The Application of Mathematical Model in Financial Field

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Abstract
With the development of society and the improvement of people's living standards, people's consumption level has become higher and higher, people have become more and more concerned about finance, and it is of great significance to apply mathematical model to the financial field. The use of mathematical models can well show the relationship between markets and the internal logical connection in the financial market, so as to promote people's control of the financial field. (Abstract)

Keywords-*Mathematical model; Financial sector; application key words*

1. INTRODUCTION

In the process of the continuous development of modern financial theory, the complexity of the theory is increasing, the application of mathematical knowledge in it is becoming more and more important, especially the formation of the new discipline of financial mathematics, mathematics in the development of the whole financial system is also more and more high status .Therefore, it is of great practical significance to analyze the application of mathematical knowledge in modern finance. Finance is a subject that draws conclusions by strict reasoning on the basis of a series of assumptions, which has much in common with mathematics. However, the difference is that financial problems are often highly realistic, so the results cannot be verified by a large number of repeated experiments. Therefore, the use of mathematical knowledge such as mathematical models in financial research has a very direct impact on the success of financial research and financial problem solving.

2. FINANCIAL MATHEMATICS

The so-called financial mathematics, also known as mathematical finance, mainly uses different mathematical tools to study some financial phenomena, and uses mathematical models to conduct quantitative analysis, so as to find the internal links in financial activities, and use these links to guide the actual activities. At present, financial mathematics refers to a good combination of modern mathematics and computer technology, and it is applied to the financial field. For some commercial banks now, financial mathematics has been widely applied in the field of management decisions and risk management, in order to get the best management decisions. Related activities of risk management are often very complex, and it is difficult to obtain the actual desired results only by using one tool. Therefore, it is often necessary to use multiple tools or models at the same time to make them cooperate with each other to meet the special needs of financial institutions and achieve the actual purpose. These banks have been in operation for many years, so they have a lot of data. Through the use of mathematical model as a tool to analyze these data, we can find out the value information and rules of these data, so as to provide managers at all levels with the corresponding means of performance evaluation. In addition, the mathematical model can be used to obtain the direct or indirect related benefits of some businesses, as well as the cost used and the capital occupied. The mathematical model can be used to analyze the behavior of customers, thus helping relevant departments to provide personalized services. And use the model to analyze the relationship between some variables, can make the corresponding prediction for the value range of some indicators in the future. Therefore, it is of great practical significance to apply mathematical model to the financial field[1].

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3. FINANCIAL APPLICATIONS

3.1. Selecting a Template

In the field of credit risk, international advanced commercial banks often establish an internal rating system to quantify credit risk through this system. Among them, the probability of possible default can be calculated by rating customers' credit, so as to reduce financial risks. Credit risk quantitative analysis, the mathematical model plays a very important role, but its main function is not the data computation, it according to the time series analysis of data, so the mathematical model of the conclusion of it is not the only, there are a large number of historical data often need to be conducted on the basis of analysis, And constantly regression testing to improve it[2].

For commercial banks, statistical models play a very important role. The first is the use of credit policy. By using a statistical model to set up the corresponding to internal risk rating system, for different regions and different scale unified approach is put forward, and the analysis of the results, the will of its own and financial institutions to get score results comparison, to determine whether there are some of the related scoring method are reasonable. Secondly, credit rating can be applied. In commercial banks, it is very important to guard against credit risks to prevent unnecessary losses. Using mathematical methods to divide and analyze the actual application behavior of enterprises, and at the same time establish the corresponding rating model, can provide scientific basis for credit approval, so as to reduce credit risk[3]. At the same time, the application of a digital model to the credit risk assessment has a very significant effect, not only the cost is lower, and fast, through the use of the score, in turn, has the consistency of the relationship between default rate, can be better in pricing model considering the goal of the unexpected loss caused by the credit rate and possible, thereby reducing the risk of the company. And by establishing a mathematical model to evaluate risk-weighted assets, the credit risk of commercial banks can be further calculated, so as to provide a scientific basis for the regulatory authorities. In addition, the data model can be used to calculate complex financial indicators, so as to divide the industry according to the real operation of the enterprise, and select indicators according to different industries as model parameters, so that the rating and risk of commercial banks can be timely early warning [4].

3.2. Market risk area

The so-called market risk value is that during the liquidation period of a trade, the volatility of the market funds can cause the market value of the investment portfolio to fall. The market risk is that in the process of market value changes, market parameters are a major factor causing risks. It is precisely because of these uncertain factors that commercial banks need to use mathematical models to analyze market risks and prevent risks in advance to prevent risks caused by artificial operations. Market risk is different from the risk of personal assets to some extent. The parameters that have a major impact on market risk are those that are sensitive to the market, including interest rate, stock and other related parameters. In order to make the mathematical model is applied to the more accurate, the Basel committee put forward the requirement of "regression test", is every bank must have a regression test, in each year by using internal model calculated risk measurements were compared with actual profit every day, and record it. Generally, the results of the test should be somewhere in between, it need to take different measures according to the circumstance, the team model to adjust or for parameter adjustment to the assumption of the model for correction, make the model results can more accord with the actual requirements, make more coverage for risk capital[5].

3.3. In the field of financial investment

For financial theory, mathematical model plays a very important role in financial risk management and financial operation cost management. First of all, the mathematical model can analyze the relationship between various objects in the financial field, and judge the feasibility of financial investment behavior based on this, so as to reduce the risk of financial investment and optimize the level of financial investment management. Secondly, the mathematical model can also distinguish the priorities of various financial management according to the situation of the financial market, so as to achieve the optimal management of financial operating costs[6] .

The following is a portfolio model

a) Income in the portfolio

The expected return in the portfolio $E\left(r_p\right)$ is the simple weighted average of expected return of all assets in the portfolio, r_i is the expected return of type i, and x is the proportion of asset investment in the total investment. There are

$$E\left(r_p\right)=E\left(xr_1+xr_2+\cdots+xr_n\right)$$
$$=x_1E\left(r_1\right)+x_2E\left(r_2\right)+\cdots+x_nE\left(r_n\right) \quad (1)$$
$$E\left(r_p\right)=\sum_{i=1}^{n}x_iE\left(x_i\right) \quad (2)$$

b) Since we can define the risk of investment as the potential possibility that the actual return deviates from the expected return, it can be expressed by variance, because variance in mathematics refers to the discrete

degree of the random variable to the mathematical expectation. This expression can be used as a calculation method to evaluate investment risk through expected return, expressed in the formula

$$\sigma_p^2 = E\left[r_{px} - E\left(r_p\right)\right]^2 \tag{3}$$

Asset valuation model

It is well known that money has a time value. The value of capital at different time points and in different periods is not constant, so it cannot be simply added or subtracted directly or compared in calculation. In order to solve this problem, Irving Fisher, an American economist, put forward this view in 1986, that is, the current value of assets is equal to the sum of future discounted cash flow values, which becomes the basis of asset valuation model. The simplest valuation model is the copy formula. Its mathematical expression is as follows:

First of all, if the cash flow of an investment t at some time in the future is $C(t)$, its discount rate is $R(t)$, n is the period number, and the total present value is PV, then we have

$$PV = \sum_{i=1}^{n} C(t)\left[1 + R(t)\right]^{-1} \tag{4}$$

Through the calculation of this mathematical expression, it lays the foundation of capitalization method of securities investment value, and its expression form can vary according to different situations. And on this basis, a discounted cash flow model (DCF) is generated, which reveals the intrinsic value of a stock, namely the sum of its discounted values of all future dividends:

$$P(t) = \sum_{i=1}^{n} D(t+k)(1+i)^{-(1+k)} \tag{5}$$

Where, $P(t)$ is the stock price at time, $D(t+k)$ is the dividend obtained at time $t+k$, and i is a constant representing the appropriate discount interest rate[7].

c) Application of capital Asset Pricing model in financial market

Capital Asset Pricing Model (CAPM) is a major achievement in the application of mathematical models in financial markets. This model, also known as CAPM model, was co-created by John Lintner and William Sharp. It mainly describes the method of determining the price of securities market. In the capital asset pricing model, all products in the market construct their portfolios according to their market value, so as to form the market portfolio. The benchmark is the market portfolio risk, which mainly describes the price of any portfolio and its risk relationship. The capital asset pricing model can be expressed by this formula:

$$E(r_i) = r_f + \beta_{im}\left[E(r_m) - r_f\right] \tag{6}$$

$E(r_i)$ in this formula represents the expected rate of return on asset i; r_f represents the risk-free rate; β_{im} is called the systemic risk of asset i, that is, Beta coefficient, which is jointly determined by the correlation of asset portfolio and market portfolio. $E(r_m)$ represents the expected market rate of return in the market, and $E(r_m) - r_f$ represents the difference between the expected market rate of return and the risk-free rate of return, which is the market risk premium. According to this formula, it can be seen that the premium between any investment portfolio and risk-free return and the premium between market portfolio and risk-free return are in direct proportion, and the proportionality coefficient is the correlation between this asset and the asset and the market portfolio. The risk premium and the risk premium of the market portfolio will be closer as the correlation increases. This relatively simple linear model can further show the relationship between return and risk, which is of great value to capital asset pricing. It can provide a model that can measure the size of risks and be used to help investors make a clear judgment on the relative size of risks and returns. The capital asset pricing model can also reflect the classic political economy of Marx's attention. Asset prices will fluctuate around asset values and refine them into relevance [8].

4. APPLICATION FOR EXAMPLE

For example, A sum of money is invested in three different profit funds, namely fund A, Fund B, and Fund C. Different funds have different income and are related to the economic situation. Suppose that the economic situation is divided into three levels: good, medium and poor, and the probability of occurrence is $P_1 = 0.2, \quad P_2 = 0.7, \quad P_3 = 0.1.$ respectively. According to the data reference of each fund, the probability distribution of returns of each fund at different levels can be obtained in the following table.

At this point, how can we invest to get a good income?

Solution: First look at the mathematical expectations of the three funds

$$E(A) = 11 \times 0.2 + 3 \times 0.7 + (-3) \times 0.1 = 4$$

$$E(B) = 6 \times 0.2 + 4 \times 0.7 + (-1) \times 0.1 = 3.9$$

$$E(C)=10\times0.2+2\times0.7+(-2)\times0.1=3.9$$

the variance

$$D(A)=(11-4)^2\times0.2+(3-4)^2\times0.7+(-3-4)^2\times0.1$$
$$=15.4$$
$$D(B)=(6-3.9)^2\times0.2+(4-3.9)^2\times0.7+(-1-3.9)^2\times0.1$$
$$=3.29$$
$$D(C)=(10-3.2)^2\times0.2+(2-3.2)^2\times0.7+(-2-3.2)^2\times0.1$$
$$=12.96$$

TABLE 1. PROBABILITY DISTRIBUTION OF FUND RETURNS

	good $P_1=0.2$	medium $P_1=0.7$	poor $P_1=0.1$
Fund *A*	11	3	-3
Fund *B*	6	4	-1
Fund *C*	10	2	-2

By analyzing the expectations of discrete random variables, it can be seen that the average return of investment fund A is the largest. But at the same time, we should pay attention to risks. At this time, through the analysis of their respective variances, the greater the variance, the greater the fluctuation of risks. In this way, the risk of fund B is the least, and the profit difference is smaller than that of fund A, so it is more reasonable to choose fund B for investment.

5. MODEL RISK

At present, the use of mathematical models in the financial market is a very common phenomenon, but the model itself has a certain risk, the risk of this model is also very serious impact on the financial market. For example, in the aspect of credit risk, the parameters of the model and the reliability of the model itself are reduced due to the imperfect data, so the risk of the model becomes particularly prominent. There are many indicators for the risk assessment of the model. Generally speaking, the more complex the model, the better, but under the existing conditions as long as the model can meet the requirements of the business and the market is the required model. *It is* very important to reduce the risk of applying mathematical models in the financial field by reducing the risk of the model, checking the relationship between the predicted

value and the actual value of the calculated variables of the model, and modifying the parameters of the model.

Limitations of mathematical models in financial practice. The core of mathematical model is mathematics. We can deduce the influence of mathematical model on finance through the influence of mathematics on finance. However, we will find some limitations in practical research. The limitations are mainly divided into two kinds: the influence of non-economic factors and the ambiguous application purpose of mathematical methods. The problems involved in the financial field are complicated and not easy to be abstracted. In short, there are many non-economic factors, such as political culture, which are not easy to be quantified. However, mathematical modeling makes assumptions and analyses on the basis of certain conditions. However, our assumptions sometimes differ from the actual situation in the real society, which greatly affects the analytical ability and accuracy of mathematical modeling. Mathematics is a language, it is more than the other forms of language concise, but not all of the financial problems are able to use mathematical modeling accurately. There will be a lot of deviations in the applications, so we're going to rational application model, maximum limit control financial risk [9].

6. CONCLUSION

The application of mathematical model in the financial field has a great advantage, this paper first analyzes the concept of financial mathematics, and on this basis, the problem is analyzed. It is important to reduce the risks caused by the use of mathematical models in the financial field by minimizing the risks of mathematical models themselves.

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The Impact of COVID-19 on Five Categories of Industries Based on CAPM Model

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Abstract

The global spread of the COVID-19 epidemic has become a common threat to human society, posing huge challenges to the economies of various countries. On this basis, evaluating the impact of it on the economy and society has become a research hotspot. The stock market, as a barometer of the economy, will reflect the economic impact of the outbreak. The COVID-19 pandemic has affected stock markets around the world, which has forced markets into an unprecedented environment that performances differently among various industries. This paper takes 2-3 stocks from U.S. market in each of the four selecting industries as sample to verify the effectiveness of the classical CAPM model before and after the COVID-19 period based on regression analysis. The data is collected from the Yahoo database, where the period from March 1 to December 31, 2019 is used as the pre-pandemic control while the period from March 1 to December 31, 2020 was labeled as a post-pandemic control. According to the analysis, the β value of bank increased before and after the epidemic while fall for Internet e-commerce, automobile manufacturing and pharmaceutical industries. These results provide guidance for dealing with similar black swan events, contribute to the stability of the market in the future, and offer opportunities for the transformation of various industries with the epidemic.

Keywords: *CAPM Model, COVID-19, Stock Market, Beta, Industry Analysis.*

1. Introduction

In retrospect, capital asset pricing was proposed beginning in the 1860s. Its core is still the mean-variance model proposed by Markovitz in "Asset Portfolio Selection", which discusses the optimal selection of asset portfolios under uncertain conditions from the relationship between the rate of return and risk of risky assets [5]. Black, Jensen, and Scholes empirically verified excess returns and found that the beta factor appears to be an important determinant of security returns [3]. Fama and MacBeth tested the relationship between the average return and risk of NYSE common stocks, put forward the idea of cross-sectional regression, and conducted an empirical analysis of CAPM from the perspective of asset portfolio, which proved the effectiveness of CAPM model [2]. On account of the simplicity and operability of the CAPM model, it has been widely used in real-life security return and risk prediction, security valuation and portfolio performance evaluation. The establishment of the Capital Asset Pricing Model is based on a series of assumptions:

- In the single-period model, investors take the mean-variance efficient combination as the standard for evaluating the quality of the investment portfolio;
- There are consistent expectations for the expected return, variance and covariance of the market;
- Investors are risk-averse and non-feeling, and they are all price receivers;
- There are no transaction fees, taxes, and information barriers in the market;
- Investors can borrow any amounts of money at risk-free rates.

The fermentation of the COVID-19 epidemic in the capital market began on January 20, during which the market was closed after the Spring Festival. According to relevant news reports, the epidemic will weigh on the stock market from both earnings and risk appetite, and the stock market will become more volatile. Baker et al. compare stock market volatility during the COVID-19 crisis with volatility during previous illnesses and historic financial crises, arguing that the impact of COVID-19 on U.S. stock markets is unprecedented [9].

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