DSO 532: Simulation for Business Analytics (JKP102, 2-3:20pm TTh)

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Course Description:

Uncertainty is everywhere. Then, businesses must make decisions in the face of uncertainty every day. Hence it is important to understand methodology for dealing with uncertainty. Simulation is one such methodology.

Simulation falls into the category of business analytics, and is one of the techniques for dealing with "big data" identified by the McKinsey Global Institute (June 2011: "Big Data: The next frontier for innovation, competition and productivity). This course is intended to teach students how to develop, implement, and use simulation methods.

The course approach is to build simulation models to answer practical questions that are motivated by operational business decisions. For example, we will use simulation to
  - Determine optimal inventory policies;
  - Decide on the staffing level and workload division in a service system.

We will begin by building our simulation models in "raw" Excel. Then, we will see the @Risk add-on to Excel to facilitate simulation model building and analysis. Finally, we will learn how to develop discrete-event simulations using the simulation software ExtendSim.

Please see the course lecture plan (at the end of this syllabus) for more detailed information on the topics covered and course requirements.

In relation to IOM 547 (Designing Spreadsheet-Based Business Models), this course goes more in-depth on simulation methodology, and on combining simulation and optimization techniques. The material is coordinated to ensure minimum overlap without also assuming knowledge from IOM 547.

In relation to IOM 599 (The Analytics Edge), this course focuses more on dealing with uncertainty in decision-making rather than on using optimization methods for decision-making. These two courses are complimentary, but the material does not overlap.

Learning Objectives:

  - Students will be able to construct simulations to evaluate the consequences of different operational business decisions, and to select the best alternative.
  - Students will understand both the power and the limitations of simulation methodology.
  - Students will relate simulation to analytics by using data to determine the input to their simulation models, and to validate their models.

Course Materials:

You will need access to Excel, and you will need to install the @Risk add-on. This is free of charge, and instructions will be provided. ExtendSim can be accessed through the Teaching Applications folder on USC Marshall. There is a coursepack available through Harvard Business Publishing (see link below). Some readings in this coursepack are required and some are optional. Finally, there will be additional readings and materials posted to Blackboard.

The link to purchase materials from Harvard Business publishing is: https://cb.hbsp.harvard.edu/cbmp/access/28003610.

Although there is no official course textbook, the following two textbooks will allow you to go deeper into simulation methodology: *Discrete-Event System Simulation* by Banks, Carson, Nelson, and Nicol (publisher: Prentice Hall) and *Simulation Modeling & Analysis* by Law and Kelton (publisher: McGraw Hill). Finally, there are many "raw" Excel simulation examples in *Excel Simulations* by Verschuuren (publisher: Holy Macro! Books).

Grading:

Your course grade will be based on the following individual and group assignments:

Class Participation:	5%
Homework (5 @5%):	25%
Case preparation questions (2 @5%):	10%
Midterm Exam:	20%
Take-Home Final:	20%
Group Project:	20%.

For class participation, each student should be prepared to contribute individually to the class discussion. The quality of the contribution is more important than the quantity of contributions.

There are five homework assignments, each to be done individually. Homework is due at the beginning of class.

There are two sets of case preparation questions, each to be done individually. The case preparation questions are intended to ensure you have read the case before coming to class, and to encourage in-class discussion.

There is one group project, to be done in teams of 3-5. Your project should be guided by a business question you would like to answer, in which uncertainty plays a large role. This may be something you have seen from your own work experience, or it may come from something outside-the-workplace. The topic must be approved by me. There are three deliverables: the project proposal, a one-page status update, and the final report and presentation.

The take-home final will be handed out on the last class session.

Prerequisites:

There is no formal prerequisite. However, familiarity with basic probability and statistics is helpful, at the level of GSBA-506ab, or GSBA-524.

Notice on Academic Integrity:

The use of unauthorized material, communication with fellow students during an examination, attempting to benefit from the work of another student, and similar behavior that defeats the intent of an examination or other class work is unacceptable to the University. It is often difficult to distinguish between a culpable act and inadvertent behavior resulting from the nervous tensions accompanying examinations. Where a clear violation has occurred, however, the instructor may disqualify the student's work as unacceptable and assign a failing mark on the paper. There may be additional penalties, including failing in the course, in accordance to the university policies, as listed in the SCampus.

For Students with Disabilities:

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DCP. Please be sure the letter is delivered to your instructor as early in the semester as possible. DSP is located in STU 301 and is open 8:30 am – 5:00 pm, Monday through Friday. The phone number for DSP is (213) 740-0776.

Emergency Preparedness/ Course Continuity:

In case of a declared emergency, if travel to campus is not feasible, USC executive leadership will announce an electronic way for instructors to teach students in their residence halls or homes using a combination of Blackboard, teleconferencing, and other technologies.

Please activate your course in Blackboard with access to the course syllabus. Whether or not you use Blackboard regularly, these preparations will be crucial in an emergency. USC's Blackboard learning management system and support information is available at blackboard.usc.edu.

Course Disclaimer:

The instructor reserves the right to make modifications to this syllabus as determined by the learning needs of this particular class of students.

Session	Date	Module	Topic	Learning Outcomes	Reading	Due
1	Tues, Aug 26	**Introduction: Decision-Making in an Uncertain World**	Introduction	Introduction to simulation; Overview of this course.	Big Data by McKinsey&Company (posted to BB)	
2	Thurs, Aug 28		Simulation in Excel How-to's	Randon number generation; Compute expected outcomes; Understand that the expectation of a function does not equal the function of the expectation.	Simulation in Excel and VBA (Optional, posted to HBS)	
3	Tues, Sept 2		Review of Probability and Statistics	Discrete and continuous random variables; Summary measures of random variables; Law of large numbers; Central limit theorem; Confidence intervals	Cornell notes (posted to BB)	
4	Thurs, Sept 4		A Potpourri of Simulation Examples	See simulations for estimating the lead-time demand distribution, the single-server queue, and a simple project management; Understand the power and the limitations of spreadsheet-based simulation.		**Installation of @Risk**
5	Tues, Sept 9	**Simulation and Optimization**	Introduction to @Risk	Perform a simulation in @Risk; Use @Risk to analyze the simulation output.		**HW1**
6	Thurs, Sept 11		More on @Risk	Review some basic inventory management (HBS online inventory management exercise); Implement an inventory model in @Risk; See the RiskOptimizer.	HBS core curriculum reading: Managing Inventory (Optional, posted to HBS)	
7	Tues, Sept 16		Stochastic Optimization	Set up a simulation with two phases (upfront capactiy determination and then demand realization); See how to incorporate optimization into simulation.		
8	Thurs, Sept 18		Combining Solver and @Risk	Determine the distribution of second stage cost; Record an Excel macro to be used during an @Risk simulation.		**HW2**
9	Tues, Sept 23	**Input Modeling**	Caution: What is random?	Understand how uniform random numbers are generated; See the infamous randu example as a caution for what can go wrong.	Cornell notes (posted to BB)	
10	Thurs, Sept 25		Random Number Generation	See the inversion method, the acceptance-rejection method, and the convolution method.	Cornell notes (posted to BB)	
11	Tues, Sept 30		More on Random Number Generation	Understand what is a Poisson process; Generate a Poisson process; Generate Normal random variables.	Cornell notes (posted to BB)	
12	Thurs., Oct 2		Determing the Input Distribution, part I	See how to use historical data to decide on your simulation input; Understand the rationale for using certain common distributions; Make histogram, bar, and Q-Q plots to help decide on the appropriate input distribution.	Cornell notes (posted to BB)	
13	Tues, Oct 7		Determining the Input Distribution, part II	Estimate the input distribution parameters; Perform chi-square and Kolmogorov-Smirnov goodness-of-fit tests.		**HW3**
14	Thurs, Oct 9		Review			**Installation of ExtendSim**
15	Tues, Oct 14		**EXAM**			

Session	Date	Module	Topic	Learning Outcomes	Reading and/ or Supplemental Material	Due
16	Thurs, Oct 16	**Discrete-Event Simulation**	Introduction to discrete event simulation and ExtendSim	Understand what is discrete-event simulation; Become familiar with the ExtendSim environment;	ExtendSim Simulation Exercises in Process Analysis User's Guide, and Exercises (A) and (B) (posted to HBS)	
17	Tues, Oct 21		More on ExtendSim	See more of ExtendSim's features.	ExtendSim Simulation Exercises in Process Analysis (C) (posted to HBS)	
18	Thurs, Oct 23		A panorama of ExtendSim models	Dave Krahl from ExtendSim will guest lecture.		**HW4**
19	Tues, Oct 28		Output Analysis	See the difference between terminating and steady-state simulations; Understand the challenges of steady-state simulation; Define a time-average and an ensemble average.		**Group Project Proposal**
20	Thurs, Oct 30	**System Design**	Process Analysis and Variability	Recall how to calculate process capacity; Review the formula for expected wait time and expected queue-length; Understand why there is waiting even when there is "enough" capacity; Tie this in with ExtendSim.		
21	Tues, Nov 4		Staffing Small Service Systems	See how to use the queueing formulae when there are time-varying arrivals; Input historical data into ExtendSim; Discuss the impact of routing decisions on capacity (staffing) needs.	Retail Bank Design Case (posted to BB)	**Case Preparation Questions**
22	Thurs, Nov 6		Staffing Large Service Systems	Set up and solve an optimization problem to determine staffing levels; Learn the square-root-safety staffing rule; See how analysis and simulation complement each other.	Call Center Design for Lion Financial Services (posted to BB)	
23	Tues, Nov 11		Network models	Learn an exact formula for the joint queue-length distribution that holds under restrictive assumptions; Test an approximation formula for accuracy using simulation		**Group Project Status Update**
24	Thurs, Nov 13		Comparison of Alternative Systems, part I	See an example that shows why there is a need for caution when comparing alternative system designs; Construct paired-t and modified two-sample-t confidence intervals.		
25	Tues, Nov 18		Comparison of Alternative Systems, part II	Use common random numbers to compare systems.	Cornell notes (posted to BB)	**HW5**
26	Thurs, Nov 20		Routing in Service Systems	Build two system designs in ExtendSim and compare their performance; Words of wisdom on simulation model verification and validation.	Fast Track Case (posted to BB); Cornell notes (posted to BB)	**Case Preparation Questions.**
27	Tues, Nov 25	Review				
	Thurs, Nov 27	Thanksgiving Holiday				
28	Tues, Dec 2	Project Presentations and Take-home final				
29	Thurs, Dec 4					