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**Thesis Title:** Pricing Options via Double Auctions

**Abstract:**

This research develops and analyses a new set of agent-based models for pricing European options and option portfolios in the context of double auctions. After the financial crisis of 2008, it became obvious that the banking industry had been over-reliant on mathematical models such as Black-Scholes in pricing financial derivatives despite their major assumptions such as the efficiency of markets, the homogeneity and the risk-neutrality of traders, and the limitations in evaluating the risk itself. Although the Black-Scholes framework is regarded as the cornerstone of arbitrage-free pricing of financial derivatives, it does not involve market microstructure in forming option prices.

In this research, I add a simulated market component to the existing option pricing methodology through modelling automated option traders and running them on various auction-based mechanisms. My simulation model consists of three consecutive steps: asset pricing, automated traders, and market mechanisms. Firstly, I simulate asset prices beyond Black and Scholes' initial assumption which also involve fat-tailed distributions and mean-reverting aspects of risk-free interest rates that are common in most underlying markets.

Secondly, I design option traders according to my extended version of Information-Inventory-Knowledge-Behaviour (IIKB) framework. While the information and knowledge layers of the framework involve gathering and computing basic statistical parameters of the market, the behavioural layer is designed using three sublayers which are responsible for determining the option price, the quantity to bid/ask and the proxy trading algorithm. I also use Zero-Intelligence (ZI) and indifference pricing techniques along with the Black-Scholes formula to generate heterogeneous option prices. For proxy trading algorithms, I re-purposed well-known inventory- and information-based trading models to deal with options. I also use popular ZIP and GD trading algorithms to model the behaviour of speculative option traders.

Finally, in the third step, I feed the orders generated from automated traders to different mechanisms and analyse the obtained option prices. First, I consider direct double auction which has the Dominant Strategy Incentive Compatibility (DSIC) property, so that traders submit only truthful orders. I develop a multi-unit, revealed and simultaneous versions of a direct double auction and run different option pricing methods on them to evaluate the aggregated option prices. I also analyse the allocative efficiency and budget-balance of the mechanism. Then, I run trading agents with proxy trading algorithms in an online double auction. I evaluate the obtained option prices and the performance of each proxy trading algorithm used.

Another important aspect of the research is the new perspective on pricing of compound financial contracts such as option portfolios using a combinatorial exchange. I explain the substitutability and complementarity of options in given option portfolios, and apply these concepts to the design of the combinatorial exchange for option portfolios. I also illustrate the expressiveness and flexibility of using combinatorial exchanges through a Tree-Based Bidding Language.

The main contributions of this research are the design and implementation of a direct double auction for multi-unit and atomic orders, revealed mechanisms for forecasting traders, inventory- and information-based option traders, LMSR option pricing based on option portfolios, and the application of combinatorial exchanges to the realm of option pricing.