EVALUATION OF DERIVATIVE SECURITY ATTRACTIVENESS

An Undergraduate Research Scholars Thesis

by

ANDREW NAKOS

Submitted to the Undergraduate Research Scholars program at
Texas A&M University
in partial fulfillment of the requirements for the designation as an

UNDERGRADUATE RESEARCH SCHOLAR

Approved by Research Advisor: Dr. Madhav Erraguntla

May 2020

Major: Industrial and Systems Engineering

TABLE OF CONTENTS

ABSTRACT

Evaluation of Derivative Security Attractiveness

Andrew Nakos
Department of Industrial and Systems Engineering
Texas A&M University

Research Advisor: Dr. Madhav Erraguntla
Department of Industrial and Systems Engineering
Texas A&M University

Options are a type of security which rely on the performance of an underlying asset, and are priced based on the current information state. By simulating the future information state and comparing it with the current information state, a profile of return likelihood is deduced through a classification algorithm for each option quote.

SECTION I

INTRODUCTION

A stock option is a type of derivative security that derives its value from the performance of the underlying stock [1]. The two main types of stock options are calls and puts. A call stock option allows a buyer to have the option (but not the obligation) to purchase the underlying stock at the specified strike price. A put stock option allows a buyer to have the option (but not the obligation) to purchase the underlying stock at the specified strike price. A European stock option can only be exercised on the date of expiration while an American stock option can be exercised at any time up to the expiration. The Black-Scholes model is an example of a model that determined the optimal price of a European Option based on generalized inputs [5]. However, one key difference between this paper and the previous work of the Black-Scholes is that this paper does not set out to describe a pricing model, but rather a risk and return model. This paper attempts to analyze American stock options through the expected return and risk taken by investors purchasing call or put options that are derivatives of airline stocks.

Risk and return are two key factors that investors consider when purchasing securities as a measure of comparison against other securities. Risk describes the likelihood that an investment will fail and return describes the amount of additional capital that an investor gains over their initial investment. The best situation for an investor is high return and low risk, however in reality, risk and return are positively correlated [7]. By helping an investor determine risk and return for a stock option, an investor can make better investment decision.

This paper focuses on options for airline stocks since they have similar factors which drive the stock price [6]. By accounting for the variables that drive the price and the changes in those variables, it is possible to predict the return and risk on a stock option. These variables will be accounted for through historical simulation, which is a commonly accepted practice in financial risk management in order to create a risk profile for various assets [2] [3] [4]. The Black-Scholes model [5] and the 10K report [6] (annual earnings report) each contain a set of several variables that are important to consider when evaluating airline stock options. By utilizing historical simulation to simulate the possible outcomes the driving variables could take at some point in the future, future returns on options bought today could be estimated, giving an investor a good idea on a risk and return profile for an individual option quote.

SECTION II

METHODS

There are several variables that affect a stock option's price. Since this paper focuses on back testing airline stock options, the variables were determined based on some of the variables listed in the annual report for a major airline, in addition to variables that are commonly used in options pricing, such as in the Black-Scholes model [5]. According to a Fiscal Year 2018 10-K filing for a major airline [6], there were several factors identified which could have adversely affected their stock and its derivatives. The model will take information from the following sources as factors: underlying asset returns risk free investment rate (from treasury bonds), crude oil price (from CL:NMX index), overall market performance (from S&P index), the overall market volatility from (VIX index) and the nature of the option quote (Underlying Price: Strike Price, Call/Put, Time to Expire). The entirety of the values of the variables listed comprise a market environment at time t. This led to a creation of the dataset formatted as follows in Table 1.

Table 1. Dataset example (represents Actuals)

St/K	Call	1/TimeToExpire	Underlying	SP_500	RF_change	Oil_change	VIX_change	Option_Change
0.367871	1	1	0.039890662	-0.000368574	0.009804	-0.000283	-0.037845	0.121951445
0.367871	0	1	0.039890662	-0.000368574	0.009804	-0.000283	-0.037845	4.668144985
0.333969	1	1	0.039890662	-0.000368574	0.009804	-0.000283	-0.037845	0.16532398
0.333969	0	1	0.039890662	-0.000368574	0.009804	-0.000283	-0.037845	3.135494216
0.301179	1	1	0.039890662	-0.000368574	0.009804	-0.000283	-0.037845	0.213841159
0.301179	0	1	0.039890662	-0.000368574	0.009804	-0.000283	-0.037845	-0.470003629

To know just how much each one of these factors affect the options price, there needed to be some measure between a change of the factor and the change in the option quote, and the effect of the nature of the option quote on those sensitivities. A comprehensive model was created using linear regression which achieved this objective.

In parallel, each of the variables that are believed to affect the options price were simulated one trading period into the future by randomly sampling from the previous one hundred trading periods (see Figure 1).

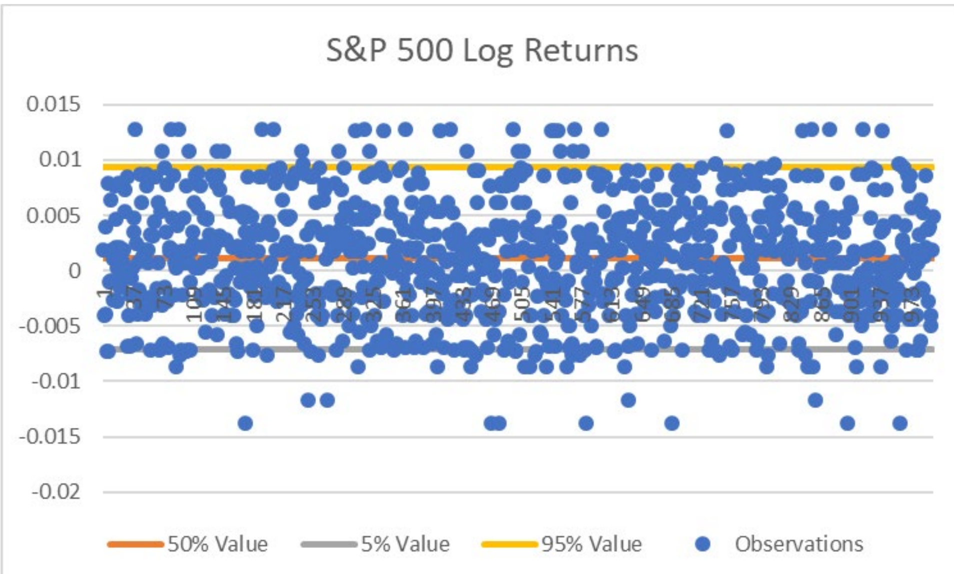

Figure 1. Simulation Example

Next, 5%, 50% and 95% values for the likely change in each factor for the next trading period was attached to the data of an option quote for the date simulated. The simulation process was repeated for each independent quote date. The 5% market environment, 50% market environment, and 95% market environment were fed into the aforementioned model, which produced an estimate of the likely range of returns as a risk metric, as well as the expected return. An output example can be seen in Figure 2.

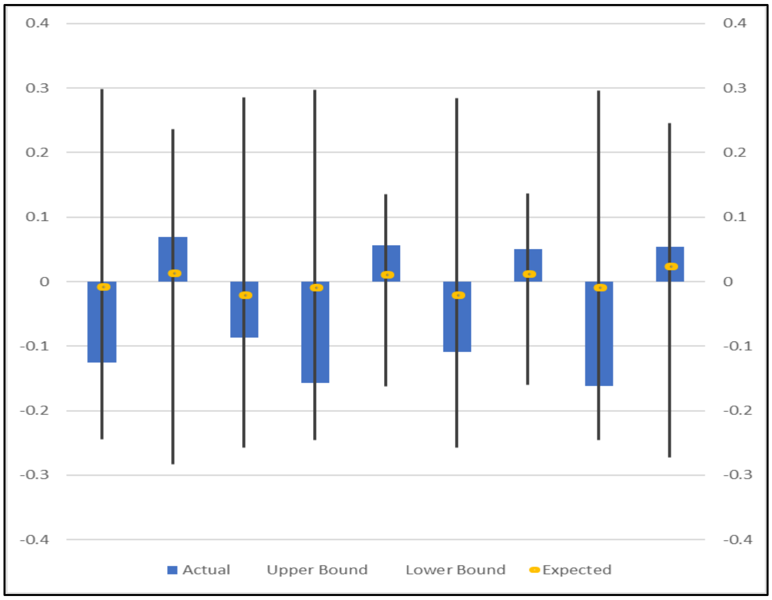

Figure 2. Model output sample

SECTION III

RESULTS

Overall, the predicted range of values using this methodology was correct 69.8% of the time, and when the time to expire was > 10 trading periods, the predicted range of values was correct 75.4% of the time. A possible reason for this improved performance is because option pricing tends to be less stable the closer to expiry, which is similar to what has been seen in previous research (generally the model is restricted to options with >10 days to expiry). In context these intervals are worse performing than methods such as pure historical simulation or filtered historical simulation methods, which tend to correctly capture tail risk at the confidence they intend to. The model back tested earlier had a breakage much higher than the intended confidence interval (69.8% correct vs. 95% confidence).

The method correctly predicted the direction of the option price 50.27% of the time with respect to the expected value, which is marginally better than a guess and at par with the industry. When selecting the 25 best options each trading period as output by the model (by magnitude of expected return) over a 1 year the model produced a 15.68% return when over the same time period the S&P 500 (the benchmark for investment returns) returned 2.092%.

SECTION IV

CONCLUSION

This paper attempted to identify model which could accurately give a risk and return profile on options quotes. The risk portion of this model was clearly subpar, however the overall performance of the return portion of model performed better than the benchmark. Looking at the driving variables of a stock price and simulating those variables into the future can give insight into the future performance of stock options. The methodology presented in this paper returned above the benchmark of investment returns by 13% year over year and is worth exploring further as a metric of next day performance by moving into options in other sectors with different risk factors. It would also be worth exploring how this methodology fared over longer time intervals. On the other hand, claims of risk should be explored using other more established methodologies such as pure historical simulation due to the subpar performance of this model in capturing risk intervals.

REFERENCES

[1] Chen, James. “How Options Work for Buyers and Sellers.” Investopedia, Investopedia, 17 Sept. 2019, www.investopedia.com/terms/o/option.asp.

[2] Boudoukh, J.; Richardson, M.; Whitelaw, R. (1998). "The Best of Both Worlds" (PDF). Risk. 11: 64–67.

[3] Jin-Chuan Duan & Jean-Guy Simonato, 1995. "Empirical Martingale Simulation for Asset Prices," CIRANO Working Papers 95s-43, CIRANO.

[4] Barone-Adesi, Giovanni & Giannopoulos, Kostas & Vosper, Les. (2000). “Filtering Historical Simulation. Backtest Analysis.”

[5] Black, Fischer; Myron Scholes (1973). "The Pricing of Options and Corporate Liabilities". Journal of Political Economy.

[6] Delta Air Lines, Inc. Form 10-K 2018. SEC EDGAR. Web. 16 September 2019.

[7] Graham, Benjamin, and David L. Dodd. Security Analysis. 6th ed., McGraw-Hill, 2009.