The Chinese University of Hong Kong

(Shenzhen)

School of Management and Economics

FIN3080 Investment Analysis and Portfolio Management

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Empirical Test of CAPM in China Stock Market

罗琦琦

118020046

I . Theory background of CAPM

In the 1960s, Sharpe, Lintner and Mossin extended Markowitz's mean-variance theory to the CAPM model. In the CAPM model, it assumes (a) the investors only care about the expected return and risk, (b) they will choose higher-yielding securities at the same level of risk and choose less risky securities at the same rate of return, (c) investors can know in advance that the probability distribution of investment returns is normally distributed, (d) the capital market is a perfect (complete) market without any friction hindering investment, (e) the betas of the assets remain constant over time, (f) stock price is independent in time series. The equation expression of CAPM model is

$$E(R_i) = R_f + \beta_i[E(R_m) - R_f],$$

where $E[R_i]$ is the expected return of asset i; R_f is the risk-free rate; $E(R_m)$ is the expected return of market portfolio; and β_i is used to describe the systematic risk, which equals to the covariance of asset i and market portfolio divided by the variance of market portfolio

$$\beta_i = \frac{Cov(R_i,R_m)}{\sigma^2_{R_m}} .$$

II . Methodology

According to the method proposed by Fama and MacBeth (1973) , I carried out the CAPM empirical test by combining the cross section regression with the time series regression. The specific steps are as follows:

① The sample data were divided into three period. The first period contained 67 weeks, the second period is 67 weeks, and the third period is 69 weeks.

② In the first period, I carried out time series regression of the weekly return of asset i $r_{i,t}$ on the weekly return of the market portfolio $r_{m,t}$ and got the estimators of each asset i, denoted as $\widehat{\beta_i}$. The regression model was

$$r_{i,t} = \alpha_i + \beta_i r_{m,t} + \varepsilon_i$$

Assume E(ε_i) = 0, then

$$E(r_{i,t}) = \alpha_i + \beta_i E(r_{m,t})$$

③ In the second period, I constructed 20 portfolios (124 individual stocks in each portfolio) by the rank of $\widehat{\beta_i}$. Then, I carried out time series regression of the risk premium of the portfolio p $r_{p,t} - r_{f,t}$ (weekly return of each portfolio – risk-free

rate) on the weekly return of the market portfolio and got the estimators of each portfolio p, denoted as $\widehat{\beta_p}$. The regression model was

$$r_{p,t} - r_{f,t} = \alpha_p + \beta_p(r_{m,t} - r_{f,t}) + \varepsilon_i$$

Assume E(ε_i) = 0, then

$$E(r_{p,t} - r_{f,t}) = \alpha_p + \beta_p E(r_{m,t} - r_{f,t})$$

The weekly return of each portfolio is the average weekly return of the stocks in each portfolio.

④ In the third period, I carried out cross-sectional regression of the average risk premium of the portfolio p $\overline{r_{p,t} - r_{f,t}}$ on the estimated $\widehat{\beta_p}$ and $\widehat{\beta_p^2}$ of each portfolio to test CAPM model. The regression model was

$$r_{p,t} - r_{f,t} = \gamma_0 + \gamma_1\beta_p + \gamma_2\beta_p^2 + \varepsilon_i$$

and the average risk premium of portfolio p was calculated by

$$\overline{r_{p,t} - r_{f,t}} = 1/T \sum_{T=1}^{33} (r_{p,t} - r_{f,t})$$

III . Sample and data

The sample was all stocks of Shenzhen and Shanghai mainboards (including small and medium-sized boards) from January 4, 2016 to December 27, 2019. All the data in the test were downloaded from CSMAR.

i. The return of asset i

The observations of the empirical test were the weekly return of all stocks of Shenzhen and Shanghai mainboards (including small and medium-sized boards) from January 4, 2016 to December 27, 2019. The monthly return rate of a single stock considering the reinvestment of cash dividend was calculated by

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

, where $P_{n,t}$ is the comparable daily closing price of stock n on the last trading day of the week t, taking into account the reinvestment of the cash dividend and $P_{n,t-1}$ is the comparable daily closing price of stock n on the last trading day of the week (t-1).

ii. The return of market portfolio

Based on the market environment of the sample stock, I chose Shanghai and Shenzhen 300 index as the market portfolio. The daily return of the index R_t^D is calculated by

$$R_t^D = \frac{r_t}{r_{t-1}} - 1$$

, where r_t is the closing index of index on the day of t and r_{t-1} is the closing index of index on the day of t-1.
The weekly return of the index is calculated by the method of compound interest.

iii. The risk-free rate

The risk-free rate was provided by CSMAR. The annual risk-free interest rate is the one-year interest rate for lump-sum time deposit and lump-sum withdrawal. Then, according to the calculation method of compound interest, the annual risk-free rate is converted into weekly risk-free rate.

IV . Analysis

There are three hypotheses:

1. Linearity --- E(γ_2) = 0
2. Positive expected return – risk trade-off --- E(γ_1) = E(R_m) $-E(R_f) > 0$
3. No idiosyncratic risk --- E(γ_0) = 0

After processing these four steps, I got the result as Table 1

Source	SS	df	MS	Number of obs	=	20
				F(2, 17)	=	0.02
Model	.000171338	2	.000085669	Prob > F	=	0.9797
Residual	.071030748	17	.004178279	R-squared	=	0.0024
				Adj R-squared	=	-0.1150
Total	.071202086	19	.003747478	Root MSE	=	.06464

rate	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
beta	-1.245547	18.0872	-0.07	0.946	-39.4062	36.91511
betasq	.710674	11.10132	0.06	0.950	-22.71105	24.1324
_cons	.7532748	7.358865	0.10	0.920	-14.77257	16.27912

Figure1 The cross-sectional regression result

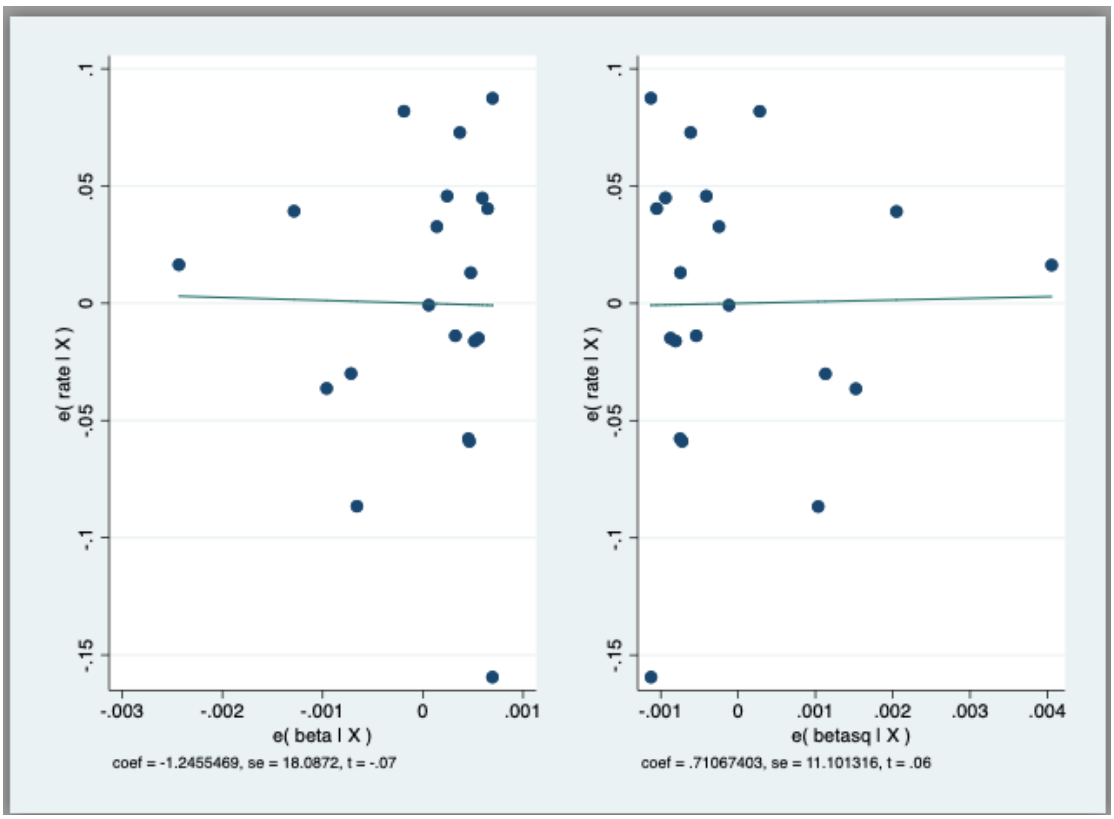

figure 2 cross-sectional regression figure

As the figure1 shows that E(γ_1) is < 0, E(γ_0) is = 0, and E(γ_2) = 0. That means the relationship between expected return and risk is linear. But they are negative related and there is no idiosyncratic risk.

V . Conclusion

The results of the empirical test shows that the CAPM model is not suitable for Chinese stock market. I think there are several reason. First, it's obviously that it's impossible the betas of the assets to remain constant over time. Second, the probability distribution of investment returns is not normally distributed. Third, stock price is independent in time series. That's why it fails to use CAPM model to estimate the stock price in Chinese stock market.

VI . Reference

Fama, E. and Macbeth, J.D. (1973). *Risk, return and equilibrium: Empirical tests.* Journal of Political Economy, 81,607-636.