


CHARLES UNIVERSITY
Faculty of mathematics
and physics

Robert Navrátil, Ph.D. Thesis

On Market Efficiency, Optimal Distributional Trading Gain, and Utility Maximization

Supervisor Report

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The thesis is based on three already published papers, namely

- Vecer, J., J. Kampen, and R. Navratil. "Options on a traded account: symmetric treatment of the underlying assets." Quantitative Finance 20.1 (2020): 37-47.
- Navratil, R., S. Taylor, and J. Vecer. "On equity market inefficiency during the COVID-19 pandemic." International Review of Financial Analysis 77 (2021): 101820.
- Navratil, R., S. Taylor, and J. Vecer. "On the utility maximization of the discrepancy between a perceived and market implied risk neutral distribution." European Journal of Operational Research (2022).

The common theme theme of these works, described in detail in the thesis, is the idea that the physical market measure and the risk neutral measure may be different. Examples of such situations are drifting markets when the markets may exhibit an upward or a downward drift, or when there is a discrepancy between the perceived future volatility. Alternative probability measures mean that the prices of the contracts are valued differently by different market players. The thesis shows that the problem of the distributional discrepancy of the probability measures naturally connects several areas of both statistics and finance as the identification of the correct measure from data is a question of hypothesis testing or Bayesian analysis, while the problem of optimal behavior of the agents is a question for utility maximization. It is shown that the optimal control of the agent should lead to a final wealth that is proportional to the likelihood ratio of the two measures (the subjective of the agent and the objective of the market).

In this context, the first paper studies portfolios with the largest volatility with respect to the index which is applied on the foreign exchange market. Creation of such portfolios is rather complicated and we have been only able to solve the situation in a two asset case, where the portfolio with the largest volatility is constructed by investing in the cheaper asset. The motivation of this study is to identify a price of a contract that covers trading losses called a passport option, the price of this contract corresponds to the strategy that

produces the largest volatility. The proof of optimality is heavily using advanced techniques from partial differential equations that we have been only able to complete with our coauthor Jorg Kampen.

The second paper identified that the stock markets were briefly not efficient during the early stages of the COVID pandemic, meaning that the asset returns became statistically predictable. However, having statistically predictable returns does not mean that such information can be converted to a statistically profitable trading strategy. The important contribution of this work is to identify the optimal trading strategy from the perspective of the utility maximization, and show that this strategy leads to statistically significant profits.

The third paper shows the optimal trading strategy in the geometric Brownian motion case where both drift and volatility can be perceived differently by the market agent. This generalizes the Merton's portfolio problem which considers only a different drift. A part of this work focuses on how to approximate the optimal payoff function by a portfolio of European options, thus making this problem static from the perspective of the market agent.

In summary, all these works have achieved a very positive feedback from these journals which resulted in their ultimate publications. The last two journals are ranked as top journals of the field (Q1) with an impact factor above 5, which can be regarded as a significant achievement even for an established researcher, not to mention a Ph.D. student. In terms of the contribution in these papers, Robert played an instrumental role, I usually came up with the conceptual ideas and Robert filled in all the necessary theoretical details, including the proofs. Computer implementations were equally shared by Robert and Stephen Taylor, who is my own previous Ph.D. student, now in Stevens Institute of Technology with a part time contract on my research grant at the Charles University.

Summary: This work exceeds the expectations on the Ph.D. thesis and I fully recommend that it is **accepted** as such.

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