

Empirical Study on Portfolio Size and Risk Diversification: Take Stock Market in China as Example

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ABSTRACT

Stock market, as a hot investment market in the world today, has become the focus of rational investment by investors. It gives individuals, companies and society the chance to optimize their assets, whereas it also brings people who interested in this field a great risk. Thus, how to reduce the risk while maintain return is a significant issue. According to modern portfolio theory, reasonable portfolio of different kinds of assets can effectively reduce investment risk as well as maintain a certain return at the same time. This paper selects twenty different stocks from SSE 50 index as samples for this empirical analysis and takes monthly return of these twenty stocks from 2015-2019 as the study object. Based on the modern portfolio theory and Markowitz mean-variance model, this paper studies the relationship between stock portfolio in China and risk diversification and the degree of diversification. The results show that the risk of portfolio decreases as portfolio size increases; when the size enlarges to a certain degree, the change of risk tends to be stable, and when the portfolio size reaches twelve stocks, the diversification risk reaches 88.45%. Thus, in order to disperse portfolio's risk and safeguard a certain return, the ideal portfolio size should be limited to six to twelve stocks.

Keywords: stock market, mean-variance model, portfolio size, risk diversification

1. INTRODUCTION

Since the beginning of the industrial revolution, the stock market has played a significant role in the process of economic production. The role has grown stronger as the structure of the economy has grown more complex, especially since the 2008 financial crisis [1-4]. Today's stock market is a highly dynamic, innovative and perpetually responsive structure to the economic environment, as well as an important influence of the economic environment, creating opportunities and equal levels of risk for all participants. In recent years, with the vigorous development of China's domestic economy and the introduction of relevant national policies, stock has become an important issue in investment and is currently receiving much attention from the society in China. Every day, many individuals are directly or indirectly involved in the stock market by investing in funds with the hope of earning a higher return. In addition, for companies, they always raise capitals by offering issuing new shares to the public. In terms of

society, stock market can optimize the allocation of social resources to the greatest extent.

The importance of stock market and its benefits are obvious. However, stocks bring risks as well as benefits. For almost all companies and individual investors, stock price forecasting is one of the main tasks, but such forecasting is always difficult to be targeted accurately [5]. It is regarded as one of the most challenging issues caused by the fact that natures of stock prices are unstable and sensitive to external economic influences [6-7]. As a result, this sensitivity could bring huge fluctuations to stock prices, leading to the loss of individual funds, business failure, society bubbles and damage the whole economy. So, how to reduce the risk in stock investment process is an important topic. Theoretically speaking, risk of stock can be classified as either systematic risk or nonsystematic risk. Systematic risk is caused by risk factors that affect the whole market, such as changes in macroeconomic situation and changes in national policies, which cannot be avoided through diversified investment [8]. The only risk

therefore that can be reduced artificially is nonsystematic risk. The relationship between return and risk suggests that there is always a trade-off between these two items: more return is accompanied by high risk. Hence, analyzing the risk-return relationship has historically been the focus of all rationale investors [9]. The modern portfolio theory by Markowitz, who is the father of modern portfolio theory, completely illustrated the relationship between risk and return rate for any asset in the stock market. He stated that a portfolio rather than a single asset has the higher ability of dispersing the risk [10-11].

Thus, based on the theory developed by Markowitz, this paper will use empirical study to test the effectiveness of portfolios in reducing risk and producing a certain yield in stocks. In view of above background, considering that most investors lack of money, time, energy and resources, as well as the exitance of many kinds of costs and fees, in the construction of a stock portfolio, one can neither choose single stock that centralize investment and risk nor choose a portfolio that is large enough to leads to an excessive risk diversification. To decide which stock to buy, investors should be able to estimate average return and risk in each stock. This paper aims to figure out the relationship between portfolio size, return and risk, and therefore to study how investors can choose an optimal portfolio which can secure certain returns as well as reduce the risks faced by investors to a significant extent. The sample of the researchr, monthly return of twenty stocks in year 2015-2019 are randomly selected as the total research sample. And then we use Markowitz's mean-variance model to study the relationship between

portfolio size and risk diversification, which is to analyze how does the investment risk change with the number of stocks in the portfolio changes and to analyze the degree to which unsystematic risk can be reduced. The results show that as the number of stocks in a portfolio increases, risk decreases at the same time and that unsystematic risk can be reduced by 88.45% when the number of stocks reaches twelve.

This paper has meaning in terms of both theoretical importance and practical importance. As for the former, this paper quantitatively analyzes the impact of portfolio size on the degree of risk diversification to get the optimal economic return, and thus it provides theoretical guidance for new investors to enter the stock market. In terms of practical importance, this paper aims to obtain a portfolio which can ensure that investors can get a certain return at a lower and cost better avoid risk at the same time.

2. DATA AND METHODOLOGY

2.1. Sample data

In this study, we use data covering a period of 5 years from 01/01/2015 to 12/31/2019 [12]. The data contains opening price and closing price a month basis. We randomly select 20 listed companies from SSE 50 index, which is comprised of the most representative fifty stocks with large size and good liquidity. The summarized data can be seen in Table 1, which is the overview of individual stock in terms of its average return, variance and standard deviation, each of which is calculated on a month basis.

Table 1. Overview performance of 20 stocks.

	Stock Name	Stock Code	Opening price in 2015	Closing price in 2019	Average monthly return	Variance	Standard deviation
S1	Kweichow Moutai	600519	172.38	1183.00	0.0977	0.0617	0.2484
S2	Shanghai Pudong bank	600000	10.97	12.37	0.0021	0.0023	0.0480
S3	China Minsheng Bank	600016	9.07	6.31	-0.0051	0.0009	0.03000
S4	Sinopec	600028	6.49	5.11	-0.0035	0.0022	0.0469
S5	Southern Airlines	600029	5.16	7.18	0.0065	0.0177	0.1330
S6	CITICS	600030	33.90	25.30	-0.0043	0.0096	0.0980
S7	CMBC	600036	16.59	37.58	0.0211	0.0076	0.0872
S8	Poly Real Estate	600048	10.82	14.43	0.0056	0.0061	0.0781
S9	China Unicom	600050	4.95	5.89	0.0032	0.0026	0.0510
S10	Tongfang co.	600100	11.68	8.77	-0.0043	0.0075	0.0866

S11	SAIC	600104	21.47	23.85	0.0018	0.0069	0.0831
S12	Sinolink Securities	600109	19.79	9.30	-0.0088	0.0037	0.0608
S13	China Northern Rare Earth China	600111	17.25	10.84	-0.0062	0.0048	0.0693
S14	Merchants Securities	600999	28.27	18.29	-0.0059	0.0095	0.0975
S15	Kangmei Pharmaceutical	600518	11.79	3.73	-0.0114	0.0155	0.1245
S16	Shandong Gold	600547	10.13	23.30	0.0217	0.0097	0.0985
S17	Oriental Pearl	600637	29.14	9.36	-0.0113	0.0036	0.0600
S18	Haitong Securities	600837	24.06	15.46	-0.0060	0.0139	0.1179
S19	Inner Mongolia Yili	600887	14.31	30.94	0.0194	0.0079	0.0889
S20	Daqin Railway	601006	10.66	8.21	-0.0038	0.0025	0.0500

2.2. Methodology

We first evaluate the performance of each stock in terms of its average monthly return and variance, which is presented in Table 1. The monthly return is defined by formula,

$$R_{it} = \frac{P_{it} - P_{i(t-1)}}{P_{it}} \quad (1)$$

in which R_{it} is monthly return of the i th stock in the t th month, and P_{it} and $P_{i(t-1)}$ are closing price of the i th stock in the t th month and $(t-1)$ th month respectively. we report the result in Table 1. It can be found that nearly half of the companies had positive average monthly returns and the other half showed the opposite. Among 20 stocks, Kweichow Moutai received the highest return with a relatively low risk, whereas Kangmei Pharmaceutical had the lowest return and a higher risk.

According to Markowitz's mean-variance model, we can use each portfolio's expected return as its return and standard deviation as the risk faced by it. We calculate average return of the portfolio based on formula,

$$R_p = \sum_{i=1}^n R_i w_i \quad (2)$$

in which R_p is the average monthly return of the portfolio, R_i is the average monthly return of the i th stock, and w_i is the weight of the i th stock in the portfolio. To simplify the calculating process, we assume $w_i = 1/n$.

The standard deviation can be calculated through the following formula,

$$\sigma_p = \sqrt{\sum_{i=1}^n w_i^2 \sigma_i^2 + \sum_{i=1}^n \sum_{j=1}^n w_i^2 \rho_{ij} \sigma_i \sigma_j} \quad (3)$$

in which σ_p and σ_i are the standard deviation of the portfolio and the i th stock respectively, and ρ_{ij} is the correlation coefficient of stock i and stock j . The data of correlation between stocks can be found in Table 2, which is calculated by using SPSS analysis software.

Then, to find the optimal solution for the portfolio, we use the following method to develop portfolios with different size. We first randomly select two stocks from the twenty stocks to form portfolio P1 and calculate its average return and standard deviation. Next, we continue to enlarge the size of portfolio: P2 means four stocks are then selected, then P3 means six stocks are selected, then 8 stocks, until all twenty stocks were contained in the portfolio. Then we calculate average monthly return and standard deviation of portfolios with different sizes. The result is presented in Table 3.

In order to directly find out the relationship between portfolio yield, risk and its size, we present the data in Table 3 with curves presented in Figure1 and Figure2.

3. EMPIRICAL RESULTS

This section presents empirical results for individual performance of twenty stocks, correlation coefficient between different stocks as well as performance of portfolios with different sizes. When the income is certain, a rational person pursues the risk minimization; when risk is certain, a rational person pursues the maximization of profit. In reality, however, investors often face a situation in which returns and risks change in the same trend. Thus, the following results aim to find an optimal balance between return and risk.

Table 2. Correlation coefficient between different stocks.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
S1	1									
S2	0.671	1								
S3	0.946	0.643	1							
S4	0.75	0.063	0.096	1						
S5	0.258	0.62	0.197	0.054	1					
S6	0.838	0.198	0.798	0.852	-0.258	1				
S7	0.81	0.62	0.631	0.671	0.636	0.52	1			
S8	0.648	0.499	0.432	0.594	0.686	0.364	0.671	1		
S9	0.203	0.417	0.487	-0.054	0.222	-0.015	-0.12	-0.275	1	
S10	-0.778	-0.615	-0.597	-0.39	-0.025	-0.678	-0.647	0.654	0.234	1
S11	0.189	0.066	-0.124	0.376	0.203	0.206	0.596	-0.535	-0.859	-0.419
S12	-0.308	0.459	-0.181	-0.747	0.466	-0.707	-0.254	0.726	0.562	0.293
S13	-0.103	0.476	-0.252	-0.374	0.828	-0.569	0.379	-0.257	-0.136	-0.033
S14	-0.213	-0.442	-0.187	-0.462	0.842	-0.701	0.132	0.677	0.342	0.326
S15	0.634	0.341	0.372	0.462	-0.027	0.639	0.661	0.503	-0.575	-0.92
S16	-0.658	-0.1553	-0.677	-0.929	-0.346	-0.643	-0.705	-0.65	-0.148	0.177
S17	0.653	0.808	0.423	0.172	0.346	0.33	0.238	0.128	0.825	-0.343
S18	-0.521	0.27	-0.451	-0.848	0.456	-0.878	-0.32	-0.25	0.317	0.405
S19	0.196	0.529	-0.036	-0.034	0.806	-0.224	0.677	0.783	-0.33	-0.334
S20	0.043	0.076	-0.106	0.261	0.779	-0.218	0.585	0.738	-0.263	0.153

To be continued,

	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
S11	1									
S12	-0.559	1								
S13	0.347	0.571	1							
S14	-0.138	0.823	0.85	1						
S15	0.72	-0.535	0.055	-0.422	1					
S16	-0.267	0.505	0.164	0.131	-0.218	1				
S17	-0.539	0.418	-0.003	0.242	-0.025	-0.277	1			
S18	-0.377	0.651	0.681	0.854	-0.539	0.609	0.127	1		
S19	0.635	0.238	0.816	0.617	0.41	-0.092	-0.019	0.338	1	
S20	0.599	-0.028	0.665	0.545	0.0047	-0.48	-0.232	0.112	0.74	1

Once obtaining correlation coefficient, we can calculate standard deviation of each portfolio. From the method we use to build portfolios, we can get ten portfolios with different sizes, and we represent each portfolio with a serial number. The second and third column shows average monthly return and standard

deviation of each portfolio. The fourth column shows the amount of return increased from the previous portfolio, and the last column gives information about the amount of risk decreased from the previous portfolio.

Table 3. Performance of portfolios with different sizes.

	Average monthly return	Standard deviation	Return increased	Risk decreased
P1	0.0499	0.1286		
P2	0.0229	0.0855	-0.0270	0.0431
P3	0.0156	0.0741	-0.0073	0.0114
P4	0.0150	0.0642	-0.0005	0.0099
P5	0.0119	0.0554	-0.0031	0.0088
P6	0.0094	0.0483	-0.0026	0.0071
P7	0.0072	0.0448	-0.0022	0.0035
P8	0.0069	0.0391	-0.0003	0.0057
P9	0.0052	0.0367	-0.0017	0.0024
P10	0.0054	0.0343	0.0003	0.0024

Based on data summarized in Table 3, we draw two graphs: Figure 1 shows average return and standard deviation of ten different portfolios, and Figure 2 shows

the change amount of return and standard deviation compared with previous portfolio.

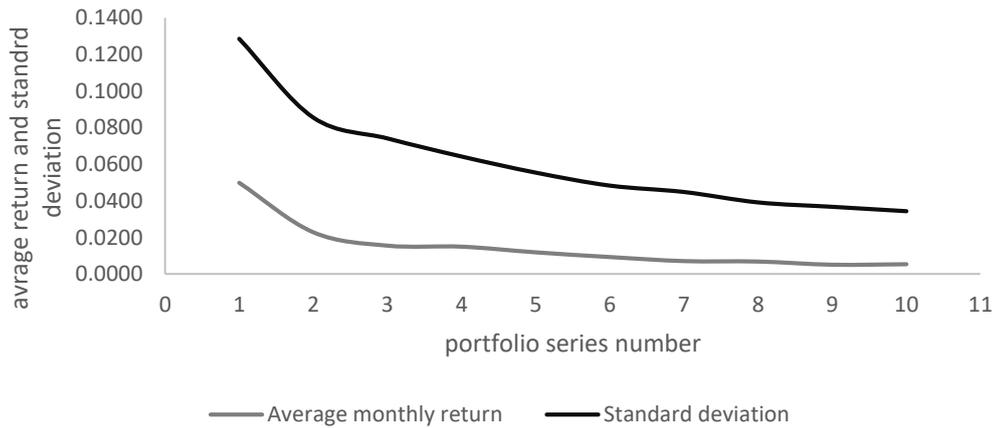


Figure 1. Average return and standard deviation of portfolios.

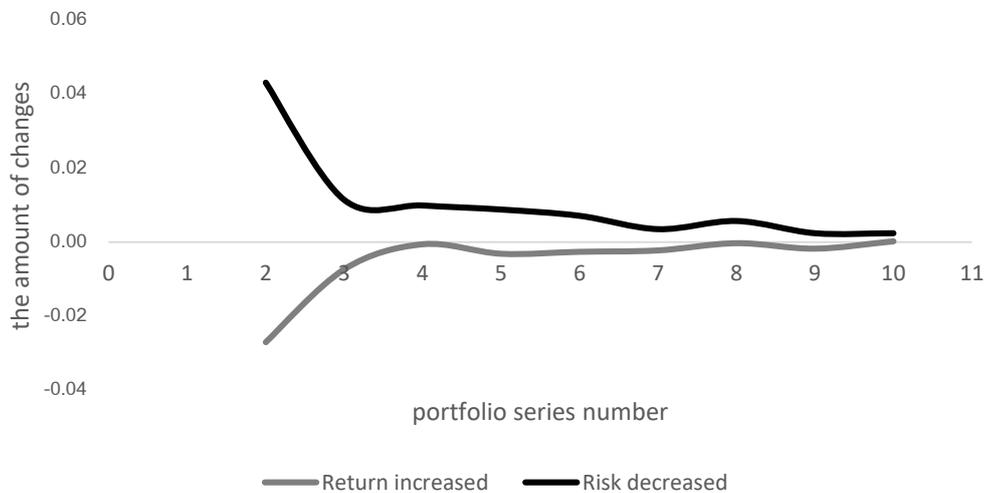


Figure 2. Amount of return increased and risk decreased of portfolios.

From Fig.1 we can find that, average return of portfolios is all positive no matter what the portfolio's size is, but as portfolio's size expands, the yield has a trend of first declining and then flattening, while standard deviation of portfolio experiences the same trend. Although returns and risks have been in a downward trend, the rate of decline slows down and tends to stable.

Looking at details of Figure 2, we can see that when the number of stocks in portfolio increases from two to four, portfolio's return has the biggest decreased amount. Then, when the number of stocks in portfolio increases from four to twenty, the change amount of portfolios' return generally fluctuates a little and finally tends to stable. As for standard deviation, when the number of stocks in portfolio increases from two to four, the reduced amount of risk reaches the highest, at 0.0431; when the number of stocks in portfolio increases from four to twelve, the decline in standard deviation account for 88.45% of the total reduced amount. After that, the change in the decline in the standard deviation gradually decreases and becomes stable.

4. CONCLUSIONS

In this paper, we use twenty stocks from a period of 2015-2019 to analyze the relationship between risk diversification and size of portfolios. It can be found that developing portfolios has an important effect in reducing the stock risk, but this result doesn't provide strong evidence that portfolio increases returns. The result shows that as the number in a portfolio increases, the risk decreases dramatically at first and tends to stable later, and when number of stocks in a portfolio reaches twelve, the risk that can be spread has reached 88.45%. In addition, the return of the portfolio decreases compared with a single asset, but its return continues to rise again as portfolio size enlarges. Thus, investors can spread their risk by developing portfolios instead of individual asset and by increasing the number of stocks in the portfolio. Furthermore, a reasonable investment scale should not exceed twelve, at which the risk can be dispersed majority and the return can be maintained on a certain level.

Therefore, the sample selected are the most representative stocks, meaning it is not enough to reflect the whole stock market. Besides, the research of this paper is based on the market data which occurs after the event. Because the capital market is affected by many factors, the research has a certain time lag. Therefore the domestic market is greatly affected by the overall environment and the application of research results is more dependent on the trend of the overall environment. Thus, this paper leaves a more detailed analysis in the future research.

AUTHOR'S CONTRIBUTION

This paper is finished independently by the author in terms of the idea, data, methodology and empirical results.

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