Empirical Analysis of New Energy Vehicle Industry Based on the CAPM Model

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Abstract. As the public's concern for energy resources and environmental protection is gradually strengthening, the new energy vehicle industry has emerged as a prominent trend in the vehicle industry's future development, and its great potential for development makes it a hot direction for financial investment. The topic of this paper concentrates on the empirical analysis of the new energy vehicle industry based on the CAPM model, so as to explore the investment opportunities and risks of the industry and provide investment advice for investors with different risk preferences. In this paper, 15 stocks representative of the new energy vehicle industry in China's A-share market are selected. The risk-free rate of return is the one-year Treasury bond interest rate, and the market index is the CSI 300 index. The time span of the data is from June 1, 2022 to December 30, 2022. The results of the research prove that most of the stocks in the new energy vehicle industry are characterized by high return and high risk, so risk-neutral or risk-loving investors may consider investing in the stocks in this industry. However, in general, the CAPM model is weak in explaining the excess returns of the stocks in this industry.

Keywords: Capital Asset Pricing Model; new energy vehicle; β; risk; empirical analysis.

1. Introduction

With the constant depletion of energy supplies and the recurrence of environmental degradation problems, new energy vehicles (NEVs), as an environmentally friendly alternative to traditional fuel vehicles, have become a trend in the development of the global automotive industry. NEV refers to a tram that is completely or mainly powered by electric energy [1], and NEVs include hybrid electric vehicles (HEVs), battery electric vehicles (BEVs), fuel cell electric vehicles (FCEVs), and so on [2]. According to the International Energy Agency, global demand for electric vehicles continues to be strong, with global sales of new energy vehicles exceeding 10 million units in 2022, a year-on-year increase of nearly 60% [3]. This trend is also evident in China, which accounts for 60% of global new energy vehicle sales in 2022 and its sales are expected to continue to rise [3]. Under these circumstances, the NEV industry has become a hot topic for investment, attracting the attention of a large number of investors.

Therefore, to better explore this popular industry's development prospect, this paper will empirically analyze this industry through the Capital Asset Pricing Model (CAPM). This study will select 15 industrial leading stocks from Choice financial terminal to construct the CAPM model and explore the explanatory power of the model's α coefficient, β coefficient, and model fit on the stock returns of this industry. Thus, the goal of this study is to explore deeply into the NEV industry's investment opportunities and risks. In addition, based on the model results, this paper will also provide industry analysis and investment recommendations for investors with different risk attitudes and investment preferences.

The following is the overall structure of this paper: the methodology is covered in the second section, which introduces the concept of CAPM, investors' risk attitudes, and investment preferences. The third part is the data selection and processing of the model, which contains the selection and descriptive statistics of individual stocks. The fourth section is the empirical analysis of the NEV industry. The final part is the conclusions of the empirical analysis.

2. Methodology

2.1. The Concept of CAPM

CAPM is a pricing model based on an extension of Harry Markowitz's mean-variance theory (commonly referred to as portfolio theory). The mean-variance theory uses standard deviation (volatility) to measure the risk level of asset. The theory suggests that high risk needs to be compensated by high returns. Unlike the mean-variance theory, the CAPM categorizes the asset risk to which an asset is exposed into idiosyncratic risk and systematic risk (or market risk). The former can be diversified through diversification, so the CAPM suggests that only systematic risk can be compensated by returns.

CAPM has the following mathematical expression:

$$E(R) = R_f + \beta \times [E(R_m) - R_f] \tag{1}$$

Where $E(R)$ is the asset's expected return, R_f represents the risk-free return, $E(R_m)$ indicates the market portfolio's expected return, and $E(R_m) - R_f$ denotes the market risk premium, the larger the value indicates that the investor receives greater compensation for taking the market risk. β Assesses the degree of volatility of the asset in relation to the overall market portfolio. The higher theβ, the greater the asset's systematic risk, and thus, the higher the required rate of return on the asset. Therefore, for the asset with substantial market risk, the CAPM suggests a high expected rate of return.

2.2. Investors' Risk Attitudes and Investment Preferences

According to Expected Utility Theory, investors' risk preferences can be categorized as risk aversion, risk neutral and risk loving.

Risk-averse investor: For a risk-averse investor, the utility function is concave, which means that an increase in wealth brings diminishing marginal utility to the investor. A risk-averse investor can forego a potentially higher return in order to receive a certain return. As a result, risk-averse investors will favor a conservative investment style, that is, they will prefer fewer volatile assets.

Risk-neutral investors: Risk-neutral investors have no significant preference for risk, so the utility function is a straight line with constant marginal utility of returns. They do not care about the riskiness of an asset but focus on the return on the asset [4]. Thus, their investment style is somewhere between risk averse and risk lover.

Risk-loving investors: For risk lovers, the utility function is convex and the marginal utility of returns is increasing. Risk lovers are more willing to accept gains from volatility. Some research shows that risk-loving investors have a higher percentage of risky financial assets in their financial asset allocation relative to risk-averse and risk-neutral investors [5]. As a result, their investment style is more aggressive, pursuing high-risk, high-yield assets.

3. Data

3.1. Data Selection and Processing

$$\mathrm{R_{i,t}} - \mathrm{R_{f,t}} = \alpha_i + \beta_i(\mathrm{R_{m,t}} - \mathrm{R_{f,t}}) + \varepsilon_{i,t} \tag{2}$$

By shifting the R_f from Equation (1)'s right side to the left, then the $(R_{i,t} - R_{f,t})$ indicates the excess return of the individual stock. The above equation is the CAPM model used in this empirical analysis. Where $(R_{m,t} - R_{f,t})$ represents the independent variable (x) and $(R_{i,t} - R_{f,t})$ denotes the dependent variable (y). The data are selected and calculated as follows:

3.1.1. Selection of risk-free rate of return (R_f)

The risk-free rate of return (R_f) is the corresponding rate of return earned by investing in an asset with zero risk. In reality, there is no such thing as a truly risk-free asset. However, treasury bonds

have a very low risk of default because they are guaranteed by the country's creditworthiness, so the risk-free rate is typically determined by the yield of treasury bonds. In this paper, the corresponding one-year Treasury bond yields from June 1, 2022 to December 30, 2022 are selected, and the data are from China Money.

3.1.2. Selection of market portfolio return (R_m)

Theoretically, market portfolio return requires the index to contain the returns of all available assets (including real estate, jewelry, and anything else of value), but such an index cannot be found in reality [6]. However, Kandel and Stambaugh argue that if the correlation coefficient between the stock index and the real market portfolio is larger than 0.7, using a stock index as a market portfolio is feasible [7]. Also, Stambaugh found that for the market portfolio, choosing a stock index yields similar results compared with choosing a portfolio of stocks, bonds, and real estate [8]. Therefore, this study will select a stock index with broader asset coverage as a proxy for the market portfolio.

The 15 stocks selected in this paper are all distributed in the Shanghai and Shenzhen Stock Exchange, so the daily return data of the CSI 300 index will be chosen as the return data of the market portfolio. The CSI 300 index has comprehensive industry coverage and covers nearly 60% of the Shanghai and Shenzhen Stock Exchange market capitalization. Moreover, the CSI 300 index is also relatively consistent with China's macroeconomic trends [9]. Therefore, the CSI 300 index has a good market representation.

The daily return of the market portfolio ($R_{m,t}$) can be calculated as follows:

$$R_{m,t} = (M_t - M_{t-1})/M_{t-1} \tag{3}$$

Where $M_t$the closing price of the CSI 300 is index at the end of period t and M_{t-1} is the closing price of the CSI 300 index at period$t-1$. So, the daily return of the market portfolio ($R_{m,t}$) in the period t can be calculated.

3.1.3. Selection of individual stocks

i. Stock selection criteria

Firstly, in order to explore the development prospects of the overall NEV industry in a comprehensive manner, this article will select stocks from various segments of the overall NEV industry, i.e., the selected stocks will cover the industry upstream (raw materials), midstream (parts production) and downstream (vehicle production and charging services).

Secondly, CAPM assumes that all investors are mean-variance optimizers, so when selecting stocks, the following two principles should be followed: first, for securities with a similar degree of risk, choose the one with a higher return. Second, for securities with similar returns, choose the one with a lower risk level. Based on the above logic, this article will mainly select leading companies in various segments of the NEV industry, which usually have the following characteristics: strong profitability, high industry status (high brand awareness), high market share, or more core technologies and patents. Therefore, they are also highly preferred by investors.

ii. Selection of stocks

Based on the stock selection criteria above, the following 15 stocks are selected for this study, as indicated in Table 1.

Table 1. 15 Stocks in the NEV industry.

Industry Chain	Upstream	Midstream	Downstream
Products	Raw Materials	Parts Production	Vehicle Production & Charging Services
Stock Code	603799	300750	600884
	002460	300014	002594
	300037	002074	601633
	603659	603489	300001
	600516	600699	300376

The time span of stock data is from June 1, 2022 to December 30, 2022, with a total of 146 trading days of data in half a year, and the data is obtained from the Choice financial terminal.

iii. Calculation of daily return of individual stocks ($R_{i,t}$)

The formula for calculating the daily return of individual stocks is as follows:

$$R_{i,t} = \left(P_{i,t} - P_{i,t-1}\right) / P_{i,t-1} \quad (4)$$

Where $P_{i,t}$the daily closing price of the individual is stock in period t and $P_{i,t-1}$is the daily closing price of the individual stock in period$t-1$. The daily return of the individual stock in period t ($R_{i,t}$) can be calculated by Equation (4).

vi. Descriptive statistics for individual stock

Table 2 shows the degree of correlation between CSI 300 and different stocks, the larger the figure means the higher the correlation coefficient between the two. From the perspective of CSI 300, most of the stocks are somewhat correlated, and 600516 has the highest correlation with it.

From the overall perspective, 600884 has a relatively high correlation with other stocks in the industry, while 603489 has a rather low correlation with the industry as a whole.

Table 2. Results of the correlation coefficient.

	CSI 300	603799	002460	300037	603659	600516	300750	300014	002074	603489	600699	600884	002594	601633	300001	300376
CSI 300	1.0															
603799	0.6	1.0														
002460	0.5	0.7	1.0													
300037	0.5	0.6	0.6	1.0												
603659	0.5	0.6	0.5	0.6	1.0											
600516	0.7	0.5	0.5	0.5	0.5	1.0										
300750	0.6	0.6	0.5	0.6	0.6	0.5	1.0									
300014	0.5	0.6	0.5	0.6	0.6	0.4	0.8	1.0								
002074	0.5	0.6	0.5	0.6	0.6	0.5	0.6	0.7	1.0							
603489	0.5	0.4	0.4	0.4	0.4	0.3	0.5	0.4	0.4	1.0						
600699	0.4	0.4	0.4	0.5	0.4	0.4	0.6	0.6	0.4	0.4	1.0					
600884	0.6	0.7	0.6	0.7	0.7	0.6	0.6	0.6	0.7	0.4	0.5	1.0				
002594	0.6	0.6	0.6	0.5	0.6	0.4	0.6	0.7	0.7	0.4	0.5	0.6	1.0			
601633	0.4	0.5	0.5	0.4	0.4	0.3	0.4	0.5	0.4	0.3	0.5	0.5	0.5	1.0		
300001	0.5	0.4	0.4	0.5	0.4	0.6	0.5	0.5	0.6	0.4	0.6	0.6	0.5	0.4	1.0	
300376	0.4	0.3	0.4	0.4	0.3	0.5	0.5	0.5	0.7	0.4	0.5	0.5	0.5	0.3	0.7	1.0

Table 3 shows the values of the mean, variance, median, maximum, and minimum for the CSI 300 index and each of the 15 stocks.

The mean daily return of CSI 300 from June 1, 2022 to December 30, 2022 is -0.03%, and the standard deviation is 1.12. For stocks, 9 of the 15 stocks have a mean daily return less than CSI 300, in contrast to 4 stocks that have a positive return, with the highest daily return being 600699. In addition, all of them have the standard deviation greater than the CSI300.

Table 3. Descriptive statistics of CSI 300 and individual stocks.

	Mean	Standard Deviation	Median	Maximum	Minimum
CSI 300	-0.03	1.12	-0.14	3.58	-2.93
603799	-0.14	2.88	-0.32	9.06	-10.00
002460	-0.10	2.79	-0.45	9.29	-6.72
300037	0.10	3.06	-0.13	8.74	-11.49
603659	-0.11	2.80	-0.38	7.37	-7.18
600516	-0.08	1.65	0.00	5.58	-4.77
300750	0.02	2.83	-0.17	7.01	-6.35
300014	0.12	3.50	-0.11	8.72	-8.08
002074	-0.12	3.13	-0.01	10.02	-10.00
603489	-0.35	2.63	-0.48	10.00	-9.24
600699	0.15	3.21	-0.08	10.01	-9.72
600884	-0.12	2.82	-0.34	8.39	-7.92
002594	-0.07	2.44	-0.32	8.19	-7.36
601633	-0.04	2.96	-0.20	10.00	-9.89
300001	-0.02	2.50	0.08	7.09	-6.86
300376	-0.01	2.37	-0.07	7.79	-6.25

4. Empirical Analysis

4.1. Construction of the Model

In order to conduct an empirical analysis of 15 stocks in the NEV industry, this study will use Excel to do a time-series regression analysis for each of the 15 stocks based on Equation (2) and related data (daily returns of the individual stocks, daily returns of CSI 300 index and one-year Treasury bond yields).

4.2. Results and Analysis

The regression results are shown in Table 4 below:

Table 4. The results of model regression.

	α	α_p-value	β	β_p-value	R^2
603799	0.7633	0.0618	1.4393	2.34E-13	0.3121
002460	0.7260	0.0674	1.3994	2.23E-13	0.3126
300037	0.7555	0.0967	1.3144	6.41E-10	0.2337
603659	0.3182	0.4447	1.1975	8.55E-10	0.2307
600516	0.0390	0.8453	1.0462	2.70E-23	0.4978
300750	0.9804	0.0127	1.4703	1.09E-14	0.3405
300014	1.0804	0.0406	1.4669	2.17E-09	0.2208
002074	0.6795	0.1431	1.3863	2.09E-10	0.2453
603489	-0.1042	0.7909	1.1057	1.88E-09	0.2224
600699	0.2706	0.5940	1.0451	6.06E-06	0.1329
600884	0.8393	0.0319	1.4652	1.13E-14	0.3401
002594	0.4234	0.2170	1.2311	1.13E-13	0.3189
601633	0.3414	0.4480	1.1738	1.87E-08	0.1978
300001	0.0454	0.9042	1.0154	7.68E-09	0.2074
300376	-0.3348	0.3693	0.8197	1.49E-06	0.1490

4.2.1. Alpha analysis

Alpha (α) indicates the portion of an individual stock's return that exceeds the market portfolio, and the CAPM assumes that the market reaches equilibrium when the alpha coefficient of an asset is 0. However, a good company or a good fund manager can create a positive alpha, and thus the higher the alpha, the higher the return of the asset.

From Table 4, it can be seen that 13 stocks have positive alpha except 603489 and 300376 which have negative alpha. Among them, 300014 has the highest alpha value of 1.08. This shows that most of the stocks in the NEV industry have returns that are higher than the returns of the market portfolio. In addition, except for the p-value of alpha of 600884, 300014, and 300750, which is smaller than its significance level$(\alpha = 0.05)$, the p-value of alpha of the remaining 13 stocks is insignificant.

4.2.2. Beta analysis

Beta (β) reflects the linkage between asset volatility and market portfolio volatility. Generally, stocks with a beta greater than 1 have a high sensitivity to market risk, and their volatility level is greater than the market's volatility level, thus they are "aggressive stocks". On the other hand, stocks with a beta of less than 1 are less sensitive to market risk, and their volatility will be less than that of the market portfolio, making them "defensive stocks". Also, the stocks with a beta equal to 1 are "neutral stocks", where the volatility and risk of the stocks are consistent with the market.

According to Table 4, stocks in the NEV industry generally have a beta greater than 1, indicating that investing in the industry will face greater volatility and expected returns than the CSI 300 index. A total of 11 stocks has a beta greater than 1, of which the top three stocks with the highest beta are 300750 (1.470), 300014 (1.467), and 600884 (1.465). This means that when the CSI 300 index rises by 10%, they are expected to rise by about 14.7%. Therefore, when investors are risk-neutral or risk-lovers, they can choose these 11 aggressive stocks to seek high profits while taking high risks.

When investors are risk averse, they can choose 300376 which has a beta of less than 1, thus seeking more robust returns. They can also choose the stocks with a beta approximately equal to 1, whose volatility is about the same as the market portfolio, i.e. 600516 (1.05), 600699 (1.05) and 300001 (1.02).

From another perspective, investors can also make asset allocation based on their expectations of the market trend and the beta of the stocks. If the investors expect the market to move up in the coming period, then they can maximize their returns by holding more stocks with beta greater than 1 [10], such as the 11 stocks with the beta greater than 1 mentioned above. If the investor is uncertain about the market trend, then the investor can choose to hold stocks with a beta of 1 (i.e. 600516, 600699, and 300001) to ensure that the volatility and returns are similar to those of the market portfolio. If the investor has a pessimistic opinion about the market, then the investor can hold a stock with a beta of less than 1 (300376) or take a short position to avoid losses [10].

In addition, from the Table 4, it can be seen that the p-value of the beta of these 15 stocks is significantly less than the significance level$(\alpha = 0.05)$, which means that the model has a high significance level and there is a linear relationship between the risk premium $\left(R_{m,t} - R_{f,t}\right)$ and the individual excess stock return$(R_{i,t} - R_{f,t})$. This also proves that beta can explain the excess stock returns of the NEV industry, which means that the CAPM model is valid for the empirical analysis of this industry.

4.2.3. Goodness of fit analysis

From the Table 4, it can be seen that the goodness of fit (r^2) values of 15 stocks are less than 0.5. Among them, six stocks each have r^2 between 0.3-0.5 and 0.2-0.3 respectively, and the remaining three stocks have r^2 in the 0.1-0.2 range. Thus, the overall fit of the model is unsatisfactory and the linear relationship between the risk premium and stock returns is weak, suggesting that there are other factors besides the market risk that have an impact on individual stock returns.

5. Conclusion

The NEV industry is the current investment hotspot and the future development trend. In order to better explore the investment opportunities and risks of the stocks related to the NEV industry, this article empirically analyzes the stocks of 15 leading companies in various segments of this industry based on the CAPM model. The model results show that the returns and the risk level of most stocks in this industry are higher than the returns and the risk level of the market portfolio (CSI 300 index). While the risk premium measured by beta explains to some extent the excess return of individual stocks, the overall applicability of the CAPM model is not favorable and there are other factors that affect the excess return of individual stocks.

There are several deficiencies in this study. Firstly, the model selects 15 stocks for empirical study, which is a small sample size. Secondly, the return of stocks is calculated based on the split-adjusted closing prices, so if the stocks have dividends, it may make the calculation of return biased. Finally, the model's selection of the CSI 300 index as the market portfolio is not comprehensive enough because it ignores other investment assets such as bonds, and precious metal investments. Improvement methods such as increasing the sample size, using adjusted closing prices to calculate individual stock returns, and choosing an index that is closer to the real market portfolio can improve the accuracy and applicability of the model to some extent.

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