Comparing Returns of Stock Options versus Purchasing Underlying Utilizing a Pairs Trading Strategy

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Github Repositiitory Link: https://github.com/jlaan1/pairs-trading-deriv

I. Introduction

Pairs trading strategy, when implemented effectively, seeks to capitalize on market inefficiencies by simultaneously buying and selling two correlated securities. This strategy hinges on identifying relationships between two securities and taking advantage of temporary divergences from their historical price relationship. By betting on the convergence of these prices, pairs traders aim to generate profits regardless of market direction, and pair trading provides an intriguing approach to navigate volatile market conditions.

Traditionally, traders have directly purchased (and shorted) the underlying depending on the direction of the relationship between the securities. However, this paper aims to deviate from this approach, and explore the performance of this strategy through trading derivatives – stock options in particular – instead. Since the losses from purchasing options is limited to the value of the option itself, it seems reasonable to assume that pair trading through derivatives would generate more positive returns than simply trading the underlying itself. This paper will explore this relationship through analyzing the price movement of two actual stocks, and empirically comparing the returns between the two methods.

II. Determining The Pair

Before the trading strategy can be implemented, there must first be a strong correlation between the two chosen stocks. I obtained the historical price data of about 15 heavily traded stocks, including Netflix (NFLX), Google (GOOG), Apple (AAPL), Vanguard (VOO), and several others. I then plotted a correlation matrix on a heatmap to determine the stocks with the strongest correlations as depicted in figure 1 below.

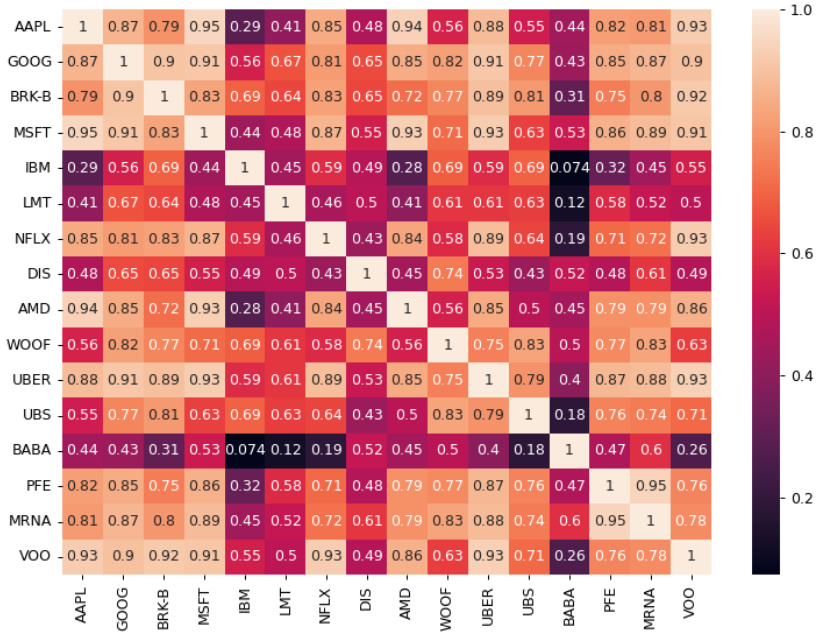

Figure 1

The stock pairs with the highest correlation were Apple and Microsoft, Vanguard and Netflix, Apple and AMD, and several others with the absolute value of their correlation coefficients above 0.90. I ultimately chose to explore this strategy on the pair Netflix and Vanguard, which had a correlation coefficient of 0.93. The relationship between the price movement of the two stocks are included below in figure 2.

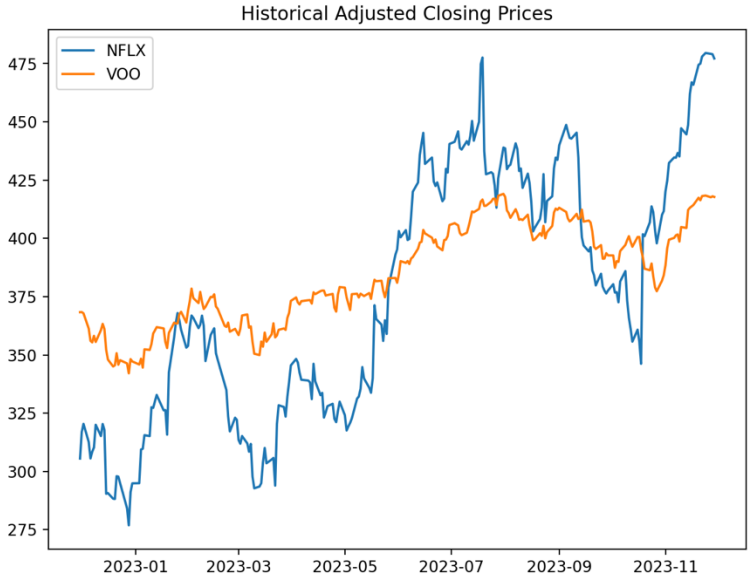

Figure 2

Several other tests were also performed to ensure that this pair of stocks exhibited a mean reversion behavior – a critical requirement for the pairs trading strategy to work. The cointegration test between the pair returned a p-value of 0.0233, suggesting that cointegration or a long-run equilibrium between the spread of the two stocks exists. A snapshot of the ratio between the two stocks is also included in the figure below.

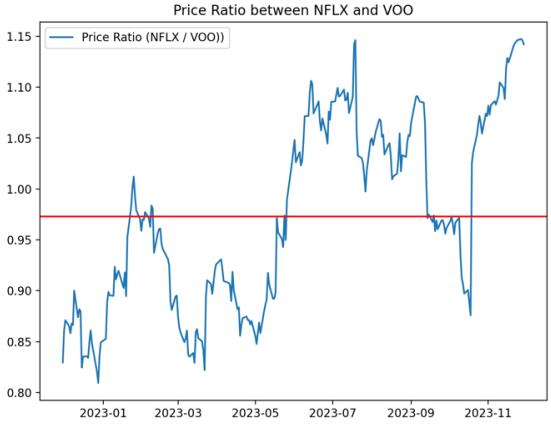

Figure 3

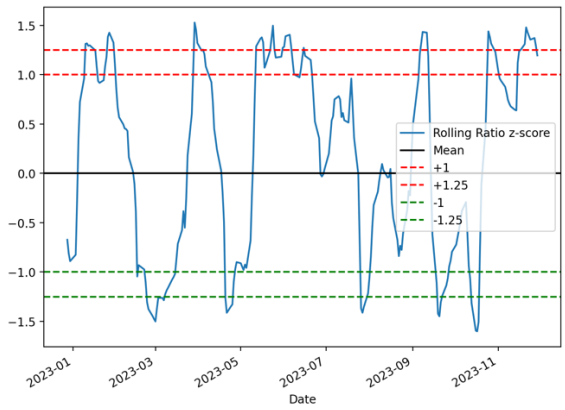

Figure 4

Evidently, the price ratio largely fluctuates between the range of 0.80 to 1.20. After normalization of the data, we observe that the ratio reverts to the origin, and this strategy will attempt to exploit the reversion to this origin. As the standardized ratio strays beyond the designated “healthy” range of between -1.0 and 1.0, the strategy will short/long with the take profit as the mean ratio of 0.

As the rolling ratio moves below -1.0, a long position on the strategy will be created, and this consists of a short position in NFLX, and a long position in VOO. Conversely, as the ratio surpasses 1.0, a short position on the strategy will be executed, through longing NFLX and shorting VOO. For the original strategy of simply purchasing the underlying, these positions will be closed when the ratio approaches 0. For the strategy implemented through derivatives, the options will be sold once the ratio nears 0. For the purposes of this paper, we will assume that these options can be easily liquidated.

III. Implementing The Strategy

Now that the entry and exit conditions are properly determined, we can determine the points in time where these conditions are met to trigger the creation of a position in the market, as follows.

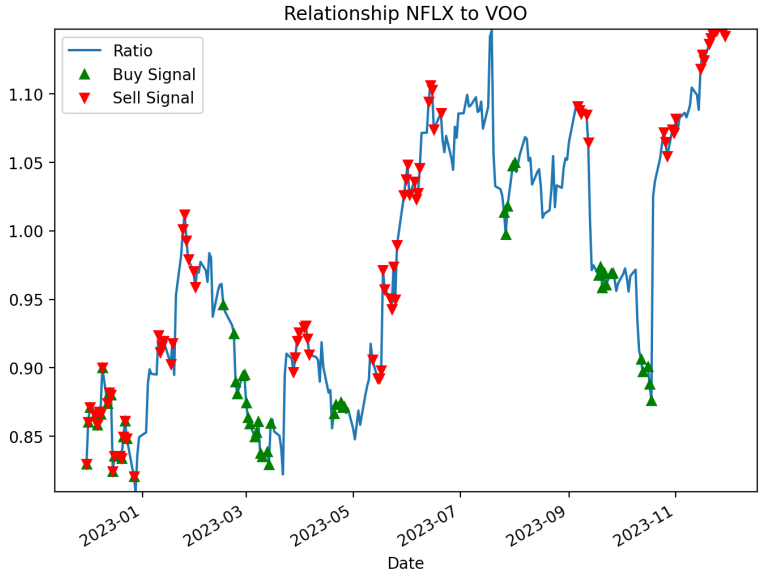

Figure 5

As seen in the figure, the buy signals correspond to a long position for the strategy, and vice versa. For simplification purposes, we will only execute on the first occurrence of each signal. For example, on 02/16 to 02/23, there was a buy signal on each day, but we will only execute the trade on 02/16 and hold the position until the ratio reverts to the mean of 0. Within this period, no other trades will be executed even if there is a signal. The details for the strategy implemented through simply purchasing the underlying has been included below.

Long Positions (Short NFLX, Long VOO)						
Trade No.	**Entry Date**	**Exit Date**	**NFLX Entry**	**NFLX Exit**	**VOO Entry**	**VOO Exit**
1	02/16	03/23	$ 350.71	$ 320.37	$ 370.77	$ 358.37
2	04/20	05/09	$ 325.35	$ 332.14	$ 375.46	$ 374.63
3	07/26	08/08	$ 422.67	$ 438.30	$ 417.07	$ 410.72
4	09/18	10/20	$ 394.40	$ 400.96	$ 407.63	$ 386.99

Short Positions (Long NFLX, Short VOO)						
Trade No.	**Entry Date**	**Exit Date**	**NFLX Entry**	**NFLX Exit**	**VOO Entry**	**VOO Exit**
5	01/10	02/13	$ 327.54	$ 358.57	3$ 54.65	$ 374.89
6	03/28	04/17	$ 323.52	$ 332.72	$ 360.72	$ 377.35
7	05/12	06/26	$ 339.89	$ 415.94	$ 375.24	$ 394.90
8	09/06	09/13	$ 445.76	$ 412.24	$ 408.49	$ 408.79

For the strategy implemented through derivatives, the price of each option at the respective entry dates as detailed above must be determined. Due to the limited information on the historical price of each option, I have chosen to utilize the Black-Scholes model to price these options at the respective dates above.[1] I have assumed that for each position, a 3-month at-the-money option will be purchased. The volatility of each stock has been calculated based on the historical data for the

[1] Refer to Appendix_A-pairs_trading_strategy.ipynb

past year and adjusted to reflect the 90-day volatility. Lastly, the 3-month treasury rate for the past year is utilized as the risk-free rate for the calculations.[2,3] The details for the options purchased are listed below.

Option Prices for Long Positions		
Trade No.	**NFLX Call Price**	**VOO Put Price**
1	$ 18.38	$ 4.06
2	$ 17.17	$ 4.01
3	$ 22.49	$ 4.32
4	$ 21.00	$ 4.21

Option Prices for Short Positions		
Trade No.	**NFLX Put Price**	**VOO Call Price**
5	$ 13.30	$ 8.05
6	$ 13.10	$ 8.24
7	$ 13.59	$ 8.82
8	$ 17.69	$ 9.77

IV. Calculating Returns

With these prices, we can now contrast the performance of both strategies.[4]

Payoffs (Long Positions)				
Trade No.	Short NFLX Payoff	Long VOO Payoff	NFLX Put Payoff	VOO Call Payoff
1	$ (30.34)	$ 12.40	$ (18.38)	$ 8.34
2	$ 6.79	$ 0.82	$ (10.38)	$ (3.18)
3	$ 15.63	$ 6.35	$ (6.86)	$ 2.03
4	$ 6.56	$ 20.64	$ (14.44)	$ 16.43
	$ (1.36)	$ 40.22	$ (50.07)	$ 23.61

Payoffs (Short Positions)				
Trade No.	Long NFLX Payoff	Short VOO Payoff	NFLX Call Payoff	VOO Put Payoff
5	$ (31.03)	$ (20.23)	$ (13.30)	$ 12.18
6	$ (9.20)	$ (16.63)	$ (13.10)	$ 8.39
7	$ (76.05)	$ (19.66)	$ (13.59)	$ 10.83
8	$ 33.52	$ (0.30)	$ 15.83	$ (9.47)
	$ 82.75	$ (56.83)	$ (24.16)	$ 21.94

Assuming an initial portfolio of $1,000 (including amount received from shorting stock) invested in a single share of NFLX and VOO, the final value of the portfolio after the 8 trades will be $1,012.92, for a total return of 1.3%.

For the strategy involving options, the total cost of the options is $ 79.05 + $ 16.60 + $ 57.68 + $ 34.89 = $ 188.22, and the total payoff is $ (28.67), thus giving a total return is -15.24%.

[2] Refer to Appendix_A-pairs_trading_strategy.ipynb
[3] Refer to Appendix_B-rates.csv
[4] Refer to Appendix_A-pairs_trading_strategy.ipynb

V. Evaluating Returns, Limitations, & Conclusion

The difference in returns is extremely discernible, but this can be attributed to several key reasons. Most importantly, we should notice that the majority of these trades last for a period of approximately 2 weeks to a month, but the option expiration date (3-month options) is substantially longer than this. Given that the rolling ratio z-score in figure 4 seem to bounce between 1 and -1, a more prudent strategy would probably be to hold on to these options rather than liquidating it when the z-score approaches 0, and only liquidate our positions when the z-score approaches 1 or -1. A majority of our positions within the options strategy involved selling the option too early before any profits are realized. Thus, selling off these options at a later time gives us more time for the z-score to move towards the opposite direction.

An extension of this strategy, in addition to the above, would probably include the use of straddles and strangles instead of purchasing a single call and put at each trade's entry price. Since the strategy is wagering on a large movement in price in at least one of the stocks in the pair, it seems rational to cover both an increase or decrease in stock price, thus the straddle/strangle. While this may increase the initial cost of setting up the option portfolio, it acts as a form of "insurance" when the price moves the opposite direction, as evident in trades 1, 2, 4, 5, 6, and 7 for NFLX.

Moreover, in the derivation of the option prices from the Black-Scholes formula, a constant volatility was utilized through calculating the returns of the stock over the past year. Since I assumed that both stocks reverted back to a general "mean," I opted against the calculation of volatility at every entry as I did not expect large changes to these values. However, a more accurate representation of this price could be derived through individually calculating the volatility at each trade's entry date.

Lastly, it could be the case that these two stocks that were chosen, namely NFLX and VOO, are not fundamentally correlated as the cointegration test has shown. It seems unlikely that results from a single test is sufficient to conclude the existence of a stationary value (the pair of stocks revert to a mean value). It would be prudent to conduct more tests, such as the Augmented Dickey-Fuller (ADF) test, to determine whether the spread of both stocks (NFLX – VOO), or the ratio of both stocks (NFLX / VOO) are indeed cointegrated through the analysis of the p-value. Due to the scope of this paper, such additional tests were not conducted, but an extension of this project should include this.