FIN 7318- MATH 7318- OPRE 7318

STOCHASTIC DYNAMIC PROGRAMMING AND APPLICATIONS TO MANAGEMENT SCIENCE

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Spring 2025, Tuesday 1 pm -3. 45 pm, JSOM room 2802

1st day of class, January 21, 2025

1- **MOTIVATION**

Stochastic Dynamic Programming is a general methodology to solve stochastic control problems. It plays an essential role in many areas of economics and management science. It deals with decision making under uncertainty for dynamic systems, which is the situation appearing commonly in a lot of applications. Although it has been a known fact for long time, it has become even more evident in view of the new problems, which are presently at the forefront of research.

We give a list of application domains, which intensively use stochastic control:

Operations Management:

Storage Models; Queuing Theory; Inventory Models; Dynamic Scheduling; Capacity Planning; Sequencing of Projects; Stochastic Maintenance; Contract theory; Pricing Management; Environmental Investment

Corporate Economics:

Growth of Firms; Financial Options; Investment Models; Real Options; Cash Management

Finance and Insurance:

Portfolio Management; Optimization between Consumption and Investment.

Retirement Planning; Wealth Management; Ruin Models; Risk Management;

Financial Markets; Credit; Options: Derivatives.

Marketing, Human Resources

Contract Theory; Incentives; Pricing Management; Competition Models

Environment; Energy

Exhaustible Resources; Management of Energy; Management of intermittency for renewable energy resources; Grid Management.

Forecasting

Inference; Sequential Learning; Detection of Changes and warning.

All these topics and others lead to a very broad research activity. They are motivated by new problems of Management of the real life.

It is important to mention that methods of stochastic control are also prevalent in System Engineering, Telecommunications and more globally in complex systems. For instance, the Covid crisis has originated a lot of epidemiology modeling, including control variables to optimize under uncertainty.

2- OBJECTIVE OF THE COURSE

The class objective is to provide a unified and comprehensive approach for both Finance and OM.

The fact that we have areas is understandable from the point of view of the development of science, but in real problems, topics are always interrelated.

Our approach will facilitate considerably the development of models overlapping several aspects of Management Science. For instance, investment theory can be considered as a topic of Operations Management or of Finance. Operations Management cannot omit innovation of technology, growth of production and similar things. Pricing Management is similarly both a topic of OM and of Marketing.

A second objective is to discuss simultaneously discrete time and continuous time models. They complement each other considerably. It is a mistake to consider that

discrete time models are simpler. In fact, continuous time simplifies and allows obtaining more insights. Discrete time formulation becomes quite confusing when several aspects are considered.

Nevertheless, the level of sophistication will be adapted, and discrete time modeling will prevail, so that all students can be comfortable with the content.

This class is self-contained. Mathematical concepts which are needed will be fully explained, and no preliminary knowledge will be required. There is no textbook. Very extensive Lecture Notes will be provided, but only what is explained orally will be requested for grading

In the oral presentation, the effort will be focused on understanding what is presented, rather than on covering all possible topics.

The class is intended for PhD students and motivated master students.

3- STUDENT WORK

The students will be asked to show their understanding of the material by presenting short syntheses of major questions. They will be involved in projects related to extensions of models, or available in published articles.

Grading: Oral Presentations, Participation 30

Test: 35

Assignments and Projects 35

4- Timetable

This is an indicative program. It will be adapted to the background of students.

Class 1: Review of Probability

Class 2: Stochastic Processes

Class 3: Markov Chains

Class 5: Markov Decision Processes

Class 6: Inventory Control and MDP

Class 7: Stochastic Maintenance

Class 8: Inventory Control with jumps

Class 9: Financial Markets in Discrete Time

Class 10: Optimal Portfolio Management

Class 11: Optimal Stopping

Class 12: Real Options

Class 13: Investment Theory

Class 14: Final Exam