Advances in Economics, Business and Management Research, volume 203
Proceedings of the 2021 3rd International Conference on Economic Management and Cultural Industry (ICEMCI 2021)

Research and Analysis of Asset Pricing Model Based on the Empirical Test of Stock Price

Junyao Chen[1, †], Yupu Wu[2, †], Yuan Xu[3, †]

[1]*School of Economics and Management, Nantong University, Nantong, Jiangsu, China*
[2]*School of Business, Shandong Normal University, Jinan, China*
[3]*Accounting，Nanjing Audit University，Nanjing，Jiangsu，China*
[*]*Corresponding author. Email: 630160813@qq.com*
[†]These authors contributed equally.

ABSTRACT
The core of stock pricing is stock valuation. Although there are many assumptions of the stock pricing model in practical application, which require investors to have enough experience and more professional knowledge, the operation is difficult. Still, the pricing model provides the real intrinsic reference value of the stock, which is of great significance and worth learning in actual investment. Through reviewing the theory of stock valuation, this paper analyzes and summarizes the main theoretical models of CAPM and DDM, based on the philosophy that everything is relative and absolute. According to the idea that stock has its intrinsic value and is the stable base of stock price, combined with the actual situation of the securities market, this paper deeply analyzes the advantages and disadvantages of the two valuation models. In this article, we mainly choose the relevant data of several companies in the same period for comparative calculation and get the capital of several companies through the CAPM model. Also, we select Ansteel company and Yangtze Power company to use DDM model to calculate their cost of capital again Then the results of DDM model and CAPM are compared and analyzed. We find that Ansteel is under-priced, Yangtze Power is over-price. Through the DDM model and CAPM model, we can compare the stock's intrinsic value and real value to make a better investment strategy.

Keywords*: CAPM model, DDM model, stock valuation*

1. INTRODUCTION

The modern capital asset pricing model (CAPM) is the first equilibrium model of financial asset pricing and the first asset pricing model to maximize investors' utility under uncertain conditions. This paper mainly studies the relationship between the expected return of assets and risk assets in the securities market and the equilibrium price formation. It describes the expected return of equilibrium assets and the relationship between the expected return and market risk. It is pointed out that the expected return rate of securities is the sum of risk-free return rate and risk compensation, which reveals the internal structure of securities return. The capital asset pricing model is an important cornerstone of modern financial theory. In many published securities investment theories, the capital asset pricing model plays an important role in investment, which is widely used in the decision-making and finance of investment companies.

This article analyzes how to price the stock value based on a different valuation model. We want to establish a framework to investigate the stock's value in different portfolio investments. Besides, the relationship between the CAPM model and the DDM model is not clear in the existing literature. The related works and analysis would be captured in our work to identify the influences of these two models based on an empirical examination.

Then, we review related works of CAPM theory in the following. One of the important developments in modern capital market theory is the Sharpe-Lintner-Mossin [1] mean-variance equilibrium model of exchange, commonly called the capital asset pricing model. And the capital asset pricing model provides a theoretical structure for the pricing of assets with uncertain returns [2]. This is exactly the main point of our study, so this most common and relatively easy use financial model, CAPM, became our research core.

Michael et al. [3] point out that the capital asset pricing model (CAPM) is one of the fundamental and most influential concepts in modern finance. It is closely related to portfolio theory and finds its application in portfolio risk management, fund performance measurement, security valuation, etc. So this why we choose this model to illustrate our research topic because we want to demonstrate the relationship between the risks of market portfolios and their corresponding returns. Eugene F. Fama and Kenneth R. French once said that The attraction of the CAPM is that it offers powerful and intuitively pleasing predictions about how to measure risk and the relation between expected return and risk [4]. Besides, just as Georges et al. [5] mentioned, CAPM relates the risk premium to each asset's covariance between the asset's return and a decision maker's inter-temporal marginal rate of substitution. We also use the functions, which can connect to charts, and calculations of the Sharpe Ratio to further explain how an asset's price or equity premium changes as the number of risks changes. Of course, the assumption of CAPM is too idealistic. Thus, it is difficult to accurately predict the actual investment scenario by CAPM. However, the CAPM can still serve as a benchmark for understanding the capital market phenomena that cause asset prices and investor behavior to deviate from the prescriptions of the model [6]. Meanwhile, we also show how a rational investor will take action under different portfolios, risks, or risk premiums and prove this assumption through a series of empirical tests.

What's more, pricing the securities is an important part of the application of CAPM. So we add the dividend discount model (DDM) to the discussion of the CAPM. Jiang and Lee [7] consider stock price fluctuations are explained by changes in the expected present value of future dividends. And we need to compare the expected present value and actual value to observe invest projects' pricing situations. Also, we choose this model because it shows how one calculates the terminal value for the dividend discount formula [8]. Through the dividend discount formula, we can easily get the terminal value of the expected present value. To work out relatively precise results, the accuracy of data is important. After all, the reliability of the DDM is primarily dependent on the estimation of required returns and growth rates [9]. From our research perspective, we mainly focus on interpreting changes among market risks, sensitivity coefficients, and portfolios. CAPM's pricing function doesn't show well. Thus we introduce DDM to solve this shortcoming. At the same time, by comparing this return with the expected return on bonds, as derived from a yield to maturity calculation, the investor can calculate a return spread between these two classes of securities that can be used to assess the relative attractiveness of each. Investors can also use these return data, along with risk data, to determine an optimal blend of assets-stocks, bonds, money market instruments, or real estate-within an asset allocation framework [10].

Last and most importantly, we use the market risk coefficients of ICBC and CITIC to calculate the risk-free interest rate and market rate of return by using the CAPM model. Next, we used the CAPM model and DDM model to conduct valuation analysis on Ansteel and Yangtze Power, respectively. Comparing the valuation of company D by using the two pricing models, we have come up with the result that the stock of Ansteel is underpriced. In the same way, Yangtze Power is overpriced.

The rest of this article is organized as follows: Section 2 specifically describes the research method; Section 3 introduces the research background. Section 4 conducts an empirical test. The last section presents our conclusions.

2. METHOD

In this article, we use CAPM and DDM models. These two models have valued stocks from different angles. The CAPM model values the stock from the perspective of market risk, while the DDM model evaluates the stock by seeking the present value of future dividends. These two models are used as our research methods to study whether stocks are overvalued. By comparing the valuation of these two methods, investors can know whether their investment portfolio is effective and adjust their investment portfolio to obtain the maximum return.

2.1. Capital Asset Pricing Model

The capital asset pricing model (CAPM) is of great significance in assessing the necessary yield of bonds. The capital asset pricing model believes that only by taking higher risks can you get higher returns. The capital asset pricing model explores the quantitative relationship between security returns and risks, that is, how much return investors should obtain to compensate for a certain degree of risk. The expected rate of return of single security consists of two parts, the risk-free interest rate, and the risk premium.

Non-systematic risks can be eliminated by diversifying investment. Therefore, the capital asset pricing model will only consider systemic risks when calculating the risk premium. According to this model, the security rate of return consists of two parts: the risk-free rate of return Rf, and the other is the market risk premium $(R_m - R_f) \times \beta_i$measured by the coefficient βi.

$$R_i = R_f + (R_m - R_f) \times \beta_i \quad (1)$$

R_f is Risk free rate, R_m is Return of market, and β_i means System risk factor of security β_i

As shown in formula(1), the CAPM model reveals the equivalence relationship between the necessary rate of return of securities and the unavoidable risk, that is, market risk. Usually, we estimate the market risk β of the security to calculate the necessary rate of return of the security. In addition, when we know the rate of return of the security, we can use Formula(1)to estimate the market rate of return and the risk-free rate of return. In the empirical test part of this article, we used this method to get the value of the market rate of return and the risk-free rate of return.

2.2. Dividend Discount Model

The dividend discount model (DDM) is one of the most basic stock intrinsic value evaluation models. In 1938, Williams and Gordon put forward the dividend discount model (DDM) of company (stock) value evaluation, which laid a theoretical foundation for quantitative analysis of virtual capital, assets, and company value. Also, they provided a strong theoretical basis for the basic analysis of securities investment. The main principle is to calculate the value of the stock itself, not its market price.

The stock's intrinsic value can be evaluated by the sum of the present value of the annual dividend income of the stock; the dividend is the return given to the shareholders by the issuing stock company, and the profit is distributed according to the shareholding ratio of the shareholders. The profit of each share is the dividend of each share. The basic formula of the dividend discount model is V= $\sum_{t=1}^{\infty} \frac{D_t}{(1+k)^t}$,Where V is the intrinsic value of each share, DT is the expected value of the dividend per share in the T year, and K is the expected rate of return or discount rate of the stock.

The formula shows that the intrinsic value is the sum of the present value of its expected dividend every year. In addition to the basic formula, according to some special dividend payment methods, the DDM model has the following simplified formulas: zero growth model, that is, the dividend growth rate is 0, and the future dividends are paid according to a fixed amount. The formula is $v = \frac{D_0}{K}$. V is the company's value, D_0 is the current dividend, and K is the rate of return or cost of capital required by investors. Constant growth model, that is, the dividend increases according to a fixed growth rate. The formula is v=$\frac{D_1}{K-g}$. Using this model, we can study the company's intrinsic value and guide investment decisions, which is the practical significance of the dividend discount model.

3. PRICING MODEL

The pricing models are often used to calculate the reasonable pricing of assets, securities, and portfolios. At the same time, we can estimate the expected rate of return of assets by reverse calculation.

The pricing model is mainly elaborated from the perspective of CAPM and DDM. Under the CAPM model, the core arguments are capital market line and securities market line.

We take the expected return μ as the dependent variable and the market risk σ as the independent variable for the capital market line. All other considerations are considered to be known data. Meanwhile, we still take the expected return as the dependent variable and the market β coefficient as the independent variable for the stock market line. Again, all other considerations are considered to be known data. It should be emphasized that both β and σ are regarded as the representatives of risk, but they are different. β number only reflects market risk, while σ number includes both market risk and dispersible risk.

As for the DDM model, the market price is a dependent variable, and the expected rate of return is an independent variable. Other data are all seen as known. We mainly use this model to compare the estimated value with the actual value and observe the asset valuation.

Investors often consider CAPM and DDM to judge whether the portfolio is reasonable. Of course, it will also be used to analyze whether securities are overvalued or undervalued.

3.1. Risk free rate & Return of market

The risk-free interest rate and the market rate of return are two very important data in the capital asset pricing model. The risk-free interest rate refers to the interest rate obtained by investing funds in a certain investment object without any risk. The risk-free interest rate is the compensation for the opportunity cost. We usually think that the national debt has no default risk, so we can get the risk-free interest rate by subtracting the inflation rate from the one-year national debt yield. The market rate of return Rm usually refers to the overall rate of return of the market portfolio. We usually use the percentage of change in the S&P 500 and Dow Jones indexes over some time to estimate this value. The method of obtaining these two data is not fixed. When we know other data in the CAPM model, we can also solve these two data by substituting other data into the CAPM formula.

3.2. Two important curves

Under the CAPM, the securities market line (SML) and capital market line (CML) are two common and important sub-concepts used to understand or analyse the model. The CML is the relationship between the market risk σ and expected market return μ, and its function is

$$\mu_i = r_f + (\mu_M - r_f)/\sigma_M \times \sigma_i \qquad (2)$$

And the SML directly reflects the link between the market β number and expected market return μ, its formula is

$$\mu_i = r_f + (\mu_M - r_f) \quad (3)$$

Fig.1 is a capital market line graph. The right straight line shows they have a positive correlation. That means that if the risk number σ has an increase and the market expected return number μ will also change with it. After all, investors need a higher return level as compensation for the increased level of investment risks. And the left curve is an efficient portfolios curve, which is a constraint line. It determines all feasible investment options in the capital market. Investors can take only the portfolios on or under the curve. Also, the extent of steepness is the reflection of the slope of the straight line. This slope is equal to the Sharpe ratio. The Sharpe ratio is an indicator of the risk premium. They must know that the higher risk premium means the same risk increase rate can increase the expected return for a rational investor. So pursuing the biggest risk premium figure is their goal. Last, the tangency point of the two lines is exactly the point that has the steepest trend or largest Sharpe ratio within the bound of efficient portfolios curve. So this tangency point presents the optimal market portfolio. We can use the known conditions to figure out the corresponding μ_M and σ_M.

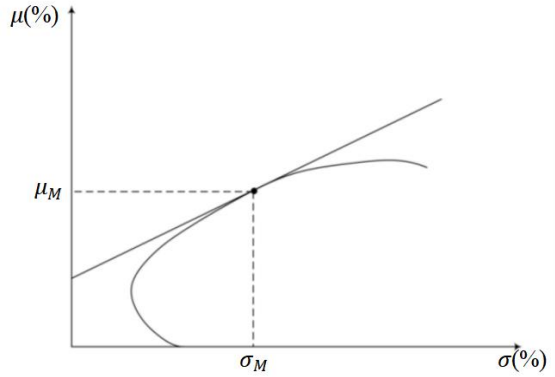

Fig.1 Capital market line

From Fig.2, we can clearly see the linear relationship between the β number and expected return quantity μ. The β number is another kind of risk. Unlike the market riskσ in CML, whose focus point is the individual asset or investment portfolio, SML puts the individual asset or investment portfolio and the whole capital market together, comparing its fluctuation in the total market. Higher β numbers, especially over 1, stand for its more fluctuated than the average fluctuation level of the capital market. As a result, this kind of investment may be riskier. The function and chart of SML are quite easily remembered and understand. Therefore, many investors or corporations bring known β numbers and return quantities μ into the formula to confirm the rationality of given investment projects.

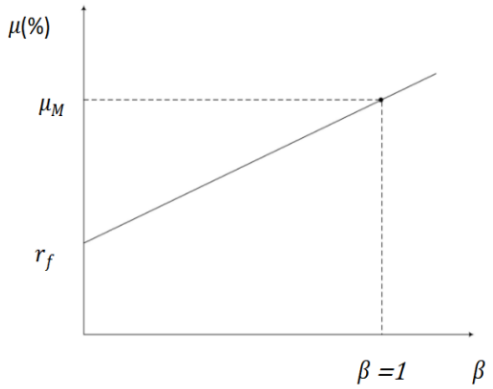

Fig.2 Securities market line

3.3. Comparison of DDM

Unlike the CAPM model's scope, the DDM model is mainly suitable for companies with large and stable dividends and noncyclical industries. In other words, the company to be valued is a company that can pay dividends stably for a long time, and it also needs to hold dividends for a long time. From the given data, we can find: current price, current divide, divide growth rate. At the same time, we also know that this is a stock with fixed dividend growth, so we need to use the constant growth model in the DDM model to calculate the price of Ansteel and Yangtze Power

$$r = \frac{D}{P} + g \quad (4)$$

Then, by comparing the valuation of the DDM and CAPM models, we can find out whether the stock is issued at a discount or a premium.

4. EMPIRICAL TEST

To verify the accuracy and practical meaning of the theory and formula. We choose some data to test the model. We collected data from the Industrial and Commercial Bank of China and CITIC Securities to calculate the risk-free interest rate and market rate of return. The data is presented in Table 1.

Table 1. Data of industrial and Commercial Bank of China and CITIC Securities Company Limited

	Expected Return	Standard Deviation	Correlation with M
ICBC	7.2%	0.4	0.3
CITIC	8.4%	0.3	0.8
Market Portfolio M		0.5	1

Table 2. Data of Ansteel and Yangtze Power

Stock	Current price (*P0*)	Current dividend (*D0*)	Dividend growth rate	β
Ansteel	100	8	0%	-0.3
Yangtze Power	127.5	10	2%	1.2

As the table shows, the expected return for ICBC is 7.2%, the standard deviation is 0.4, and the correlation with M is 0.3, while the data for CITIC are 8.4%, 0.3, and 0.8. Besides, for the market portfolio M, its standard deviation number is 0.5, and the correlation with the M figure is naturally 1.

Then, we substitute the data in the table into the CAPM model to obtain the risk-free interest rate and market rate of return. The calculated risk-free interest rate and market rate of return will be used to evaluate Angang and Yangtze Power. We collected relevant data from Angang and Yangtze Power, and the data is shown below in Table 2.

It can be seen from the table that, for Ansteel, the current price, current dividend, dividend growth rate, and β value of ICBC are respectively 100, 8, 0%, and -0.3, while the data for Yangtze Power are 127.5, 10, 2% and 1.2.

Of course, we will use DDM to test the actual valuation of these two stocks. Are they overpriced? Or is it underpriced? Or is the price just right?

4.1. Risk-free rate & Return of market

Under the premise that the yields of ICBC and CITIC are known, we only need to calculate the market risk coefficient β of ICBC and CITIC to calculate the market yield and risk-free interest rate.

$$\beta i = \frac{COV(r_i, r_m)}{VAR(r_m)} \quad (5)$$

According to formula (5), we get $\beta_a = 0.24$ and $\beta_b = 0.48$. We know that the expected return of ICBC is 7.2%, and the expected return of CITIC is 8.4%. According to formula (1), we can get the return of the market $r_m = 11\%$, and the risk-free rate $r_f = 6\%$.

4.2. Results of two curves

After calculating the risk-free interest rate and market portfolio rate of return, the equations of SML and CML can be further specified.

Firstly, because of the former calculation, we know that r_f= 6%, and μ_M= 11%, so put them into the SML formula (3). We get the result of

$$\mu_i = 0.06 + 0.05\beta_i \quad (6)$$

At the same time, we can point out portfolios A and B on this SML line on Fig.3. In fact, point A (β_A= 0.24,μ_A= 7.2%) and point B (β_A= 0.48,μ_A= 8.4%) are both on the line. This consequence also verifies our function and assumptions are right.

Secondly, adding the condition that σ_M is equal to 0.5, the CML function (4) can get its final result

$$\mu_i = 0.06 + 0.1\sigma_i \quad (7)$$

However, we can't point out the portfolio A and B on the CML line. Because the points on the CML line are combinations of the risk-free asset and risky assets, if we want to work out the position on CML charts, the weight of each side is necessary. Unfortunately, there is no such item in the given data.

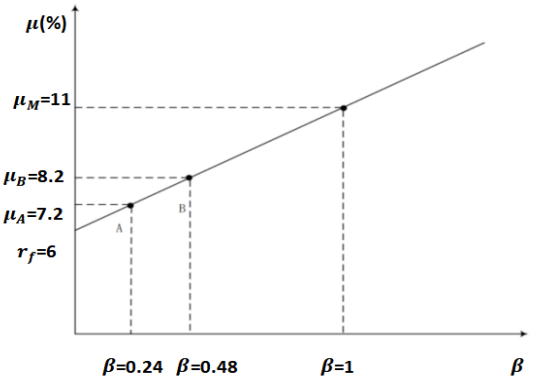

Fig.3 Securities market line in Empirical test

4.3. Valuation using DDM model

According to the DDM model, we can get the Cost of Capital by using the following formula (4);

So,$r_A = 8\%$, $r_Y = 10\%$

According to the CAPM model, we can get the Cost of Capital by using the following formula(1);

So,r_A =4.5%, $r_Y = 12\%$

Compare to the expected return calculated before, Ansteel is under-priced since the calculated cost of capital is higher than the expected return. And Yangtze Power is over-priced since the calculated cost of capital is lower than the expected return. In other words, Ansteel is trading at a price below their real value, Yangtze Power is trading at a price above their real value.

This paper mainly analyzes the main contents of the CAPM model and DDM model, including (the formula, application scope, and limitation conditions of the CAPM model, the formula of image and DDM model, and the scope of application, and the restriction conditions, etc.). However, neither the CAPM model nor the DDM model

can fully reflect the actual stock price, and its implementation has certain limitations. For example, the DDM model is an absolute valuation method suitable for enterprises in large, stable, and non-cyclical industries. However, according to our survey, the industrial structure of the mainland stock market and the dividend ratio of listed companies are not high, and the dividend ratio and quantity are different. Due to the unstable dividend yield, it is difficult to predict the dividend growth rate. On the other hand, the CAPM model with more constraints is difficult to implement, whether it is a complete market hypothesis, inflation rate invariable assumption, or assumption of the constant discount rate. Therefore, when analyzing the market, we should comprehensively analyze the formula according to the specific situation.

5. CONCLUSION

In this article, we use the data of ICBC and CITIC to calculate the market rate of return and the risk-free rate of return. Then we use the CAPM model and the DDM model to value the Ansteel and Yangtze Power, respectively. By comparing the valuation of Ansteel and Yangtze Power by the CAPM and DDM models, we have made a judgment on whether the value of Ansteel and Yangtze Power is overestimated.

First, we use the variance of ICBC and CITIC, the expected return of ICBC and CITIC, and the correlation with the market of ICBC and CITIC to calculate the market risk coefficient β of ICBC and CITIC. According to formula (5), we got that the market risk coefficient of ICBC was 0.24, and the market risk coefficient of CITIC was 0.48. Based on the CAPM model, we use the market risk coefficients of ICBC and CITIC and the expected returns of ICBC and CITIC to calculate the market rate of return and the risk-free rate of return. In this way, we finally find out that risk-free rate (R_f) equals 6 % and the return of the market (R_m) means 11 percent. Getting the value of R_f and R_m, we use the CAPM model and the DDM model to estimate the stocks of Ansteel and Yangtze Power, respectively. When using the DDM model for valuation, Ansteel 's expected rate of return is 8%, and Yangtze Power's expected rate of return is 10%. When the CAPM model is used for valuation, the expected rate of return of Ansteel is 4.5%, and the expected rate of return of Yangtze Power is 12%. By comparing the valuation of the two stocks by the CAPM model and the DDM model, we have come to the following conclusions. The necessary rate of return required for Ansteel to take risks is less than the present value of future dividends, so Ansteel is undervalued. In the same way, Yangtze Power is overvalued. At this time, investors should sell Yangtze Power's stock in their portfolio and buy Ansteel's stock to obtain more profits.

The innovation of this article is to propose an application method of the CAPM model and DDM model in investment activities. The disadvantage of this article is that the method proposed in this article has some limitations. The method proposed in this article is only suitable for large companies with stable and predictable dividends and is not applicable to companies with huge dividend volatility. In the future, we will explore investment strategies for start-up companies.

REFERENCES

[1] Merton R C. An intertemporal capital asset pricing model[J]. Econometrica: Journal of the Econometric Society, 1973: 867-887.

[2] Bollerslev T, Engle R F, Wooldridge J M. A capital asset pricing model with time-varying covariances[J]. Journal of political Economy, 1988, 96(1): 116-131.

[3] Zabarankin M , Pavlikov K , Uryasev S . Capital Asset Pricing Model (CAPM) with drawdown measure[J]. European Journal of Operational Research, 2014, 234(2):508–517.

[4] Fama E F, French K R. The capital asset pricing model: Theory and evidence[J]. Journal of economic perspectives, 2004, 18(3): 25-46.

[5] Dionne G , Li J , Okou C . An Extension of the Consumption-Based CAPM Model[J]. Social Science Electronic Publishing, 2012.

[6] Perold A F. The capital asset pricing model[J]. Journal of economic perspectives, 2004, 18(3): 3-24.

[7] Jiang X, Lee B S. An empirical test of the accounting based residual income model and the traditional dividend discount model[J]. The Journal of Business, 2005, 78(4): 1465-1504.

[8] Penman S H. A synthesis of equity valuation techniques and the terminal value calculation for the dividend discount model[J]. Review of accounting studies, 1998, 2(4): 303-323.

[9] Farrell Jr J L. The Dividend Discount Model: A Primer[J]. Financial Analysts Journal, 1985, 41(6).

[10] Payne T H, Finch J H. Effective teaching and use of the constant growth dividend discount model[J]. Financial Services Review, 1999, 8(4): 283-291.