UNIVERSITY OF TORONTO
FACULTY OF ARTS & SCIENCE | Department of Mathematics

Departmental PhD Thesis Exam

Thursday, September 11th, 2025 at 10:00 a.m. (sharp)
via Zoom / BA6290B

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Supervisor : Luis Seco

Thesis title : From Theory to Practice: a Stochastic Framework for Utility-Driven Capital Allocation

Abstract

In this thesis, we study utility-driven capital allocation on causal graphs that encode real economic drivers, with a particular focus on multi-period stochastic control and externalities. The central question is to what extent a semantically grounded causal feature map, together with an externality-aware utility function, can be used to model the economically meaningful policies, allocations, and structural interventions between states of the economy.

More precisely, motivated by dynamic programming, production-based asset pricing, and integrated climate-economic models, we formulate a multi-period optimization problem over resource, capacity, and policy controls on a directed acyclic causal graph. This formulation propagates policy interventions along structural edges and keeps both forecasts and allocations interpretable. We make progress on three fronts. In terms of robustness, we prove that bounded forecast error perturbs the multi-period value by at most $O(\varepsilon)$ under Lipschitz and compactness assumptions. In a computational direction, we show that deciding whether any finite-horizon policy attains a target discounted utility is NP-complete via a reduction from 0–1 Knapsack. In a representation-theoretic direction, we establish conditions under which learned low-dimensional dynamics are strict contractions, implying a unique fixed point and geometric convergence of iterative algorithms in latent spaces. Altogether, the thesis shows how causal graphs combined with externality-aware utility functions can help determine optimal allocations and interventions in an interpretable fashion, and provides mathematical guarantees that make such models tractable for long-horizon decision making.