Why did Electric Vehicle Stocks Grow Quickly during the COVID-19 Pandemic? An Empirical Explanation Based on the Capital Asset Pricing Model

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Abstract—Despite the overall economic depression, stocks from the electric vehicle sector had a quick growth during the COVID-19 pandemic. This research applies the Capital Asset Pricing Model to investigate whether the quick growth of electric vehicle stocks can be explained from a risk-return perspective. Based on the regressions of the electric vehicle ETF returns on the market returns during three half-year periods, the relatively high R^2 scores indicate that the Capital Asset Pricing Model can mostly explain the growth of electric vehicle stocks. Moreover, the increasing beta shows that the electric vehicle ETF was risker, whose growth was partially due to the increased risk. The significant abnormal return in the second half of 2020 was related to the remarkable degree of quantitative easing worldwide. This research shed light on understanding the growth of electric vehicle stocks during the COVID-19 pandemic and confirming the validity of the Capital Asset Pricing Model in the electric vehicle sector.

Keywords-CAPM; Electric vehicle industry; stock; COVID-19.

1. INTRODUCTION

Investors widely use the Capital Asset Pricing Model (CAPM) to get an expected return for stocks. In the CAPM model, the market is explained through a risk-return perspective, which contributes the high return of a security to its high volatility [1]. After the CAPM model was proposed, plenty of further studies criticized its validity as the expected return from CAPM often had a discrepancy with the real market, which was referred to as abnormal returns [2]. During the COVID-19 pandemic, the overall global economy experienced a downturn, and the stock market experienced higher volatility than before. Whether the Capital Asset Pricing Model can explain these market movements remains a question.

Studies have been conducted regarding the impact of the COVID-19 pandemic on the stock market movements. Höhler and Lansink focused on the food supply chain and measured the profit and stock price change due to COVID-19 applying the CAPM model [3]. Dang Ngoc, Vu

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Thi Thuy, and Le Van investigated the abnormal returns of Vietnam-listed stocks during the COVID-19 pandemic [4]. He, Sun, Zhang, and Li discussed the effect of the COVID-19 pandemic on the Chinese stock market with respect to different sectors [5].

This research focuses on the movement of the global electric vehicle sector during the COVID-19 pandemic. To obtain more electric vehicle related stocks, the research selects the data of Global X Funds - Global X Autonomous & Electric Vehicles ETF (DRIV) to represent the whole electric vehicle industry. Stocks from the electric vehicle sector had a quick growth during the pandemic. This study aims to figure out whether these movements can be explained by the Capital Asset Pricing Model, i.e., whether the growth was due to increased risk or abnormal returns. Moreover, the study investigates the electric vehicle sector movement by comparing and analyzing the data from three half-year periods. The study includes three main steps: (1) Find the beta of DRIV through running a regression of DRIV returns on market returns; (2) Get an expected return of DRIV in each period using the Capital Asset Pricing Model; (3) Compare the actual return of DRIV with the expected return and find the differences. If the discrepancy between actual returns and expected returns is small, the growth of electric vehicle stocks can be explained through a risk-return perspective. On the contrary, if the Capital Asset Pricing Model does not work well, the growth is largely attributed to abnormal returns.

The rest of the paper is organized as follows. Sec. 2 describes the data origination and the Capital Asset Pricing Model and metrics for statistical tests. Sec. 3 describes and analyzed the results of this research. Subsequently, Sec. 4 gives a comprehensive discussion on the results and the findings of this research. Eventually, a brief summary is given in Sec. 5.

2. DATA & METHODS

2.1 DATA

Data used in this research was collected from the S&P Capital IQ platform [6]. Data of stocks includes the adjusted close price of S&P 500 (SPX) and Global X Funds - Global X Autonomous & Electric Vehicles ETF (DRIV). Data of bonds include the interest rate of the one-year United States Treasury Bill. These data are based on daily market performance and cover the period of one and a half years from December 30, 2019, to June 29, 2021, with a total of 377 trading days. The trading data is visualized in Fig. 1.

2.2 Methods

2.2.1 Group of data

To analyze the growth of electric vehicle stocks during the COVID-19 pandemic, the research divides the data into three groups based on the timeline: December 30, 2019, to June 29, 2020 (first half 2020), June 30, 2020, to December 29, 2020 (second half 2020) and December 30, 2020, to June 29, 2021 (first half 2021). Each group of data covers a half-year period.

2.2.2 The Capital Asset Pricing Model

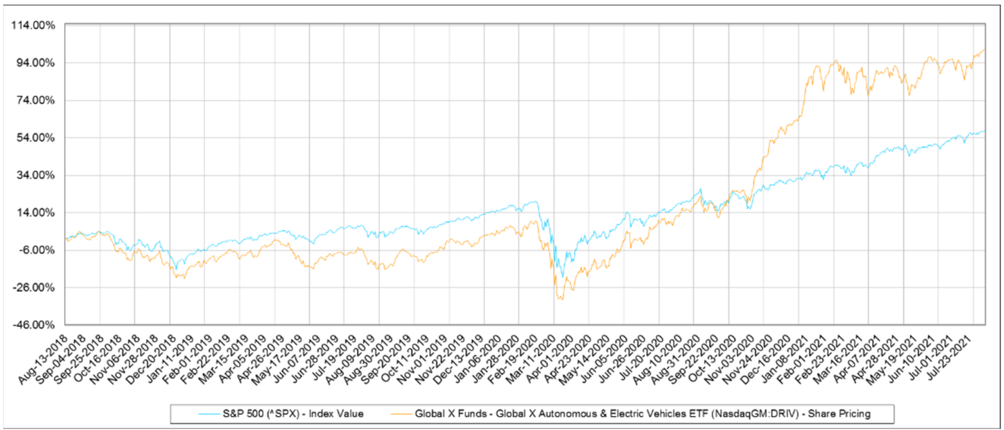

Figure 1. Trading data of DRIV and SPX for three years from August 2018 to August 2021

The Capital Asset Pricing Model (CAPM) is used in this research to calculate the expected returns of electric vehicle stocks in three half-year periods during the COVID-19 pandemic. Then the expected returns are compared with actual returns, and the discrepancies are analyzed. CAPM stated a linear relationship between the expected return on given security with its beta [1]. According to CAPM, the calculation of the expected return on a given security i follows the formula:

$$E(R_i) = R_f + \beta_i \times [E(R_M) - R_f] \tag{1}$$

The formula shows that the expected return on security i equals the risk-free rate plus the product of βi and market risk premium. The meanings and calculations for each variable are illustrated as follows.

2.2.2.1 Beta (β): Beta measures the volatility of given security compared to the market [1]. From a risk perspective, beta also means the security's systematic risk compared to the market risk, and stocks with high betas are generally riskier [7]. The calculation of beta follows the formula:

$$\beta_i = \frac{Cov(R_i, R_M)}{\sigma^2(R_M)} = \rho_{i,M} \times \frac{\sigma_i}{\sigma_M} \tag{2}$$

$Cov(R_i, R_M)$ in the beta formula refers to the covariance between the return on security i and the market portfolio return. Covariance measures whether two random variables move together. $Cov(R_i, R_M)$ is calculated by $\rho_{i,M} \times \sigma_i \times \sigma_M$, where $\rho_{i,M}$ refers to the correlation between the return of security i and market portfolio, and σ is the standard deviation of the returns [8]. $\sigma^2(R_M)$, the square root of (R_M), refers to the variance of the return of the market portfolio, which measures the volatility of the market portfolio [9].

DRIV is the given security in this research, and SPX refers to the market portfolio. To calculate the beta of DRIV, one first calculates the daily returns of DRIV and SPX. The return of DRIV on day N follows the formula:

$$Return\ on\ Day\ N = \frac{Adjusted\ Close\ price\ of\ Day\ N}{Adjusted\ close\ price\ of\ Day\ (N-1)} - 1 \quad (3)$$

Then the returns of DRIV and SPX are each classified into three groups based on the timeline, which can be referred to in section 2.2.1. Using excel functions, the variance of the returns of SPX and the covariance between the returns of DRIV and the returns of SPX is calculated, which leads to the beta of DRIV for three periods.

2.2.2.2 Risk-free rate (R_f): Risk-free rate refers to the return for investors by investing in a safe asset, which can not default in theory and generates stable returns [1]. This research uses a one-year US Treasury Bill as a risk-free asset. The risk-free rate for each period is calculated by taking the average of daily T-Bill interest rates over the course of 6 months. The formula is as follows:

$$R_f = \frac{R_f(t)+R_f(t+1)+R_f(t+2)+\cdots+R_f(t+n-1)}{n} \quad (4)$$

$R_f(t)$ is the interest rate for the one-year US Treasury Bill on the first day of each period and $R_f(t+n-1)$ refers to the last day of each period. There is a total of n days in the period.

2.2.2.3 Market risk premium $E(R_M)-R_f$: Market risk premium is the difference between expected market return and the risk-free return [1]. In this research, the expected market return in each period is calculated by:

$$Expected\ market\ retun\ in\ Period\ X = \frac{Price\ of\ SPX\ on\ the\ last\ day\ of\ period\ X}{Price\ of\ SPX\ on\ the\ first\ day\ of\ period\ X} - 1 \quad (5)$$

With the risk-free rates from the last step, the market risk premium for each period is calculated by the expected market returns minus the risk-free rate.

2.2.2.4 Alpha: Alpha is the difference between the actual return of a security compared to its expected return and is also referred to as "abnormal returns" [10]. In this research, the actual return of DRIV during each period is calculated using the formula:

$$Actual\ return\ of\ DRIV\ in\ Period\ X = \frac{Price\ of\ DRIV\ on\ the\ last\ day\ of\ period\ X}{Price\ of\ DRIV\ on\ the\ first\ day\ of\ period\ X} - 1 \quad (6)$$

The expected return of DRIV can be acquired using the Capital Asset Pricing Model with the variables calculated as above. Then, alpha for each period is calculated using the actual return of DRIV minus the expected return of DRIV.

2.2.3 Metrics of statistical tests

R^2 score is the percentage of variance in the dependent variable that the independent variables can explain. In statistics, the R^2 score measures the model's efficiency in predicting future results [11]. R^2 score is calculated by:

$$R^2 = 1 - \frac{SS\ residual}{SS\ total} \tag{7}$$

where SS residual is the sum of squares of residuals and SS total is the total sum of squares. R^2 is crucial in this research to measure the efficiency of the Capital Asset Pricing Model in predicting the future growth of electric vehicle stocks. R^2 score also measures the efficiency of stock price information [12].

3. Results

As shown in Figure. 2, the daily returns of DRIV and SPX in the first half of 2021 are highly correlated with an R^2 score of 66.54%. After running a linear regression, with the return of SPX on the x-axis and the return of DRIV on the y-axis, the equation of the regression trendline is $y = 1.4687x - 0.0002$.

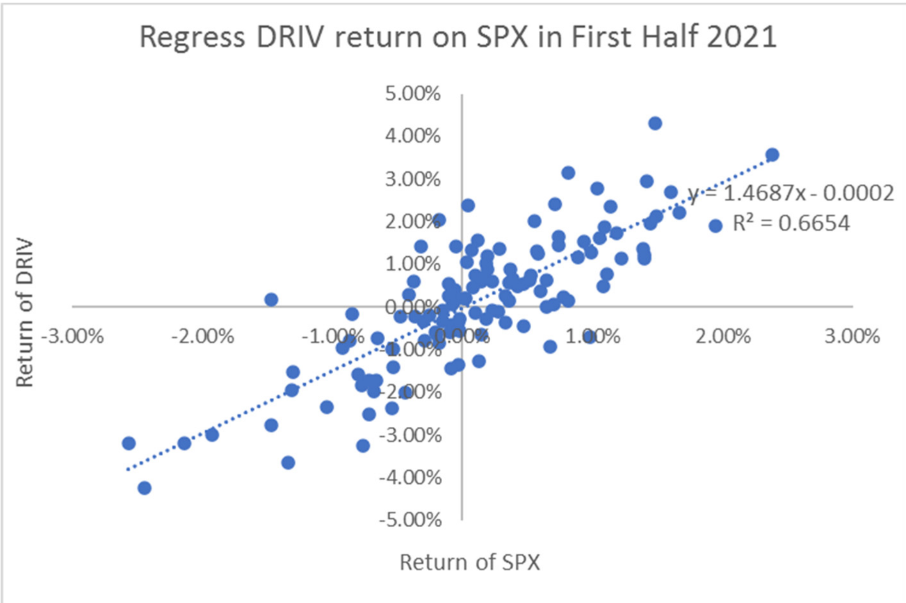

Figure 2. The above scatter plots show that the relationship between the return of DRIV and the return of SPX can be regarded as linear

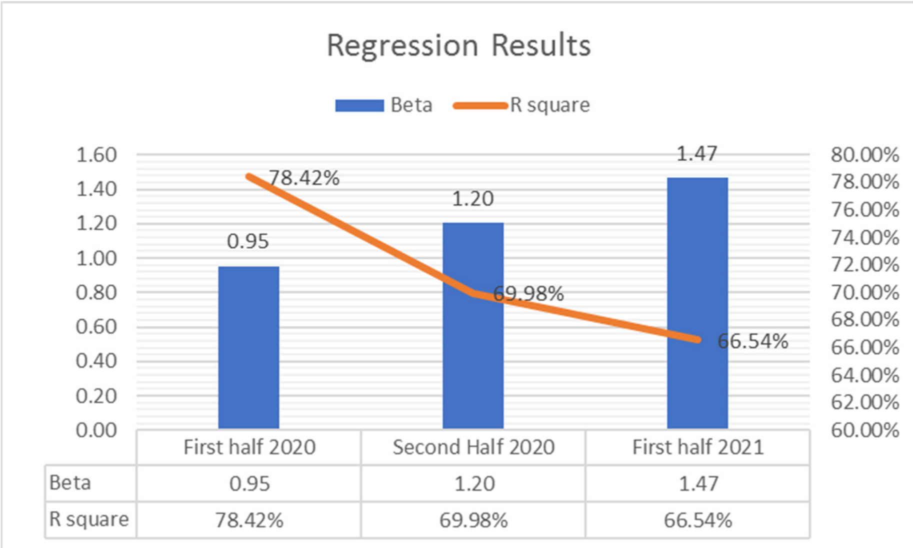

Figure 3. The beta of DRIV in the three periods increased while R^2 decreased during the COVID-19 pandemic

In terms of the beta formula (Eq. (2)) given in Sec. 2, the beta of DRIV in the first half of 2020, second half 2020, and first half 2021 is 0.95, 1.20, and 1.47, respectively. R^2 scores for the regressions in these three periods are 78.42%, 69.98%, and 66.54%, respectively. As illustrated in Figure. 3, the beta of DRIV shows an increasing trend during the COVID-19 pandemic, while R^2 scores show a decreasing trend, though the R^2 scores of these three regressions were still more than 60%.

Based on Eqs. (4) and (5), the risk-free rate and market risk premium are calculated as follows. As a list in Table. 1, in first-half 2020, second-half 2020 and first-half 2021, risk-free rate was 0.07%, 0.13% and 0.62% respectively and market risk premium was -5.29%, 20.09% and 14.38% respectively. Then, the expected return of DRIV is -4.98% for the first half of 2020, 24.33% for the second half of 2020, and 21.74% for the first half of 2021 using the Capital Asset Pricing Model.

The historical adjusted closing price of DRIV indicates that the actual return of DRIV is -2.46% for the first half of 2020, 61.92% for the second half of 2020, and 18.22% for the first half of 2021. Comparing the actual return of DRIV with the expected return using the Capital Asset Pricing Model, alpha is -3.52%, 37.6%, and 2.52% in these three periods. The Alpha of DRIV in the second half of 2020 is significantly higher than alpha in the other two periods, which is depicted in Figure. 4.

TABLE I. EXPECTED RETURN OF DRIV USING CAPM

	First half 2020	Second half 2020	First half 2021
Risk-free rate	0.07%	0.13%	0.62%
Beta	0.95	1.20	1.47

Market risk premium	-5.29%	20.09%	14.38%
CAPM expected return	-4.98%	24.33%	21.74%

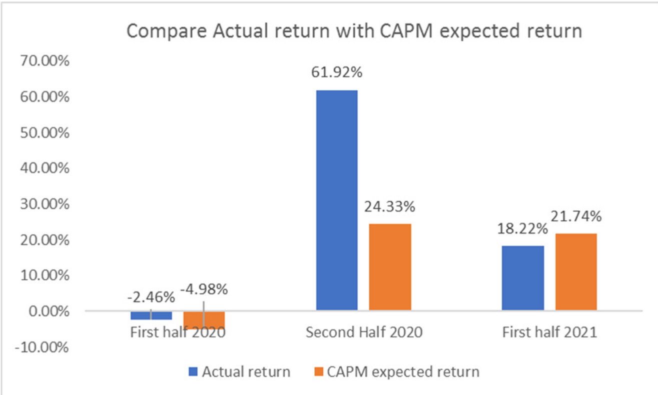

Figure 4. The difference between actual returns of DRIV and the expected returns of DRIV is the greatest in the second half of 2020

4. Discussion

From Figure. 3, the beta of DRIV increased in the three periods of the pandemic, which shows that electric vehicle stocks were generally more volatile to the change in market return. Bilinski and Lyssimachou state that stocks with high beta are riskier and are more likely to generate much higher or lower returns than low beta stocks [7]. The increase in the beta of DRIV in this research suggests a higher risk in the electric vehicle sector during the pandemic.

The R^2 scores are all above 65%, as exhibited in Figure. 3, which shows that the Capital Asset Pricing Model can explain more than 65% of the growth of electric vehicle stocks. It also shows that the Capital Asset Pricing Model can be regarded as efficient in predicting the future growth of electric vehicle stocks. The decreasing R2 scores in this research can be explained from a stock price efficiency perspective. From Bramante, Petrella, and Zappa, an increase in R^2 scores indicates a delay in the price discovery process and a decreasing efficiency of stock price information [12]. Cheng, Leung, and Yu also state that the decrease of R-square is related to the arrival of new firm-level information [13]. When the COVID-19 pandemic first started in January 2020, it affected many firms in the electric vehicle industry, but these influences were not well-reflected on the stock price. As firms disclosed more announcements and annual reports in the second half of 2020 and the first half of 2021, there was increasing price efficiency in the electric vehicle sector, which explains the decrease of R^2 scores of DRIV.

From Figure. 4, compared with the first half of 2021, the expected return of DRIV is significantly higher in the second half of 2020 and the first half of 2021, which is largely associated with the increase in market risk premium as listed in Table. 1. In the second half of 2020 and the first half of 2021, the market recovered from the pandemic-related crash and investing in the market generated more returns than investing in the risk-free asset. As a result, the market risk premium increased, leading to a higher expected return of DRIV.

The actual return of DRIV has the greatest discrepancy with the expected return in the second half of 2020, with a significant alpha of 37.6%, as displayed in Figure 4. In the first half of 2020 and the first half of 2021, the difference between the actual return of DRIV and the expected return is much smaller, which shows that the Capital Asset Pricing Model performs well, and the growth of electric vehicle stocks is largely due to increasing beta and market risk premium. The large abnormal return in the second half of 2020 is related to the worldwide influence of quantitative easing (QE) policy. The aggressive QE policy, especially in the United States, greatly reduced the interest rate of deposits and increased people's incentive to invest in the stock market. Consequently, the electric vehicle sector had a large abnormal return in the second half of 2020. Moreover, the abnormal return is also related to the emotion of investors. Cai, Clacher took the study, and Keasey denotes the inaccuracy of the Capital Asset Pricing Model during the 2008 financial crisis and concludes that when the market acts irrationally, it violates the underlying assumption of the CAPM, leading to a large abnormal return [14]. In the second half of 2020, during the COVID-19 pandemic, the constantly changing ups and downs in the stock markets reflected the unstable moods of investors, which may also be a reason for the abnormal return.

5. Conclusion

In conclusion, the reasons for the quick growth of electric vehicle stocks during COVID-19 are demonstrated based on the Capital Asset Pricing Model. The reasonable discrepancy between actual returns and expected returns indicates that the growth of electric vehicle stocks can mostly be explained from a risk-return perspective. The increase of DRIV beta in three periods shows that the relative risk of the electric vehicle sector increased during the pandemic. The abnormal return in the second half of 2020 is largely due to the changing fiscal policy. Therefore, the Capital Asset Pricing Model performs well in the electric vehicle sector in the pandemic, which is further confirmed by the relatively high R^2 scores. These results offer a guideline for understanding the electric vehicle sector movement during the pandemic and pave a path for making future investment decisions in this area.

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