
Intro to Simulation (using Excel)

DSC340

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Generating random numbers in Excel

- Excel has a RAND() function for generating “random” numbers
 - The numbers are really coming from a formula and hence are often called **pseudo-random**
 - =RAND() generates a number between 0 and 1, where all values are equally likely (the so-called Uniform distribution)
 - =RANDBETWEEN(**low**, **high**) generates a pseudo-random # between **low** and **high**, where all #'s are equally likely
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Generating random numbers in Excel

- We can use RAND() to generate #'s from other distributions
- To generate values from the Normal distribution
 - =NORMINV(RAND(), mean, standard_deviation)
- E.g., =NORMINV(rand(), 10,5)
 - ...will generate a random number from a Normal distribution with mean 10 and std. dev. 5.

Generating random numbers in Excel

“Why bother generating random numbers?”

Creating a Simulation

- What is a simulation?
 - Investigating a real-life phenomenon, process, or problem using a model.
- The Excel features we have discussed can be blended together to create a simulation
 - The flexibility of Excel allows us to create many types of **simulation models**

■ Why use a model?

Value from simulation modeling

1. In business (and life), "do overs" are not always possible
 - Simulations let you experiment with different decisions and see their outcomes
 2. Humans have a poor ability to assess odds in some situations
 - You can use repeated simulation "trials" to assess odds of various outcomes
- Companies typically use simulations to assess the **likelihood of outcomes** that may follow from different actions
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Creating a Simulation

- Because you can simulate so many different kinds of situations, there is no one “recipe” to follow
 - Makes it challenging, and creative (even fun?!)
- Simulations typically require bringing together lots of Excel skills!
 - If you can do Excel simulations, then you are good at Excel

Simulation modeling in Excel

- First get your model of the problem (finance/profit/cost/capacity/*whatever*) correct, before making certain inputs random
 - Visually separate your model on the Worksheet
 - Then make the necessary inputs random
 - Refresh the Worksheet many times to see the random values change and check whether your model's calculations seem to behave properly
 - Then add a Data Table to automate **many, many** trials of your model, collecting the output(s) you want
 - Then add some summarizing statistics (e.g., average) based on the results you obtained in your Data Table
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General tips on modeling in Excel

- Organize – keep your worksheet neat
 - Be clear on how to do any given calculation on paper first
 - Then identify the corresponding Excel function, using Google search if you don't know the name of the Excel function
 - Don't embed data values within formulas
 - Put data values in visible cells and reference that data
 - Don't put too much logic in one cell
 - If it starts to get complicated, split the logic across more cells
 - Remember to use the power of the Data Table
 - ...for trying different parameter values
 - ...for replicating multiple trials of random #'s
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1st Simulation example: dice game

- We play a game against 2 opponents
 - 3 players (we are player 1)
 - Each player rolls a die
 - To win, a player needs to roll a # bigger than the other two dice values
 - If it's a tie, then the game is called a tie
 - You want to simulate a play of the game and report whether you win, lose, or tie
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2nd sim. example: inventory management

- Demand is uncertain, and you want to determine how many of your product to stock
 - Let's assume that demand is uniform between 50 and 150 units
 - Each units costs you \$6
 - Your price is \$10
 - If you end up with unsold units, you will have to "dump" them at \$2 salvage value

 - Simulate one "play" of this game, where you stock a certain quantity and then see how much profit you make (given some random demand realization)
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Repeating simulation "trials"

- The real power of simulations comes from being able to consider many trials
 - In Excel, the Data Table concept provides a convenient means for doing so
 - Previously, we used the Data Table concept repeatedly analyze a spreadsheet model for different parameter values, without randomness
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Repeating simulation “trials”

- If our spreadsheet model contains a **random input**, we again can use a Data Table to repeatedly analyze the model
 - To do this, we define a long **column** of trials as the left column defining our Data Table
 - Each trial corresponds to the need to re-run the sheet, creating the new random number(s), and seeing how results change
 - It's convenient to give each trial a # (e.g., 1,2,3,...) but usually you don't want to use those #'s in any formula you are using
 - Therefore, the Data Table's “**column input cell**” should point to an **unused cell** in your spreadsheet (again, because you don't want to use the trial-# for anything)
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2nd sim. example revisited

- Let's now use a Data Table with the prior example
 - The Data Table will automate the process of considering many different scenarios
 - In this case, the scenarios do not correspond to different interest rates (as in the last class), but rather to different random #'s
 - Create a Data Table that will address 200 random scenarios
 - At the end, we can average over those scenarios
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3rd simulation example

- As a hotel manager, you are involved in a major renovation of a hotel that will have space for 100 standard hotel rooms. You are wondering whether some of that space should be used for "luxury suite" rooms, each of which would be twice the size of a standard room. For example, you could plan for 20 suites, in which case you would have remaining space for 60 standard rooms ($100 - 2 \cdot 20 = 60$). Your overall construction costs won't be impacted by this decision, because a suite costs about twice as much to build as a normal hotel room.
- You predict being able to fetch \$99/night and \$169/night for standard and luxury rooms, respectively.
- Anticipated demand for...
 - Standard rooms – mean of 50, standard deviation of 10
 - Luxury suites – mean of 20, standard deviation of 10
 - Note: you can upgrade a customer from standard → luxury, if the better room is available.
- Occupied rooms incur the following nightly cost (for cleaning/upkeep/"utilities"):
 - Standard rooms – \$12.50
 - Luxury suites – \$25
- You estimate fixed costs (including amortized building costs and other overhead such as staff salaries) at \$6000 per night.

How would you deal with this problem?

- Old school approaches
 - See what other hotels have done, hope that they had a better method than you
 - Use intuition
 - Ask colleagues / friends / family
- New school approach
 - Do the above, but also use modeling / data
- Sometimes, you won't have any "intuitive feel" for the right answer, when things get complicated
 - Even worse, you might think you have the intuition, but it's wrong
- Sometimes you can develop a very accurate model, if the assumptions and inputs are quite clear

Recall: Simulation modeling steps

1. First get your model of the problem (finance/profit/cost/ capacity/*whatever*) correct, before making certain inputs random
2. Then make the necessary inputs random
3. Then add a Data Table to automate **many, many** trials of your model, collecting the output(s) you want
4. Then add some summarizing statistics (e.g., average) based on the results you obtained in your Data Table

	A	B	C	D	E	F	G	H
1	# Luxury rooms	# Standard rooms		Nightly Overhead	Room units	Units per Std room	Units per Luxury room	
2	30	40		\$6,000.00	100	1	2	
3								
4		Price	Cleaning cost		Demand	# filled (excluding upgrades)	cost (excluding upgrades)	revenue (excluding upgrades)
5	Standard	\$ 99.00	\$ 12.50		55	40	\$ 500.00	\$ 3,960.00
6	Luxury	\$ 166.00	\$ 25.00		13	13	\$ 325.00	\$ 2,197.00
7								
8							Profit (excl. upgrades)	\$ 5,332.00
9							Upgrades revenues	\$ 1,485.00
10							Upgrades costs	\$ 375.00
11							Total profits (incl. overhead)	\$ 442.00
12								
13								
14								
15								
16								
17								
18								
19								
20		\$ 442.00						
21								
22								
23								
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26								
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10019								
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10022		Average		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
10023								
10024								

What to make random?

- Demand assumptions
 - Standard rooms – mean of 50, standard deviation of 10
 - `=NORMINV(RAND(),50,10)`
 - Luxury suites – mean of 20, standard deviation of 10
 - `=NORMINV(RAND(),20,10)`
- To remove unwanted non-integer and negative #'s, we will use:
 - `=MAX(0,ROUND(NORMINV(RAND(),50,10),0))`
 - Luxury suites – mean of 20, standard deviation of 10
 - `=MAX(0,ROUND(NORMINV(RAND(),20,10),0))`
- The impact of ignoring neg. #'s should be small, because neg. #'s are over 5 and 2 std deviations below the mean
 - See <http://www.mathsisfun.com/data/standard-normal-distribution-table.html> and click on "Z onwards" button