Validation on the Effectiveness of CAPM: Based on Data from China Growth Enterprise Market

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Abstract. Based on Markowitz's Portfolio Theory, Sharpe, Lintner and Mossin made contribution to advance the development of the Capital Asset Pricing Model. However, later research proves that the CAPM is not available in many markets. There are many researches showing that CAPM is not applicable in China's asset market. The China Growth Enterprise Market, or CNX, is a crucial stock exchange designed to give high-tech, fast-growing businesses access to capital and expansion space. A number of studies show that the COVID-19 affected China's asset market significantly, but the majority of relative research concentrate on the applicability of other asset pricing models, for example, the Fama-French factor models instead of CAPM. This study investigates the effectiveness of CAPM model from 2020 to 2022 using statistics of stocks selected from the China Growth Enterprise Market. This research selected 100 stocks in CNX and made sure the sample is composed of stocks in various industries. Then, this study collected monthly data of stock return, market return and risk-free interest rate from CSMAR database and Choice Financial Terminal. Afterwards it divided the data into three equal parts based on time scale and tested the correlation between CNX stock returns and the beta parameter through a combination of the BJS method and the FM method. These results show that from 2020 to 2022, CAPM is not effective in the China Growth Enterprise Market.

Keywords: β coefficients, CAPM, BJS method, FM method, China growth enterprise market.

1. Introduction

The American economist Markowitz first introduced the use of stock price volatility and the expected return of riskier assets to examine asset selection and combination, opening up the study and discussion about CAPM. In 1964, Sharpe proposed CAPM theory and pointed out that there was a correlation between asset returns and systemic market risk [1]. Later, Lintner and Mossin contributed to improve and complete the model, forming CAPM theory that is widely used now [2, 3]. Early studies strengthened the theory. Jensen, Black and Scholes selected listed companies in the New York Stock Exchange as respondents and collected statistics between January 1926 and March 1966 [4]. The study found a positive linear correlation between systematic risk and stock returns. Using US stock data before 1969, MacBeth and Fama conducted a cross-sectional two-stage regression examination and found a positive link between beta coefficient and average stock returns [5].

But since the 1970s, an increasing number of studies have questioned CAPM's usefulness in a variety of asset markets. Roll proposed the famous “Poll Criticism”, as his empirical test proposed that the market index cannot represent real market portfolio [6]. Reiganum used stock data from 1963 to 1977 and discovered that the positive correlation between beta and the expected stock returns disappeared [7]. Reiganum also discovered the Small Firm Effect. Haugen disovered that among the component stocks of the S&P 500 Industrial Index, there was an inverse relationship between the level of risk and the actual return [8]. Bartholdy and Peare tested the CAPM and the Fama-French Three-Factor Model based on data from the New York Stock Exchange [9]. They discovered that both model fit poorly. Fama and French separated the stock samples into six sets according to two new criteria, which are the B/M ratio and the company size, and introduced Fama-French Three-Factor Model [10]. Studies toward the effectiveness of CAPM in China stock market also presented mixed results. The studies showed that CAPM fitted poorly in the security market in China compared to security markets in other countries. This might result from market immaturity, imperfect market mechanisms, and investor irrationality. Shi conducted an empirical study using 50 A-shares from the Stock Exchange of Shanghai as respondents and found that the respondents' stock returns showed a negative correlation with risk factors, which deviated from the reality [11]. Yang and Xing conducted an empirical analysis using all Shanghai A-share samples from 1993 to 1995 over three years. The findings demonstrated that the correlation between returns and the systematic risk did not follow the theoretical predictions of the CAPM model [12]. Gu and Liu used Shenzhen A-share data from 2000 to 2006 to evaluate the CAPM model. The results demonstrated that under the certain circumstance, the linear correlation between stock returns and the square term of the P-value as well as other non-market factors did not exist [13]. Chinext was established on October 30, 2009. Among studies circling the Chinext, researchers centered less on CAPM and more on the efficacy of the Fama-French factor model.. Liu, Zhu and Li tested the effectiveness of Fama-French three-factor model based on Chinext data from 2010 to 2013 [14]. The research found out that the Fama-French three-factor model fitted quite well in the ChiNext market. Ma and Shen tested the Fama-French five-factor model using Chinext data during 2010 and 2020 and drew the conclusion that the Fama-French five-factor model fitted the Chinext market to a certain degree [15]. Li used Chinext statistics to examine the performance of the Fama-French three-factor model and CAPM. The empirical results showed that improved Fama-French three-factor model performed better than CAPM [14].

Historical research has shown that CAPM fit poorly in many boards of the China's security markets, but a relatively small number of them focused on the Chinext. Among studies that concentrated on the Chinext, few of them discussed the effectiveness of CAPM. CAPM has always been an essential model in explaining the relationship between returns and risks. Therefore, my research intends to complete this part of research by using recent data. The study is meaningful in exploring the pricing pattern of an important part of the market and examining the development of the market mechanism of the Chinext. In following parts, this study first reviews the theory and assumption of CAPM. Afterwards, it introduces the source of the data used and the calculation of important indicators. Then, this study gives a brief summary of the operating principles about the method proposed by Black, Jensen and Scholes and the cross-sectional examination method brought up by Macbeth and Fama. Finally, this research presents the empirical results of the BJS test and the FM test and draw the conclusion.

2. Data and Method

100 individual stocks in the Chinext are selected out as the sample. This study collects the monthly data of the sample stocks from 2020 to 2022, that is 36 observations for a single sample stock. The source of the stock data is CSMAR database. The indicator includes the daily comparable price of the individual stocks. As a result of stock splits, rights issues, bonus issues, and other factors affecting share capital, the closing prices released by the exchange have also changed. Therefore, the closing prices announced by the exchange are not comparable over time. To address the issue, CSMAR database provides comparable daily closing prices, including comparable daily closing prices with a consideration of the reinvestment of cash dividends as well as comparable prices of daily closing prices without considering cash dividends. The comparable daily closing prices are calculated based on the closing prices on the first days of listing, and they are derived by recursion from the closing prices on the first listing days. Monthly return of the individual stock is calculated by:

$$r_{n,t} = \frac{P_{n,t}}{P_{n,t-1}} - 1 \tag{1}$$

Here, $P_{n,t}$ represents the daily comparable closing price (taking the reinvestment of cash dividends into consideration) for stock n on the last trading day of month t. For market return, this study chooses Shenzhen Stock Exchange Component Index (SZI). The calculation method of the

Shenzhen Component Index involves selecting stocks from the 500 listed companies that are representative of the companies in the Shenzhen Stock Exchange. The number of circulating shares is used as the weight when calculating the sample based on the weighted average approach. The base date is set at July 20, 1994, with the base index value set at 1,000 points. All stocks in the Chinext board are traded in Shenzhen Stock Exchange. The article regards return of SZI as a better representation of the market return. The data of monthly SZI are selected from the Choice Financial Terminal. Monthly return of the index is calculated by:

$$R_{n,t} = \frac{I_{n,t}}{I_{n,t-1}} - 1 \quad (2)$$

where $I_{n,t}$ represents the closing index of SZI on the last trading day in month t. The yearly interest rate of the one-year fixed deposits for residents is chosen to be the risk-free interest rate. This study translates the original annual risk-free rate into monthly data using the compound interest computation method.

BJS method is a regression analysis method based on time-series statistic and was proposed by Jensen, Black and Scholes. The advantage of this method is that it effectively addresses the error issues in CAPM testing pointed out by Lintner. The specific process can be divided into the following three testing steps. First, one needs to carry out beta coefficient estimation for each stock

The research period is divided into three equal segments. The first segment is from January 1, 2020 to December 31,2020. This study uses stata to conduct time series regression and estimate a beta coefficient for every single stock. The model refers to:

$$R_{it} - R_{ft} = \beta_{it}(R_{mt} - R_{ft}) + \varepsilon_{it} \quad (3)$$

Then, one sorts the stock sample based on the ascending order of the beta coefficients. The whole sample is divided into 10 groups with 10 stocks in each group. Grouping can, on the one hand, lessen the effect of the single stock beta coefficient's estimation bias during the sorting phase. On the other hand, clustering equities into similar groups ensures that they have comparable levels of systematic risk. In this way, stocks that are highly relevant are combined. It is also possible to prevent the diversification of stochastic risk that can result from random pairings. It will be hard for empirical research conducted during the testing period to determine whether the unsystematic risk will have an impact on stock prices if a significant portion of the risk has already been diversified when the stock portfolio is created. Subsequently, one needs to realize beta coefficient estimation for the portfolio. Data during the second time segment, that is from January 1 2021 to December 31 2021, is used for estimation in this step. The arithmetic average value of the monthly stock returns in each group is used as the monthly return of the group. Next, this research designated the market's excessive return as the independent variable and the portfolio return as the dependent variable. The target is to get an estimation of beta for each stock group. The regression model refers to:

$$R_{pt} = \alpha_{pt} + \beta_{pt}(R_{mt} - R_{ft}) + \varepsilon_{it} \quad (4)$$

The sample during the third time segment (January 1 2022 to December 31 2022) is used as the data for test. In this step, the beta estimates of the portfolio which are estimated in step 2 are set as the independent variable of the regression.Monthly return of the portfolio is calculated in the same way as in step 2. Portfolio return R_p represents the arithmetic mean the monthly returns in 12 months. The regression model refers to:

$$R_p = \gamma_0 + \gamma_1\beta_p + \varepsilon_p \quad (5)$$

Here, γ_0, γ_1 are the coefficient to estimate as well as the indicator of the test.

FM method is also known as the cross-sectional testing method first brought up by Macbeth together with Fama. The regression is conducted based on the data in the third time segment. The regression model refers to:

$$R_p = \gamma_0 + \gamma_1 \beta_p + \gamma_2 {\beta_p}^2 + \gamma_3 \sigma_p + \varepsilon_p \quad (6)$$

In the model, the quadratic term of the portfolio beta estimates is added in the function. Furthermore, the residuals of the standard deviation of the group beta estimates is also set as one of the independent variables. If systematic risk and expected return on stocks are correlated linearly, then γ_2 should be 0. If the beta parameter is the only variable that will make impact on the stock's expected return, that is to say taking any unsystematic risk will not bring excessive return, then γ_3 should be 0. If the investors tend to avoid risk, taking higher risk means getting higher return, then γ_1 should be positive.

3. Results and Discussion

The results of regression toward each individual stock are given. Table 1 records the estimates of the beta coefficient and information about the goodness of fit based on data from period 1. The estimates of the beta coefficient for individual stocks range from -1.62 to 2.51. Among the 100 individual stocks selected, there are only 28 stocks whose beta estimates are significant. Most of the estimation displays a p-value larger than 0.1. The statistics of R-squared also show poor model fit. Only 8 regressions display R-squared over 0.5. This study also uses a sample with a longer time span (2018-2020) and weekly data in 2020 to check whether the overall poor goodness of fit results from low data frequency. Samples with other individual stocks are examined as well. The results are similar to that displayed in Table 1. This suggests that the model may not be suitable to explain the correlation between individual stock returns and systematic risk. The market risk fails to explain the majority of reasons for changes in stock returns. Several factors may participate in affecting stock pricing together. The variance in stock returns may be partially explained by the unsystematic hazards unique to individual stocks. Based on the estimates of beta coefficient, the respondents are divided into 10 groups with ten stocks in every single group. The grouping detail are shown in Table 2.

Table 3 shows the estimates of beta coefficient and the test results about the goodness of fit. The estimates of portfolio beta coefficient range from -0.514531 to 0.466815. Their R-squared values are also extremely low, even lower than those present in the individual regressions. 8 R-squared values are lower than 0.1 and only one of them is higher than 0.2. None of the grouping regression displays a p-value less than 0.1, showing that all statistics results are not significant. This suggests that even though stocks with close beta estimates are grouped in order to diversify unsystematic risks, CAPM model still cannot fit the data well. To be sure, the overall poor significance level may result from the existence of some nonstationarity in the relations and to the lack of more complete aggregation. But because the R-squared values are so low, it's possible that the CAPM model has little explanatory ability. Fig. 1 displays the scatter plot of the average returns throughout the portfolio and its beta values. The graph indicates that the average returns of a portfolio do not seem to be correlated with its beta values. Furthermore, one uses the average returns of each group as the dependent variable and the portfolio beta coefficients obtained from the regression during the estimation period as the independent variable to perform a simple linear cross-sectional regression. Table 4 gives the regression outcomes of the test in step 3.

Table 1. Beta coefficient estimates of individual stocks.

stock code	Beta estimates	R-squared	P-value	stock code	Beta estimates	R-squared	P-value
300001	0.5848162	0.0797	0.368	300031	1.14205	0.508	0.009
300002	0.46125	0.0663	0.419	300032	0.2647596	0.05	0.485
300003	0.558715	0.2614	0.089	300033	0.6395133	0.165	0.19
300004	0.0288752	0.07	0.948	300034	1.25927	0.4319	0.02
300005	0.3343551	0.0323	0.576	300035	0.542853	0.1074	0.298
300006	0.2505847	0.0294	0.594	300036	0.8910236	0.3558	0.041
300007	0.4200058	0.0616	0.437	300037	1.160176	0.4428	0.018
300008	-0.2181688	0.0088	0.771	300039	0.3048264	0.083	0.364
300009	0.885384	0.2365	0.109	300040	0.091195	0.0078	0.785
300010	1.15842	0.1933	0.153	300041	0.3206745	0.0605	0.441
300011	0.304276	0.1191	0.272	300042	0.9982197	0.2801	0.077
300012	0.8043424	0.4197	0.023	300043	0.5273505	0.1632	0.193
300014	1.737534	0.7038	0.001	300044	0.6729362	0.398	0.028
300015	0.378995	0.1235	0.263	300045	0.8413237	0.2718	0.082
300016	1.215164	0.4671	0.014	300046	-0.616994	0.121	0.268
300017	0.7231233	0.2901	0.071	300047	0.3381754	0.1263	0.257
300018	0.3603369	0.071	0.403	300048	-0.7033594	0.1366	0.237
300019	0.606804	0.0511	0.48	300049	0.7848085	0.3301	0.051
300021	-0.1108585	0.0084	0.777	300050	-0.6017388	0.2463	0.101
300022	-0.5322078	0.196	0.15	300051	0.9690338	0.1604	0.197
300024	0.4374101	0.2342	0.111	300052	0.8252064	0.379	0.033
300025	-0.4542416	0.18	0.169	300053	0.2812963	0.054	0.468
300026	0.2735394	0.0567	0.456	300054	1.307474	0.5766	0.004
300027	0.6302591	0.0985	0.32	300055	0.2647206	0.0793	0.375
300030	1.184433	0.2142	0.13	300056	-0.4964502	0.1549	0.206
300057	0.1152851	0.0117	0.738	300084	-0.1958286	0.0447	0.51
300058	0.8184562	0.289	0.071	300085	1.105608	0.3097	0.06
300059	1.541542	0.6146	0.003	300086	1.433751	0.208	0.136
300061	0.0848668	0.0032	0.862	300087	0.7325604	0.0852	0.357
300062	-0.8331303	0.014	0.714	300088	1.201766	0.4449	0.018
300063	0.7403422	0.1345	0.241	300089	0.3318525	0.0439	0.513
300065	0.9556267	0.1789	0.171	300091	-0.0928074	0.0053	0.821
300066	-0.0564672	0.0029	0.869	300092	0.1732645	0.0148	0.706
300067	-0.1396296	0.015	0.704	300093	0.4806289	0.167	0.187
300068	0.675429	0.2567	0.093	300094	-0.4260006	0.0376	0.546
300069	0.0727933	0.0044	0.838	300095	0.7726677	0.1462	0.22
300070	0.315033	0.0587	0.448	300097	0.6185778	0.0469	0.499
300071	-0.5532286	0.1335	0.243	300098	0.2306642	0.0152	0.703
300072	0.8821639	0.1904	0.156	300099	-9.81E-06	0	1
300073	1.03935	0.2444	0.102	300100	-0.2752634	0.0067	0.8
300074	0.5440594	0.0839	0.361	300101	0.8149388	0.3056	0.062
300075	0.8579489	0.5436	0.006	300102	0.1502786	0.872	0.0027
300076	0.2228839	0.0511	0.48	300103	-0.1017801	0.0072	0.793
300077	0.5414595	0.0942	0.332	300105	-0.3829734	0.1631	0.193
300078	0.7167045	0.2248	0.119	300106	-1.623366	0.2245	0.12
300079	0.1741396	0.0281	0.602	300107	-0.1357948	0.0172	0.685
300080	0.1511369	0.011	0.745	300109	0.9517835	0.3255	0.053
300081	0.9442509	0.3633	0.038	300110	0.453804	0.1287	0.252
300082	0.8217914	0.3205	0.055	300111	0.2928275	0.0441	0.512
300083	2.509297	0.6357	0.002	300112	0.10801	0.0073	0.792

Table 2. Grouping details

1	2	3	4	5	6	7	8	9	10
300106	300105	300099	300079	300039	300110	300097	300049	300036	300037
300062	300100	300004	300076	300070	300002	300027	300012	300081	300030
300048	300008	300069	300098	300041	300093	300033	300101	300109	300088
300046	300084	300061	300006	300089	300043	300044	300058	300065	300016
300050	300067	300040	300055	300005	300077	300068	300082	300051	300034
300071	300107	300112	300032	300047	300035	300078	300052	300042	300054
300022	300021	300057	300026	300018	300074	300017	300045	300073	300086
300056	300103	300102	300053	300015	300003	300087	300075	300085	300059
300025	300091	300080	300111	300007	300001	300063	300072	300031	300014
300094	300066	300092	300011	300024	300019	300095	300009	300010	300083

Table 3. Regression results for the portfolios

Group number	β estimates	Std.err.	t	P-value	R-squared
1	-0.1408816	0.4091018	-0.34	0.738	0.0117
2	-0.5145315	0.3359978	-1.53	0.157	0.19
3	0.2646429	0.3999991	0.66	0.523	0.0232
4	0.0270058	0.4118323	0.07	0.949	0.0004
5	0.1103923	0.3291716	0.34	0.744	0.0111
6	0.3515243	0.3838522	0.92	0.381	0.0774
7	-0.3939624	0.3874578	-1.02	0.333	0.0937
8	0.1865119	0.2967462	0.63	0.544	0.038
9	0.0754749	0.5305648	0.14	0.89	0.002
10	0.466815	0.2854376	1.64	0.133	0.211

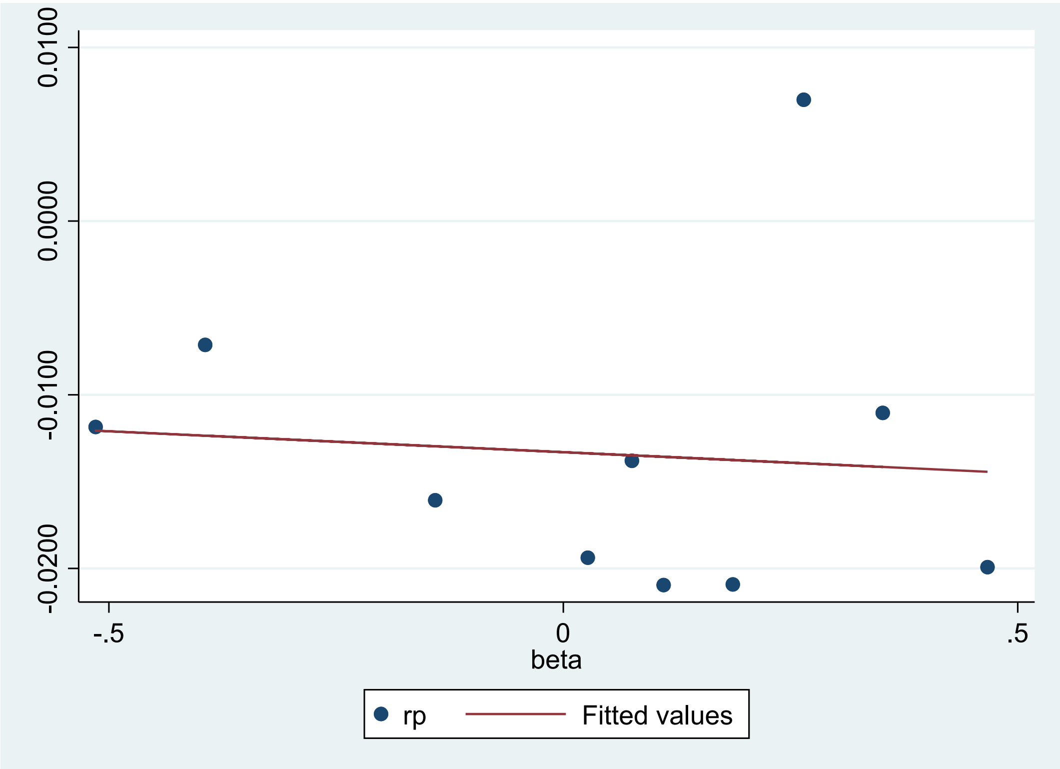

Figure 1. Scatter plot of group beta values and group average returns (Photo/Picture credit: Original).

Table 4. Cross-sectional regression results based on data in period 3

Coefficient	Estimates	Std.err	t	P-value
γ_0	-0.002412	0.0096258	-0.25	0.808
γ_1	-0.0133037	0.0028953	-4.59	0.002
	R2		0.0078	

From table 4, the estimates of γ_0 is -0.002412. A negative estimate of the constant term does not conform to the real monthly risk-free interest rate (0.1241%). In addition, the estimates of γ_1 is -0.0133037, which is also less than zero. The result of a negative beta estimates shows that when the systematic risk rises, the investors will not ask for higher returns, which does not conform to the facts. Moreover, the fit of the equation is poor, presenting a coefficient of determination of only 0.0078. The result indicates that the fitting result is not ideal. As a result, it can be deducted that systematic risk and stock returns do not significantly correlate linearly, and their negative association is not very strong. It can be inferred that several other risk variables in addition to systematic risk have a stronger influence on stock price. The testing outcomes suggest that CAPM is not effective in Chinext. For investors who want to invest in the Chinext ,CAPM model can not offer effective instructions. This also reflects the immature securities market and imperfect institutions in the Chinext.

Folllowing shows the result of the regression using the cross-sectional regression method proposed by Fama and MacBeth to investigate the applicability of CAPM in the Chinext. The results are shown in Table 5. None of the four coefficients passed the significance examination as the p-values are all much higher than 0.1. This implies that CAPM has limited applicability in the Chinext. The estimate of γ_1 is positive, which conforms to CAPM. This result shows that the investors are risk-averse and pursue higher returns with higher risk considering unsystematic risks. However, the result need further test since the coefficient is not significant. The estimates γ_2 is larger than zero but not significant. Therefore, whether stock returns and systematic risk linearly correlate can not be demonstrated. The estimate of γ_3 is positive and much greater than the estimate of γ_1, suggesting that systematic risks are not the only factor that affect stock returns.

Table 5. Regression results for FM test

Coefficient	Estimates	Std.err.	t	P-value
γ_0	-0.0416414	0.021821	-1.91	0.105
γ_1	0.0028327	0.0106028	0.27	0.798
γ_2	0.0405805	0.0390967	1.04	0.339
γ_3	0.0648229	0.0514164	1.26	0.254

4. Conclusion

To sum up, this piece evaluates the CAPM's performance in the China Growth Enterprise Market. (Chinext) using monthly data on stocks traded from 2020 to 2022. BJS method and FM method are used for empirical tests.Both models suggest that CAPM is not effective in explaining the factors that affect stock returns. For both individual stocks and portfolios, the first and second steps of the BJS test fail to show a positive linear connection between stock returns and systematic hazards. The empirical results in the third step of the BJS test and the FM test exhibit poor significance level of coefficients for the independent variables. Conclusively, CAPM is not applicable to the Chinext and there are factors other than systematic risks that affect asset pricing in this market. To mention, results presented may result from factors such as the choice of stocks and testing periods. The results may suggest that the Chinext is still an immature market and its institutions are to be improved. For investors who want to invest in the Chinext, CAPM may not be a useful model that can provide instructions for their investment plan. For future studies, the effectiveness of other models (e.g., Fama-French Three-Factor Model and Fama-French Five-Factor Model) can be tested to discover other potential variables that affect asset pricing in this market.

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