The Applicability of Capital Asset Pricing Model in Shenzhen A-shares

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Abstract: This paper empirically tests the effectiveness of CAPM in the Chinese securities market using industry index data from 2012 to 2020 based on the industry grouping approach and with reference to the relevant research base of Chinese and foreign scholars. And draw the following conclusion: CAPM model is generally applicable to Shenzhen A-shares during 2012-2020.

Key words: Shenzhen A-shares , Capital asset pricing model

1.Introduction

The Capital Asset Pricing Model (CAPM), one of the cornerstones of modern finance, is a fundamental theoretical mathematical model in the financial profession, created in the mid-1960s by American economists William Sharpe (1964), John Limner (1965) and Mossin (1966), among others, in Markowits modern asset portfolio management theory[0] and the "two-fund separation theorem"[0] This model is widely used in the field of investment decision making and corporate finance because it reflects the nature of the economic market to a certain extent and is widely accepted by academics.

Since the introduction of the Capital Asset Pricing Model (CAPM), foreign scholars have made a lot of additions and extensions to it theoretically, for example, Bernnan added the influence of tax factors to the model and found that the traditional CAPM theoretical framework still holds[0] For example, Bernnan added the effect of taxation to the model and found that the traditional CAPM framework still holds; Fischer Black considered the case of risk-free assets that cannot be borrowed freely and proposed a zero-beta CAPM theory.[0] The CAPM theory of zero beta was developed by Fischer Black, who considered the case where risk-free assets could not be borrowed freely. With the continuous addition and improvement of theories, the focus of scholars' research on CAPM has shifted to empirical testing. Most of the early validation studies supported the CAPM, such as Black, Jensen[0] and Scholes, Fama and Macbeth[0] Both classic studies found a positive linear relationship between average stock returns and the beta coefficient. However, in the late 1980s, as empirical research advanced, some scholars challenged and questioned the CAPM, finding that other factors besides the β coefficient influenced asset returns, e.g. Banz and Reinganum argued that firm size effects had a significant impact on returns and that smaller firms tended to have higher abnormal returns[0] ; Fama and French et al. find that firm size, the degree of capitalisation of the market and the ratio of book value to market value of equity have significant effects on differences in asset returns, while the

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beta coefficient does not have convincing explanatory power[0] . These studies challenge the traditional CAPM theory: either the CAPM model cannot fully explain asset returns and other factors other than the beta coefficient need to be included, or the beta coefficient is measured in relation to other variables, such as firm size.

At present, the debate among scholars on the validity of the CAPM theory continues. Despite the different research methods and perspectives, most of the literature uses a number of individual stock data and market composite indices as research objects to test the validity of CAPM in the Chinese securities market with reference to the BJS approach. However, even if a two-way regression is used to group the stocks, it is only a "static grouping", and as the Chinese stock market continues to develop, the number, size and trading system of listed companies have changed significantly, which may lead to variable selection bias.

In view of this, this paper empirically tests the effectiveness of the CAPM in the Chinese securities market based on a comprehensive study by scholars at home and abroad, using industry index data from 2012 to 2020 based on the industry grouping method.

2. Theoretical model

2.1 Model derivation

Suppose there is a security i that forms a new portfolio P with a market portfolio M. Portfolio P must fall in the feasible set, but will not exceed the capital market line, so it can only be tangent to the efficient portfolio boundary at one point (let the point be A). At point A, the slope of the portfolio P boundary must be equal to the slope of the capital market line, and because the slope of the capital market line is equal to the Sharpe ratio, the slope of the portfolio P boundary at point A is equal to the Sharpe ratio. The expectation of the portfolio and the covariance of the portfolio lead to the formula

$$E(R_p) = W_i E(R_i) + (1 - W_i) E(R_m)^0$$

where $\mathrm{E}(\mathrm{R}_\rho)$ is the expected return on pW_i isR_i Percentage of investment

$E(R_m)$is the expected rate of return of the market portfolio, and$(1 - W_i)$ is the proportion of the market portfolio invested

$$\sigma_p = \sqrt{W_i^2 \sigma_i^2 + (1 - W_i)^2 \sigma_m^2 + 2W_i(1 - W_i)\sigma_{im}}$$

whereσ_p is the covariance of portfolio p, andσ_{im} is the covariance between capital i and the market portfolio m. Find the slope of portfolio P at point A$\frac{dE(R_p)}{d\sigma_p}$. The numerator is$\frac{dE(\sigma_p)}{dW_i} = E(R_i) - E(R_m), dE(\sigma_p) = [E(R_i) - E(R_m)]dW_i$

The denominator is$d\sigma_p = \frac{W_i^2\sigma_i^2 - \sigma_m^2 + \sigma_m^2 W_i + \sigma_{im} - 2W_i\sigma_{im}}{\sqrt{W_i^2\sigma_i^2 + (1-W_i)^2\sigma_m^2 + 2W_i(1-W_i)\sigma_{im}}} dW_i$

After deformation$\frac{dE(R_P)}{d\sigma_p} = \frac{[E(R_i) - E(R_m)][\sqrt{W_i^2\sigma_i^2 + (1-W_i)^2\sigma_m^2 + 2W_i(1-W_i)\sigma_{im}}]}{W_i^2\sigma_i^2 + (1-W_i)^2\sigma_m^2 + 2W_i(1-W_i)\sigma_{im}}$

Because at point AW_i = 0 $\sigma_m = \sigma_p$ therefore$\frac{dE(R_P)}{d\sigma_p} = \frac{[E(R_i)-E(R_m)]\sigma_m}{\sigma_{im}-\sigma_m^2}$

Since the capital market slope is$\frac{E(R_m)-R_f}{\sigma_m}$ (Sharpe ratio) so$\frac{[E(R_i)-E(R_m)]\sigma_m}{\sigma_{im}-\sigma_m^2} = \frac{E(R_m)-R_f}{\sigma_m}$

The deformation gives$E(R_i) = R_f + \frac{\sigma_{im}}{\sigma_m^2}E(R_m) - R_f$, the$\beta_{im} = \frac{\sigma_{im}}{\sigma_m^2} = \frac{cov(R_m R_{i1})}{Var(R_m)}$ The final result is

$$E(R_i) = R_f - \beta_{im}[E(R_m) - R_f]$$

2.2 Model establishment

From the above process it can be concluded that

$$E(R_i) = R_f - \beta_{im}[E(R_m) - R_f]$$

where E(Ri) is the expected return on asset i, Rf is the risk-free rate, E(Rm) is the expected return on the asset portfolio, and β_{im} coefficient is the ratio of the covariance between the return on asset i and the market return to the variance of the market return, reflecting the change in the return on asset i due to changes in the risk premium, and is used to measure the systematic risk of the market. In order to carry out the next step of the empirical test, the capital asset pricing model (CAPM) needs to be a one-dimensional linear regression model that can be introduced into historical data, and then the CAPM model can be tested by regression to see if it is applicable in the securities market. The final empirical model set for the test is

$$R_{it} - R_{ft} = \alpha_i + \beta_i[E(R_{mt}) - R_{ft}] + \varepsilon_{it}$$

whereR_{it} is the stock yield in period t of stock i, andR_{ft} is the risk-free rate of interest for period t, andR_{mt} is the market combined return in period t, andε_{it} is the random error term in period t, andα_i andβ_i are the parameters to be estimated.

3. Data Sources and Interpretation

3.1 Data selection

This paper selects 1377 constituent stocks of Shenzhen A-shares from 2012 - 2020 as the research object for testing the applicability of the Capital Asset Pricing Model (CAPM). Drawing on the research methodology of the existing literature, this paper screens the sample as follows: (1) exclude companies that are ST or PT (2) exclude observations with abnormal key indicators (3) exclude companies with less than two consecutive years of observations in the sample (4) exclude companies that lack data for the corresponding years. The remaining constituents are mainstream investment stocks with good representation, high liquidity and active trading in the Shanghai market, which can fully reflect the returns of mainstream investment in the market and meet the requirements of the CAPM model for market portfolio construction.

3.2 Data interpretation

1. Risk-free rate of return

Based on the concept of risk-free asset, treasury bonds issued by the central government of sovereign countries with relatively strong comprehensive national power are generally considered to be a more desirable risk-free asset and the 10-year treasury yield is commonly used as the risk-free rate of return. The risk-free rate of return R in this paper is based on the monthly ten-year treasury bond yields for the same period from 2012 to 2020 added together and divided by 12 to arrive at the current year's ten-year treasury bond yield as the risk-free rate. The final calculated risk-free rate for 2012 - 2020 based on the 10-year Treasury yield is 0.0342. The data is obtained from the bloomberg database.

2. Individual stock returns

In this paper, we use the annual individual stock return considering cash dividend reinvestment as the individual stock return applied in the empirical evidence denoted as$r$, and$r$ based on the formula $r_{nt} = \frac{p_{nt}}{p_{nt-1}} - 1$ is calculated.

where$p$ is the comparable price of the daily closing price of stock n on the last trading day in year t for which cash dividends are considered for reinvestment.p_{nt-1} is the comparable price of the daily closing price of stock n in year t-1 on the last trading day of the year considering reinvestment of cash dividends. Data from csmar database.

3. Market returns

In this paper, we use the market capitalization-weighted average market return as the market return applied in the empirical evidence, which is denoted asR_n In the rest of the paper, it is referred to as the market return in order to distinguish it from the individual stock returns.R_m In the rest of the paper, to distinguish it from individual stock returns, it is denoted as market return.

Market ReturnR_n is obtained from the following formula:$R_{nt} = \frac{\sum_n W_{nt} r_{nt}}{\sum_n W_{nt}}$

where R_{nt} is the market capitalization-weighted average market return of outstanding r_{nt} denotes the individual stock return for stock n in year t, and W_{nt} denotes the market capitalisation of stock n outstanding in year t-1.

W_{nt}Then the calculation is based on the following formula.$W_{nt} = V_{nt-1} \times P_{nt-1}$

V_{nt-1}Number of shares of stock n outstanding in year t-1;P_{nt-1} Closing price of stock n in year t-1.

The final calculated market return for Shenzhen A-shares for 2012 - 2020 is The above data is sourced from the csmar database.

4. Calculation of beta coefficient

According to the formula$\beta_{im} = \frac{\sigma_{im}}{\sigma_m^2} = \frac{cov(R_i, R_m)}{Var(R_m)}$, the beta coefficients for each stock in the Shenzhen A-share from 2012 - 2020 are derived via the excel calculation tool.

5. Classification of stocks in different sectors

This paper classifies the 1,377 constituent stocks of Shenzhen A-shares in 2012-2020 into 19 sectors according to the 2012 edition of the industry classification of the Securities and Futures Commission. Fourteen of these industries were selected for specific study. (The sample data for accommodation and catering, residential services, repair and other services, education, health and social work, combined are 6, 1, 6, 7 and 5 stocks respectively and the sample data size is too small to be included in the study)

4.Testing the validity of the Capital Asset Pricing Model (CAPM)

4.1 Full sample empirical evidence

To test the capital asset pricing model, the$R_{it} - R_{ft}$ as the explanatory variable β coefficient as the explanatory variable to do a regression so as to verify the$R_{it} - R_{ft}$ relationship with the beta coefficient.

The difference between each stock return and the risk-free rate ($R_{it} - R_{ft}$) and β coefficient is shown in the figure, the correlation coefficient is 0.1180618, and the p-value is less than 0.05, the t-value is greater than 2.56 indicating that the regression result is significant at 1% level of significance, and the goodness of fit R^2 is 0.3271. This indicates that the capital asset pricing model has strong applicability in Shenzhen A-shares, but there is still a random error of 0.0004659, indicating that the risk premium cannot perfectly explain the investment returns of individual stocks and there may still be other risk factors affecting stock prices.

4.2Empirical evidence by sector

1. Descriptive statistics for different industry data

The table(Table1) below depicts the mean, standard deviation, minimum and maximum values of stock returns and beta coefficients for the fourteen sectors.

The mean value of R_i for each industry in the table shows that the Culture, Sports and Entertainment industry has the largest average stock return in the 2012 - 2020 time period of .406; the Mining industry has the smallest average stock return of .094.

In this paper, the beta coefficient represents the risk premium of each sector's stocks relative to the market, which reflects systematic risk and market excess premium. beta > 1 indicates that the average risk of the sector's stocks is greater than the market risk and the excess return is greater than the market excess return, at which point the sector is more active than the overall market and outperforms the market; conversely, beta < 1 indicates that the sector portfolio's risk is less than the market risk and the excess return is less than the market Conversely, β < 1 means that the risk of the sector portfolio is less than the market risk and the excess return is less than the market excess return.

Table1. Descriptive statistics

	Variable	Obs	Mean	Std. Dev.	Min	Max
Manufacturing	Ri	864	.18	.145	-.156	1.498

	β	864	1.208	.715	-863	9.634
Mining	Ri	19	.094	.133	-.07	.387
	β	19	.762	.595	-.004	2.013
Electricity, heat, gas and water production and supply	Ri	35	.104	.08	-.155	.264
	β	35	.931	.384	-.002	1.743
Real Estate	Ri	48	.142	.088	-.023	.353
	β	48	1.029	.622	-.024	3.18
Construction	Ri	31	.104	.101	-.071	.382
	β	31	.949	.412	.329	1.83
Transport, storage and postal services	Ri	23	.137	.102	-.01	.475
	β	23	.982	.422	.329	2.017
Financial Services	Ri	24	.234	.198	.045	.835
	β	24	1.238	.734	.061	3.478
Scientific research and technical services	Ri	9	.253	.144	-.025	.412
	β	9	1.523	.608	.699	2.535
Agriculture, forestry, livestock and fisheries	Ri	16	.201	.112	.035	.406
	β	16	.236	.51	-.183	1.454
Wholesale and retail trade	Ri	54	.132	.148	-.096	.78
	β	54	1.183	.825	.018	5.058
Water, Environment and Public Facilities Management	Ri	26	.106	.088	-.015	.385
	β	26	1.018	.513	.266	2.466
Culture, sport and entertainment	Ri	17	.406	.359	-.03	1.387
	β	17	.326	1.911	-2.673	3.193
Information transmission, software and information technology services	Ri	112	.243	.136	-.028	.663
	β	112	1.526	.734	-.434	3.187
Rental and business services	Ri	27	.177	.149	-.062	.647
	β	27	1.393	.781	.271	3.88

2. Empirical testing

To test the correlation between the average stock return R_i and the beta coefficient, we used the linear regression equation.

$$R_i = k_0 + k_1\beta_i + \varepsilon_i$$

where R_i is the average return per stock over the period 2012 - 2020, and β_i is the respective stock's β coefficients, the k_0 and k_1 are the estimated parameters, and ε_i is the random error term. A linear regression using stata software for each of the fourteen sectors yields the following table(Table2).

Table2.Analysis of regression

	Manufacturing	**Mining**	**Electricity, heat, gas and water production and supply**	**Real estate, rental and business services**	**Construction**	**Transport, storage and postal services**	**Financial Services**

	Ri	Ri	Ri	Ri	Ri	Ri	Ri
β	0.123^{***}	0.109^{*}	0.0985^{**}	0.0847^{***}	0.166^{***}	-0.00957	0.205^{***}
t-value	(22.48)	(2.30)	(3.09)	(5.09)	(4.90)	(-0.18)	(5.47)
_cons	0.0320^{***}	0.0112	0.0126	0.0550^{**}	-0.0530	0.147^{*}	-0.0197
t-value	(4.17)	(0.25)	(0.39)	(2.76)	(-1.52)	(2.61)	(-0.37)
N	864	19	35	48	31	23	24

	Scientific research and technical services	**Agriculture, forestry, livestock and fisheries**	**Wholesale and retail trade**	**Water, Environment and Public Facilities Management**	**Culture, sport and entertainment**	**Information transmission, software and information technology services**	**Rental and business services**
	Ri	Ri	Ri	Ri	Ri	Ri	Ri
β	0.0584	-0.00909	0.154^{***}	0.119^{***}	-0.129^{**}	0.0847^{***}	0.130^{***}
t-value	(0.68)	(-0.15)	(12.01)	(4.64)	(-3.67)	(5.37)	(4.67)
_cons	0.164	0.203^{***}	-0.0508^{**}	-0.0152	0.448^{***}	0.113^{***}	-0.00507
t-value	(1.16)	(6.31)	(-2.75)	(-0.52)	(6.77)	(4.25)	(-0.11)
N	9	16	54	26	17	112	27

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Based on the results of the stata linear regression, we arrive at the data in the table above. Next, we will analysis the data in depth and further discuss the correlation between the average stock return R_i and the beta coefficient.

Firstly, a positive or negative beta represents whether the risk premium and the average return of this stock are positively or negatively correlated. Based on the data in the table, we can deduce that the beta values for manufacturing, mining, electricity, heat, gas and water production and supply, real estate rental and business services, construction, finance, wholesale and retail trade, water, environment and public facilities management, information transmission, software and information technology services and rental and business services are all positive, which indicates that the risk premium of these stocks is positively correlated with its average return is positively correlated. The p-values are all significant at the 1% or 5% level again indicating that the capital asset pricing model can explain such data and thus the validity of the CAPM in Shenzhen A-shares. Conversely, the negative beta values for Transportation, Storage and Post, Agriculture, Forestry, Animal Husbandry and Fisheries, and Culture, Sports and Entertainment indicate that the risk premium of these stocks is negatively correlated with its average return. The negative correlation indicates that the capital asset pricing model is not applicable in the analysis of these stocks, and therefore cannot be used as a condition for the validity of the CAPM in the Chinese stock market.

The next step is to analysis the data for stocks with positive beta in more detail, although they all have a positive effect, the magnitude of the significance level also provides clearer evidence of the conclusion. The mining sector is significant at the 10% level, the electricity, heat, gas and water production and supply sector and the culture, sports and entertainment sector are significant at the 5% level, while the manufacturing, real estate, rental and business services, construction, finance, wholesale and retail, water, environment and utilities management, information transmission, software and information technology services and Rental and business services is significant at the 1% level and is the most significant and meaningful result for the study. In contrast, the β value for Scientific Research and Technology Services is positive, but its result is not significant, so the data for this stock does not prove our research question.

In summary, we can conclude from the data information that the CAPM model is generally applicable to Shenzhen A-shares in 2012-2020, and when we break it down to each industry, the CAPM is applicable in the remaining industries discussed in this paper, except for scientific research and technical services, transportation, storage and postal services, agriculture, forestry, animal husbandry and fishery, and culture, sports and entertainment. It can be seen that the linear relationship between the average return on asset portfolios and the beta coefficient in the traditional CAPM model still holds in the Shenzhen A-shares, using the Shenzhen A-shares from 2012-2020 as the research sample.

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