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.

Learning Objectives

- Students will learn how to use simulation models to evaluate the consequences of different operational business decisions, and to select the best alternative.
- Students will be able to construct simulations in “raw” Excel, and also be able to use the @Risk add-on to Excel to build more sophisticated simulations.
- Students will understand discrete-event simulation, and how to build a discrete-event simulation using ExtendSim.
- Students will relate simulation to analytics by using data to determine the input to their simulation models, and to validate their models.
- Students will understand both the power and the limitations of simulation methodology.
Required 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:
To be provided.

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).

Prerequisites and/or Recommended Preparation:

Knowledge of basic statistics, at the level of BUAD 310, is recommended.

Course Notes:

The lecture slides will be posted to Blackboard.

Grading Policies:

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

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Class Participation:</td>
<td>5%</td>
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<tr>
<td>Homework (5 @5%):</td>
<td>25%</td>
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<tr>
<td>Case preparation questions:</td>
<td>10%</td>
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<tr>
<td>Midterm Exam:</td>
<td>20%</td>
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<tr>
<td>Take-Home Final:</td>
<td>20%</td>
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<tr>
<td>Group Project:</td>
<td>20%</td>
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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. 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.
**MARSHALL GUIDELINES**

**Add/Drop Process**

If you are absent six or more times prior to *Insert date* (the last day to withdraw from a course with a grade of “W”), I may ask you to withdraw from the class by that date. These policies maintain professionalism and ensure a system that is fair to all students.

**Statement 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 DSP. Please be sure the letter is delivered to me (or to your TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776. For more information visit [www.usc.edu/disability](http://www.usc.edu/disability).

**Statement on Academic Integrity**

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one’s own academic work from misuse by others as well as to avoid using another’s work as one’s own. All students are expected to understand and abide by these principles. *Scampus*, the Student Guidebook, ([www.usc.edu/scampus](http://www.usc.edu/scampus) or [http://scampus.usc.edu](http://scampus.usc.edu)) contains the University Student Conduct Code (see University Governance, Section 11.00), while the recommended sanctions are located in Appendix A.

Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: [http://www.usc.edu/student-affairs/SJACS/](http://www.usc.edu/student-affairs/SJACS/). Failure to adhere to the academic conduct standards set forth by these guidelines and our programs will not be tolerated by the USC Marshall community and can lead to dismissal.

**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](http://blackboard.usc.edu).
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<th>Date</th>
<th>Session</th>
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<tr>
<td>13-Jan</td>
<td>1</td>
<td>Introduction: Decision-Making in an Uncertain World</td>
<td>Introduction</td>
<td>Introduction to simulation; Overview of this course.</td>
<td>Big Data by McKinsey &amp; Company (posted to BB)</td>
<td>13-Jan</td>
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<tr>
<td>15-Jan</td>
<td>2</td>
<td>Simulation in Excel How-to's</td>
<td>Random number generation; Compute average outcomes; Understand that the average of a function does not equal the function of the average.</td>
<td>Simulation in Excel and VBA (Optional, posted to HBS)</td>
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<td>15-Jan</td>
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<tr>
<td>20-Jan</td>
<td>3</td>
<td>Review of Probability and Statistics, part I</td>
<td>Discrete and continuous random variables; Summary measures of random variables.</td>
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<td>20-Jan</td>
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<td>22-Jan</td>
<td>4</td>
<td>Review of Probability and Statistics, part II</td>
<td>Law of large numbers; Central limit theorem; Confidence intervals</td>
<td>Cornell notes (posted to BB)</td>
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<td>22-Jan</td>
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<td>27-Jan</td>
<td>5</td>
<td>A Potpourri of Simulation Examples</td>
<td>See simulations for the single-server queue, and a simple project management; Understand the power and the limitations of spreadsheet-based simulation.</td>
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<td>Installation of @Risk</td>
<td>27-Jan</td>
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<td>29-Jan</td>
<td>6</td>
<td>Introduction to @Risk</td>
<td>Perform a simulation in @Risk; Use @Risk to analyze the simulation output; Construct histogram plots.</td>
<td>HW1</td>
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<td>29-Jan</td>
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<tr>
<td>3-Feb</td>
<td>7</td>
<td>Decision-Making in @Risk</td>
<td>Construct Simtables in @Risk; Use simulation to evaluate the consequences of various possible decisions when there is uncertainty.</td>
<td>HBS core curriculum reading: Managing Inventory (Optional, posted to HBS)</td>
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<td>3-Feb</td>
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<tr>
<td>5-Feb</td>
<td>8</td>
<td>More on @Risk</td>
<td>Review some basic inventory management (HBS online inventory management exercise); Implement an inventory model in @Risk; See the RiskOptimizer.</td>
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<td>5-Feb</td>
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<td>10-Feb</td>
<td>9</td>
<td>Stochastic Optimization</td>
<td>Set up a simulation with two phases (upfront capacity determination and then demand realization); See how to incorporate optimization into simulation.</td>
<td>HW2</td>
<td></td>
<td>10-Feb</td>
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<tr>
<td>12-Feb</td>
<td>10</td>
<td>Combining Solver and @Risk</td>
<td>Determine the distribution of second stage cost; Record an Excel macro to be used during an @Risk simulation.</td>
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<td>12-Feb</td>
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<tr>
<td>17-Feb</td>
<td>11</td>
<td>Caution: What is random?</td>
<td>Understand how uniform random numbers are generated; See the infamous randu example as a caution for what can go wrong.</td>
<td>Cornell notes (posted to BB)</td>
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<td>17-Feb</td>
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<tr>
<td>19-Feb</td>
<td>12</td>
<td>Random Number Generation</td>
<td>See the inversion method, the acceptance-rejection method, and the convolution method.</td>
<td>Cornell notes (posted to BB)</td>
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<td>19-Feb</td>
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<tr>
<td>24-Feb</td>
<td>13</td>
<td>More on Random Number Generation</td>
<td>Understand what is a Poisson process; Generate a Poisson process; Generate Normal random variables.</td>
<td>Cornell notes (posted to BB)</td>
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<td>24-Feb</td>
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<tr>
<td>26-Feb</td>
<td>14</td>
<td>Determining the Input Distribution, part I</td>
<td>See how to use historical data to decide on your simulation input; Make histogram, bar, and Q-Q plots to help decide on the appropriate input distribution.</td>
<td>Cornell notes (posted to BB)</td>
<td></td>
<td>26-Feb</td>
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<tr>
<td>3-Mar</td>
<td>15</td>
<td>Determining the Input Distribution, part II</td>
<td>Estimate the input distribution parameters; Perform chi-square and Kolmogorov-Smirnov goodness-of-fit tests.</td>
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<td>3-Mar</td>
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<tr>
<td>5-Mar</td>
<td>16</td>
<td>Review</td>
<td>Review</td>
<td></td>
<td>Installation of ExtendSim</td>
<td>5-Mar</td>
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<td>10-Mar</td>
<td>17</td>
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<td>EXAM</td>
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<td>Session</td>
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<tr>
<td>12-Mar</td>
<td>18</td>
<td>Introduction to discrete event simulation and ExtendSim</td>
<td>Understand what is discrete-event simulation; Become familiar with the ExtendSim environment;</td>
<td>ExtendSim Simulation Exercises in Process Analysis User's Guide, and Exercises (A) and (B) (posted to HBS)</td>
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<tr>
<td>24-Mar</td>
<td>19</td>
<td>More on ExtendSim</td>
<td>See more of ExtendSim's features.</td>
<td>ExtendSim Simulation Exercises in Process Analysis (C) (posted to HBS)</td>
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<tr>
<td>26-Mar</td>
<td>20</td>
<td>A panorama of ExtendSim models</td>
<td>Guest Lecture</td>
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<td>Group Project Proposal</td>
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<tr>
<td>31-Mar</td>
<td>21</td>
<td>Output Analysis</td>
<td>See the difference between terminating and steady-state simulations; Understand the challenges of steady-state simulation; Define a time-average and an ensemble average.</td>
<td>HW4</td>
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<tr>
<td>2-Apr</td>
<td>22</td>
<td>Process Analysis and Variability</td>
<td>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 &quot;enough&quot; capacity; Tie this in with ExtendSim.</td>
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<td>7-Apr</td>
<td>23</td>
<td>Staffing Small Service Systems</td>
<td>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.</td>
<td>Retail Bank Design Case (posted to BB)</td>
<td>Case Preparation Questions</td>
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<tr>
<td>9-Apr</td>
<td>24</td>
<td>Staffing Large Service Systems</td>
<td>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.</td>
<td>Call Center Design for Lion Financial Services (posted to BB)</td>
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<td>14-Apr</td>
<td>25</td>
<td>Network models</td>
<td>Learn an exact formula for the joint queue-length distribution that holds under restrictive assumptions; Test an approximation formula for accuracy using simulation</td>
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<td>Group Project Status Update</td>
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<td>16-Apr</td>
<td>26</td>
<td>Comparison of Alternative Systems</td>
<td>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.</td>
<td>Cornell notes (posted to BB)</td>
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<td>21-Apr</td>
<td>27</td>
<td>Routing in Service Systems</td>
<td>Use common random numbers to compare systems; Build two system designs in ExtendSim and compare their performance;</td>
<td>Fast Track Case (posted to BB); Case Preparation Questions</td>
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<tr>
<td>23-Apr</td>
<td>28</td>
<td>Review</td>
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<td>HW5</td>
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<td>28-Apr</td>
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<td>30-Apr</td>
<td>30</td>
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<td>Project Presentations and Take-home final</td>
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