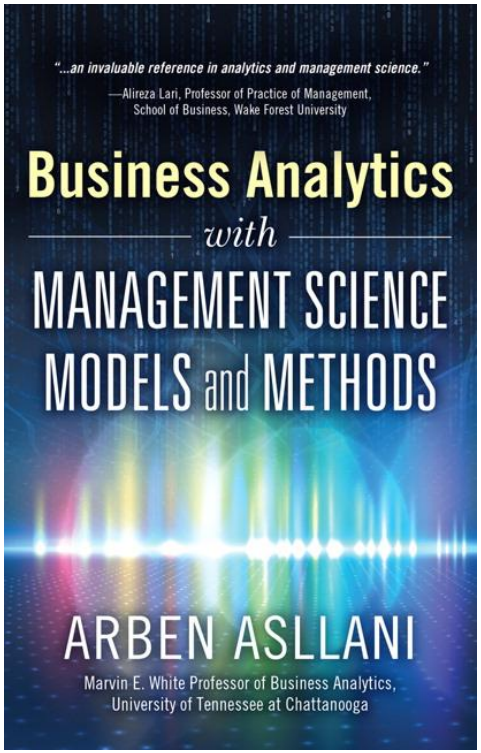
Business Analytics
Prescriptive Models



Based on

Business Analytics With Management Science Models and Methods

by

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Chapter 10

Business Analytics with Simulation

Business Analytics with Management Science Models and Methods

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Chapter Outline

- Chapter Objectives
- Simulation in Action
- Introduction
- Basic Simulation Terminology
- Simulation Methodology
- Simulation Methodology in Action
- Exploring Big Data with Simulation
- Wrap up

Chapter Objectives

- Discuss the potential use of computer simulation to improve organizational performance
- Explore the role of simulation as a management science tool for optimization and decision making
- Discuss advantages and disadvantages of using simulation as a decision making tool
- Provide examples of systems from real world business situations and explain how simulation can be used to improve such systems
- Distinguish between discrete and continuous simulation models and their ability to replicate business settings
- Distinguish between static and a dynamic simulation models and their ability to replicate business settings

Chapter Objectives

- Distinguish between deterministic and stochastic simulation models and explore business situations where these models can be used
- Discuss the four basic elements of a computer simulation model: entities, locations, processes, and resources
- Suggest a simulation methodology which can be used to model business situations in the era of big data and underscore the importance of following each step in the methodology
- Discuss potential sources of data inputs for simulation models and how big data have changed the process of data collection
- Understand the concept of validation and verification as an important step in the simulation process

Simulation in Action

- Blood Assurance is a full-service regional blood center serving more than 70 health care facilities
  - Primary goal: *to meet the demand for platelets and minimize waste*
- A simulation based decision support system to investigate, design, and test alternative strategies for platelet collection
  - Objective: to develop a platelet collection strategy that would reduce waste and meet demand for type specific platelets
  - Allows modeling of complex and stochastic problems.
  - Mimic the complexity of the blood inventory management system.
  - Suggest appropriate collection strategies to reduce platelet waste by 50% and decrease unmet demand for type specific platelets by 16%.

Introduction

- What is Simulation?
  - One of the most preferred techniques when investigating the behavior of complex business models.
  - An effective method to assist management in evaluating different operational alternatives.
  - In a case-by-case basis, the simulation methodology can generate acceptable policies that are nearly optimal
- Advantages of Simulation
  - To investigate a wide variety of “what if” questions about real-world systems before implementing potential costly changes
  - can test new facility locations, product designs, or new scheduling policies without any cost disruptions

Basic Simulation Terminology

- System
  - A collection of entities and sub-entities that interact with each other as they process input into output
  - A simulation model is also a system because it is used to represent a real life system
- State of a system
  - the set of variables necessary to describe the system and their values at a given point

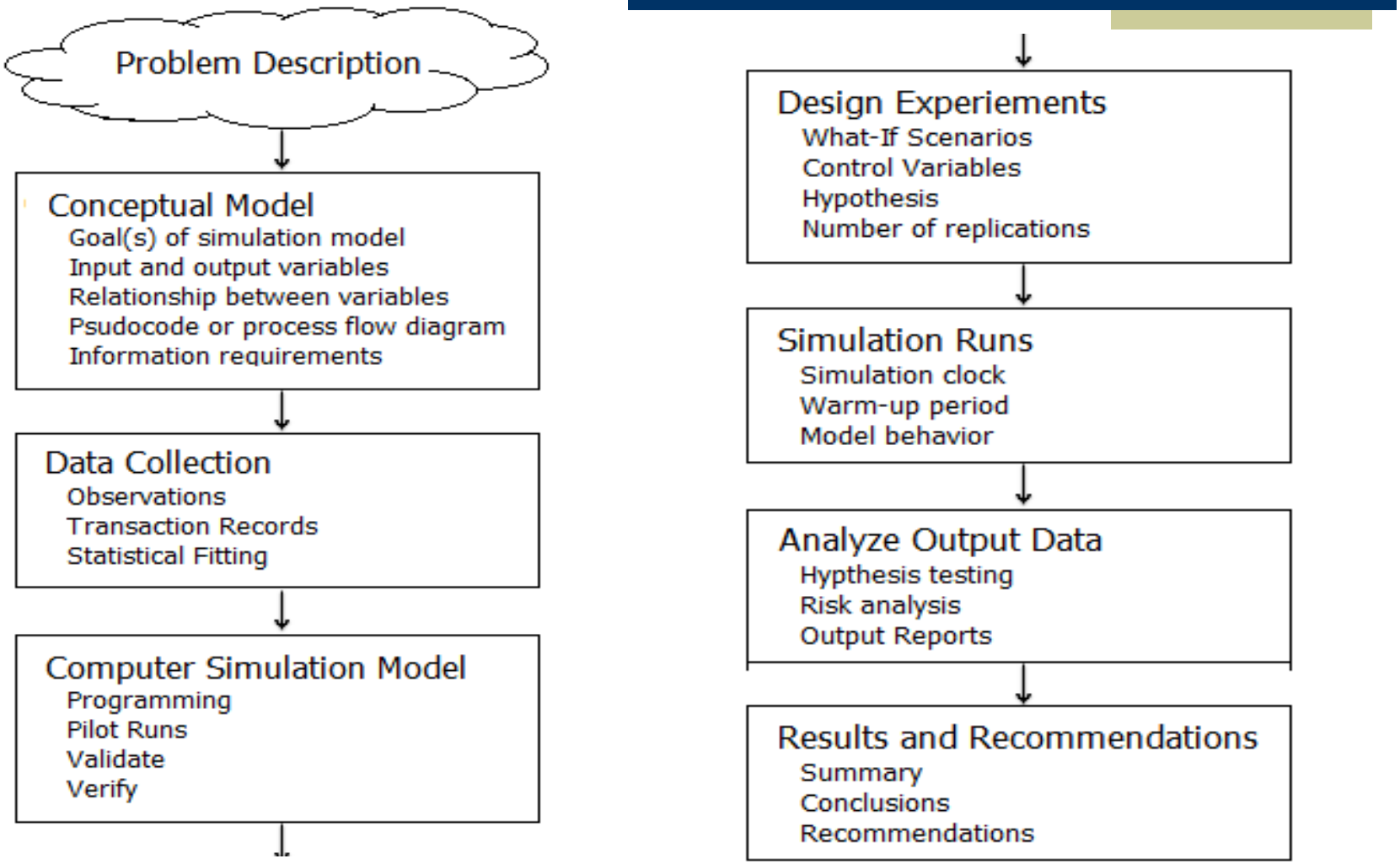
Basic Simulation Terminology

- Discrete versus continuous models
  - A simulation model is discrete when the state of the variables changes at discrete points in time
  - A continuous simulation model, on the other hand, has variables whose state changes continuously.
  - Changes in the continuous models are tracked over time according to a set of equations, typically involving differential equations

Basic Simulation Terminology

- Static versus dynamic simulation models
  - A static simulation model represents the system at a given point in time
  - Static simulation models are sometimes referred as Monte Carlo simulation models
  - A dynamic model, however, represents the system over a period of time
- Deterministic versus stochastic simulation model
  - A deterministic simulation model contains no random variables
  - Stochastic simulation models have at least one random input variable, and thus random output of stochastic models

Simulation Methodology



Problem Description

- The basis of the simulation model
- Sources:
  - Requests for proposal documents
  - Business reports
  - Interviews with the management team
  - Other sources
- Purpose of the study can help establish the objective function and dependent variables
- The scope of the study is defined by
  1. Time required to complete the simulation study
  2. The organizational unit which is included in the study

Conceptual Model

1. Starts with identifying the goals of the model
2. The modeler identifies the set of input variables for the model
   - Stochastic or Deterministic
3. Relationships between variables are explored.
   - Intermediate variables are calculated; later lead to output variables
4. A high level flow diagram or a pseudo code
5. The final goal of the conceptual model: to produce a list of information requirements.
6. The modeler needs to answer the following questions:
   - What information is needed to build the simulation model?
   - What information is already available?
   - What information needs to be collected?

Data Collection

- Data is collected through historical records, system documentations, personal observations, and interviews
- Before being used in the model, data should be tested:
  - Must ensure that input variables are independent
  - Must also ensure that input variables are homogenized
  - Must represent the input variables as to their deterministic or stochastic values

Computer Simulation Model

- A logical model of the process must be developed based on:
  - The data collected
  - The modeling constructs of the simulation software
- Four basic elements
  - Entities, Locations, Process flow for entities and Resources.
- Several software packages provide the ability to generate random values
- A pilot run with a limited number of replications
- The validation process ensures that the simulation model represents the correct real life system
- The verification process ensures that the simulation model represents the real life system correctly

Design Experiments and Simulation Run

- Design Experiments
  - One of the main advantages of simulation is the ability of the decision maker to conduct What-If scenarios without actually making physical changes to the existing system
  - With a validated model a variety of alternatives may be tested and optimized: to identify the best scenarios and the minimum number of replications
- Simulation Runs
  - Many simulation software programs allow for a visual observation, and the decision maker can gain important insight by studying the changes of the state of the system overtime

Analyze Output
Results and Recommendations

- Analyze Output
  - The statistical analysis of the output variables is conducted
  - Points and intervals are estimated to measure the performance of the system, and hypothesis testing and risk analysis are performed and output reports are prepared
- Results and Recommendations
  - The simulation methodology concludes with a summary of the results, main findings and conclusions, and most importantly practical recommendations
  - The best scenario is identified and the best combination of decision variables is recommended
  - Far reaching decisions should not be based solely on the outcomes of simulations

Simulation Methodology in Action (ch10_blood_collection.xlsx)

1. Problem Description
   - A fictional Blood Bank Agency (BBA) wants to determine the optimal level of collection is in order to maximize the agency's revenue and meet the weekly demand for blood platelets
   - Assume that the agency spends about $150 to process collected blood units into one unit of blood platelets
   - The agency charges receiving hospitals about $400 per platelet
   - There is also a $20 disposal cost for each unit of unused platelets
2. Conceptual Model
   - Ideally the agency should collect enough platelets to meet the demand but not exceed it.
   - The platelet inventory management is complicated by unpredictable demand for a product with a shelf life of only a few days.

Simulation Methodology in Action (ch10_blood_collection.xlsx)

- Data Collection
  - The simulation model implements a stochastic pull system
  - Data used in the model can be retrieved from the operational activity of the blood center during one full year
  - The weekly demand for platelets is an uncontrolled variable

Weekly Demand for Platelets	Probability
300	.10
500	.25
800	.35
1000	.30

Simulation Methodology in Action (ch10_blood_collection.xlsx)

- Computer Simulation Model

	A	B	C	D	E	F	G	H	I
1		Calculation Table					Cumulative Distr	Weekly D	Probability
2		Collection Level	300				0	300	10%
3		Random Number	0.695434629	<---rand()			10%	500	25%
4		Demand	800	=VLOOKUP(C3, $G$2:$H$5, 2)			35%	800	35%
5							70%	1000	30%
6		Processing cost per unit	$150				above-=G4+I4		100%
7		Revenue per unit	$400						
8		Disposal cost per unit	$20						
9									
10		Total revenue	$120,000	<---=C7*MIN(C2, C4)					
11		Total processing cost	$45,000	<---=C6*C2					
12		Total disposal cost	$0	<---=IF(C4>C2, 0, (C2-C4)*C8)					
13		Net revenue	$75,000	<---=C10-C11-C12					

F9 to recalculate the spreadsheet

Simulation Methodology in Action (ch10_blood_collection.xlsx)

- Computer Simulation Model

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1		Calculation Table					Cumulative Distribution	Weekly Demand	Probability						
2		Collection Level	300				0	300	10%						
3		Random Number	0,527864795	<---rand()			10%	500	25%						
4		Demand	800	=VLOOKUP(C3, $G$2:$H$5, 2)			35%	800	35%						
5							70%	1000	30%						
6		Processing cost per unit	$150				above-=G4+I4		100%						
7		Revenue per unit	$400												
8		Disposal cost per unit	$20												
9															
10		Total revenue	$120 000	<---=C7*MIN(C2, C4)											
11		Total processing cost	$45 000	<---=C6*C2											
12		Total disposal cost	$0	<---=IF(C4>C2, 0, (C2-C4)*C8)											
13		Net revenue	$75 000	<---=C10-C11-C12											
14							Collection level	400	600	800	1000				
15	below-=C13						Mean	96 094,00	129 042,00	151 910,00	$140 716	<---=AVERAGE(E17:E1016)			
16	$75 000,00	400	600	800	1000		Standard Dev	12 204,27	36 488,16	72 466,15	96 315,21	<---=STDEV(E17:E1016)			
17	1	$100 000	$24 000	$200 000	$250 000		Confidence Interval	756,41	2 261,52	4 491,42	5 969,57	<---=CONFIDENCE(0.05,K16,1000)			
18	2	$100 000	$150 000	$200 000	$166 000		Upper Limit	96 850,41	131 303,52	156 401,42	146 685,57	<---=K15+K17			
19	3														
20	4														
21	5														
22	6														
23	7														
24	8														
25	9														
26	10														
27	11														
28	12	$100 000	$150 000	$74 000	$166 000										
29	13	$100 000	$24 000	$200 000	$166 000										
30	14	$100 000	$150 000	$200 000	$250 000										
31	15	$100 000	$150 000	$200 000	$250 000										
32	16	$100 000	$108 000	$200 000	$250 000										

Sheet1 Sheet2 Sheet3

Ready

To generate series of numbers:

1. Enter 1 in cel A17 and select the cel.
2. Click: *Home -> Editing -> Fill -> Series*.
3. In the *Series* dialog box, enter 1 as a *'Step value'* and 1000 as a *'Stop value'*.
4. Choose *'Columns' and* click OK.

Simulation Methodology in Action (ch10_blood_collection.xlsx)

- Computer Simulation Model

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1		Calculation Table					Cumulative Distribution	Weekly Demand	Probability						
2		Collection Level	300				0	300	10%						
3		Random Number	0,527864795	<---rand()			10%	500	25%						
4		Demand	800	=VLOOKUP(C3, $G$2:$H$5, 2)			35%	800	35%						
5							70%	1000	30%						
6		Processing cost per unit	$150				above-=G4+I4		100%						
7		Revenue per unit	$400												
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10		Total revenue	$120 000	<---=C7*MIN(C2, C4)											
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14							Collection level	400	600	800	1000				
15	below-=C13		400	600	800	1000	Mean	96 094,00	129 042,00	151 910,00	$140 716	<---=AVERAGE(E17:E1016)			
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17	1		$100 000	$24 000	$200 000	$250 000	Confidence Interval	756,41	2 261,52	4 491,42	5 969,57	<---=CONFIDENCE(0.05,K16,1000)			
18	2		$100 000	$150 000	$200 000	$166 000	Upper Limit	96 850,41	131 303,52	156 401,42	146 685,57	<---=K15+K17			
19	3		$100 000	$150 000	$200 000	-$44 000	Lower Limt	95 337,59	126 780,48	147 418,58	134 746,43	<---=K15-K17			
20	4		$100 000	$150 000	$200 000	$166 000									
21	5		$58 000	$150 000	$74 000	$166 000									
22	6		$100 000	$150 000	$200 000	$250 000									
23	7		$100 000	$150 000	$74 000	$250 000									
24	8		$100 000	$150 000	$200 000	$166 000									
25	9		$100 000	$150 000	-$10 000	-$44 000									
26	10		$100 000	$150 000	$74 000	$166 000									
27	11		$100 000	$108 000	$200 000	$250 000									
28	12		$100 000	$150 000	$74 000	$166 000									
29	13		$100 000	$24 000	$200 000	$166 000									
30	14		$100 000	$150 000	$200 000	$250 000									
31	15		$100 000	$150 000	$200 000	$250 000									
32	16		$100 000	$108 000	$200 000	$250 000									

Sheet1 Sheet2 Sheet3

Ready

F9 to recalculate the spreadsheet

To generate scearios:

1. Select the range (A16:E1016).
2. Click: *Data -> Forecast:What-If Analysis -> Data Table*.
3. Select any blank cell as a *'Column input cell'* (for example, D8).
4. Choose collection level (cell C2) as the *'Row input cell'*.
5. Click OK to simulate 1,000 net revenues for each collection level.

Simulation Methodology in Action

- Analyze Output, Results, and Recommendations

Collection level	400	600	800	1000	
Mean	*95,968.00*	*127,026.00*	*149,558.00*	*$140,548*	*<---=AVERAGE(E17:E1016)*
Standard Dev	*12,379.02*	*38,691.09*	*74,823.36*	*98,554.86*	*<---=STDEV(E17:E1016)*
Confidence Interval	767.25	2,398.05	4,637.51	6,108.38	*<---=CONFIDENCE(0.05,K16,1000)*
Upper Limit	96,735.25	129,424.05	154,195.51	146,656.38	*<---=K15+K17*
Lower Limt	95,200.75	124,627.95	144,920.49	134,439.62	*<---=K15-K17*

  - As a result, the recommendation is that the blood bank agency must establish a collection level goal between 800 to 1000 unit platelets per week

Simulation Methodology in Action

- Analyze Output, Results, and Recommendations

Collection level	400	600	800	1000	
Mean	*95,968.00*	*127,026.00*	*149,558.00*	*$140,548*	*<---=AVERAGE(E17:E1016)*
Standard Dev	*12,379.02*	*38,691.09*	*74,823.36*	*98,554.86*	*<---=STDEV(E17:E1016)*
Confidence Interval	767.25	2,398.05	4,637.51	6,108.38	*<---=CONFIDENCE(0.05,K16,1000)*
Upper Limit	96,735.25	129,424.05	154,195.51	146,656.38	*<---=K15+K17*
Lower Limt	95,200.75	124,627.95	144,920.49	134,439.62	*<---=K15-K17*

- If the blood bank agency decides on collection level of 800 unit platelets per week, then for 95% the net revenue will be between 144,920 and 154,196.

Exploring Big Data with Simulation

- Simulation models can use big data to provide more in-depth analysis and processing in advance
  - Volume: allows the simulation modeler to use larger data sets to better define statistical distributions which then generate more reliable inputs for the simulation model.
  - Simulation modeling focuses more on relationships and less on causality, as such it can be an appropriate tool to deal with the high complexity and with large amount of computations presented by big data.

Wrap up

- The importance of simulation has increased significantly.
  - As velocity and variety of data increase, the decision makers turn to simulation as an appropriate tool for complex systems and uncertain data.
  - As volume increases, decision makers can take advantage of statistical fitting software to better estimate statistical distributions of input variables.
- Simulation models allow the decision makers to compare alternative scenarios and control variables in ideal experimental conditions without altering the physical reality and, in so doing, save costs.

Wrap up

- The use of Microsoft Excel is suggested for relatively simple models.
- The proposed methodology can also be used when specialized simulation software is utilized to model more advanced and complex business systems.
- The model validation and verification processes are very important for the reliability of the simulation results
- Simulations should always be accompanied by appropriate statistical analysis for both summary and analysis of large volumes of output generated by such models.

End of The Lecture

Thank You