Data Analysis of Effective Frontier of The Shanghai and HongKong Stock Market in Different Periods

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Abstract—To demonstrate the risk and yield changes of the Shanghai and Hong Kong stock market in different periods, effective frontier computing model of the stock market was founded by comparing the historical data of more than 20 composite indices of the Shanghai-Hong Kong stock market, each four stock indices were selected as the research object, the two effective frontier curves were drawn, and the effective frontier curves of the Shanghai-Hong Kong stock market were compared with the change of the expected rate of return in 2010-2019. The results showed that with the increase of investment risk, when the investor's willingness to invest in a risky portfolio gradually increased, the expected return rate in the Shanghai stock market was higher than that of the Hong Kong stock market, the investment value was higher in general. The effective frontiers comparison of the two stock markets in 2010-2013 and 2016-2019 showed that the investment risk of the Shanghai-Hong Kong Stock Exchange decreased after the opening of Shanghai-Hong Kong Stock Connect.

Keywords-data analysis; effective frontier; the Shanghai and Hong Kong stock market; stock index

1. INTRODUCTION

With the integration of the global economy, China has accelerated the process of internationalization of the capital markets, Shanghai-Hong Kong Stock Connect, Shenzhen-Hong Kong Stock Connect, and Shanghai-London Stock Connect had been opened and achieved interconnection relationship among the mainland capital market, China's Hong Kong and the world market [1]. On the one hand, the capital accommodation measures promoted the process of internationalization of the A-share market and RMB, on the other hand, the considerable fluctuation of foreign regional finance also affected the income situation of the domestic capital market. The correlation among capital markets directly affected the benign development of China's financial markets, as well as the asset allocation, investment optimization, and risk control of investors in related fields. Domestic scholars had studied the problems among capital markets after capital financing and achieved some results. Zhou Chun ping presented countermeasures such as liberalizing the entry threshold of the Shanghai-Hong Kong Stock Exchange and perfecting the trading system to narrow the A-H share price difference [2]. Feng Yongxuan used the binary GARCH-BEKK model to analyze the Shanghai-Hong Kong Stock Connect after the implementation of the two cities to enhance the linkage effect, volatility spillover effect of the Shanghai stock market on the Hong Kong stock market significantly enhanced [3]. Fang Yan considered the interconnection of nonlinear

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dynamics between the stock markets and the sudden changes in the linkage process and used t-Copula to capture the characteristics of asymmetric tail dependence between the financial markets [4]. These studies focused on the correlation between the Shanghai and Hong Kong stock markets and the impact of interconnection on the Shanghai-Hong Kong stock prices after the Shanghai and Hong Kong Stock Connect, the investment risk and income status of the Shanghai and Hong Kong stock market in the past decade were less researched, the effective frontier was taken as the index in this paper, the risk and yield changes of the Shanghai and Hong Kong stock market were analyzed, the research's aim provided a certain reference for investors how to enter the Shanghai-Hong Kong stock market.

2. EFFECTIVE FRONTIER COMPUTING MODEL

Effective frontier is defined as the effective set of portfolios that can meet both the highest yield at the same risk level and the lowest risk at the same expected rate of return level, the effective frontier is derived from Markowitz's portfolio theory. Effective frontier solving is to meet these two constraints. The ratio coefficient of the combination is selected to minimize the variance of the combination [5].

If the stocks in the Shanghai and Hong Kong stock markets met the basic assumptions, the following secondary planning problems were effectively advanced.

$$\min_{x} \sum_{i=1}^{8} \sum_{k=1}^{8} x_i \, x_k \sigma_{ik} \tag{1}$$

$$\sum_{i=1}^{8} x_i \, \overline{r_i} = p \tag{2}$$

$$s.t. \begin{cases} \sum_{i=1}^{8} x_i \, \overline{r_i} = p \\ \sum_{i=1}^{8} x_i = 1, i = 1,2, \dots ,8 \\ x_i \geq 0, i = 1,2, \dots ,8 \end{cases} \tag{3}$$

where, x_1, x_2,..., x_8 is the investment weight of each stock index at the time of investment average annualized return in 2019, σ_{ik} is the co-variance between the stock index i and the stock index k, when $i = k$, the σ_{ik} represents the variance of the stock index i, p is the lowest acceptable rate of return.

The closing prices of the eight stock indices of the Shanghai-Hong Kong stock market for 2010-2019 were included in the table, and the expected annualized return $E(R_p)$ of each stock index was calculated separately.

The daily yield R for the stock index is.

$$R = \frac{P_t - P_y}{P_t} \tag{4}$$

The average daily return on a stock index is

$$\overline{R} = \frac{\sum_{i=1}^{n} R_i}{n} \tag{5}$$

The annualized yield Y of the stock index is

$$Y = (1 + \bar{R})^N - 1 \tag{6}$$

The standard deviation σ for the daily rate of return on a stock index is

$$\sigma = \sqrt{\frac{\sum_{t=1}^{n}(R_i - \bar{R})^2}{n-1}} \quad (7)$$

The annualized standard deviation σ_P for stock indices is

$$\sigma_P = \sigma \times \sqrt{N} \quad (8)$$

where, P_t is the today's closing prices of the stock index,P_y is the yesterday's closing prices of the stock index,$\bar{R}$ is the average daily return rate of a stock index, R_i is the daily return rate of a stock index in the *i*-th day, n is the exchange day number of the stock index, *N* is the exchange day number of the stock index in one year in the Shanghai-Hong Kong stock market, its value is calculated according to real exchange day number in one year between both markets respectively.

For each given yield *p*, the corresponding $\sigma_P$can be solved, each pair (σ_P, *p*) constitutes a coordinate point on the standard deviation-expected rate of return graph, by adjusting the parameter *p*, to obtain an optimal or effective portfolio, that is an effective frontier [6].

3. Data Selection And Calculation

3.1 Data Selection

To analyze the risk and yield of stocks, the following three principles were followed in the selection data [7]: (1) The data with a more upward trend in historical performance data was selected. (2) The stock composite index was used to characterize the overall performance changes and macro correlation between Shanghai and Hong Kong stock markets. (3) Comprehensive indices with relatively large fluctuations in trend were chosen.

Based on the above principles, the historical data of more than 20 composite indices of the Shanghai-Hong Kong stock market were compared, the four stock indices of the Shanghai Stock Exchange were selected: the Shanghai Composite Index (000001), the Shanghai Super-000043, the Shanghai 180 Index (000010) and the Shanghai 50 Index (000016), and the four stock indices of the Hong Kong Stock Exchange: Hang Seng Index (HSI), Hang Seng Hong Kong 35 Index (HSHK35), Hang Seng Hong Kong China Enterprises Index (HSCCI) and the Hang Seng Property Classification Index (HSPI) were used to characterize changes in the Shanghai and Hong Kong stock markets. The raw data were the daily closing prices of each stock index in the period of 2010-2019, of which the Shanghai Stock Exchange's index data were derived from SINA Finance, the Hong Kong Stock Exchange's index data were from WIND Financial Terminals, and the data collection and processing time was March 2020.

3.2 Parameter Calculation

To study the effective frontiers of the Shanghai-Hong Kong stock market, it needed to calculate the annualized expected return, annualized variance, and annualized standard deviation of the selected stock indices in the Shanghai-Hong Kong stock market, and the average annualized return, annualized variance, and annualized standard deviation of the four stock indices in Shanghai and Hong Kong were shown in Table 1 and 2 respectively. From the data in Table 1, since 2010, the Shanghai stock market's stock had been at a relatively high level of annualized return, the average annualized yield remains at about 6.7%, for a long time, the asset risk of stocks was also at a relatively high level, the average annualized variance remained at about

0.0772. As can be seen from the data in Table 2, the annualized return rate of stocks in Hong Kong stock market had been at a relatively low level for a long time, with the average annualized return rate remaining at about 2.0%. The asset risk of stocks had also been at a relatively low level, with the average annualized variance remaining at about 0.0288.

TABLE 1. THREE PARAMETERS OF THE FOUR SHANGHAI STOCK INDICES

	000001	**000043**	**000010**	**000016**
annualized rate of return	6.62%	4.92%	6.88%	8.52%
annualized variance	0.0594	0.0705	0.0830	0.0959
annualized standard deviation	0.2437	0.2654	0.2881	0.3097

TABLE 2. THREE PARAMETERS OF THE FOUR HONG KONG STOCK INDICES

	HSPI	**HSI**	**HSHK35**	**HSCCI**
annualized rate of return	2.28%	1.72%	3.15%	0.98%
annualized variance	0.0352	0.0260	0.0236	0.0304
nnualized standard deviation	0.1875	0.1611	0.1536	0.1743

4. EFFECTIVE FRONTIER ANALYSIS

4.1 Effective Frontier Change

In the case of the same sample data, assuming different expected yield *p*, using the yield and variance data of each stock index, the combined points of the model's ten earnings and standard deviation were obtained, with the annualized standard deviation as the horizontal axis, the expected yield as the vertical axis, and the effective frontier of the Shanghai and Hong Kong stock market were shown in Figure 1 and Figure 2 respectively. From the curve shown in Figure 1, it showed that the minimum risk differential of the Shanghai Stock index was 0.156, and the annualized yield was 2.06%. The curve shown in Figure 2 indicated that the minimum risk differential of the Hong Kong stock index was 0.143, and the annualized yield was 2.33%. All these demonstrated that when the minimum risk was set in the Shanghai and Hong Kong stock markets, the expected yield was higher in the Hong Kong stock markets. When investors chosen the least risky portfolio to invest in, it was more appropriate to invest in the Hong Kong stock market.

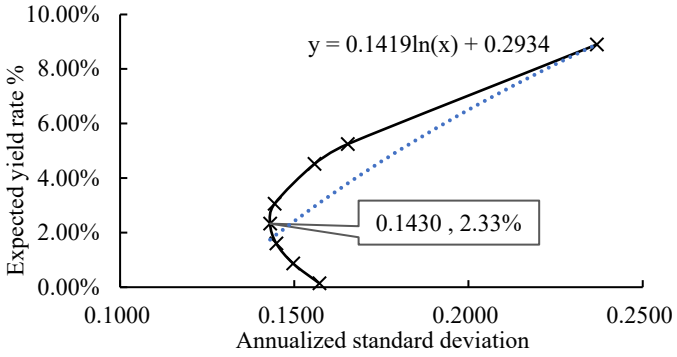

Figure 1. The effective frontiers of the four composite indices of the Shanghai stock market

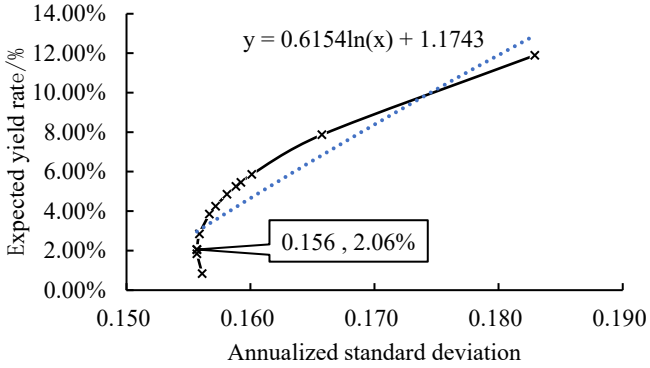

Figure 2. The effective frontiers of the four composite indices of the Hong Kong stock market

In Figure 1 and Figure 2, the effective frontier of the minimum annualized standard deviation was changed significantly in the first half, with the standard deviation of the portfolio increased, its expected yield also increased, there was a difference in the expected rate of return increases, the two effective frontier curves were fitted with the number function, The effective frontier curve of Shanghai stock market could be fitted to y=0.6154ln(x)+1.1743, and the effective frontier curve of the Hong Kong stock market could be fitted to y = 0.1419ln(x)+0.2934, compared with the slope of the two fitting functions, when the standard deviation gradually increased, the expected yield of the Shanghai stock market increased even more.

4.2 Effective Frontier in A Long Period

To analyze the different degrees of the effective frontiers between the Shanghai and Hong Kong stock markets, the comparison of the effective frontier curves of the Shanghai and Hong Kong stock markets for the period 2010-2019 was shown in Figure 3. Starting at the higher point of the standard deviation, the expected yield on the Shanghai stock market had been higher than the expected yield on the Hong Kong stock market. As the standard deviation fell, the expected yields of the two markets approached, with the two curves interchanging at (0.1579, 4.73%), i.e., the standard deviation of 0.1579 and the expected yield of 4.73%, after which, the expected yields in Shanghai remained below the expected yields of the Hong Kong market. When

investors were willing to bear the annualized standard deviation of 0.1579 or more, the Shanghai stock market had a high return on stock returns, when investors were willing to bear the annualized standard deviation of 0.1579-0.156, the Hong Kong stock market was better, and when investors could only bear the annualized standard deviation of 0.143-0.156, they could only invest in the Hong Kong stock market.

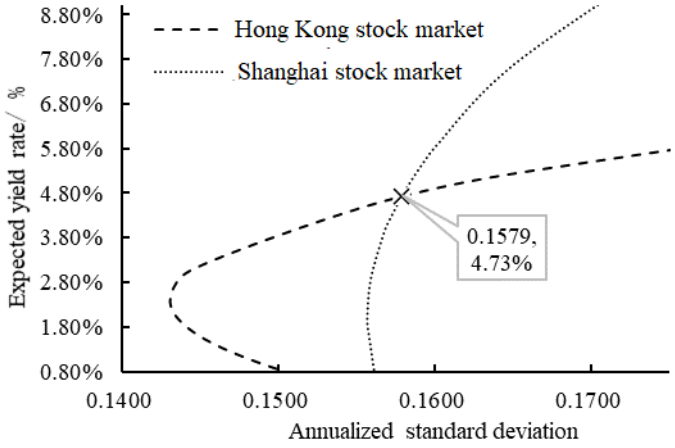

Figure 3. An effective frontier comparison of the Shanghai-Hong Kong stock market

4.3 Effective Frontier in A Short Period

Domestic financial policy and capital market reform directly affected the stock market changes, especially after the Shanghai-Hong Kong Stock Connect, Shenzhen-Hong Kong Stock Connect, the Shanghai-Hong Kong stock market had changed. As the Shanghai-Hong Kong Stock Connect in 2014 was opened, the Shanghai market was shocked by the IPO registration system reform and the central bank ten downgrades and other events in 2015, the data of these two years were excluded, the same length of time period data was selected for measurement analysis, The stock indices of the Shanghai and Hong Kong stock markets were selected in the period of 2010-2013 and 2016-2019, the changes in the effective frontiers of the Shanghai-Hong Kong stock market were analyzed after the Shanghai-Hong Kong Stock Connect, in order to illustrate the correlation of the Shanghai and Hong Kong stock markets in a number of a short period. The effective frontiers of the Shanghai and Hong Kong stock markets for 2010-2013 and 2016-2019 were shown in Figure 4 and Figure 5, respectively.

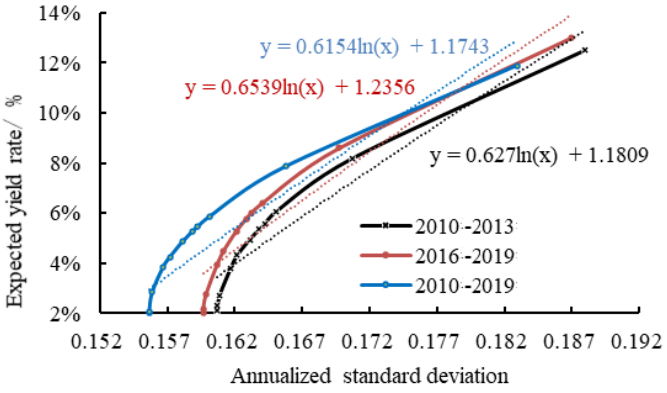

Figure 4. Effective frontier comparison of the Shanghai stock market in different periods

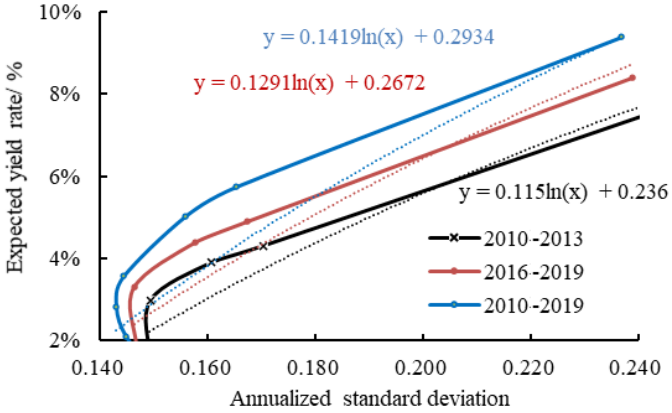

Figure 5. Effective frontier comparison of the Hong Kong stock markets in different periods

As can be seen from Figure 4, the minimum standard deviation of the inflection point in the effective forward curve in Shanghai was 0.161 and 0.160, respectively, and the minimum annualized yield was 2.10% and 2.15%, respectively, before and after the opening of the Shanghai-Hong Kong Connect. The slope of the effective frontier fitting function is 0.627 and 0.654, respectively. It indicated that the lowest risk value in Shanghai was reduced, but the yield is higher, and the yield was expected to increase by a larger margin. As seen from Figure 5, the minimum standard deviation of the effective frontier curve inflection point in the Hong Kong stock market was 0.149 and 0.146 in 2010-2013 and 2016-2019, respectively, with a minimum annualized yield of 2.48% and 2.80%, respectively. The slope of the effective frontier fitting function is 0.115 and 0.129, respectively, and it showed that the lowest risk value of the Hong Kong stock market was lower, but the yield was higher, and the yield was expected to increase by a larger margin. Compared the gap between the slope of effective frontiers fitting functions for 2010-2013 and 2016-2019, the gap in the Shanghai stock market had been significantly shortened, i.e., the stock investment income and benefits of the Shanghai stock market had increased significantly, and investors had chosen to invest in the Shanghai market at a higher

value than before. To sum up, after the opening of the Shanghai-Hong Kong Stock Connect, the investment risk of wo stock markets had decreased, but the investment income had increased on the basis of the original, it indicated that the opening of the Shanghai-Hong Kong Stock Connect had made the investment value of the two places stocks significantly increase, that is also the opening of the Shanghai-Hong Kong Stock Connect promoted the interconnection of the financial markets of the two places, and played a positive role to accelerate the internationalization of the RMB [8].

5. CONCLUSION

(1) In the long period of 2010-2019, the effective frontier analysis of the Shanghai-Hong Kong stock market indicated that the Shanghai-Hong Kong stock market effective frontier difference was large when the Shanghai-Hong Kong stock market is in the lowest risk situation, the Hong Kong stock market risk was lower and returns higher. As portfolio risk increased, so does the expected yield, which differs in the range of expected returns, and the Shanghai stock market increased even more, and as portfolio risk increased, the expected return of the Hong Kong stock market was higher.

(2) Before and after the opening of the Shanghai-Hong Kong stock connect, the two periods of 2010-2013 and 2016-2019 were selected to analyze the effective frontiers of both the stock markets. It showed that after the opening of the Shanghai-Hong Kong Stock connect, the investment risk of the Shanghai and Hong Kong Stock exchange decreased, the investment income increased on the original basis.

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