Ph.D. Dissertation Defense

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Degree:	Doctor of Philosophy
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Date:	Tuesday, May 6th, 2025
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Title:	Three essays on optimal execution under capital ratio constraints
Chairperson:	Dr. Zachary Feinstein, Financial Engineering, School of Business
	Dr. Somayeh Moazeni, Analytics and Decision Sciences, School of Business
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Abstract

The three essays in this dissertation explore optimal execution strategies under capital ratio constraints, addressing critical challenges in financial regulation and risk management. These essays explore static and dynamic liquidation strategies under capital ratio chance constraints in both single-agent and multi-agent settings, highlighting their implications for regulatory compliance.

The first essay, *"Optimal Portfolio Execution Strategies under Chance Constraints on the Capital Adequacy Ratio"* addresses the challenge of balancing revenue generation from liquidation with the regulatory requirement to maintain a minimum capital ratio throughout the execution horizon. We formulate this as a Joint Chance Constrained Problem (JCCP) to ensure compliance under market uncertainty. To overcome the computational complexity of JCCP, we propose a scalable relaxation -- the Individual Chance Constrained Problem (ICCP). Numerical results show that ICCP closely approximates JCCP while significantly reducing computation time, offering a robust and efficient framework for analyzing static liquidation strategies under regulatory constraints.

The second essay extends the static framework to a dynamic setting using safe reinforcement learning (RL) to study optimal execution under capital ratio constraints. By reformulating the problem conservatively, we apply RL to derive optimal policies and compare them with static benchmarks. Results show that RL improves both objective value and constraint satisfaction, particularly under high volatility or strict capital ratio requirements. Moreover, stronger asset correlation further widens the gap between dynamic and static strategies. This study highlights the adaptability and effectiveness of dynamic decision-making in optimizing liquidation strategies while ensuring regulatory compliance.

The third essay generalizes the single-agent model to a multi-agent setting, where agents seek optimal equilibrium liquidation strategies under a shared capital adequacy constraint. We show the existence of Nash equilibrium solutions and compute them numerically. Comparing a single agent, an aggregate agent, and multiple interacting agents, we find that more agents lead to intensified competition, front-loaded liquidation, which in turn enhances capital ratio compliance. Higher permanent price impacts lead to more heterogeneous and competitive behavior. These findings reveal how competition and coordination shape liquidation outcomes in multi-agent financial systems.