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Ph.D. Dissertation Defense

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Degree:	Doctor of Philosophy
School/Department.:	School of Business / Financial Engineering
Date:	Wednesday, April 22, 2026
Time:	1:00 – 3:00 pm
Location:	Babbio 601
Title:	Forecasting and Managing Financial Risk: Volatility Modeling with GARCH–RNNs and Quadratic Variation Portfolio Methods
Chairperson:	Dr. Zhenyu Cui, Financial Engineering, School of Business Dr. Steve Yang, Financial Engineering, School of Business
Committee Members:	Dr. Zachary Feinstein, Financial Engineering, School of Business Dr. Majeed Simaan, Finance/Financial Engineering, School of Business Dr. Foad Mahdavi Pajouh, Management, School of Business

Abstract

This dissertation studies dynamic financial risk from both forecasting and portfolio management perspectives, aiming to improve how risk is modeled, predicted, and controlled over time. Conventional volatility models often rely on rigid parametric structures or offer limited interpretability, while classical portfolio approaches such as mean–variance (MV) optimization are sensitive to estimation error and become time-inconsistent in multi-period settings. To address these limitations, this dissertation develops three related essays that provide a coherent framework for modeling and managing financial risk in dynamic environments.

The first essay presents a unified volatility modeling framework that embeds GARCH dynamics directly within recurrent neural networks. The proposed GARCH-GRU and GARCH-LSTM architectures incorporate the GARCH(1,1) update into the gating mechanisms of GRU and LSTM cells, preserving the economic interpretability of GARCH parameters while allowing the models to learn nonlinear, state-dependent patterns in financial time series. Empirical analysis on major U.S. equity indices shows that these models deliver more accurate and robust forecasts of volatility and tail risk than classical GARCH specifications and modern neural baselines, including during the COVID-19 stress period.

The second essay introduces a mean quadratic variation (MQV) framework for portfolio selection. By replacing terminal variance with quadratic variation as the risk measure, the framework provides a path-dependent representation of portfolio risk that is naturally suited to dynamic investment problems. In contrast to MV methods, which face high-dimensional covariance challenges and time inconsistency, the MQV formulation is tractable and yields exact time consistency in multi-period settings. Empirical evaluations demonstrate that MQV-based portfolios achieve greater stability, lower turnover, and improved out-of-sample performance relative to their MV counterparts.

The third essay extends the MQV framework by incorporating Gerber-type threshold-based statistics into the construction of the quadratic-variation risk matrix. The resulting MQV-Gerber statistics (MQVGS) framework combines QV-based scaling with threshold-filtered co-movement, reducing the impact of noise while emphasizing economically meaningful joint movements. Empirical results show that MQVGS maintains competitive out-of-sample returns while consistently achieving lower turnover, with more pronounced advantages during the COVID-19 period across multiple asset universes.