Big data analysis of the effectiveness for capital asset pricing model under COVID-19

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Abstract. In 2020, the novel coronavirus outbreak in China and rapidly spread around the world, causing a great impact on the economies of all countries, but also brought great uncertainty to the global financial market. The epidemic may not only trigger a crisis of supply, investment and supply chain disruption, but also further spread to the financial market, exacerbating systemic risks in the financial market and having a certain impact on the pricing of various types of assets. On this basis, this study conducts an empirical study on stock pricing under the influence of COVID-19 based on capital asset pricing model model to explore its effectiveness. To be specific, this paper selected two representative stocks from five different industries, namely medical care, catering, agriculture, tourism, and automobile, and used their returns from 2015 to 2019 for regression analysis, so as to predict the returns during the epidemic period and judge the effectiveness of the capm model during the epidemic period. These results shed light on guiding further exploration of assets pricing model.

1 Introduction

In the development of modern market economy, the pricing of securities market is also one of the core issues in the study of financial economics [1]. In 1952, Markowitz published Portfolio Selection Effective Diversification of Investment, which explained and elaborated the modern portfolio theory in detail [2]. Later, Sharpe found the relationship between stock return rate and stock systemic risk on the basis of Markowitz model [3]. The outbreak of COVID-19 in China in 2020 and its rapid spread around the world have had a great impact on the economies of all countries and brought great uncertainty to the financial markets. The epidemic may not only lead to the crisis of supply, investment and supply chain disruption, but also may be further transmitted to the financial market, exacerbate the systemic risk of the financial market, bring a certain impact on the pricing of various types of assets, and add various countermeasures of countries [4-6]. For example, under the quantitative easing liquidity in the United States, the valuation of financial assets has risen sharply, so the stock market has four circuit breaks. Tourism, catering and other industries have been greatly affected by the epidemic, and their stock prices will fluctuate greatly. At the same time, the pharmaceutical and biotechnology industries are attracting attention because of the research and development of vaccines and treatment solutions, and the stock price will be greatly affected. The uncertainty and rapid change of the epidemic can lead to fluctuations in investor sentiment, which can trigger fluctuations or declines in the stock market. Therefore, the study on the effectiveness of individual stocks of enterprises in different industries in asset pricing during the epidemic can provide investors with some references for the fitting degree of CAPM model, and also has significance for the development of enterprises and the impact on the macro economy [7-10].

The capital asset pricing model is based on a series of assumptions about investors and the market, and through rigorous theoretical derivation, the risk-return equilibrium relationship between assets and asset portfolios is obtained. Over the years, many scholars have conducted empirical analysis and theoretical research on the effectiveness of CAPM model in China's stock market, which has played a certain role in promoting the development of China's stock market. Therefore, this paper also conducts empirical research on stock pricing under the influence of COVID-19 based on CAPM model to explore its effectiveness.

2 Data & Method

In this paper, 2 representative stocks are selected from each of five different industries, namely medical care, catering, agriculture, tourism and automobile. Eviews software is used to analyze the stock returns of these 10 stocks in a total of 20 quarters from January 2015 to December 2019, and the least square linear regression is performed to estimate β. Then put β into the CAPM formula to calculate the return rate of 12 quarters in the

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three years from 2020 to 2022, compare the predicted value and the actual value, and test the regression result by MSE model.

2.1 Data source and retrieving

In order to study the effectiveness of CAPM asset pricing model under COVID-19, In the pharmaceutical industry, manufacturing, agriculture, catering, tourism these representative industries selected 10 stocks 600276 Hengrui Medical, 600196 Fosun Pharmaceutical, 600104 SAIC Motor, 601633 Great Wall Motor, 600598 Beidhuang, 600965 Fucheng Shares, 600754 Jinjiang Hotel, 60100 7 Jinling Hotel, 600138 CYTS, 600749 Tibet Tourism. The time span is 8 years from 2015 to 2022. Due to the long time span, this paper takes quarterly as the analysis period and quarterly return rate as the analysis variable. The data is derived from the daily k line of the relevant stocks on the flush website, and its data is exported in Excel form, and then the opening and closing prices of each quarter are found. Take the first quarter of 2015 as an example: the opening price of the first quarter is the opening price of the day on January 1, 2015, and the closing price of the first quarter is the closing price of the day on March 31, 2015. If there is no data at the beginning and end of the quarter, the corresponding data is selected for the date closest to the beginning and end of the quarter. The obtained data were divided into two groups. The first group selected the yield data spanning from January 2015 to December 2019 as the training set, carried out the OLS least square method, established the one-dimensional linear regression equation between the quarterly return rate of individual stocks and the quarterly return rate of the market, and obtained the β value and R2 in the regression results of each stock. The second group selected the return rate from January 2020 to December 2022 as the test set, and substituted the β in the regression result of the first group of data into the CAPM model to predict the predicted return rate in each quarter. Finally, the MSE model is used to analyze the quarterly forecast rate of return and the actual rate of return in the second group. Through the analysis results, the effectiveness of CAPM model in asset pricing under COVID-19 is analyzed.

2.2 CAPM model

Capital pricing model is a kind of equilibrium pricing theory of risk assets, mainly studies the relationship between the expected return of assets and risk assets in the security market, and how the equilibrium price is formed.

$$E(r_i) = r_f + \beta_i[E(r_m) - r_f] \quad (1)$$

Here, $E(r_i)$ represents the expected rate of return of a single security, $E(r_m)$ represents the expected rate of return of a market portfolio, r_f represents the risk-free interest rate, and β_i represents the β coefficient of i security. By transposition of the above formula, the standard form of the CAPM model under the risk-free interest rate condition is:

$$E(r_i) - r_f = \alpha + \beta_i[E(r_m) - r_f] \quad (2)$$

where $E(r_i)$-r_f represents the risk premium of i securities, $E(r_m)$-r_f represents the risk premium of market asset portfolio, α is the intercept term, that is, the error term of pricing. It can therefore be seen that β_i can be used as a correlation coefficient between the two parts of the risk premium. The model can be interpreted as determining the expected rate of return by analyzing the correlation between a single security or portfolio and a capital market portfolio. In the equilibrium state, the risk β_i of an asset held by an investor can be regarded as the systemic risk of the asset. Therefore, the meaning of the CAPM model is that the expected return rate of any asset i is equal to the risk-free return rate r_f plus the risk premium, that is, the beta coefficient of asset i is multiplied by the risk premium per unit β.

2.3 Setting of variables

The risk-free rate of return data used in this paper comes from the yield rate of national debt with three-month maturity in China, which is exactly matched with the time interval of quarterly stock return rate selected in this paper. The Shanghai Composite Index can accurately reflect the development trend of the stock market and has good market representation. As a value-weighted index, it also meets the requirements of CAPM model on the structure of market mix. In addition, the 10 samples of individual stocks selected in this paper are all traded on the Shanghai Stock Exchange, so the market return rate is represented by the return rate of stocks in the Shanghai Composite Index and its quarterly return rate is calculated. E(r_m) is the market portfolio yield at t.

3 Results and discussion

Using the least square method (i.e., the first phase of data according to the Eq. (2)) the beta coefficient of each strand was obtained by regression, as shown in Table 1. The estimated β value of the return of 10 stocks is between 0.76 and 1.77, and the β value of 6 stocks is greater than 1, indicating that there is an obvious positive correlation between the return rate of selected stocks and the market return rate. This indicates that before the COVID-19 epidemic, when the market rose, the return rate of stocks also rose; When the market goes down, the return of the stock also goes down, and the decline of the stock with a β coefficient greater than 1 is greater. Based on the β coefficient of individual stocks in Table 1, the data for the second period, the COVID-19 period,according to$E(r_i) = r_f + \beta_i[E(r_m) - r_f]$ to predict and analyze,and obtain the predicted returns of each stock, as shown in Table 2.

As can be seen from Table 2, at the beginning of COVID-19, the forecasted quarterly returns of the selected stocks except Hengrui Pharmaceutical were in a loss state, and the Shanghai Composite Index was also in a negative state in the first quarter of 2020. Among them, in the first stage of least squares regression, the yield of

Jinling Hotel shares with the largest β value also changed the most during COVID-19.

Based on the forecast results for the quarterly returns of individual stocks during the second period, i.e. COVID-19, this is combined with real returns using the following formula in the MSE model:

$$MSE = \frac{1}{N}\sum_{I=1}^{N}(R_i - \widehat{R_i})^2 \quad (3)$$

where N represents the number of forecast periods and Ri is the real rate of return, which is the predicted rate of return. The smaller the value of MSE, the more effective the CAPM model is in pricing assets under COVID-19 conditions, and the calculation results are shown in Table 3.

Table 1. Estimations of β coefficients for each stock.

	Intercept	β	R^2
Hengrui Pharmaceutical	0.10	0.72	0.32
Fosun Pharmaceutical	0.01	0.99	0.43
Great Wall Motor	-0.01	1.18	0.42
Saic Motor Corporation	0.03	0.76	0.25
Jinling Hotel	0.04	1.77	0.61
Jinjiang Hotel	0.02	1.07	0.32
The Great Northern Wilderness	0.03	1.18	0.35
Fu Cheng Stock	0.01	1.32	0.47
Tibet tourism	0.00	1.27	0.49
China CYts Tours Holdings Limited	-0.01	0.86	0.34

Table 2. Individual stock yields.

	2020.1	2020.2	2020.3	2020.4	2021.1	2021.2	2021.3	2021.4	2022.1	2022.2	2022.3	2022.4
Hengrui Pharmaceutical	1.67%	15.34%	14.62%	14.26%	8.01%	11.88%	8.40%	10.25%	1.03%	12.08%	1.11%	10.61%
Fosun Pharmaceutical	-10.29%	8.45%	7.46%	6.96%	-1.60%	3.71%	-1.07%	1.47%	-11.16%	3.98%	-11.06%	1.96%
Great Wall Motor	-14.77%	7.65%	6.46%	5.86%	-4.37%	1.98%	-3.73%	-0.71%	-15.80%	2.30%	-15.68%	-0.12%
Saic Motor Corporation	-5.73%	8.65%	7.89%	7.50%	0.94%	5.01%	1.35%	3.29%	-6.39%	5.22%	-6.31%	3.67%
Jinling Hotel	-16.74%	16.83%	15.05%	14.16%	-1.16%	8.34%	-0.22%	4.32%	-18.29%	8.82%	-18.10%	5.20%
Jinjiang Hotel	-10.75%	9.58%	8.51%	7.96%	-1.32%	4.44%	-0.74%	2.00%	-11.70%	4.73%	-11.58%	2.53%
The Great Northern Wilderness	-11.09%	11.29%	10.10%	9.51%	-0.71%	5.63%	-0.07%	2.95%	-12.12%	5.95%	-12.00%	3.53%
Fu Cheng Stock	-14.57%	10.45%	9.12%	8.46%	-2.96%	4.12%	-2.26%	1.12%	-15.73%	4.48%	-15.59%	1.78%
Tibet tourism	-14.69%	9.32%	8.05%	7.41%	-3.55%	3.24%	-2.87%	0.37%	-15.80%	3.59%	-15.66%	1.00%
China CYts Tours Holdings Limited	-10.92%	5.35%	4.49%	4.06%	-3.37%	1.23%	-2.91%	-0.72%	-11.68%	1.47%	-11.59%	-0.29%

Table 3. MSE value of each share.

	Hengrui Pharmaceutical	Fosun Pharmaceutical	Great Wall Motor	Saic Motor Corporation	Jinling Hotel	Jinjiang Hotel	The Great Northern Wilderness	Fu Cheng Stock	Tibet tourism	China CYts Tours Holdings Limited
MSE	0.04	0.10	0.30	0.02	0.07	0.03	0.10	0.04	0.04	0.03

From the Table. 3, it can be seen that the MSE value of the selected stocks is between 0.03 and 0.3, the average value is 0.077, and the MSE value is small, indicating that the difference between the predicted quarterly return and the actual quarterly return is small, and the quarterly return forecast of individual stocks using the CAPM model is more accurate and the error is small, indicating that the CAPM model is effective for asset pricing under the COVID-19 situation.

4 Limitations and prospects

It should be noted that this study has some shortcomings and defects. In fact, this study only selects ten stocks to represent the overall situation of the entire stock market, there may be a lack of representativeness, but due to practicality, it is impossible to list them one by one, whether it is the Shanghai Composite Index, the Shenzhen Composite Index or the CSI 300 Index can not fully represent the market, can not cover all the influencing factors of the market, so the market rate of return obtained by the index has a certain error, and the β coefficient and yield calculated thus may also have errors.

The traditional CAPM model assumes that it is too idealistic, and many conditions can hardly be met in the actual market, while the development of China's stock market is relatively slow, and stock prices are affected by systemic risks and other factors at the same time, resulting in slow response of stock prices to information. Finally, because this study is still in the preliminary research stage, the research protocol is not perfect, and there are few existing studies on this topic, the literature that can be referenced and the literature cited are limited, which all limit the effectiveness of the CAPM model in application.

5 Conclusion

To sum up, the impact of the epidemic on the stock market has become a research hotspot in related fields, and the expected return estimation model commonly used at present is difficult to obtain data in practical applications, and the results obtained are highly subjective. To this end, this paper studies the effectiveness of the CAPM model in the expected return of assets in the stock market during the epidemic. Based on the capital asset pricing model, this paper uses the average interest rate of three-month treasury bonds in the current year as the risk-free interest rate, calculates the expected return of the stock during the epidemic period from 2020 to 2022, and compares it with the actual return of the three years that have been obtained, and conducts an empirical study on the effectiveness of the CAPM model during the epidemic.In other words, the CAPM asset pricing model is still valid in the three-year pandemic macro environment from 2019 to 2022

According to the empirical analysis, this paper puts fo rward the following suggestions. Primarily, the governm ent and regulatory departments should strengthen supervi sion, reduce the proportion of individual investors, appro priately increase the proportion of collective investors an d investors, and make the investment structure more reas onable. In addition, for relevant regulatory authorities an d government agencies, it is necessary to improve the inf ormation disclosure system, improve the authenticity of i nformation, ensure that investors can obtain accurate info rmation, and provide more ideal conditions for models. F or investors, it is necessary to establish a good concept of value, make reasonable investments, and promote the sta ble operation of the stock market.

When using the CAPM model to estimate the stock return, it is expected to establish a reasonable dynamic prediction model based on the comprehensive internal and external conditions, national economic policies and industry development conditions, improve the accuracy and scientificity of the return, and minimize the impact of the defects of the CAPM model on the results. In the future development, with the deepening of relevant research, more and more perfect methods will appear, which will be of great reference significance for the current CAPM model effectiveness research.

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