

Application of Big Data in Stock Market based on Capital Asset Pricing Model

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Abstract. This text aims to discuss the application value of the capital asset pricing model in real life. In this case, the stock price performance of Exxon Mobil and ConocoPhillips from September 2019 to June 2022 was analyzed by calculating the expected earnings of the two stocks and comparing the expected value to the real value. The outcome turns out that the calculated value showed a big deviation, which leads to the conclusion that the CAPM model theoretically can predict the expected earnings of stocks. However, this can be obtained from our calculation results, but affect the stock price factors, war, national economic conditions, macro policy, and so on, it requires a long time of large deviation to make this conclusion confidence, so the CAPM model cannot predict the expected earnings of stocks in the short term

Keywords: CAPM; Financial Beta; Risk and Return; Asset Pricing; Stock Return.

1. Background

The 1990s witnessed a rapid convergence of Communications, Computers, and Consumer electronics. This convergence has allowed humans to invent the internet, smartphones, and an abundance of data, with Data Science playing a major role in analyzing these data and providing predictive analytics that leads to actionable items in many fields and businesses. Finance is a field with a large amount of information and data that can be utilized to improve decisions, people have found many models to predict the trend and try to make a larger profit.

The text will mainly discuss one of the financial models --Capital Asset Pricing Model (CAPM) [1,2,3,4]. In this text, this model will be used to analyze and calculate the expected return of two different stocks: Exxon Mobile and ConocoPhillips, and compared the expected value to the actual return to find out if Capital Asset Pricing Model is accurate enough to help people to get a better profit.

2. Method

We used the CAPM to analyze the stock price performance of Exxon Mobil and ConocoPhillips from September 2019 to June 2022

2.1 Introduction of Capital Asset Pricing Model (CAPM)

The CAPM is used to explain the relationship between systematic risks and expected returns. It can be used to measure the systematic risk and expected return.[5]

The model is based on the portfolio theory of Harry Markowitz[1]and was formally introduced by William Sharpe[2].

Below is the formula of the model:

$$ER_i = R_f + \beta_i (ER_m - R_f)$$

2.2 Factors in the Formula

Risk-free Rate (R_f)

The risk-free rate[6] is a theoretical rate of return with no risk. It cannot exist because there will always be some risk while having an investment.

In hypothesis, the risk-free rate is the least return a speculator anticipates for any venture since extra hazard will not be acknowledged only if the potential rate of return is more prominent than the risk-free rate.

Usually, most risk/return models assume that there is a "risk-free rate" for firm valuations.

The most common risk-free asset is the 10-year US Treasuries; the minimum expected rate of return on the investments with no risk and is the starting point. on which many evaluation models are based.

Even if the returns investors expect are considered risk-free, the risk-free rate is just a simplification and should always be remembered, because all investments have certain level of risk.

Below is the formula for the free risk rate

$$\text{Free-risk Rate} = (1 + \text{Government Bond Rate}) / (1 + \text{Inflation Rate}) - 1 \quad [11,12]$$

According to this formula the free-risk rate in June 2022 was calculated as 4.7738%

Beta (β_i)

Beta (β) [7] is a measure of the methodical volatility or risk of a security or portfolio relative to the market as a whole (in this case it's the S&P 500).

It can measure the volatility of individual stocks against the systematic risk of the entire market. Each of these data points represents an individual stock's return relative to the overall market's return.

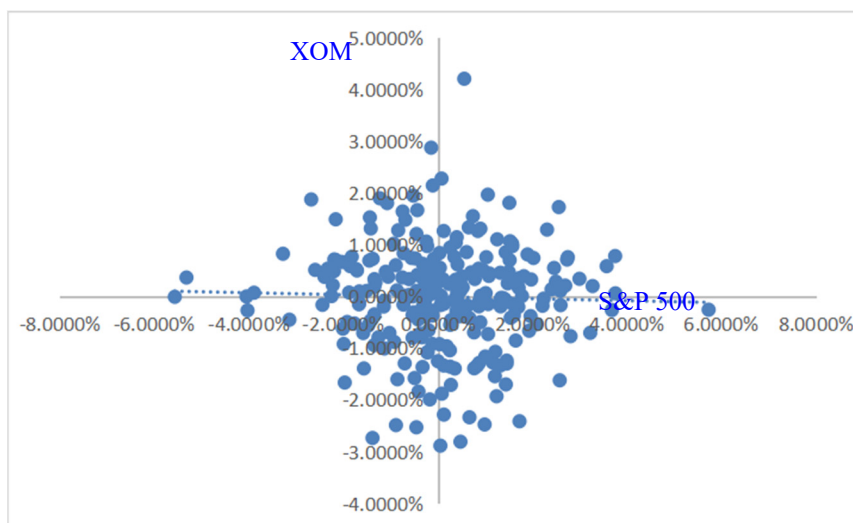
Beta can describe the market movements to show activity in a stock's returns. A stock's beta is calculated by dividing the product of the variance of the security's return and the market's return by the market return's variance over a given period.

There are many methods to calculate the beta value, in this case study, the beta values of two stocks are calculated by the slop method which is the most classic method in real life:

Below is the Beta value of two different stocks--Exxon Mobile(XOM) and ConocoPhilips (COP)

		S&P	
		< Median	> Median
XOM	< Median	-0.032339479	-0.038253633
	> Median	-0.024956754	-0.032339479
-0.045504293			

(a)

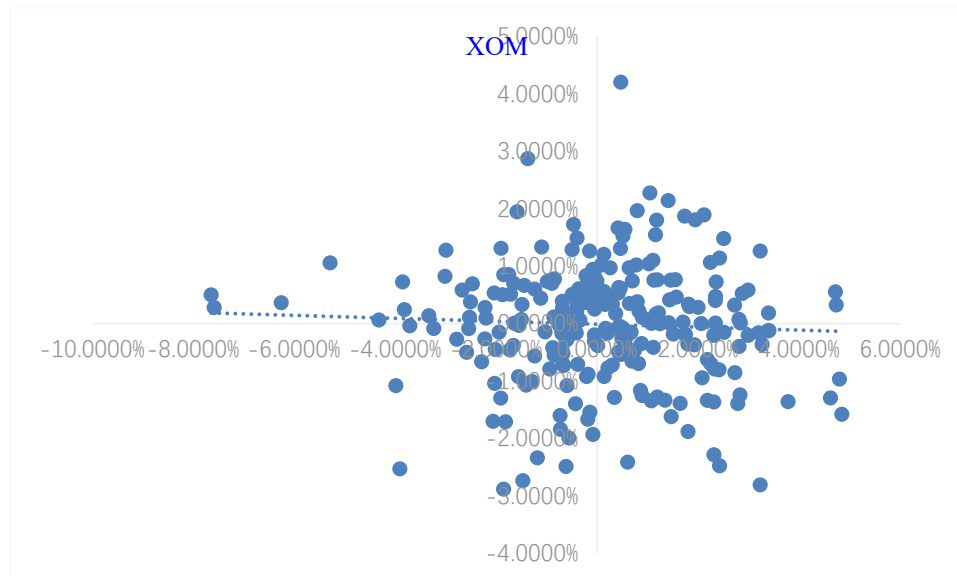


(b)

Figure 1. Beta value of XOM

		S&P	
		< Median	> Median
COP	< Median	-0.066288389	-0.058818044
	> Median	-0.085102154	-0.079220333
-0.258957594			

(a)



(b)

Figure 2. Beta value of COP

Beta can also be calculated by the Covariance/Variance Method, the below is the formula:

$$\text{Beta Formula} = \text{Covariance (Ri, Rm)} / \text{Variance (Rm)} \quad [10]$$

$$\text{Covariance (Ri, Rm)} = \sum (R_{i,n} - R_{i,avg}) \times (R_{m,n} - R_{m,avg}) / (n-1)$$

$$\text{Variance (Rm)} = \sum (R_{m,n} - R_{m,avg})^2 / n$$

The beta coefficients calculated by the formula are generally the same as the slope method.

2.3 Market Risk Premium (ERm – Rf)

The market risk premium (MRP) [8] equals to the expected return on a market portfolio minus the risk-free rate. This would include the universe of inevitable assets, including stocks, bonds, real estate, and so on.

The market risk premium describes the relationship between the yield on Treasuries and the return on a portfolio of assets. The risk premium reflects the required, historical, and expected returns. While the historical market risk premium is the same for all investors, the required and expected market premiums are different.

Investors need to be compensated for risk and opportunity costs. The risk-free rate is the theoretical rate of return paid on a risk-free investment. Since long-term US Treasuries have a low risk of default, it is often used as a proxy for the risk-free rate. However, the rate of return is quite low due to the reliability of this hypothesis.

The formula is shown below:

$$\text{Market Risk Premium EMR} = \text{Expected Market Return RFR} - \text{Risk-Free Rate}$$

*Expected Market return [9]:

The expected return is the profit or loss of an investment with historical return rate that an investor predicted.

In the short term, investment returns can be considered as a random variable that can have any value. Expected returns are based on historical data, but do not always provide a reliable forecast of

future returns. Therefore, the outcome is not ensured. The expected return is only a measure of probability and is used to indicate the possibility to produce a positive return and the potential return of a particular investment.

XOM					
Date	Return on Investment	probability of return			
2022/6/30	25.11%	-0.72	-0.180792	expected return	-0.180792
2022/3/31	16.83%	-0.72	-0.121176		
2021/12/31	14.69%	-0.72	-0.105768		
2021/9/30	-3.37%	-0.72	0.024264		
2021/6/30	-7.92%	-0.72	0.057024		
2021/3/31	-11.30%	-0.72	0.08136		
2020/12/31	-12.88%	-0.72	0.092736		
2020/9/30	1.82%	-0.72	-0.013104		
2020/6/30	4.09%	-0.72	-0.029448		
2020/3/31	7.00%	-0.72	-0.0504		
2019/12/31	9.09%	-0.72	-0.065448		

Figure 3. Expected Market return of XOM [16,17]

COP					
Date	Return on Investment	probability of return			
2022/6/30	24.45%	0.58	0.14181	expected return	0.14181
2022/3/31	20.02%	0.58	0.116116		
2021/12/31	12.79%	0.58	0.074182		
2021/9/30	8.03%	0.58	0.046574		
2021/6/30	3.43%	0.58	0.019894		
2021/3/31	0.04%	0.58	0.000232		
2020/12/31	-5.91%	0.58	-0.034278		
2020/9/30	-2.57%	0.58	-0.014906		
2020/6/30	4.77%	0.58	0.027666		
2020/3/31	9.70%	0.58	0.05626		
2019/12/31	14.70%	0.58	0.08526		

Figure 4. Expected Market return of COP [18,19]

According to this formula, the Market Risk Premium of COP was calculated as 0.94072 and the XOM's Market Risk Premium is -0.22853.

3. Result

3.1 Expected Return of Investment (ER_i)

Lastly according to the formula:

$$ER_i = R_f + \beta_i (ER_m - R_f)$$

The expected return of COP would be 0.01731561 and the expected return of XOM would be 0.05128482.

In conclusion, according to the historical data and the Capital Asset Pricing Model, ConocoPhillips would have a lower return in the future compared to Exxon Mobil.

4. Discussion

William Sharpe, notes that two kinds of risk are included in an individual investment:

1. Systematic Risk: The market risk that can't be reduced by portfolio diversification. For example, Interest rates, recessions, and wars.

2. Unsystematic Risk: This risk relates to a specific company or industry. The Strikes, mismanagement, or shortage of an essential component in the manufacturing process are all considered as unsystematic risks.

The CAPM is used to illustrate the relationship between systematic risks and expected returns. Therefore, it can be used to measure the systematic risk and expected return and is widely used for riskier investments. The model's main is the more risk investors take, the higher yields they should get, hence the presence of the market risk premium should be considered in the formula.

The market portfolio used to find the market risk premium is not an asset to buy or invest in but only a theoretical value. Most of the time, investors will use a major stock index, such as the S&P 500, as a proxy for the market. Therefore, it is an imperfect comparison.

Although, based on the criticisms of the CAPM and the assumptions behind the use of the CAPM in portfolio construction, he may not be able to predict with precision. There can still be some value in using the CAPM as a tool to assess the reasonableness of future expectations or to make comparisons.

According to the latest data the average return of Exxon Mobil from July to September in 2022 is -0.2714% [19] and the average return of ConocoPhillips is 12.4863% [20]

The model had calculated results which are completely different compared to the real situation. Therefore, the capital asset pricing model can't make a good prediction in this case. After doing some research [13,14,15], there are several possible reasons that can lead to the deviation of the model.

The political problems affect a lot. The stock price of many energy companies is affected by the war between Russia and Ukraine [11], since Russia is the 3rd biggest supplier of oil to the US but the Russia and Ukraine news flip flop frequently which lead to the unstable situation for the companies.

At the same time the increased inflation rate has also had a big impact on the stock market due to the inflation [14,15]. The value of currency and expectations of earnings growth were reduced and the different costs were all increased. In this way, the stock price gets even lower. However meanwhile, if there is an associated increase in the price of oil, an exposure to energy producers may provide defensive benefits.

Also, right now the US is undergoing a recession, during this period there is often a decrease in consumer spending and an increase in unemployment rate, as a result, the stock market is likely to experience depressed stock prices, and it may take some time for prices to recover [15].

Lastly, the observation period did not last long enough for an accurate prediction, if possible, the observation time can be even longer to predict a general trend.

5. Conclusion

In conclusion, several advantages and disadvantages of the CAPM have been listed below. Firstly, helping investors decide if they can make a particular investment by calculating the expected return on investment. Secondly, the formula is very simple and easy to use for most of the investors. However, the CAPM is an important tool for investors, it is one of the few formulas that take systematic risk involved, so when it comes to accessing both risk and reward the model would be very useful. However, think of the unrealistic assumption CAPM has made, and the changeable factors in the reality, when it comes to a special time, as the war between Ukraine and Russia started, this model cannot estimate the risk and return accurately.

The Capital Asset Pricing Model can make a prediction for the investors but in the real case, there can be many factors that can greatly affect the stocks so the model isn't very suitable for predicting the short term. Also, it can be affected by the length of the observation time.

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