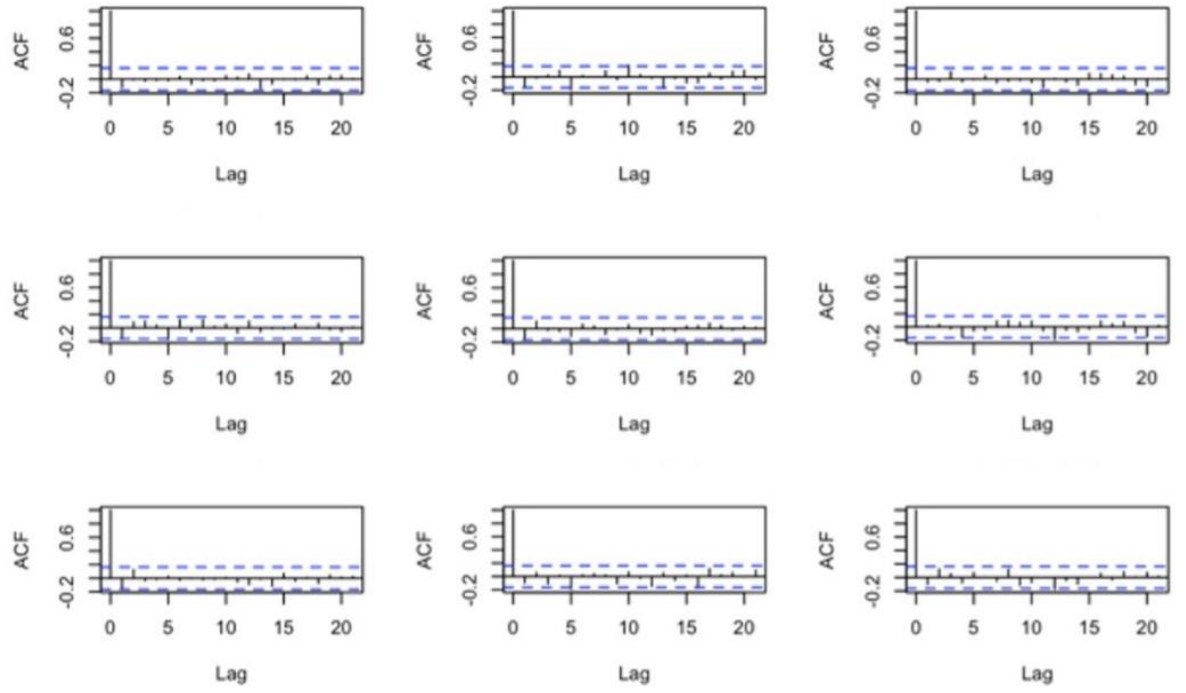

Figure 5: ACF of the 9 stocks.

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2.4. Portfolio Construction

Considering the case of short sell, the weights of stocks could be negative values, with the sum to be one. Then the function of the portfolio would be:

$$y_{without\ RF} = w_1 \times r_1 + w_2 \times r_2 + \cdots + (1 - \sum_{i=1}^{N-1} w_i) \times r_N \quad (2)$$

$$y_{with\ RF} = w_1 \times r_1 + w_2 \times r_2 + \cdots + (1 - \sum_{i=1}^{N} w_i) \times r_{rf} \quad (3)$$

$w_{1:N}$: Weights of $r_{1:N}$. Here N=9, $r_{1:N}$ are the returns of the 9 stocks mentioned in 2. Fama experiment respectively. Specifically, r_{rf} is the return of risk-free asset. Given 9 stocks, which would cause a huge amount of computation, "optim" function is applied to get the minimum variance portfolio, tangency portfolio and the highest return portfolio.

2.5. Minimum Variance Portfolio

There are two cases, without or with risk-free asset, taking account. And in this paper, a risk-free asset with yearly return 2% would be considered. After implementing the first situation on Rstudio, the minimum variance portfolio could be found out with standard deviation equal to 0.043, with the mean return of the portfolio being -0.005, however. And the weights assignment is as shown in Table 3, it seems that by constructing such a portfolio, minimum variance is accompanied by loss.

Table 3: Weights of 9 stocks in the minimum variance portfolio without risk-free asset.

Asset	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9
Weight	0.0078	0.0274	0.0923	-0.0143	-0.0417	0.0813	-0.0764	0.5917	0.3318
Mean					-0.005				
Sd					0.043				

It is obvious that the minimum variance would be 0 with risk-free asset, so some risk would be suffered to get a mean return of 0.005 in the second situation. The corresponding minimum variance portfolio could be found out with standard deviation equal to 0.009. And the weights assignment is as shown in Table 4, where r_9 holds the largest absolute value and is negative, which is the same in the Table 5.

Table 4: Weight distribution of 9 stocks in the minimum variance portfolio with risk-free asset.

Asset	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{rf}
Weight	-0.020	0.054	-0.088	0.005	0.064	0.007	0.029	0.007	-0.148	1.091
Mean					0.005					
Sd					0.009					

2.6. Tangency Portfolio

As for the two conditions of tangency portfolio, same as the above, the frontier and the efficient frontier of mean and standard deviation should be worked out first, then the portfolio with the largest Sharpe Ratio will be selected.

When risk-free asset is not included, the plot of frontier can be found in Figure 6. And the largest Sharpe Ratio is 0.303, with the weights listed in Table 5. It is shown that r_8 and r_9 account for the most positive and negative part respectively. It can be inferred that MTR is more stable and is relatively high in return, low in risk, while real estate investment trust being the opposite.

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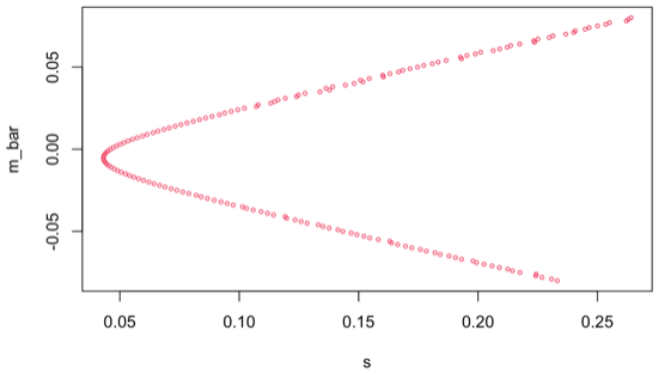

Figure 6: Frontier portfolios of 9 stocks without risk-free asset.

Table 5. Weight distribution of 9 stocks in the tangency portfolio without risk-free asset.

Asset	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9
Weight	-0.56	1.85	-2.40	0.10	1.83	0.53	0.62	2.30	-3.27
Largest Sharpe Ratio					0.303				

And when risk-free asset is included, the plot of frontier can be found in Figure 7. And the largest Sharpe Ratio is 1.268, with the weights listed in Table 6. Apart from the risk-free asset, the largest part, belonging to r_9, only takes an absolute value of 0.0148, which is still quite small.

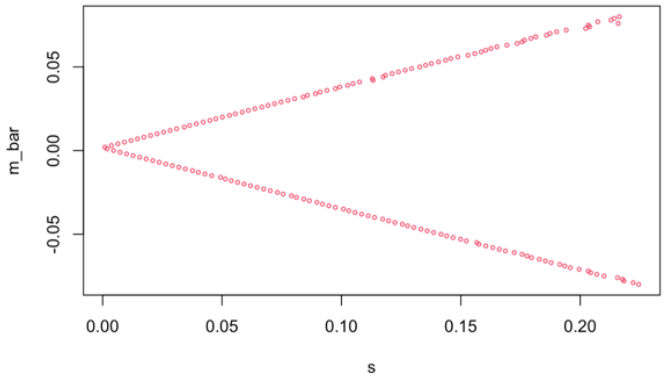

Figure 7: Frontier portfolios of 9 stocks with risk-free asset.

Table 6: Weight distribution of 9 stocks in the tangency portfolio with risk-free asset.

Asset	r_1	r_2	r_3	r_4	r_5
Weight	-0.0019	0.0056	-0.0087	0.0005	0.0059
Return	r_6	r_7	r_8	r_9	r_{rf}
Weight	0.0007	0.0031	0.0001	-0.0148	1.0094
Largest Sharpe Ratio	1.268				

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2.7. Highest Return Portfolio

"Optim" function would still be used here, but the negative value of mean return would be returned in the function "mean_p", since "optim" always calculate the minimal value. Due to the dramatically large weights would be given if no boundary is set, the lower and upper bound of weight would be set to be -5 and 5 respectively. Then the highest return without risk-free asset would be 0.330 with standard deviation being 1.623 and the corresponding weights are listed in Table 7, with r_3 and r_9 being positive only.

Table 7: Weight distribution of 9 stocks in the highest return portfolio without risk-free asset.

Asset	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9
Weight	500%	500%	-500%	500%	500%	500%	500%	500%	-2900%
Highest retrun	0.330								
Sd	1.623								

Table 8: Weight distribution of 9 stocks in the highest return portfolio with risk-free asset.

Asset	r_1	r_2	r_3	r_4	r_5
Weight	-500%	500%	-500%	-500%	500%
Return	r_6	r_7	r_8	r_9	r_{rf}
Weight	-500%	-500%	-500%	-500%	2600%
Highest retrun		0.239			
Sd		1.547			

And the highest return with risk-free asset would be 0.239 with standard deviation being 1.547 and the corresponding weights are listed in Table 8. There is no doubt that the largest part belongs to the risk-free asset, but it is stunning to find r_2 and r_5 still being positive, where r_2 is China Unicom Hong Kong Ltd and r_5 is CK Hutchison Holdings Ltd.

2.8. Minimum Variance Portfolio of Full Complete Dataset

Using similar method as above mentioned, the minimum variance portfolio without risk-free stock could be found out with standard deviation equal to 0.052, with the mean return of the portfolio being 0.002. And the weights of great importance, with an absolute value larger than 0.1, are as shown in Table 9.

Table 9: Important weights in the minimum variance portfolio without risk-free asset.

Asset	China.Mobile	Henderson.Land.Development	AAC.Technologies
Weight	0.1146510	-0.1754852	0.3975126
Mean return	0.002		
Sd	0.052		

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And the minimum variance portfolio with risk-free stock could be found out with standard deviation equal to 0.009, with the mean return of the portfolio set to be 0.005. And the weight of great importance, larger than 0.01 is as shown in Table . It's not surprising that the risk-free asset occupies majority of the portfolio, which almost reaches 90%. And among the remaining stocks, only AAC Technologies Holdings Inc occupies more than 0.002, which is the same situation as without risk-free stock.

Table 10: Important weight in the minimum variance portfolio with risk-free asset.

Asset	PetroChina	HSBC	China life	CNOOC	CITIC	Unicom
Weight	0.017	0.015	0.017	0.013	0.017	0.017
Return	New World	Hang Lung	Alibaba	Hengan	AAC	Risk-free
Weight	0.017	0.018	0.011	0.012	0.024	0.881
Mean return		0.005				
Sd		0.009				

2.9. Tangency Portfolio of Full Complete Dataset

Same method will be applied and when risk-free asset is not included, the plot of frontier can be found in Figure 8. And the largest Sharpe Ratio is 0.348, a little bit larger than that of 9-stocks portfolio, with the important weights listed in Table 11. It is not surprising that Hengan International Group Company Ltd owns the largest absolute proportion for its business field involving two major pieces of maternal and child hygiene products and household paper, where both are lucrative and relatively suffer less risk.

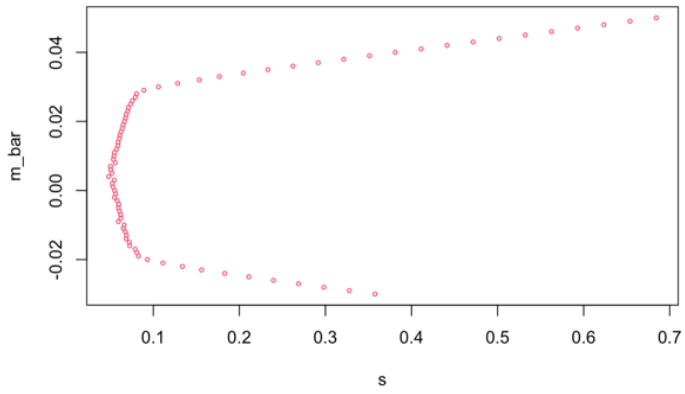

Figure 8: Frontier portfolios of 50 stocks without risk-free asset.

Table 11: Important weights in the tangency portfolio without risk-free asset.

Asset	China.Life.Insurance	CK.Hutchison	CLP
Weight	0.1795	0.1437	-0.1702
Return	Sunny.Optical	Hengan.International	AAC
Weight	-0.4639	0.6645	0.2556
Largest Sharpe Ratio	0.348		

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When risk-free asset included, the plot of frontier can be found in Figure 9. And the largest Sharpe Ratio is 1.585, a bit larger than that of 9-stocks portfolio, with the important weights listed in Table 12. Similar to the situation of minimum variance portfolio of full data set, the risk-free asset occupies majority of the portfolio, which is closer to 90%. Besides, as shown in Table 12, among the essential stocks, most of them only counts about 0.01, while only 1 of them account more than 0.02, that is China Life Insurance Co. Ltd.

Table 12: Important weights in the tangency portfolio with risk-free asset.

Asset	ICBC	CCBC	BOC	PetroChina	China Life	Sinopec	Sun Hung Kai
Weight	0.014	0.011	0.012	0.016	0.021	0.013	0.014
Return	CITIC	Unicom	Hang Lung	Alibaba	Hengan	AAC	Risk-free
Weight	0.019	0.020	0.011	0.011	0.013	0.015	0.894
Largest Sharpe Ratio	1.585						

3. Conclusion

This paper uses Fama experiment to get the number of 9 stocks to construct portfolios almost without the effect of idiosyncratic risk. Next, “optim” function in R language is used to figure out the most appropriate weight distribution of each construction. The results show that MTR.Corp.Ltd occupies the most in minimum variance portfolio and tangency portfolio of 9-stock, while AAC.Technologies and Hengan.International being the corresponding one in those of 50-stock respectively. Besides, Link.Real.Estate.Investment.Trust owns the largest absolute value in the 9-stock highest return portfolio.

However, this paper only works out the optimal one, which means all other possibilities are ignored and the sketch is not complete as a result.

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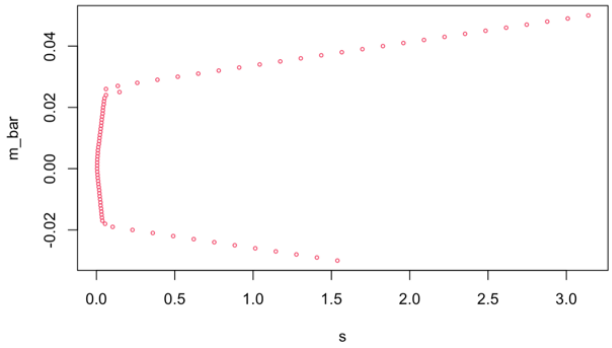

Figure 9: Frontier portfolios of 50 stocks with risk-free asset.

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