

MTH 40A/B Winter 2019

1.- Title: Static Hedging with Digital Options

Author: Marko Vukovic

Supervisor: Foivos Xantos

Abstract: In this paper we explore the concept of static hedging for exotic options using binary options. There is a review of sublattice theory, as well as the concept of market completeness and spanning using Ross' Theorem. An algorithm is outlined that uses the underlying prices at maturity and returns a positive basis of payoffs across all end states that can be replicated with a portfolio of binary options. We then evaluate the algorithm against a delta hedging strategy by comparing the error when hedging both vanilla and exotic options in the trinomial model.

2.- Title: Finding Critical Vaccination Proportions to Eradicate Micro-Parasites Using an Age Dependent Model.

Author: Susan Stanley

Supervisor: Katrin Rolf

Abstract: The goal of this thesis was to investigate the effects of vaccines on the transmission of micro-parasites from one individual to another. To do so, an age-dependent SIR model ODE system was analysed. From the results presented in the thesis the process of herd immunity is explained. Herd immunity is the concept that explains why every single person in a population does not have to be vaccinated in order for a micro-parasite to enter an endemic state. The equation used in the thesis illustrates that as the percentage of the population that is successfully vaccinated approaches the critical value, the force of infection weakens. This means that the more individuals vaccinated, the less forceful the parasite is, which in turn results in less infected. In addition, MATLAB plots were given to assess the effect of varying the force of infection. Most importantly, the solution curves when no individuals were vaccinated were compared to the solutions when a specific portion of the population was successfully vaccinated. This graph exhibited that the population that did not receive vaccines had significantly higher rates of infection, and a notable delay in immunity compared to the population where a portion of the population was vaccinated. In the future, epidemiologists or professionals working with the spread of parasites can use the information included in the thesis in their own studies. The addition of a time dependent variable can be utilized to predict the spread of an outbreak, or work in different variables to account for the loss of immunity over time and how that would affect people later in their lives.

3.- Title: The Financial Performance of Renewable Energy Firms

Author: Kenji Hewitt

Supervisor: Alexey Rubtsov

Abstract: This paper studies the impact of climate change on energy producing assets and explores alternative methods to mitigate the adverse effects of climate change to support the transition to lower carbon emitting economies. We investigate risk-adjusted returns of two distinct portfolios, one comprised of alternative energy stocks and the other comprised of traditional energy stocks. The study applies modern portfolio theory to construct CVaR efficient portfolios (where CVaR - Conditional Value at Risk - is the objective function to minimize) using historical stock prices. Backtesting of the portfolios is done to study their performance with real market data. The sample period used to backtest the efficient portfolios is from January 2013 to July 2018, where the portfolios will be rebalanced and their returns evaluated on a monthly basis. The resulting Sharpe Ratio for the traditional portfolio is three times higher than its counterpart. These findings suggest that investors, regardless of their exact preferences, will be more likely to invest in the "black" traditional portfolio over the "green" alternative energy portfolio. The long run implication of this is that little investment will be directed towards the alternative energy sector, and this lack of investment is yet another barrier that renewable technologies face. Therefore the implementation of carbon taxes, carbon mitigating policies, and/or creating subsidies for low carbon-footprint firms may be needed to encourage investment into the renewable energies sector.

4.- Title: Automatic Personality Insights from Speech

Author: Reaz Huq

Supervisor: Pawel Pralat

Abstract: We tested various machine-learning models on a corpus of audio samples that predicted the speaker's personality based off of the content and prosodic qualities of their speech. The best model obtained a 53% classification accuracy for Big Five scores, constituting a 20 percent gain over a baseline random model. MindTime classification accuracy was 69.2% on average which was a 36 percentage point gain over a baseline random model. Both results confirm the intuitive hypothesis that an individual's personality manifests itself in their speech and that it is possible to predict an individual's personality based off of speech alone. Further research in this area could be conducted using deep learning methods, larger datasets, and introducing other possible manifestations of personality (such as body language or facial expressions).

5.- Title: Pricing weather contracts under mean-reverting exponential Levy processes

Author: Jaimie Porthiyas

Supervisor: Pablo Olivares

Abstract: We price weather contracts when the underlying asset is the cumulated temperature over certain period in selected sites in Ontario province. To this end we simulate a continuous-time mean-reverting stochastic model with noises driven by a time-changed Levy process, a seasonal component and stochastic volatility among other features.

6.- Title: They Don't Make Them Like They Used To: Rhythmic Complexity and the Evolution of Popular Music

Author: Gabrielle Turcotte
Supervisor: Lawrence Kolasa

Abstract: It is without a doubt that music has evolved over the past decades. Art has always changed with the times and music is no exception. The question is, has it gotten better or does music suffer from the old adage, "they don't make them like they used to?" The aim of this study is to analyze and compare the rhythmic complexity of popular music over the years using applications of time-frequency analysis. "Classical pianist Artur Schnabel said: "The notes I handle no better than many pianists. But the pauses between the notes — ah, that is where the art resides" [1]. From this statement and using similar methodology from the paper "Music: Broken Symmetry, Geometry and Complexity" by James Walker et al., we will investigate these pauses between notes called "rests", their lengths, occurrence and two types of entropy of the generated sequence of rests. A higher degree of entropy would indicate a higher degree of rhythmic complexity versus a song with a lower entropy value. What is expected is, through the emergence of technology-based music, beats and rhythms have become more standardized and predictable vs. the instrument-based music created by musicians before electronic music arrived. This would be demonstrated by a trend of decreasing entropy of popular music over time, specifically in songs with an electronic-based sound. What was discovered is that while there may not have been an observable trend over time, what was noticeable is the decrease in diversity of entropies within the most popular songs of a decade. The ranges in entropy were much larger in previous decades, while in the 2010s, the entropies of the most popular songs were much more similar. Further, we discovered that certain songs had larger decreases between their two types of entropy, which could be attributed to repetition of percussive rhythms in the song.

7.- Title: Environmental, Social and Governance Investing: A Portfolio Optimization Approach

Author: Anny-Aysel Ineza
Supervisor: Alexey Rubtsov

Abstract: This paper examines the performance of the incorporation of environmental, social, and governance (ESG) criteria into investment strategies. We do so on the basis of real data from ESG stocks and non-ESG stocks, and compare the return of both portfolios by using two investment strategies. The first strategy

is by Mean-Variance optimization and the second is by Value-at-Risk (VaR) optimization. We use the Sharpe ratio to compare the performance of the two portfolio optimization strategies applied to the portfolio of ESG and non-ESG stocks, over the investment period. The results observe out-performance of the ESG portfolio over the period under review. We find that the integration of ESG stocks to a portfolio gives an opportunity to manage risk, leading to lower downturn risk while attaining high returns.

8.- Title: Hedging Interest Rate Risk

Author: Sadia Billoo

Supervisor: Dr. Rubtsov

Abstract:

This thesis explores the management and measurement of interest rate risk. The primary reason for fluctuations in bond values and values of other fixed income securities is due to changes in the term structure of interest rates. To obtain an overview of the total interest rate risk and to manage the sensitivities of different securities to interest rate movements, certain risk measures are used. This paper compares traditional risk measures, such as Macaulay and Fisher-Weil durations, to measures more directly linked with the dynamic term-structure of interest rates. The latter focuses on one-factor diffusion models, specifically the Cox-Ingersoll-Ross measure and the derivation of stochastic durations from this model. In order to measure and compare the effectiveness of these measures, certain immunization strategies using bonds are constructed to seek a desired cash flow.