The Practice and Analysis of CAPM on Energy Commodity ETFs

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Abstract. As one of the most dominant asset pricing models in the field of finance, the Capital Asset Pricing Model (CAPM) is frequently used to assess the risk and expected return in project finance. Yet, this mathematical model is still lacking in studies in the field of energy commodities. In this paper, the CAPM (expected return, beta, risk-free rate, and market rate of return) and some statistical tools (mean, standard deviation, variance, and covariance) will be used to study the investment risks on expected returns of four common energy commodity ETFs (USO Oil, BNO Brent Oil, UNG Natural Gas, UGA Gasoline) from 2017 to 2021. The research findings show that those assets which have positive beta values (USO, BNO, and UGA) result in positive expected returns, and the only energy commodity ETF (UNG) that has a negative value of beta ends with a negative expected return. In addition, risks and expected returns are positively correlated to each other. This means that the larger the beta value (higher risk), the higher the expected return in general, and vice versa. For example, in this study, UGA which has the largest beta value (2.34) generates the highest expected return (0.3732), and UNG which has the smallest value of beta (-0.28) gains the lowest expected return (-0.0222) or suffers a loss in this study.

Keywords: CAPM, beta, investment, energy, commodity

1 Introduction

Commodities are common goods like raw materials, basic resources, agricultural, or mining products that are usually bought and sold through exchange-traded futures contracts. Commodity ETFs are exchange-traded funds (ETFs) invested in physical commodities, such as copper, soybeans, oil, and natural gas. With the popularity and rise of the futures market in recent years, commodities gain the attention of investors from all over the world. However, due to the unique nature of investing in commodities (in the form of futures), investors need to carefully weigh the various risks associated with investing in commodities, especially the market risk which is not diversifiable but will influence the price of commodities.

The methodology that the author will use in this paper to examine the connection between the risk of an investment and its corresponding expected rate of return is the

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capital asset pricing model (CAPM). According to Perold, this mathematical model is based on the idea that not all risks should affect portfolios, particularly when held along with other investments in a portfolio, a risk that is diversifiable is not a risk at all [1]. For instance, the risk that cannot be shunned refers to systematic or market risk, and the risk which can be eliminated by diversification is called unsystematic (industries or individual business) risk. By carefully reviewing the relationship between the asset risks and expected returns for four distinct types of energy commodity ETFs (USO Oil, BNO Brent Oil, UNG Natural Gas, and UGA Gasoline) during the period 2017 to 2021, investors can better understand the overall investment performance and the associated risk factors in energy commodity ETFs then invest in energy commodities based on their risk preferences. The result of the study is analyzed and discussed by tables and figures.

2 Literature Review

The capital asset pricing model (CAPM) has a huge impact on illustrating the connection between systematic risk and the expected rate of return. This financial model was designed separately by William Sharpe, Jack Treynor, John Lintner, and Jan Mossin in 1960s, and Sharpe was awarded by a Nobel Prize in 1990 for his achievement on the CAPM [2]. The CAPM that was originated by Sharpe relies on systematic (market) risk, and his model can demonstrate and explain how the risk of an asset and its expected return are related [3]. Soon after, Lintner contributed to the idea of the risk-free rate by using risk-free borrowing and lending on his CAPM [4]. In Sharpe and Lintner's works, the concept of risk premium is specified as subtracting the risk-free rate from the expected return of an investment. According to French, another individual developer of the CAPM, Treynor, who began to design the theory of CAPM without the influence of other scholars, utilized the notion of experiment space to explain the risk [5][6]. In the following decades, as more scholars showed interest in the CAPM and further researched it, the theoretical foundation of the CAPM has gradually become more refined and innovated into several integrated models, such as LCAPM (Liquidity Adjusted Capital Asset Pricing Model) and CCAPM (Consumption Capital Asset Pricing Model). Temporarily, the basic version of CAPM has become a foundation in investment valuation and corporate finance, and a wide range of financial decisions are made based on the CAPM in various fields all around the world. According to Dempsey, investors can use this model to calculate the required rate of return for an investment, set sales prices in the utility regulation, establish standards for fund managers, and so on [7].

Even though the CAPM is regarded as a cornerstone of investment valuations in the contemporary world and is widely used in many financial decisions making, it is somehow challenged by many researchers. For instance, Banz claimed that within or without the presence of Beta, the size effect contributes more to the model than Beta [8]. Banz's conclusion is based on his implementation of the CAPM on the NYSE during the period of 1936 to 1975. Regardless of how many scholars criticize the inability of the CAPM to explain the connection between asset risks and expected returns, the CAPM retains its power and popularity in financial projection in the contemporary world. Yet not so many researchers have attempted to use the CAPM in examining energy commodities. Latunde, Akinola, and Dare conducted a research article utilizing the CAPM to explain the connection between risk and return of four Deutsche Bank crude oil assets [9]. Yet, Latunde, Akinola, and Dare's research was limited to the study of crude oil only. Besides, the data they used to conduct their study was considerable early (from 2014 to 2018), so the study's results failed to reflect the overall performance and the relationship between investment risks and returns of energy commodities in the post-2018 period, especially in the COVID period.

In this paper, the relationship between asset risks and expected returns of four different energy commodity ETFs (USO Oil, BNO Brent Oil, UNG Natural Gas, and UGA Gasoline) during the period of 2017 to 2021 is examined and analyzed by using the CAPM.

3 Methodology

3.1 Population and Sample

This research is quantitative research with secondary data. The total population of this research is 4 energy commodity ETFs (USO Oil, BNO Brent Oil, UNG Natural Gas, and UGA Gasoline) which are listed and traded on the New York Stock Exchange for the period January 2017 to December 2021. All the populations are sampled for this study.

3.2 Data Source

The data used in this study is secondary data that was collected from Yahoo Finance in the form of the daily closing price of USO Oil, BNO Brent Oil, UNG Natural Gas, and UGA Gasoline. The research period starts in January 2017 and ends in December 2021. Other data sources such as, the historical data of S&P 500 index and US 10-year Treasury Yield from 2017 to 2021 can also be found on the website https://finance.yahoo.com.

3.3 Research Method

The methodology that will be used in this paper to examine the connection between asset risk and its corresponding expected rate of return is the capital asset pricing model (CAPM). According to Sharpe [3], The formula of CAPM is given as:

$$E(R_i) = R_f + \beta_i[E(R_m) - R_f] \quad (1)$$

The operational variables of the CAPM are defined as:

$E(R_i)$ = The expected rate of return on securities i

R_f = The return on risk-free assets

β_i = Systematic risk or the market risk

$E(R_m)$ = The expected rate of return on the market portfolio
N is the length of years (N=5) for this research
i = 1(1)N (range from 1 to 5 in this study).

R_f represents the return on risk-free assets over a certain period. The average annual US 10-year Treasury Yield from 2017 to 2021 will be calculated as the annual risk-free rate on the asset in this study.

$$R_f = \frac{\sum R_f}{N} \tag{2}$$

R_m represents the return on the US market portfolio over a certain period. The annual return of S&P 500 index from 2017 to 2021 will be calculated as the annual return of the US market portfolio.

$$R_m = \frac{\text{Martet Index}_t}{\text{Market Index}_{t-1}} - 1 \tag{3}$$

β_i is calculated as the covariance between the return of an individual ETF and the market return divided by the variance of the market portfolio.

$$\beta_i = \frac{\text{cov}(R_i, R_m)}{\text{Var}(R_m)} \tag{4}$$

R_i is the return on the asset i. $\overline{R_i}$ and $\overline{R_m}$ are the means of the asset return and market return.

$$\text{cov}(R_i, R_m) = \frac{1}{N-1}\sum_{i=1}^{N}(R_i - \overline{R_i})(R_m - \overline{R_m}) \tag{5}$$

The variance of the market return is calculated by taking the differences between the annual market return from 2017 to 2021 and the mean.

$$\text{Var}(R_m) = \frac{1}{N-1}\sum_{i=1}^{N}(R_m - \overline{R_m})^2 \tag{6}$$

4 Results Analysis and Discussion

4.1 Performance of the four energy commodity ETFs against the market

Figure 1-4 show the overall price performance of USO Oil, BNO Brent Oil, UNG Natural Gas, and UGA Gasoline compared to the performance of the market portfolio over the period 2017 to 2021. The price of both USO, BNO, and UGA show a similar moving trend with the market across the period, whereas UNG shows some detrend movements in 2017, 2019, and the second half of 2020 and 2021. This difference gives UNG the possibility to hedge against market risk. Despite the similarity of movements on USO, BNO, and UGA, the increasing speed of UGA and BNO grows more rapidly than USO when entering 2021. There were two drops in the market index which led to the prices of those three oil-related commodity ETFs (USO, BNO, and UGA) plummeting. One occurred at the end of 2018 when USO and BNO are peak in the research period. The other occurred at the beginning of 2020 (the outbreak of COVID). After the spread of the COVID, all four energy commodity ETFs were affected by the decline to varying degrees. USO Oil dropped the largest in price by more than 50% in 2020.

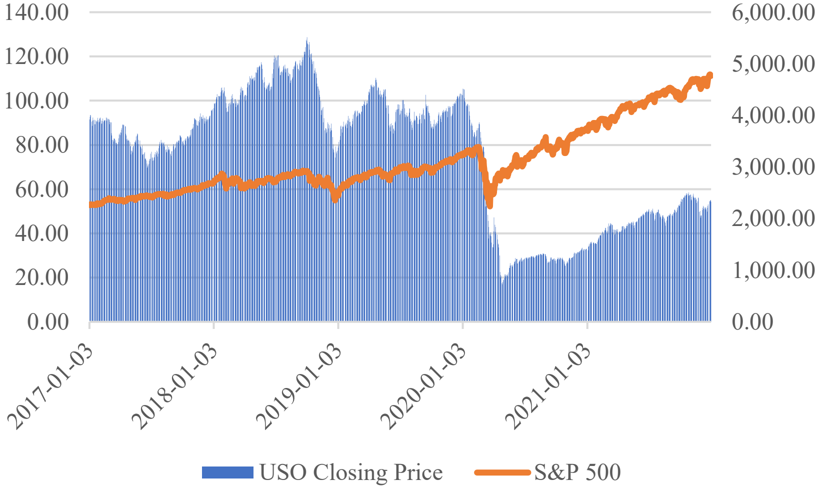

Fig. 1. USO performance vs. S&P 500 performance

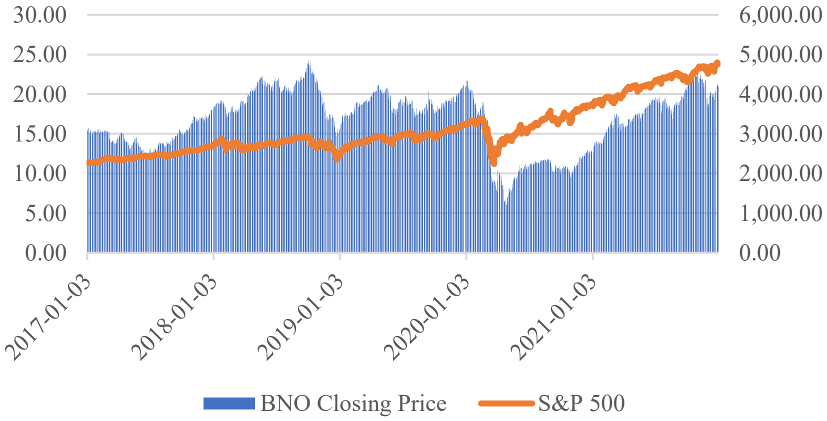

Fig. 2. BNO performance vs. S&P 500 performance

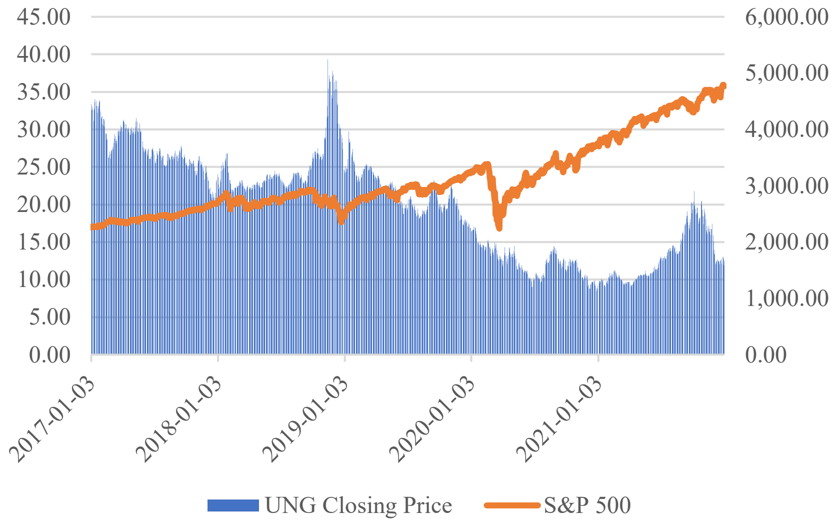

Fig. 3. UNG performance vs. S&P 500 performance

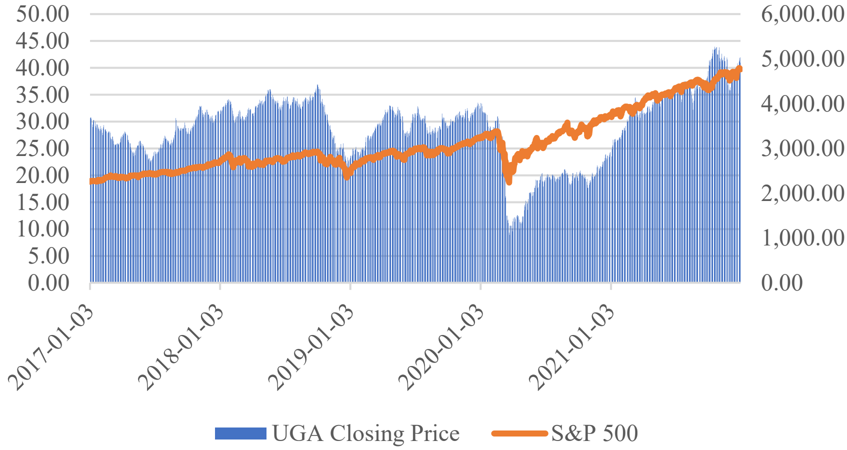

Fig. 4. UGA performance vs. S&P 500 performance

4.2 Asset returns, market returns, and risk-free rates by year

Table 1 shows the annual returns of USO Oil, BNO Brent Oil, UNG Natural Gas, and UGA Gasoline during the period of 2017 to 2021, the market returns on the US market portfolio which is measured by the annual return of the S&P 500 index, and the risk-free returns in the US which is measured by the average annual US 10-year Treasury Yield.

Table 1. Asset returns, market returns, and risk-free rates by year (made by the author).

Year	USO	BNO	UNG	UGA	$\boldsymbol{R_m}$	$\boldsymbol{R_f}$
2017	0.0247	0.1543	-0.3758	0.0169	0.1942	0.0233
2018	-0.1957	-0.1530	0.0596	-0.2807	-0.0624	0.0291
2019	0.3261	0.3601	-0.3177	0.4125	0.2888	0.0214
2020	-0.6779	-0.3823	-0.4543	-0.2488	0.1626	0.0089
2021	0.6468	0.6234	0.3576	0.6849	0.2689	0.0144
$\boldsymbol{\overline{R}}$	0.0248	0.1205	-0.1461	0.1170	0.1704	0.0194

From the table above, BNO has the highest average annual return at 0.1205 or 12.05%, whereas UNG has a negative average annual return at -0.1461 or -14.61% over the research period. This may suggest that UNG is negatively correlated (or have a negative beta) with the market portfolio. The market portfolio records an average of 0.1704 or 17.04% return per year, and the average risk-free return on assets over the period is 0.0194 or 1.94% per year. It is clear to see that those four energy commodity ETFs outperformed or underperformed the market in some years; however, none of them exceeds the market portfolio in average annual return.

The highest annual asset return in the research period happened in 2021 when UGA recorded a 0.6849 or 68.49% annual return. This number outperforms the market (0.2689 or 26.89% return in 2021) by more than 2.5 times which might suggest that UGA has a large beta. The smallest annual asset return during the research period occurred in 2020 when USO lost 67.79% in its value. The largest annual return of the market portfolio took place in 2019 when the market index went up by 0.2888 or 28.88% during the year.

4.3 Covariances, variances, betas, expected returns, and YTD returns

Table 2 shows the covariances between the market portfolio and USO, BNO, UNG, and UGA, the variance of the market portfolio, betas calculated by equation (4), betas collected from Yahoo Finance (based on 5-year monthly data), the expected returns on assets based on the CAPM formula, and the year-to-date returns on USO, BNO, UNG, and UGA in 2022 (end by Sep.2).

Table 2. Covariances, variances, betas, expected returns, and YTD returns (made by the author).

	USO	BNO	UNG	UGA
$\boldsymbol{cov(R_i, R_m)}$	0.0384	0.0366	-0.0054	0.0460
$\boldsymbol{Var(R_m)}$	0.0196	0.0196	0.0196	0.0196
$\boldsymbol{\beta_i}$ (Calculated)	1.96	1.86	-0.28	2.34
$\boldsymbol{\beta}$ (Yahoo Finance)	2.24	2.07	1.96	2.03
$\boldsymbol{E(R_i)}$	0.3151	0.3008	-0.0222	0.3732
$\boldsymbol{R_i}$ (YTD at Sep.2, 2022)	0.3028	0.3847	1.4049	0.2841

From the table above, UGA has the largest covariances (0.046) with the market portfolio which corresponds to the largest beta (2.34) in the four energy commodity ETFs. The expected return on UGA in 2022 is calculated at 0.3732 or 37.32% by using the CAPM formula. The year-to-date return on UGA is at 0.2841 or 28.41% by the end of September 2, 2022, which is 8.91% lower than the number based on the CAPM. Considering there are still three months left in 2022, the actual annual return on UGA in 2022 might move closer to the expected return by calculation. USO has a remarkably close expected return value (0.3151) compared to its year-to-date return (0.3028) so far. The year-to-date return of both BNO (0.3847) and UNG (1.4049) have already exceeded their expectations (0.3008 & -0.0222).

By comparing the betas calculated using annual data with the betas obtained from Yahoo Finance (stated as from 5Y monthly data), the betas of USO and BNO tend to be slightly smaller, while the beta of UGA tends to be slightly larger when using annual data. It is important to note that the beta of UNG calculated using annual data differs significantly from the beta obtained from Yahoo Finance (calculated using monthly data). The expected return on UNG in 2022 (-0.0222) also largely varies from its year-to-date return in 2022 (1.4049). This might suggest that the price of UNG fluctuates in a much shorter period. In other words, monthly or daily data should be used when calculating the beta of UNG instead of annual data, or the CAPM may not be well suited to pricing natural gas considering the other three ETFs are oil-related energy commodities. Another explanation for this phenomenon may be that the price of natural gas is more susceptible to external factors, such as military and COVID than oil-related products.

The average value of beta for the four energy commodity ETFs is 1.47 (the average value is 2.075 if using data collected from Yahoo Finance). This high value of beta suggests that the industry of energy commodities is exceptionally risky.

4.4 Risk vs. Expected return

Figure 5 demonstrates the correlation between the beta values or risks and the expected returns of those four energy commodity ETFs. The x-axis denotes the risks or values of beta, and the y-axis signifies the expected returns. The line drawn in the figure that shows the market risks of USO, BNO, UNG, and UGA refers to the security market line that inherits from the CAPM. It can be observed from the figure above that risks and expected returns are positively correlated. For example, UGA, which has the largest value of beta (2.34) in the study generates the highest expected return, whereas UNG, which has the smallest (also negative) value of beta (-0.28) will suffer a loss on the investment. This suggests that a larger value of beta (or higher risk) implies a higher return on asset, and a negative value of beta indicates a negative return (or a loss) on the investment.

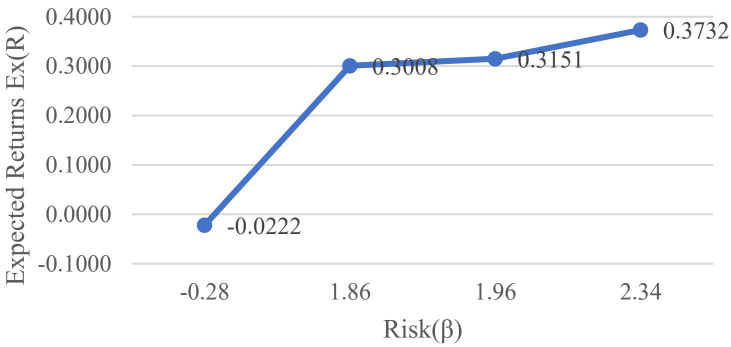

Fig. 5. Risk vs. Expected return

5 Conclusion

The Capital asset pricing model (CAPM) is studied and analyzed to demonstrate the connection between the expected return on asset and risk in this research. Based on the analysis and discussion in the previous section, the summary of the research is shown as follows:

First, all the energy commodity ETFs with beta values larger than 0 (USO, BNO, and UGA) have positive expected returns, whereas UNG which has a negative value of beta is the only commodity that shows a negative expected return.

Second, in section 4.4, Figure 5, the systematic risks of those four energy commodity ETFs are demonstrated. The security market line depicts a positive linear relationship between the risks and the expected returns. This suggests that risks and expected returns are positively correlated, which means that investors who buy an asset with a larger beta value (or a higher risk) should expect a higher return on the asset at the same time. Investors who purchase an asset with a negative value of beta should bear a loss on the investment while the market portfolio gains a positive return.

Third, the average systematic risk of the four energy commodity ETFs is 1.47. This suggests that the energy commodity industry is very risky in general. Considering only four energy commodities are sampled in this study, the result might not be representative at all. However, investors who are interested in this industry should pay attention before investing in it.

Fourth. the beta value of UNG which is calculated by annual data is significantly different from the value collected from Yahoo Finance which is supposed to be calculated from 5-year monthly data. This suggests that UNG might have a shorter period of price fluctuations. Therefore, it is better to use monthly or even daily data to calculate the beta value of UNG. Or the CPAM is not suitable for projecting the expected return on natural gas ETFs.

Some limitations of this research are:

First, the sample size is relatively small since this research only examines four different energy commodity ETFs. There are many other similar and various products in the market. To better study the Capital Asset Pricing Model, the research objects can be broader (adding more diverse types of energy commodities) or more segmented (studying different ETFs of one energy commodity).

Second, this research only uses the basic CAPM model to calculate the investment risk and expected return. In addition to the CAPM, some other models are available to use in conducting this research.

For Further Researchers: Conduct this research with the development models of CAPM, such as LCAPM (Liquidity Adjusted Capital Asset Pricing Model), CCAPM (Consumption Capital Asset Pricing Model), or other advanced models that can explain the correlation between asset risk and expected return.

For Investors: The energy commodity industry is a very risky industry to invest money in. Therefore, investors who are risk-averse should avoid investing their money in this industry. Investors who are risk-averse but still want to invest in energy commodities should first consider BNO since it has the lowest risk as well as the smallest expected return. Investors who are risk takers should also make careful decisions before entering this field since those three energy commodity ETFs with positive beta values only vary in lesser amounts of expected returns (the expected return of UGA is about 7% higher than USO and BNO) but share substantial amounts of systematic risks. Investors who are interested in investing money in UNG should be aware of the uncertainty of this ETF since it might result in a loss to the investment.

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