An empirical option pricing algorithm to potentially replace unsatisfactory theoretical models

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There are known discrepancies in commonly used option pricing models, such as Black-Scholes, resulting from questionable assumptions made in their derivation. We developed a numerical algorithm that avoid many of these assumptions and instead rely on historical data to accurately price options.

An option contract is a type of financial derivative. Financial derivatives are instruments that derive their value from other assets, for example a stock. The most simple option is the European call option which gives you the right, but not the obligation, to buy an asset (the underlying asset) for a predetermined price (the strike price) at an agreed upon time in the future (at maturity).

To derive the fair price of an option is far from an easy task. In fact, it is so difficult that Robert C. Merton and Myron Scholes received the 1997 Nobel Memorial Prize in Economic Sciences for their contributions to the task. A result of their work is the Black-Scholes formula which has become standard in academia as well as the industry for calculating option prices.

The key idea behind the Black-Scholes formula is to offset losses and gains of the option by buying and selling the underlying asset, a process called hedging, continuously in just the right way to eliminate all risks. Since the investment becomes riskless by doing this, the option price must match the cost of the hedging to be fair. The fathers of Black-Scholes formula were able to calculate the cost of the hedging by assuming that the underlying asset follows a specific stochastic process, the geometric Brownian motion. This is one of a few questionable assumptions the formula is derived through that make the final result not completely accurate. A lot of effort in research of option pricing has been put into modifying the Black-Scholes formula and modelling the stochastic process better without entirely convincing results. We take a different approach by developing a Monte Carlo method, a numerical algorithm which relies on data to describe the underlying asset instead of a stochastic process.

We evaluate our algorithm in a theoretical setting, where the Black-Scholes formula holds, by simulating artificial data from the geometric Brownian motion and use this data as input. We found that our algorithm produces price estimates that matches the results from Black-Scholes formula. Additionally, we validate the algorithm with data simulated from another stochastic process (SABR) and find precise results once again.

After having validated the algorithm, we apply it on real historical data to estimate empirical option prices. Our results can potentially be used in a trading strategy that take advantage of mispricings in financial markets or by financial institutions to correctly price option contracts they offer to clients. The algorithm is especially useful for pricing infrequently traded options for which market participants cannot rely on previously quoted prices.