NC STATE UNIVERSITY

Operations Research PhD Final Exam

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Dynamic Game Theoretic Models in Marketing and Finance

Advisor: Dr. Negash Medhin
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Abstract:

We use Differential Games (DG) as basic mathematical tool to study competition in general Market and Financial Markets. First we break up the normal product life cycle of a product into three sub-stage life cycles, set up non-cooperative deterministic DG models for each sub-stage life cycle, and derive optimality conditions for them, which in general, are a set of Boundary Value Problems (BVPs) or Differential-Algebraic Equations (DAE), and design algorithms for numerical solution. One of the algorithms is based on full discretization, and is first-order algorithm; the other algorithm is based on Shooting method and Random Perturbation technique, and belongs to quasi-Newton method. From the numerical results, we draw optimal competition strategies for each product life cycle, and we compare the difference between open loop and closed-loop controls, and find out general criteria about how to employ these two different controls in reality. Second, we set up Leader-Follower DG and cooperative DG for marketing competition. The motivation for these two special kinds of games comes from practical considerations. To solve Leader-Follower DG, we have to solve a non-classical optimal control problem. We use Calculus of Variations to derive a system of optimality conditions for it, and design an algorithm to obtain numerical solution. This algorithm is random, and second order. In cooperative DG model, we adopt Evolutionary Algorithm (EA) to solve the model. From the numerical results, we compare the above three kinds of DG, and draw practical guidelines about how to choose a specific kind of DG in real competitions. Third, we set up Stochastic Differential Game (SDG) for general market competition. The motivation comes from incomplete information and randomness in reality. We derive a set of optimality conditions for our SDG model using Dynamic Programming (DP). The set of optimality conditions consists of Stochastic Partial Differential Equation (SPDE). Then, we design algorithm to solve this SPDE. At last, we extend SDE to financial marketing. We regard the pricing process as SDG between option seller and buyer, and then we set up SDE model for option pricing. Then, we derive optimality conditions for our pricing model.