An Empirical Study of the COMFORT Option Pricing

Executive Summary

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Banking and Finance

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Option pricing is one of the core issues in the field of finance. Since the last century, it has been discussed by numerous researchers. In 1973, Black and Scholes proposed a new perspective of thinking option pricing. They proved that the option can be priced by a mathematical model. Their theory has been a great breakthrough in both industry and researches. Since then, more and more scholars have developed the models from different perspectives, e.g. the variance gamma (VG) model, GARCH model etc. are widely used. Among these researches, it is notable that a new multivariate time series model proposed by Paolella and Polak(2015), namely COMFORT. This model combines GARCH-type dynamics with an SV structure, and it can better capture the volatility characteristics of stock index. Based on these above, this research aims to price stock options based on the Black-Scholes model, Levy process models, GARCH model, and COMFORT model, and compares the pricing performance of these models.

In this thesis, the basic principles of the Black-Scholes model, Levy model, GARCH model, COMCORT model and two methods, Fourier method and Monte Carlo method, are introduced, and the logical relationship between them are clarified. Based on this, The Standard & Poor's 500 (S&P500) Index is employed for empirical research. Among various stock indices, S&P 500 index is generally considered to be the ideal subject of stock index option contracts. It is characterized by wide sampling, strong representativeness, high accuracy, and good continuity. The sample period is from 2008-04-01 to 2022-12-30, and it contains 3716 days of price. Observe that this period covers the global financial crisis of 2008 and the COVID-19, which is highly representative. It finds that the S&P 500 index generally shows a sustained upward trend, but there is a noticeable turning point in 2021, which may be closely related to factors such as the COVID-19 pandemic and global economic turmoil. In addition, in terms of the yield series, the S&P 500 index yield exhibits characteristics of volatility and accumulation, with significant fluctuations in 2008 and 2021, which is clearly influenced by factors such as financial crises and pandemics.

Based on this, this thesis chooses three different days as the option pricing benchmark, which feature high, medium and low annual volatility. To calculate the annualized volatility, a 251 days rolling window is chosen to calculate the standard deviation of the day at the middle. The return sequence is fitted and priced under the following four models: (1) Black-Scholes; (2) Variance-Gamma (VG); (3) GARCH; (4) COMFORT-GARCH. Then, to price the call option contract, the return to the specific model is fitted. After fitting, the fitted model parameters are adopted to calculate the option prices. As for Black-Scholes and Variance Gamma model, the Fourier method option pricing equation and the characteristic equations are used to compute the option prices under different maturities and moneyness. While, the GARCH and COMFORT-GARCH models, however, need to take advantage of the Monte-Carlo method.

It finds that the option prices are increasing with moneyness, which shows a negative correlation between option price and strike price since moneyness is a ratio of the initial price to strike price. Option prices are increasing with maturity, and the results are consistent with theoretical analysis. In addition, compared with the other three models, the COMFORT-GARCH

model yields a more stable price change with a smaller magnitude. The results confirms that the COMFORT-GARCH model focuses more on the impact of the changes in the underlying index itself (index level and volatility) on option prices. In addition, the results show that the relationship between moneyness and the inverse volatility is quite complex. Overall, as for the other three models, it shows that the volatility increases with the increase of moneyness. However, the results of the COMFORT-GARCH model reveal that higher moneyness corresponds to lower volatility. This result is consistent with theoretical analysis, and it further indicates that the COMFORT-GARCH model is more adequate for capturing volatility information, and has applicability in option pricing.

In all, the research shows that COMFORT-GARCH model can better capture the volatility characteristics of S&P 500 index, yielding a more stable price change with a smaller magnitude. It may have wide applicability in the multivariate setting for potentially large numbers of assets.