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Ph.D. Dissertation Defense

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Date:	Wednesday, April 29, 2026
Time:	9:00 – 11:00 am
Location:	Online (Zoom Link: https://stevens.zoom.us/j/92472664729)
Title:	**Risk-Averse and Distributionally Robust Stochastic System: Decision-Making Under Uncertainty**
Chairperson:	Dr. Zhenyu Cui, Financial Engineering, School of Business
Committee Members:	Dr. Darinka Dentcheva, Mathematical Science, School of Engineering and Science Dr. Mathieu Laurière, Mathematics and Data Science, NYU Shanghai Dr. Papa Momar Ndiaye, Financial Engineering, School of Business Dr. Zachary Feinstein, Financial Engineering, School of Business

Abstract

This dissertation investigates decision-making under uncertainty in stochastic dynamical systems, with a focus on integrating risk-averse and distributionally robust methodologies into continuous-time control and game-theoretic frameworks. A unifying theme is the duality between risk measures and distributionally robust optimization (DRO): the optimization of a coherent or convex risk measure can be equivalently reformulated as a worst-case expectation over an ambiguity set of probability models.

The first main contribution develops a framework for risk-averse mean field games (MFGs) in which the classical expected cost criterion is replaced by a time-consistent dynamic risk measure induced by g-expectations, which are nonlinear expectations constructed via backward stochastic differential equations (BSDEs). We establish well-posedness of the representative agent's control problem and characterize mean-field Nash equilibria through two complementary approaches: a dynamic programming formulation yielding a coupled risk-averse Hamilton–Jacobi–Bellman and Fokker–Planck (HJB–FPK) PDE system, and a stochastic maximum principle leading to a system of mean-field forward–backward SDEs. We prove the existence of classical solutions to the MFG system and show that the resulting feedback control induces an approximate Nash equilibrium for the corresponding finite-player game. When the generator is convex and positively homogeneous, we further establish an equivalent DRO representation under Girsanov-type drift distortions, providing a tractable interpretation of ambiguity aversion in large-population games.

The second main contribution addresses the classical Merton portfolio optimization problem under model ambiguity. We recast the problem as a max–min stochastic control program and analyze two specifications of the ambiguity set. Under Kullback–Leibler divergence balls around a reference market measure, we establish an equivalence with risk-averse control via entropic value-at-risk and derive optimal policies through an HJB equation on an augmented state space. Under Wasserstein balls on the terminal-wealth distribution, we apply Kantorovich duality to reduce the robust problem to a family of standard Merton problems parameterized by a dual variable, together with a one-dimensional outer optimization. Both frameworks are further extended to a Heston stochastic volatility environment, where the adversary can simultaneously distort the asset return drift and the volatility dynamics, yielding a genuinely richer robust formulation on a two-dimensional state space.