

# Stochastic Optimal Control Techniques for a Regime-Switching Model with Applications in Finance

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## Abstract

In these lectures, we focus on Dynamic Programming Principle and Stochastic Maximum Principle. Firstly, we present these two methods, which are fundamental tools of Stochastic Optimal Control Theory. Moreover, we introduce Markov chains and time-delay concepts. Then, we present stochastic optimal control problems of finance and economics in a Markov regime-switching jump-diffusion market with and without delay component in the dynamics of our model. We formulate portfolio optimization problems as a two player zero-sum and a two player nonzero-sum stochastic differential games. We provide an extension of Dynkin formula to present the Hamilton-Jacobi-Bellman-Isaacs equations in such a more general setting. We illustrate our results for a nonzero-sum stochastic differential game and investigate the impact of regime-switches by comparative statics of a two state Markov regime-switching jump-diffusion model. We prove the existence-uniqueness theorems for a stochastic differential delay equation with jumps and regimes (SDDEJR) and for an anticipated backward stochastic differential equation with jumps and regimes (ABSDEJR). Furthermore, we give the duality between an SDDEJR and an ABSDEJR. We establish necessary and sufficient maximum principles under full and partial information for an SDDEJR. We show that the adjoint equations are represented by an ABSDEJR. We apply our results to a problem of optimal consumption problem from a cash flow with delay and regimes.

**Emel Savku** received her BSc. (2008) and MSc. (2010) degrees from Ankara University, Department of Mathematics. She worked on Functional Analysis, specifically Summability Theory for her MSc. research. She got her PhD. degree from Financial Mathematics program of Middle East Technical University, Institute of Applied Mathematics in 2017. Her main focus is on Stochastic Optimal Control with applications to finance. Her doctoral thesis mainly investigates Markov regime-switching models within the framework of Stochastic Optimal Control, Game Theory and Time-Delay. After her defense, she worked at TEDU and Bilkent University for two semesters as an adjunct faculty. She obtained French Embassy Young Visiting Researcher Fellowship award and visited Ecole Polytechnique, France for two months and following this period, she obtained her first post-doctorate position (2019) from Ecole Polytechnique, Centre de Mathématiques Appliquées (CMAP) for 18 months. During this period, her research was mainly on Market Making and some applications of tick size pilot program of Europe. By September 2020, she has been a post-doctorate at University of Oslo, Department of Mathematics, Norway. Now, she studies in the intersection of Reinforcement Learning and Stochastic Optimal Control. She presented her scientific results in many prestigious conferences all over the world and serves as a referee for several international journals.