

# Determination of Risk-Free Interest Rates in Financial Assets

Shi Ke

School of Economics and Management, Xidian University, Xi'an, 710118, Shaanxi, China

**Abstract:** *The most basic of pricing of financial products is to choose a reasonable benchmark discount rate, that is, an appropriate risk-free interest rate. Due to the diversification and fragmentation of the financial market, this paper uses the capital asset pricing model as the basis to study how to determine risk-free interest rates for three different industries: manufacturing, finance, and technology. There are some differences.*

**Keywords:** Financial assets, Different industries, Risk-free interest rates, CAPM

## 1. Introduction

The risk-free interest rate is the interest rate that does not contain credit risk and is an ideal investment income. The selection of risk-free interest rates is the basis for pricing financial assets. For example, the use of stock dividend discount models and Gordon models, and the use of capital asset pricing models involve benchmark discount rates, that is, the selection of risk-free interest rates, that is, risk-free rates. It is the basis of all other interest rates and asset prices. Existing studies have selected a certain interest rate or weighted average interest rate as the risk-free interest rate from the overall market, without considering the market segmentation and diversity. This article focuses on three different industries: manufacturing, finance, and technology. Starting with, use capital asset pricing models to conduct empirical research on representative companies in the industry, and infer the appropriate risk-free interest rates for various industries. With a view to reducing the possibility that the price of financial assets deviates from the theoretical price.

## 2. Literature Survey

In our country, the research of risk-free interest rate stays in simply taking the weighted average of a certain low-risk interest rate or a certain number of low-risk asset return rates in the capital market to replace the risk-free interest rate. Song Jian, a domestic scholar, thinks that the bank's annual interest rate of three-month lump sum deposit and lump sum withdrawal should be used instead of the risk-free interest rate. Hire Wenxiu, Han Rende, and Lu Ni think it is more scientific to choose one-day report and other financial instruments as risk-free assets in China's financial market and to use weighted average interest rate to estimate risk-free interest rate in financial pricing.

In countries with mature market economic system and perfect financial market mechanism, short-term treasury bonds are often used as risk-free assets in practice. For example, in the United States, the interest rate of three-month Treasury bonds is used as risk-free interest rate, while in the United Kingdom, the repo rate of two-week treasury bonds is used as risk-free interest rate. Based on this interest rate, the financial products in their respective financial markets are priced. In the international financial market,

inter bank credit products with higher credit level are usually used as risk-free assets, i.e. LIBOR is used as the risk-free benchmark interest rate. The target assets of risk-free interest rate determined by developed countries in financial market have the characteristics of strong liquidity, high level of secondary market participation, high asset credit, no default risk, stable income, and small risk.

In general, most scholars do not consider the industry segmentation of China's financial market in the research process of risk-free interest rate, but conduct an overall analysis; foreign scholars have less research on China's stock market, most of the research is aimed at the stock market situation of developed countries.

## 3. Method

### 3.1 Related concepts

CAPM was developed by American financial scientists in the 1960s. Its expression is that the expected return of any risky asset is equal to the risk-free interest rate plus the asset risk premium. It is an equilibrium theory of how risks and returns are priced and measured. The fundamental role is to confirm the relationship between expected returns and risks and reveal whether there are abnormal returns in the market. The expected rate of return of an asset is linked to indicators that measure the risk of the asset. The purpose is to assist investors in determining the price of capital assets, that is, when the market is in equilibrium, the return rate is required to have a linear relationship with the systemic risk of the securities market.

### 3.2 Model design

In this paper, capital asset pricing model (CAPM) is used to estimate the risk-free interest rates of manufacturing, financial and technological enterprises. As shown in the following formula, where RF is the risk-free interest rate,  $E(R_M)$  is the expected return rate of the market, so  $E(R_M) - RF$  is the market risk premium;  $\beta_{IM}$  is the beta coefficient, which refers to the systematic risk of asset I. It is the equilibrium theory of how to price and measure risk and return. Its basic function is to confirm the relationship between expected return and risk, and to reveal whether

there is abnormal return in the market. Therefore, this paper uses this formula to deduce  $R_F$

$$E(R_i) = R_F + [E(R_M) - R_F] \beta_{IM}$$

### 3.3 Additional assumptions of CAPM

The fund can be borrowed or lent unrestricted at the level of risk-free discount rate  $R$ . All investors have the same opinion on the probability distribution of securities return, so there is only one efficiency boundary in the market. And all investors have the same investment period, and only one period.

All securities investment can be subdivided without limitation, and can contain non integral shares in any portfolio.

All investors can get sufficient market information in time and free of charge. There is no inflation and the discount rate remains unchanged.

Investors have the same expectation, that is, they have the same expectation for the expected yield, standard deviation and the covariance between securities.

The above hypothesis shows that: first, investors are rational, and strictly in accordance with the rules of Markowitz model for diversified investment, and will choose a portfolio from somewhere in the effective boundary; second, the capital market is a completely effective market, without any friction to hinder investment.

### 3.3 Data sources

All the data in this paper are from Dong fang fortune.com. In recent 3-5 years, the monthly closing prices of representative enterprises in different industries and their corresponding market monthly closing prices are used to calculate the monthly return rate and market monthly return rate of different enterprises; the regression equations of market monthly return rate and enterprise monthly return rate are fitted by linear regression to determine beta coefficient; the long-term treasury bonds, short-term treasury bonds, three-month Shibor, central bank benchmark interest rate, and national government bonds are selected As a risk-free interest rate, inter bank lending and other interest rates are substituted into the capital asset pricing model, and the monthly yield of different industries is introduced. The monthly yield of different industries is compared with the real monthly yield of the industry, and the most suitable risk-free interest rate is determined by trend fitting and variation coefficient.

## 4. Results

### 4.1 Manufacturing analysis

Considering the representativeness of the research enterprises, in the manufacturing industry, Gui Zhou Mao tai is selected as the research object. As Gui Zhou Mao tai is a listed company of Shanghai Stock Exchange, Shanghai Stock Exchange index is selected as the market yield. In this

case, 58 groups of data from January 30, 2014 to October 31, 2018 are selected.

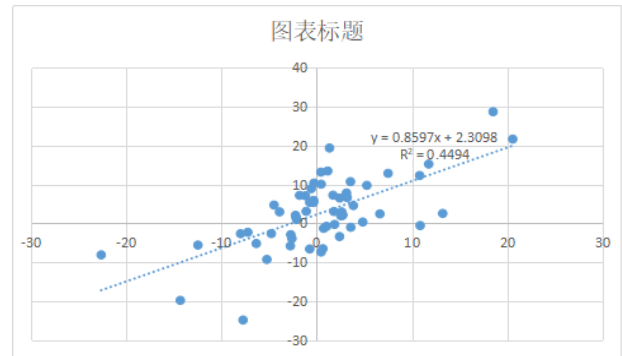


Figure 1: The fitting curve of market monthly yield and industry monthly yield in manufacturing industry

In the figure above, the horizontal axis is the market monthly yield, and the vertical axis is the industry monthly yield. The regression equation is:  $Y = 0.8597X + 2.3098$ .

The beta coefficient is 0.8597, and the R-square is 0.4494. The fitting degree is very good. The coefficient of market return is 0.86, which is significant at 1%. So the model expression is:  $E(r_i) = r_f + [E(r_m) - r_f] * 0.86$ . So the beta coefficient of banking industry is 0.86

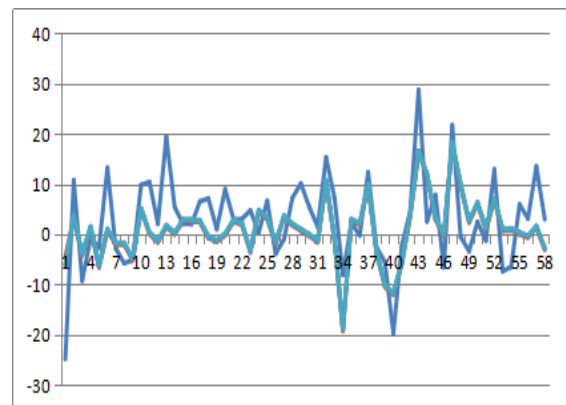


Figure 2: Comparison of monthly yields of manufacturing industries with expected yields under different standards

It can be seen from the figure that the expected return curve of the manufacturing industry under different standards is basically consistent with the actual return curve.

Table 1: Statistical analysis table of short-term treasury bond interest rate (2.1726%), long-term treasury bond interest rate (3.4983%), three-month Shibor (3.9707%), central bank benchmark interest rate (4.75%) as risk-free interest rate

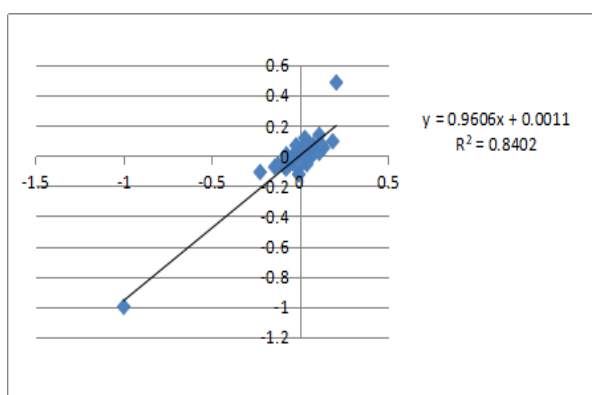
Monthly rate of return	sum	average	variance	Coefficient variation
Actual	163.85	2.82	80.16	3.16
Short term treasury bonds	49.43	0.85	35.61	7.00
Long term treasury bonds	58.35	1.00	36.02	5.96
Three months Shibor	62.19	1.07	36.02	5.59
Bank benchmark interest rate	68.53	1.18	36.0	5.07

From the table: the lowest coefficient of variation is 5.079706, that is, the difference between the expected yield and the actual yield under the expected monthly yield of the

benchmark interest rate of the central bank is the smallest. For the manufacturing industry, the expected monthly yield of the benchmark interest rate of the central bank can be selected as the risk-free interest rate. To sum up, when choosing the benchmark interest rate of the central bank as the risk-free interest rate, the difference between the industry's monthly return rate and its real return is the smallest, so for the manufacturing industry, it is more appropriate to regard the benchmark interest rate of the central bank as the risk-free interest rate.

**4.2 Financial industry analysis**

Select the representative enterprise of banking industry in the financial industry: Minsheng Bank. Since the company is listed on the Shanghai Stock Exchange, the return rate of Shanghai Stock Exchange index is selected as the market return rate. At the same time, 58 sets of data from January 2014 to October 2018 are selected for research.

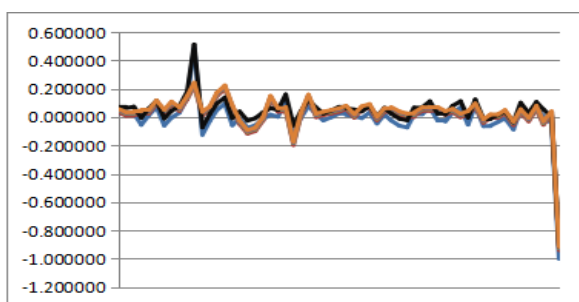


**Figure 3:** The fitting curve of market monthly yield and industry monthly yield in Financial industry

It can be seen from the figure that the beta coefficient is 0.9606, but the R2 value is 0.8402, indicating that the goodness of fit of the equation is good. The coefficient of market return is 0.961, the corresponding sig value is 0.000, the result is significant, so the model expression is:

$$E(ri) = rf + [E(rm) - rf] * 0.96$$

So the beta coefficient of banking industry is 0.96



**Figure 4:** Comparison of monthly yields of Finance industries with expected yields under different standards

It can be seen from the figure that the expected return curve of the Finance industry under different standards is basically consistent with the actual return curve.

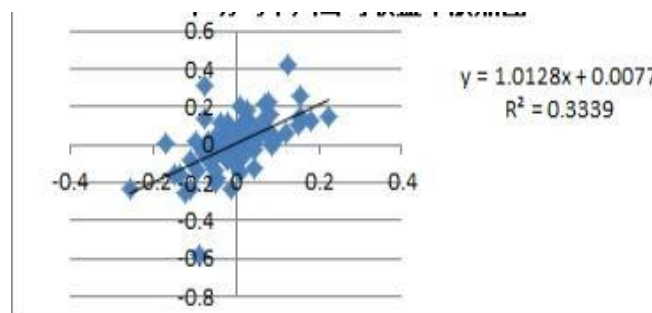
**Table 2:** Statistical analysis table of short-term treasury bond interest rate (2.1726%), long-term treasury bond interest rate (3.4983%), three-month Shibor (3.9707%), central bank benchmark interest rate (4.75%) as risk-free interest rate

Monthly Rate of return	sum	average	variance	Coefficient variation
Actual	0.52	0.01	0.02	7.27
Short term treasury bonds	0.68	0.01	0.02	12.22
Long term treasury bonds	1.46	0.02	0.02	5.71
Three months Shibor	1.74	0.02	0.02	4.80
Bank benchmark interest rate	2.29	0.03	0.02	3.98
National Bank	2.11	0.03	0.02	3.97

From the table: the lowest coefficient of variation is 3.973156, that is, the difference between the expected rate of return and the actual rate of return under the national interbank offered rate is the smallest. For the financial industry, the national interbank offered rate can be selected as the risk-free rate. To sum up, when selecting the national interbank offered rate as the risk-free interest rate, the difference between the industry's monthly return rate and its real return is the smallest, so for the financial industry, it is more appropriate to regard the national interbank offered rate as the risk-free interest rate.

**4.3 Analysis of science and technology**

Select the representative enterprise of science and technology stocks: ZTE Co., Ltd. as the company is listed on Shenzhen Stock Exchange, the return rate of Shenzhen index is selected as the market return rate, and 96 sets of data from November 2010 to October 2018 are selected for research.

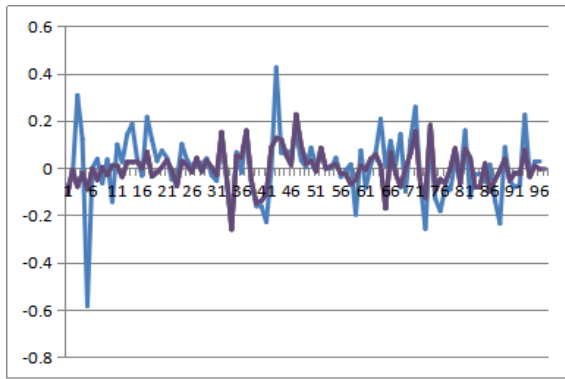


**Figure 5:** The fitting curve of market monthly yield and industry monthly yield in science and technology

In the figure above, the horizontal axis is the market monthly yield, and the vertical axis is the industry monthly yield. From the figure, we can see that the beta coefficient is 1.0128, but the R2 value is 0.3339 > 0.1, which is small, but the goodness of fit of the equation is good under the R-square standard of economics. And at a significant level of 1%. So the model expression is:

$$E(ri) = rf + [E(rm) - rf] * 1.01$$

So the beta coefficient of banking industry is 1.01



**Figure 6:** Comparison of monthly yields of Technology industries with expected yields under different standards.

It can be seen from the figure that the expected return curve and the actual return curve of science and technology under different standards are different.

**Table 3:** Statistical analysis table of short-term treasury bond interest rate (2.1726%), long-term treasury bond interest rate (3.4983%), three-month Shibor (3.9707%), central bank benchmark interest rate (4.75%) as risk-free interest rate

Monthly rate of return	sum	average	variance	Coefficient variation
Actual	0.51	0.00	0.01	24.88
Short term treasury bonds	-0.26	-0.00	0.01	-27.93
Long term treasury bonds	-0.28	-0.00	0.01	-26.29
Three months Shibor	-0.26	-0.00	0.01	-27.58
Bank benchmark interest rate	-0.28	-0.00	0.01	-25.76

It can be seen from the figure that the beta coefficient is 1.0128, but the R2 value is 0.3339; however, we find that the coefficient of variation calculated by this group of data is relatively large, and the R2 value obtained through linear regression before is too small, so we think that for technology stocks, it is not suitable to use the capital asset pricing model to calculate their expected return. The correlation between the return rate of technology stocks and the market return rate is low, so we think that for technology stocks, it is not suitable to use the capital asset pricing model to calculate the expected return rate. The reason for this phenomenon may be that there are a lot of speculation in technology stocks, and the change of their prices does not reflect the normal investment behavior. Therefore, we don't think we can use capital asset pricing model to calculate the value of technology stocks.

## 5. Conclusion

### Different industries are suitable for pricing at different risk-free interest rates

Through the empirical study of different industries, the conclusion is as follows:

For the manufacturing industry, it is more appropriate to regard the benchmark interest rate of the central bank as the risk-free interest rate.

For the financial industry, it is more appropriate to use the national interbank offered rate as a risk-free rate.

For technology stocks, it is not suitable to use CAPM to calculate their risk-free interest rate .

### The expected return calculated by different risk-free interest rates has little difference

The average of short-term treasury bond interest rate (2.1726%), long-term treasury bond interest rate (3.4983%), three-month Shibor average (3.9707%), central bank benchmark interest rate (4.75%) and national inter-bank lending average interest rate (4.59%) are brought into the calculation of the expected yield. Through comparison, it is found that there is no significant difference between the results of the expected yield. However, the difference between the expected and the actual rate of return is relatively large, which may be caused by the premise assumption of the capital asset pricing model. The capital asset pricing model requires the market to be an effective market, but the current situation of China's market is not an effective market, so there are some differences.

## 6. Suggestions

Because different industries are suitable for different risk-free interest rates, the market segmentation and diversification should be considered in asset pricing, and the risk-free interest rates should be selected for market pricing. At the same time, we should pay more attention to the interest rate alternative basket which can be used as risk-free interest rate, and carry out real-time monitoring and adjustment, so as to avoid large financial fluctuations.

In the selection of risk-free interest rate, we should also consider the change of macroeconomic situation and its impact on the risk-free interest rate alternative basket. In the case of ineffective market, macroeconomic policy has a very strong guiding role.

Improve the internal structure of the enterprise. Because the corporate governance system is a slowly changing process in the formation of the enterprise, it is necessary to start at the grassroots level to improve the relevant governance institutions of the enterprise. When reforming the financial institutions of state-owned enterprises, relevant management mechanisms should be improved from the grassroots level.

(4) Establish a sound risk management system. A sound risk management information system can not only help relevant personnel of an enterprise effectively identify risks in the current market environment, but also provide some useful information.

(5) Strengthening the system construction and strengthening the external control system construction, because from a legal perspective, there are still some shortcomings in the supervision of Chinese enterprises. Although China's socialist legalization construction has continued to deepen, due to the current level of social development and people Restrictions on their own quality and related legal provisions are still inadequate, so enterprises should take this into consideration, because these are very important for the actual risk control and external control of the enterprise



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## Author Profile

**Shi Ke**, female, Xi'an, Shaanxi, is now pursuing Master degree in school of Economics and Management, XIDIAN University. since 2018, and field of research is Finance.

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