Empirical Analysis on the Applicability of Two Capital Asset Pricing Models to New Energy Vehicle Stocks

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ABSTRACT

For the policies of many countries aimed at controlling carbon dioxide emissions, the new energy vehicle industry has developed rapidly. However, after the impact of COVID-19, many industries have been cleared out of the national list and the new energy vehicle industry has been left behind, and a large number of national funds have been used for new energy vehicles. As a new and special industry, the stock of new energy vehicles may differ the overall a-share market shares from the applicability of asset pricing model. This paper conducts an empirical analysis on the applicability of CAPM model and Fama-French three-factor model in the stock market of new energy vehicle industry. The study found that the three-factor model's applicability is better than the CAPM model, and scale factor and book-to-value ratio factor have a certain reference significance, while market factor still has good reference significance, which amount of variation is greater than the rate of yield. In addition, in China's new energy vehicle stocks, there is a small-scale effect, and the medium and high book value ratio of stocks show a certain book value ratio benefit.

Keywords: *CAPM model; Fama-French three-factor model; new energy vehicle stock*

1. RESEARCH BACKGROUND AND LITERATURE REVIEW

The pricing of stocks has always been the focus of most investors, and the factors affecting stock pricing have also become a protracted topic of discussion. According to the practical investment experience and the analysis of transaction data, combined with the theory of relevant disciplines, the researchers constantly improve the capital asset pricing theoretical system and pricing model from the CAPM model to the multi-factor model.

Starting from 2019, many countries around the world have introduced policies aimed at controlling carbon dioxide emissions. Take the European Union's "CARBON credits" policy. The policy has prompted companies to speed up the production of new energy vehicles to meet carbon emissions requirements. In 2020, in the wake of the COVID-19 pandemic, many countries made deliberate adjustments to the flow of funds to different sectors -- some sectors were "cleared" from the investment list, while most countries retained the new energy vehicle sector. The stock of new energy vehicles differs from the overall a-share market shares from the applicability of asset pricing model. Some conclusions established in the overall A-share stock market may not be established in the new energy vehicle industry. On the contrary, the new energy vehicle industry can also conclude that the overall A-share market can not be drawn. Therefore, this paper conducts an empirical analysis on the applicability of CAPM model and Fama-French three-factor model in the stock market of new energy vehicle industry, providing certain reference values for investors and policy issuers in this sector.

Yunhui Jin and Lin Liu (2001)[1], using the CAPM model to test China's stock market, believe that there is no doubt about the effectiveness of the "mean-variance" of the market composite index representing the market portfolio. Whether there are no-risk-free assets and the earnings of stocks were not only related to factors outside of Beta, but also not linear to Beta. They finally concluded that the CAPM model did not apply to the market. Shaohua Chen (2020)[2] and Shicheng Fan (2021)[3] analyzed the earnings of Chinese stocks and Chinese liquor industry based on the CAPM model respectively, and reached the conclusion that the CAPM model is not applicable. Xin Yang, Zhanhui Chen(2003)[4] study the nature of the stock yield and the applicability of Fama-French three-factor asset pricing model in China A-share market, that the Shanghai A-share market has scale

effect and shareholder equity book to value ratio effect, based on the three-factor model can fully explain the A-share market yield section difference. The study of Zhigang Ouyang and Fei Li (2016)[5] analyzing the momentum effect and reversal effect of stock prices based on the monthly data of Shanghai and Shenzhen A-shares shows that the interpretation ability of the four-factor model is better than that of the three-factor model and the CAPM model. Shengmin Zhao, Honglei Yan and Kai Zhang (2016)[6] added the company's profitability factor (RMW) and investment level factor (CMA) based on the Fama-French three-factor model, and found that the three-factor model was more suitable for China's stock market at that time.

In conclusion, there are more models available over time. However, it does not mean that the newer the model, the better the fitting effect. For specific sectors, finding a suitable pricing model is significant for investors. Therefore, this paper tests the applicability of two models in the new energy vehicle stocks in recent years to find the applicable pricing model with this sector.

2.EMPIRICAL ANALYSIS

The following model selects new energy vehicle stocks in A shares, and removes ST, *ST and two missing data, a total of 29 stocks. Specific data were chosen for 36 months from January 1, 2018, to December 31, 2020. Stock data comes from the RESSET database.

2.1. CAPM model

Related assumptions of the CAPM model:

$$E\left(R_p\right) = R_f + \frac{E(R_M) - R_f}{\sigma_M} \qquad (1)$$

In the capital market line formula, R_f represents the risk-free rate, $E\left(R_p\right)$ represents the expected yield of a portfolio, σ_M represents the standard deviation of the market portfolio, and the $E(R_M)$ represents the expected return rate of the market portfolio.

Refer to the Black,E., Jenson, M.C,Scholes's approach of the monthly yield as a measure of the sample stock yield. The corresponding risk-free and market yields are given by the Ruisi database. The main steps are as follows:

① First divided the data into three parts: 1 January 2018 —— 31 December 2018 (Part I), 1 January 2019 —— 31 December 2019 (Part II); 1 January 2020 —— 31 December 2020 (Part III).

② Uses the data from the first part to return the excess returns of a single stock and the market index to estimate the Beta value, and then group it according to the Beta value size (divided into six groups, each group have five stocks except for the last group which has four stocks).

$$R_i - R_f = \alpha_i + \beta_i(R_m - R_f) + \varepsilon_i \qquad (2)$$

In formula(2),R_i represents the actual return of stock, R_m represents the actual return of market portfolio.

Table 1 New energy vehicle stock grouping and β coefficients

Group 1		Group 2		Group 3	
stock code	β	stock code	β	stock code	β
002192	3.312	002824	1.883	600297	1.257
000532	3.107	600366	1.679	002057	1.040
002741	2.507	603011	1.655	000970	1.034
002346	2.100	002782	1.575	000407	1.027
601012	2.066	002334	1.355	000828	1.004
Group 4		Group 5		Group 6	
stock code	β	stock code	β	stock code	β
002130	0.959	600995	0.770	002136	0.309
002497	0.903	002126	0.749	600885	0.221
002805	0.866	002340	0.727	600478	0.170
601028	0.847	603826	0.700	600277	0.106
002026	0.797	603035	0.632		

③ Uses the second part of the data to calculate the average yield for each combination and the estimate of β for each group.

$$R_p - R_f = \alpha_p + \beta_p(R_T - R_f) + \varepsilon_p \qquad (3)$$

Table 2 β coefficients of the combination

	1	2	3	4	5	6
β	1.106	1.043	0.622	1.034	0.879	0.851
F	99.59	20.21	7.15	75.15	26.46	15.00
P	0.00	0.00	0.02	0.00	0.00	0.00
σ^*	0.030	0.063	0.063	0.033	0.041	0.053
R^2	0.91	0.67	0.42	0.88	0.73	0.60

According to Table 2, it is clear that all β values are greater than 0 and pass the F test, the risk yield of the surface stock portfolio shows a positive relationship with the risk yield of the market combination, the test results are credible, and the β coefficients' estimate with the average returns for each combination during the test time period is valid.

□ Use the β value of the portfolio obtained in the time series and combine with the data of the third period, the β value of the portfolio and the average return rate of the portfolio are regression. The regression equation is as follows:

$$R_p = r_0 + r_1\beta_p + \varepsilon_p \qquad (4)$$

R_p is the yield of the portfolio in the third period (p

stands for group 1 to 6 of Table 1）, β_p is gotten from step ③:

Table 3 Results of regression

parameter	estimated value	standard deviation	t	p
r_0	-0.044	0.039	1.14	0.32
r_1	0.081	0.041	1.95	0.12

As shown in Table 3, at the significance level of 0.05, the coefficients are significantly 0. The coefficient of is significantly 0, indicating that China's new energy vehicle industry does not have much speculation, the market development is basically perfect, basically, meets the potential requirements of CAPM model. When the coefficient is significantly 0, it indicates that the market does not compensate investors for the risks they take. It can be seen that there is no obvious linear relationship between return rate and systemic risk, and systemic risk is not strong in explaining stocks.

⑤In order to prove that excess returns are determined by systemic risk, non-systematic factors are added into the regression equation：

$$R_p = r_0 + r_1\beta_p + r_2\beta_p^2 + r_3\sigma_p + \varepsilon_p \qquad (5)$$

Table 4 Results of regression

parameter	estimated value	standard deviation	t	p
r_0	-0.038	0.232	0.16	0.89
r_1	0.199	0.528	0.38	0.74
r_2	-0.090	0.303	0.30	0.79
r_3	-0.775	0.675	-1.15	0.37

As shown in the table above, the coefficients are not significant after non-systematic risks are added to the regression equation. Where $r_1 > 0$ indicates that the stock return rate of the new energy vehicle industry is positively correlated with systemic risk, which is consistent with CAPM theory. $r_3 \neq 0$, indicating that factors affecting asset pricing include non-systematic risks, which is inconsistent with the CAPM hypothesis. $r_0 < 0$, the return rate of risk-free capital is not positive, which does not conform to reality.

1.2. The Fama-French three-factor model

The Fama-French three-factor model covers the scale effect (SMB) and the book to value ratio effect (HML) where the CAPM model was not added to the model:

$$E[R_{it}] - R_f = \beta_i(E[R_{mt}] - R_f) + a_iSMB_{p/t} + b_iHML_{p/t} \qquad (6)$$

$SMB_{p/t}$ indicates the scale effect of the corresponding time t, $HML_{p/t}$ indicates the book to value ratio effect of the corresponding time t, Rf represents risk-free rates, $E[R_{it}]$ represents the expected yield of the market portfolio.

According to the grouping criteria of the Fama-French three-factor model, The article classifies the original data by the market value at the end of each year (50%, 50%), Break the 29 stocks into large market capitalization (B) and small market capitalization (S) groups. Each group was then sorted by the book to value ratio (30%, 40%, and 30%). Finally, it is divided into six groups.

The groups were weighted based on the grouping situation. With the market value of individual stocks at the end of a year divided by the sum of the market value of the group at the end of a year as the weight to calculate the yield rate of the groups:

$$SMB = \frac{(S/L+S/M+S/H)}{3} - \frac{(B/L+B/M+B/H)}{3} \qquad (7)$$

$$HML = \frac{(S/H+B/H)}{2} - \frac{(S/L+B/L)}{2} \qquad (8)$$

Scale factor is the arithmetic mean of the weighted combined monthly yield of the S group minus the arithmetic mean of the weighted combined monthly yield of the B group. The book to value ratio factor is the arithmetic mean of the weighted combined monthly yield minus the weighted combined monthly yield of the L group; the market factors are treated with the CAPM model above.

As the economic data to uneven data in the majority. Do the ADF-test first:

Table 5 ADF test results

Portfolio	t	p	Critical value		
			1%	5%	10%
S/L	-6.64	0.00	-4.24	-3.54	-3.20
S/M	-5.63	0.00	-4.24	-3.54	-3.20
S/H	-6.30	0.00	-4.24	-3.54	-3.20
B/L	-6.09	0.00	-4.24	-3.54	-3.20
B/M	-4.97	0.00	-4.24	-3.54	-3.20
B/H	-5.79	0.00	-4.24	-3.54	-3.20

Judging from the table above, the p values of time series ADF test of S/L, S/M, S/H, B/L, B/M, B/H are all 0.00, so the null hypothesis can be rejected, and the sample data is stable, supporting the regression evidence for the next step.

The regression analysis was performed according to :

$$E[R_{it}] - R_f = \beta_i(E[R_{mt}] - R_f) + a_iSMB_{p/t} + b_iHML_{p/t} \qquad (9)$$

Table 6 Results of the three-factor model regression

	Intersection	correlation coefficient		
		MKT	SMB	HML
S/L	0.003	1.111	0.583	-0.392
	T=0.30 P=0.77	T=8.00 P=0.00	T=3.30 P=0.00	T=-2.19 P=0.04
	F=35.15	P=0.00	R^2=0.77	
S/M	-0.007	1.005	0.329	0.058
	T=-0.93 P=0.36	T=10.02 P=0.00	T=2.57 P=0.01	T=0.45 P=0.65
	F=45.59	P=0.00	R^2=0.81	
S/H	0.004	0.877	0.034	0.301
	T=0.45 P=0.66	T=7.44 P=0.00	T=0.22 P=0.82	T=1.99 P=0.06
	F=21.36	P=0.00	R^2=0.67	
B/L	-0.001	0.819	-0.996	-0.712
	T=-0.08 P=0.93	T=7.61 P=0.00	T=-7.27 P=0.00	T=-5.15 P=0.00
	F=103.03	P=0.00	R^2=0.91	
B/M	0.002	1.120	-0.611	0.085
	T=0.19 P=0.85	T=6.94 P=0.00	T=-2.97 P=0.01	T=0.41 P=0.68
	F=20.46	P=0.00	R^2=0.66	
B/H	-0.002	1.053	-0.447	0.595
	T=-0.15 P=0.88	T=7.69 P=0.00	T=-2.56 P=0.02	T=3.38 P=0.00
	F=19.91	P=0.00	R^2=0.65	

For the model as a whole, all groups passed the F test, demonstrating that MKT, SMB, HML can well explain the excess yield changes in the stock portfolio.

For the constant term, all six groups of P values greater than 0.05 did not pass the P test, indicating that other factors besides the MKT, SMB, HML triple had a greater impact on the excess returns of the portfolio investment.

For the regression coefficient of the market factor (MKT), the six groups of coefficients were less than 0.05, the P test was significantly unequal to 0, and the coefficient was positive. Except for S/H and B/L, the regression coefficients of market factors in other groups

are greater than 1. It shows that the excess yield of the portfolio is proportional to the excess yield of the market, and besides the S/H, the B/L portfolio fluctuates less than the excess yield of the market.

For the scale factor (SMB), the coefficient in the S group was positive, and all groups passed the T-test except for the S/H group, indicating that the excess yield of the portfolio was positively associated with the scale factor in small-scale cases. However, the coefficients are less than 1, indicating that the excess yield fluctuation range of the portfolio is greater than that of the scale factor. (The B group is in a similar way.)

For the book to value ratio factor (HML), in the low book to value ratio group, there was a negative relationship between the portfolio income and the book to value ratio factor, while the remaining group showed a positive relationship. The S/M, S/H, B/M coefficient was not significant, and the other three coefficients are significant. The coefficients are all less than 1, indicating that the excess yield fluctuation range of the portfolio is greater than that of the book value ratio factor.

For the model fit degree, the R2 for the six groups is greater than 0.65, the model has a high fit.

3.CONCLUSIONS

This paper conducts an empirical test of Chinese new energy vehicle stocks through CAPM model and Fama-French three-factor model and obtains the following conclusions:

First, the three-factor model fits better overall than the CAPM model. It shows that in the stock investment of new energy vehicle, scale factor and book-to-value factor have certain reference significance, while market factor still has good reference significance. However, the coefficient of some groups is not significant, indicating that there are still differences between China's stock market and the mature stock market in developed countries.

Secondly, the return of stocks in China's new energy vehicle is positively related to the market yield, but the degree of return change is less than the market risk and return change degree. The main reason may be that China's new energy vehicle belongs to the period of rapid development, the expansion of enterprise profitability, assets scale, many investment opportunities, facing small risks.

Thirdly, the influence of SMB factor on businesses (except for S/H) is significant, indicating that the new energy vehicle stocks in China have a "small-scale effect." Most small-scale stocks are enterprises in the growth stage, with much room for development.

Finally, in China's new energy vehicle stocks, medium to high book to value ratio stocks show a certain

book to value ratio benefit, indicating that the investment value of these enterprises is high.HML factor negatively correlates to their yields.

AUTHORS' CONTRIBUTIONS

Yunfei Wu and Heng Xiao contributed to the conception of the study;

Yunfei Wu and Heng Xiao contributed to analysis and manuscript preparation;

Yunfei Wu performed the data analyses and wrote the manuscript;

Yunfei Wu and Heng Xiao helped perform the analysis with constructive discussions.

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