Chapter 6

Prescriptive Analytics: Optimization and Simulation

Learning Objectives (1 of 2)

6.1 Understand the applications of prescriptive analytics techniques in combination with reporting and predictive analytics

6.2 Understand the basic concepts of analytical decision modeling

6.3 Understand the concepts of analytical models for selected decision problems, including linear programming and simulation models for decision support

6.4 Describe how spreadsheets can be used for analytical modeling and solutions

Learning Objectives (2 of 2)

6.5 Explain the basic concepts of optimization and when to use them

6.6 Describe how to structure a linear programming model

6.7 Explain what is meant by sensitivity analysis, what-if analysis, and goal seeking

6.8 Understand the concepts and applications of different types of simulation

6.9 Understand potential applications of discrete event simulation

Opening Vignette

School District of Philadelphia Uses Prescriptive Analytics to Find Optimal Solution for Awarding Bus Route Contracts

Discussion Questions

1. What decision was being made in this vignette?
2. What data (descriptive and or predictive) might one need to make the best allocations in this scenario?
3. What other costs or constraints might you have to consider in awarding contracts for such routes?
4. Which other situations might be appropriate for applications of such models?

Model-Based Decision Making

- Prescriptive analytics – making decision using some kind of analytical model
  - Descriptive and predictive analytics creates the foundation (i.e., choice alternatives) for prescriptive analytics (i.e., making best possible decision)
- Descriptive and Predictive leads to Prescriptive
  - Descriptive, Predictive → Prescriptive
- Example
  - Profit maximization based on optimal spending on promotions and product/service pricing

Prescriptive Analytics Model Examples

- INFORMS publications such as **Interfaces**, **ORMS Today**, and **Analytics Magazine**, include real-world cases illustrating successful analytics applications.
- Modeling is a key element to prescriptive analytics
  - Mathematical modeling
- TurboRouter – DSS for ship routing
  - In just a few weeks, company saved $1-2M
- Example: which customers should receive certain promotional offers to maximize overall response (while staying within a pre-specified budget).

Application Case 6.1

Optimal Transport for ExxonMobil Downstream through a Decision Support System (DSS)

Questions for Discussion

1. List three ways in which manual scheduling of ships could result in more operational costs as compared to the tool developed.
2. In what other ways can ExxonMobil leverage the decision support tool developed to expand and optimize their other business operations?
3. What are some strategic decisions that could be made by decision makers using the tool developed?

Major Modeling Issues (1 of 2)

- Problem identification and environmental analysis (information collection)
- Variable identification
  - Influence diagrams, cognitive maps
- Forecasting (predictive analytics)
  - More information leads to better forecast/prediction
- Multiple models: A decision system can include several models, each of which representing a different part of the decision-making problem
  - Static versus dynamic models
  - See categories of models in the next slide

Major Modeling Issues (2 of 2)

- Model Management
  - Models (like data) must be managed to maintain their integrity and applicability
  - Model-based management systems (MBMS)
- Knowledge-Based Modeling (KBM)
  - DSS usually uses quantitative models
  - Expert systems use qualitative, KB models
- Current trends in modeling
  - Cloud-based modeling tools (efficient and cost effective)
  - Transparent models (multidimensional/visual models)
  - Model of models
    - e.g., Influence Diagrams (to build and solve models)
  - …

Categories of Models

Table 6.1 Categories of Models

Category	Process and Objective	Representative Techniques
Optimization of problems with few alternatives	Find the best solution from a small number of alternatives	Decision tables, decision trees, analytic hierarchy process
Optimization via algorithm	Find the best solution from a large number of alternatives, using a step-by-step improvement process	Linear and other mathematical programming models, network models
Optimization via an analytic formula	Find the best solution in one step, using a formula	Some inventory models
Simulation	Find a good enough solution or the best among the alternatives checked, using experimentation	Several types of simulation
Heuristics	Find a good enough solution, using rules	Heuristic programming, expert systems
Predictive models	Predict the future for a given scenario	Forecasting models, Markov analysis
Other models	Solve a what-if case, using a formula	Financial modeling, waiting lines

Application Case 6.2

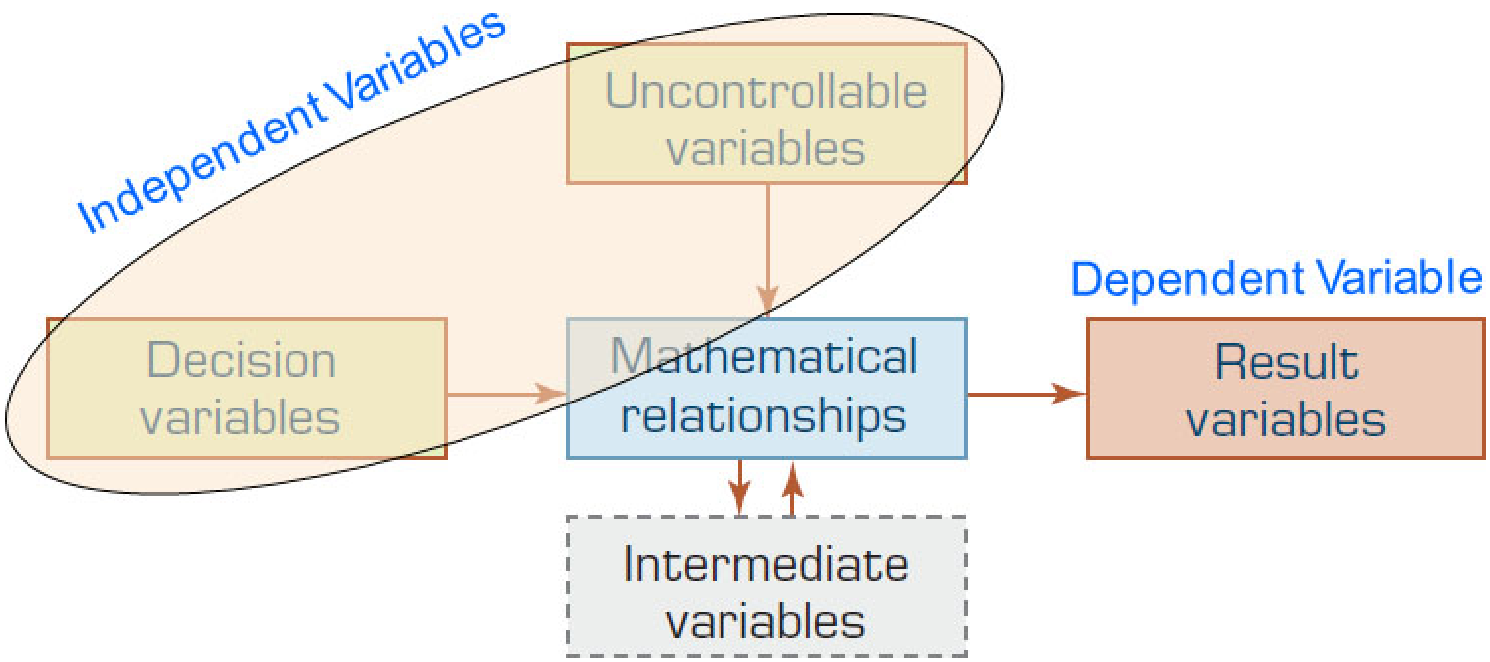
Ingram Micro Uses Business Intelligence Applications to Make Pricing Decisions

Questions for Discussion

1. What were the main challenges faced by Ingram Micro in developing a BIC?
2. List all the business intelligence solutions developed by Ingram to optimize the prices of their products and to profile their customers.
3. What benefits did Ingram receive after using the newly developed BI applications?

Structure of Mathematical Models for Decision Support

- Non-Quantitative Models (Qualitative)
- Quantitative Models: Mathematically links decision variables, uncontrollable variables, and result variables



Examples - Components of Models

Table 6.2 Examples of Components of Models

Area	**Decision Variables**	**Result Variables**	**Uncontrollable Variables and Parameters**
Financial investment	Investment alternatives and amounts	Total profit, risk Rate of return on investment (ROI) Earnings per share Liquidity level	Inflation rate Prime rate Competition
Marketing	Advertising budget Where to advertise	Market share Customer satisfaction	Customer's income Competitor's actions
Manufacturing	What and how much to produce Inventory levels Compensation programs	Total cost Quality level Employee satisfaction	Machine capacity Technology Materials prices
Accounting	Use of computers Audit schedule	Data processing cost Error rate	Computer technology Tax rates Legal requirements
Transportation	Shipments schedule Use of smart cards	Total transport cost Payment float time	Delivery distance Regulations
Services	Staffing levels	Customer satisfaction	Demand for services

The Structure of a Mathematical Model

- The components of a quantitative model are linked together by mathematical (algebraic) expressions—equations or inequalities.
- Example: **Profit - *P* = *R* − *C***
  - where ***P*** = profit, ***R*** = revenue, and ***C*** = cost
- Example: Simple Present-Value formulation

$$P = \frac{F}{(1+i)^n} = \frac{100{,}000}{(1+0.1)^5} = 62{,}092$$

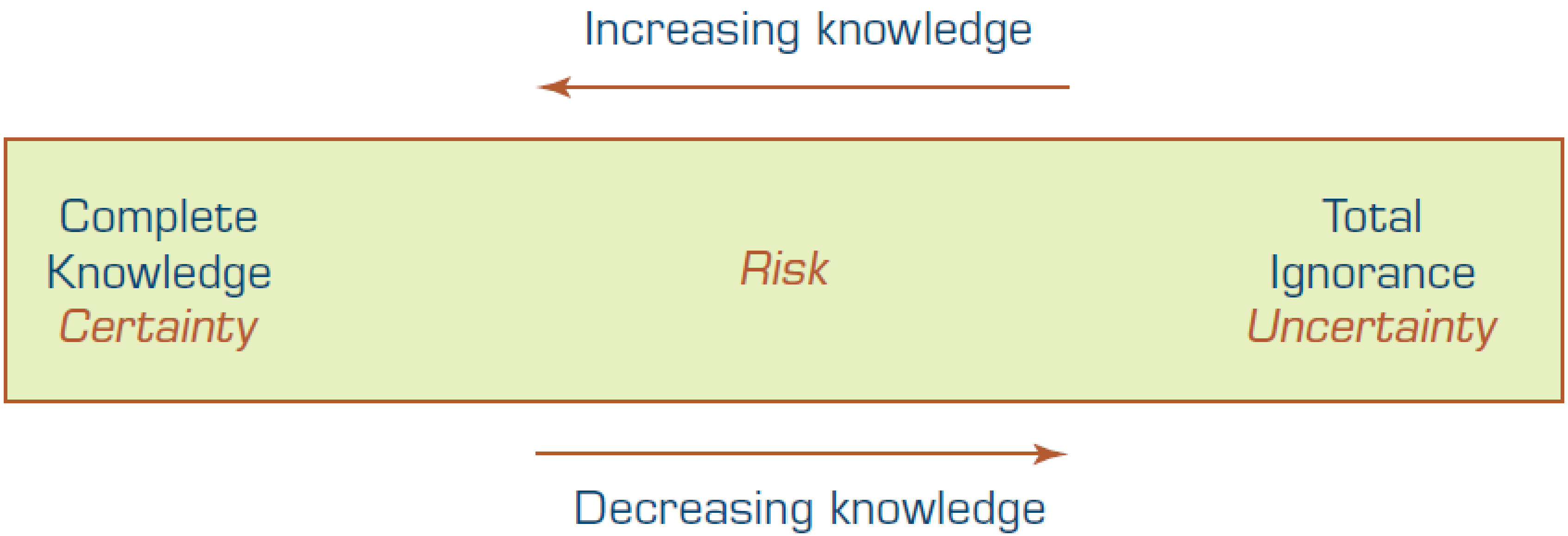
  - where ***P*** = present value, ***F*** = future cash-flow, ***i*** = interest rate, and ***n*** = number of period/years

Modeling and Decision Making - Under Certainty, Uncertainty, and Risk (1 of 2)

- Certainty
  - Assume complete knowledge
  - All potential outcomes are known
  - May yield optimal solution
- Uncertainty
  - Several outcomes for each decision
  - Probability of each outcome is unknown
  - Knowledge would lead to less uncertainty
- Risk analysis (probabilistic decision making)
  - Probability of each of several outcomes occurring
  - Level of uncertainty → Risk (expected value)

Modeling and Decision Making - Under Certainty, Uncertainty, and Risk (2 of 2)

- The **zones** of decision making



Application Case 6.3

American Airlines Uses Should-Cost Modeling to Assess the Uncertainty of Bids for Shipment Routes

Questions for Discussion

1. Besides reducing the risk of overpaying or underpaying suppliers, what are some other benefits AA would derive from its “should-be” model?
2. Can you think of other domains besides air transportation where such a model could be used?
3. Discuss other possible methods with which AA could have solved its bid overpayment and underpayment problem.

Decision Modeling with Spreadsheets

- **Spreadsheet**
  - Most popular **end-user modeling tool**
  - Flexible and easy to use
  - Powerful functions (add-in functions)
  - Programmability (via macros)
  - What-if analysis and goal seeking
  - Simple database management
  - Seamless integration of model and data
  - Incorporates both static and dynamic models
  - Examples: Microsoft Excel, Lotus 1-2-3

Application Case 6.4

Pennsylvania Adoption Exchange Uses Spreadsheet Model to Better Match Children with Families

Questions for Discussion

1. What were the challenges faced by PAE while making adoption matching decisions?
2. What features of the new spreadsheet tool helped PAE solve their issues of matching a family with a child?

Application Case 6.5

Metro Meals on Wheels Treasure Valley Uses Excel to Find Optimal Delivery Routes

Questions for Discussion

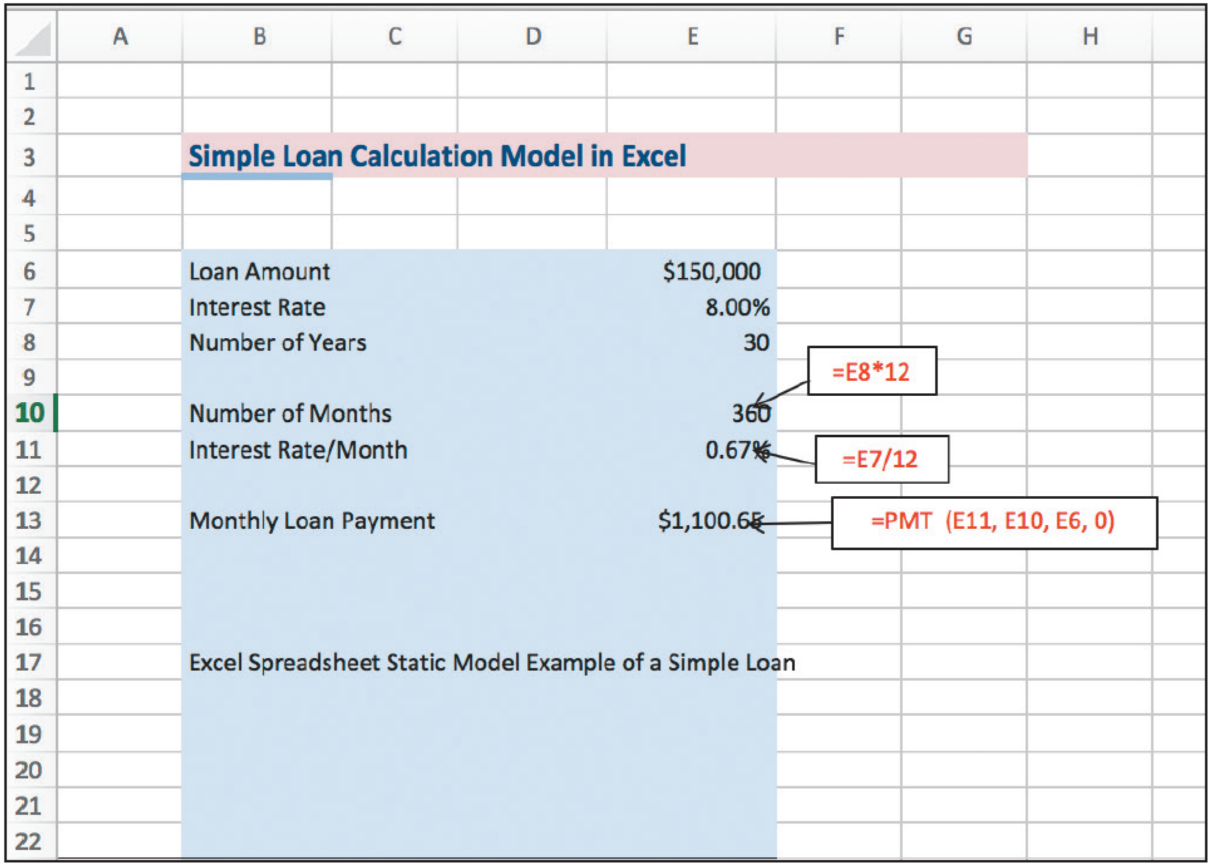
1. What were the challenges faced by Metro Meals on Wheels Treasure Valley related to meal delivery before adoption of the spreadsheet-based tool?
2. Explain the design of the spreadsheet-based model.
3. What are the intangible benefits of using the Excel-based model to Metro Meals on Wheels?

Excel Spreadsheet - Static Model Example

Simple loan calculation of monthly payments

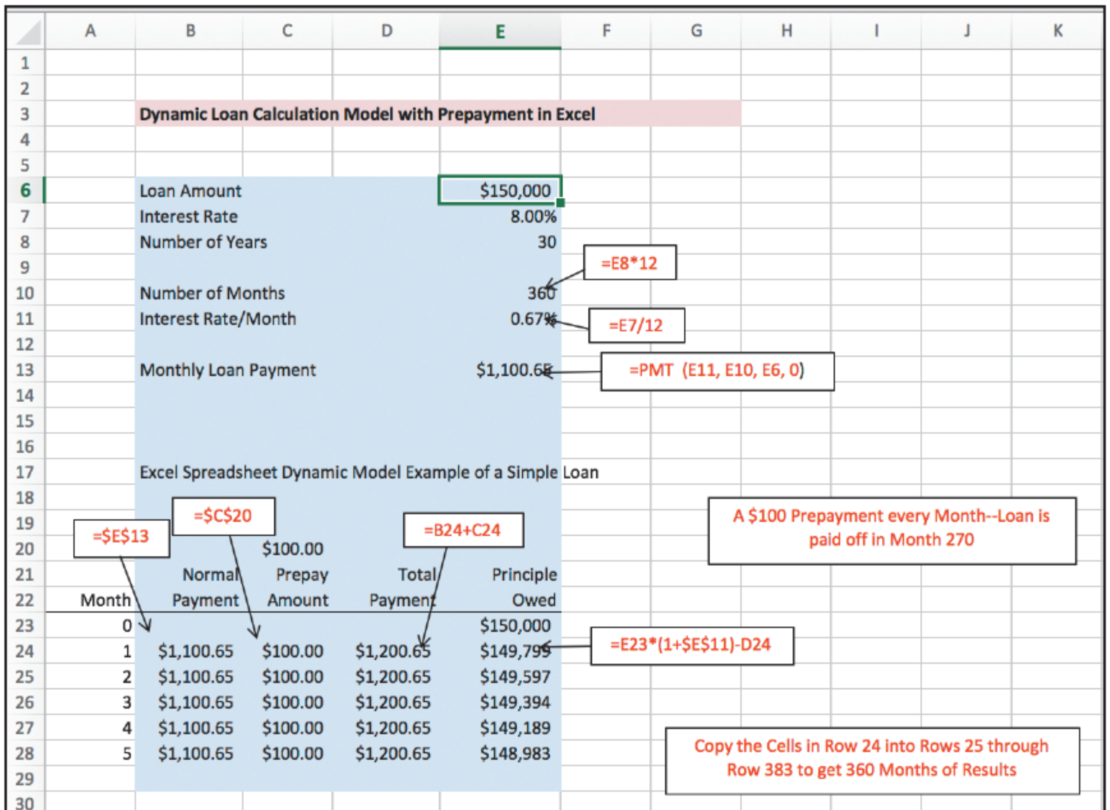
$$F = P(1+i)^n$$

$$A = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$$



Excel Spreadsheet - Dynamic Model Example

Simple loan calculation of monthly payments & effects of prepayment



Dynamic Loan Calculation Model with Prepayment in Excel

Loan Amount	$150,000
Interest Rate	8.00%
Number of Years	30
Number of Months	360
Interest Rate/Month	0.67%
Monthly Loan Payment	$1,100.65

=E8*12

=E7/12

=PMT (E11, E10, E6, 0)

Excel Spreadsheet Dynamic Model Example of a Simple Loan

=$E$13

=$C$20

=B24+C24

Month	Normal Payment	Prepay Amount	Total Payment	Principle Owed
		$100.00		
0				$150,000
1	$1,100.65	$100.00	$1,200.65	$149,799
2	$1,100.65	$100.00	$1,200.65	$149,597
3	$1,100.65	$100.00	$1,200.65	$149,394
4	$1,100.65	$100.00	$1,200.65	$149,189
5	$1,100.65	$100.00	$1,200.65	$148,983

=E23*(1+$E$11)-D24

A $100 Prepayment every Month--Loan is paid off in Month 270

Copy the Cells in Row 24 into Rows 25 through Row 383 to get 360 Months of Results

Optimization via Mathematical Programming

- Mathematical Programming
  - A family of tools designed to help solve managerial problems in which the decision maker must allocate scarce resources among competing activities to optimize a measurable goal
- Optimal solution: The best possible solution to a modeled problem
  - **Linear programming (LP):** A mathematical model for the optimal solution of resource allocation problems. All the relationships are linear.

Application Case 6.6

Mixed-Integer Programming Model Helps the University of Tennessee Medical Center with Scheduling Physicians

Questions for Discussion

1. What was the issue faced by the Regional Neonatal Associates group?
2. How did the HPSM model solve all of the physician's requirements?

LP Problem Characteristics

1. Limited quantity of economic resources
2. Resources are used in the production of products or services
3. Two or more ways (solutions, programs) to use the resources
4. Each activity (product or service) yields a return in terms of the goal
5. Allocation is usually restricted by constraints

Linear Programming Steps

1. Identify the …
   - Decision variables
   - Objective function
   - Objective function coefficients
   - Constraints
     - Capacities / Demands / …
2. Represent the model
   - LINDO: Write mathematical formulation
   - EXCEL: Input data into specific cells in Excel
3. Run the model and observe the results

Modeling in LP - An Example

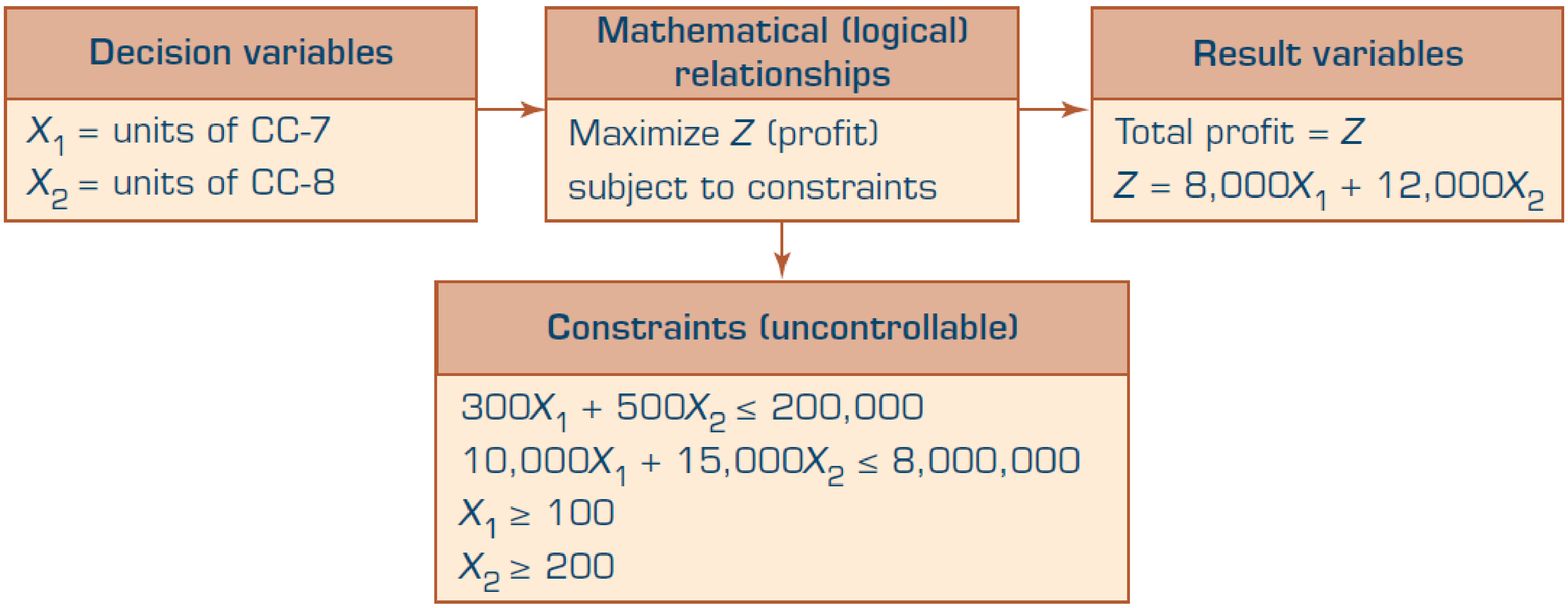
The Product-Mix Linear Programming Model (for MBI Corporation)

- **Decision variable:** How many computers to build?
- Two types of computers: CC-7 and CC-8
- **Constraints:** Labor, Materials, and Marketing limits

	CC-7	**CC-8**	**Rel**	**Limit**
Labor (days)	300	500	<=	200,000 /mo
Materials ($)	10,000	15,000	<=	8,000,000 /mo
Units	1		>=	100
Units		1	>=	200
Profit ($)	8,000	12,000	(Max)	

Objective: Maximize Total Profit / Month

LP Solution – Algebraic Formulations



LP Solution with Excel

Decision Variables:

X_1 : unit of CC-7

X_2 : unit of CC-8

Objective Function:

Maximize Z (profit)

$$z = 8000x_1 + 12000x_2$$

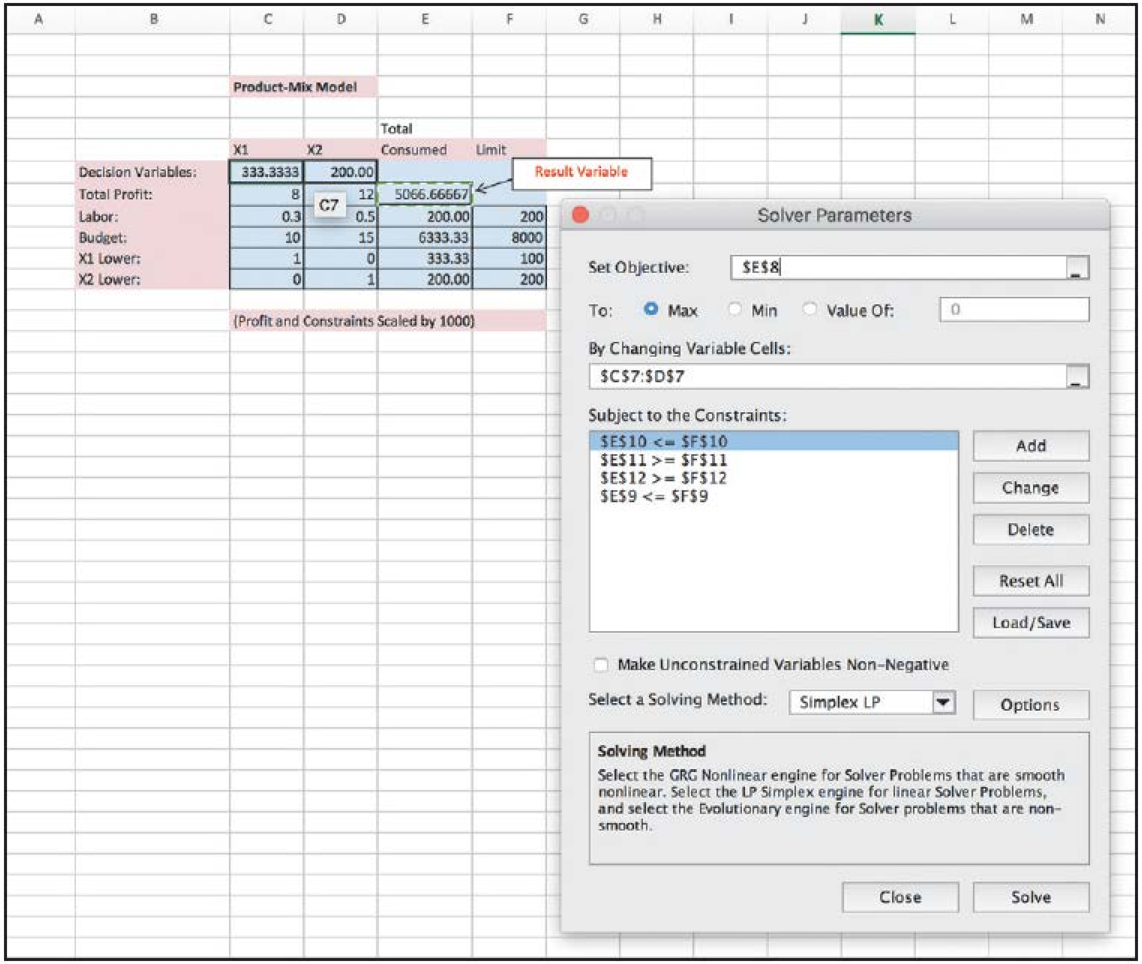
Subject To

$$300X_1 + 500X_2 \le 200K$$

$$10000X_1 + 15000X_2 \le 8000K$$

$$X_1 \ge 100$$

$$X_2 \ge 200$$



Illustrating the Power of Spreadsheet Modeling (1 of 3)

- Election Resource Allocation Problem (Data)

State	Electoral Votes	W/E	N/S	Influence Function
NV	6	West		F1
CO	9	West		F2
IA	6	West	North	F3
WI	10	West	North	F1
OH	18	East	North	F2
VA	13	East	South	F2
NC	15	East	South	F1
FL	29	East	South	F3
NH	4	East		F3

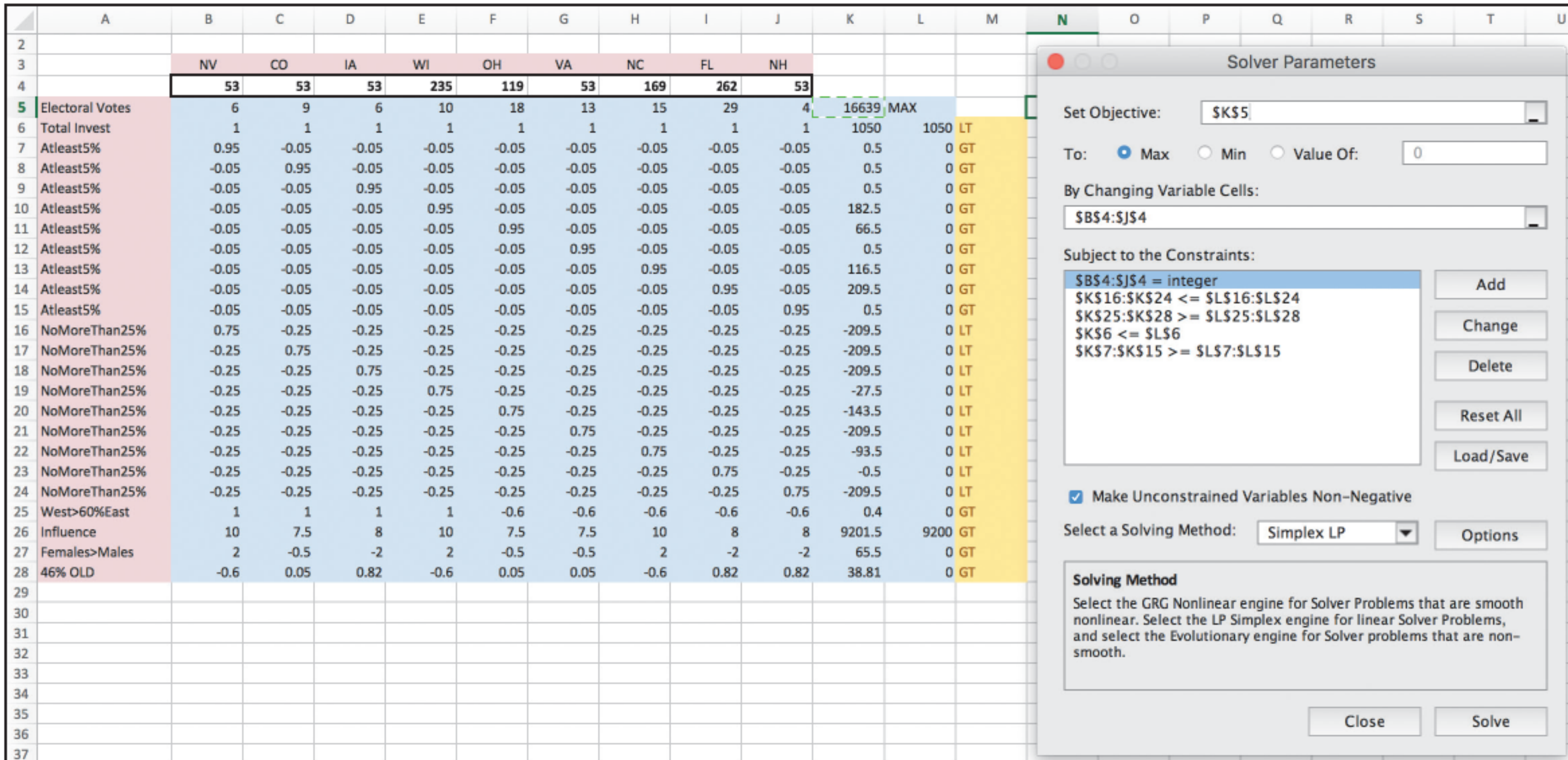
F1	Young	Old		
Men	3	1	4	
Women	3	3	6	
	6	4	10	Total

F2	Young	Old		
Men	1.5	2.5	4	
Women	2.5	1	3.5	
	4	3.5	7.5	Total

F3	Young	Old		
Men	2.5	2.5	5	
Women	1	2	3	
	3.5	4.5	8	Total

Illustrating the Power of Spreadsheet Modeling (2 of 3)

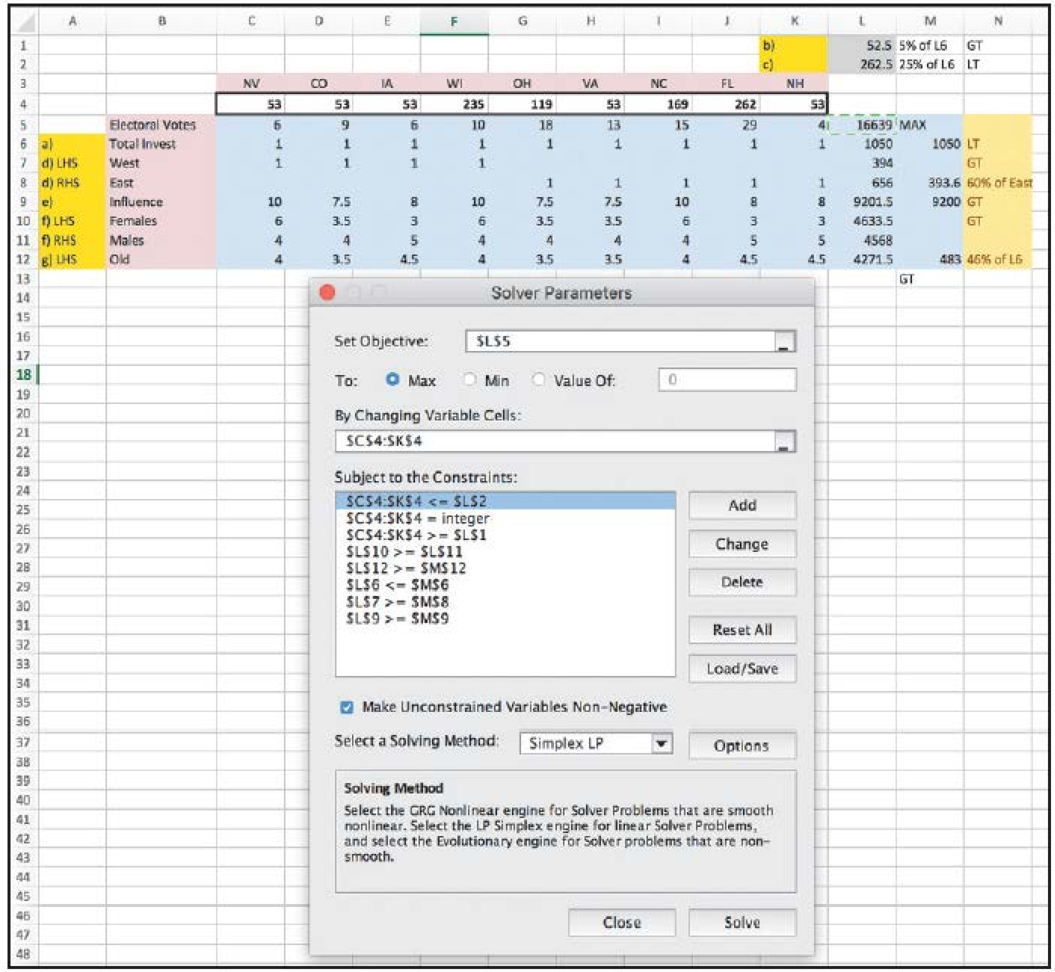
- Election Resource Allocation Problem (Formulation)



	A	B	C	D	E	F	G	H	I	J	K	L	M
3		NV	CO	IA	WI	OH	VA	NC	FL	NH			
4		53	53	53	235	119	53	169	262	53			
5	Electoral Votes	6	9	6	10	18	13	15	29	4	16639	MAX	
6	Total Invest	1	1	1	1	1	1	1	1	1	1050	1050	LT
7	Atleast5%	0.95	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	0.5	0	GT
8	Atleast5%	-0.05	0.95	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	0.5	0	GT
9	Atleast5%	-0.05	-0.05	0.95	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	0.5	0	GT
10	Atleast5%	-0.05	-0.05	-0.05	0.95	-0.05	-0.05	-0.05	-0.05	-0.05	182.5	0	GT
11	Atleast5%	-0.05	-0.05	-0.05	-0.05	0.95	-0.05	-0.05	-0.05	-0.05	66.5	0	GT
12	Atleast5%	-0.05	-0.05	-0.05	-0.05	-0.05	0.95	-0.05	-0.05	-0.05	0.5	0	GT
13	Atleast5%	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	0.95	-0.05	-0.05	116.5	0	GT
14	Atleast5%	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	0.95	-0.05	209.5	0	GT
15	Atleast5%	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	0.95	0.5	0	GT
16	NoMoreThan25%	0.75	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	-209.5	0	LT
17	NoMoreThan25%	-0.25	0.75	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	-209.5	0	LT
18	NoMoreThan25%	-0.25	-0.25	0.75	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	-209.5	0	LT
19	NoMoreThan25%	-0.25	-0.25	-0.25	0.75	-0.25	-0.25	-0.25	-0.25	-0.25	-27.5	0	LT
20	NoMoreThan25%	-0.25	-0.25	-0.25	-0.25	0.75	-0.25	-0.25	-0.25	-0.25	-143.5	0	LT
21	NoMoreThan25%	-0.25	-0.25	-0.25	-0.25	-0.25	0.75	-0.25	-0.25	-0.25	-209.5	0	LT
22	NoMoreThan25%	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	0.75	-0.25	-0.25	-93.5	0	LT
23	NoMoreThan25%	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	0.75	-0.25	-0.5	0	LT
24	NoMoreThan25%	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	0.75	-209.5	0	LT
25	West>60%East	1	1	1	1	-0.6	-0.6	-0.6	-0.6	-0.6	0.4	0	GT
26	Influence	10	7.5	8	10	7.5	7.5	10	8	8	9201.5	9200	GT
27	Females>Males	2	-0.5	-2	2	-0.5	-0.5	2	-2	-2	65.5	0	GT
28	46% OLD	-0.6	0.05	0.82	-0.6	0.05	0.05	-0.6	0.82	0.82	38.81	0	GT

Illustrating the Power of Spreadsheet Modeling (3 of 3)

- Election Resource Allocation Problem (Compact Formulation)



Common Optimization Models

- **Assignment (best matching of objects)**
- **Dynamic programming**
- **Goal programming**
- **Investment (maximizing rate of return)**
- **Linear and integer programming**
- **Network models for planning and scheduling**
- **Nonlinear programming**
- **Replacement (capital budgeting)**
- **Simple inventory models (e.g., economic order quantity)**
- **Transportation (minimize cost of shipments)**

Multiple Goals, Sensitivity Analysis, What-If Analysis, and Goal Seeking (1 of 4)

- Multiple Goals
  - Simple-goal vs. multiple goals
  - Vast majority of managerial problems has multiple goals (objectives) to achieve
    - Attaining all goals **simultaneously**
- Methods of handling multiple goals
  - Utility theory
  - Goal programming
  - Expression of goals as constraints, using LP
  - A points system

Multiple Goals, Sensitivity Analysis, What-If Analysis, and Goal Seeking (2 of 4)

- Certain difficulties may arise when analyzing multiple goals:
  - Difficult to obtain a single organizational goal
  - The importance of goals change over time
  - Goals and sub-goals are viewed differently
  - Goals change in response to other changes
  - Dynamics of groups of decision makers
  - Assessing the importance (priorities)

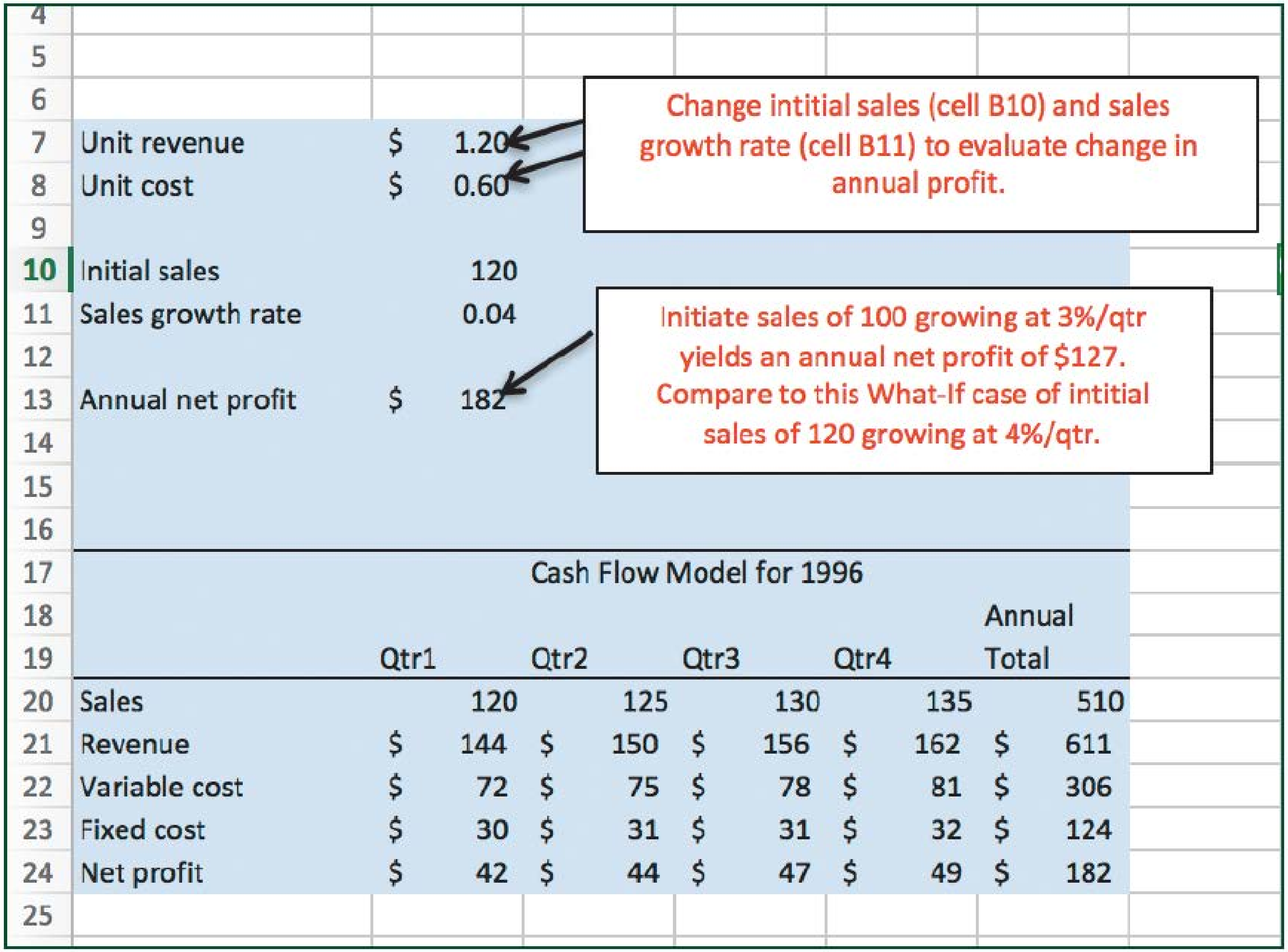
Multiple Goals, Sensitivity Analysis, What-If Analysis, and Goal Seeking (3 of 4)

- Sensitivity analysis
  - It is the process of assessing the impact of change in inputs on outputs
  - Helps to …
    - eliminate (or reduce) variables
    - revise models to eliminate too-large sensitivities
    - adding details about sensitive variables or scenarios
    - obtain better estimates of sensitive variables
    - alter a real-world system to reduce sensitivities
    - …
  - Can be automatic or trial and error

Multiple Goals, Sensitivity Analysis, What-If Analysis, and Goal Seeking (4 of 4)

- What-if analysis
  - Assesses solutions based on changes in variables or assumptions (scenario analysis)
  - What if we change our capacity at the milling station by 40% [what would be the impact on output?]
- Goal seeking
  - Backwards approach, starts with the goal and determines values of inputs needed
  - Example is break-even point determination
    - In order to break even (profit = 0), how many products do we have to sell each month?

What-If Analysis Example in Excel



4											
5											
6											
7	Unit revenue	$	1.20								
8	Unit cost	$	0.60								
9											
10	Initial sales		120								
11	Sales growth rate		0.04								
12											
13	Annual net profit	$	182								
14											
15											
16											
17					Cash Flow Model for 1996						
18										Annual	
19		Qtr1		Qtr2		Qtr3		Qtr4		Total	
20	Sales		120		125		130		135		510
21	Revenue	$	144	$	150	$	156	$	162	$	611
22	Variable cost	$	72	$	75	$	78	$	81	$	306
23	Fixed cost	$	30	$	31	$	31	$	32	$	124
24	Net profit	$	42	$	44	$	47	$	49	$	182
25											

Goal Seeking Example in Excel

5					
6					
7	**Investment Problem**		Initial Investment:		$ 1,000.00
8	**Example of GoalSeeking**		Interest Rate:		10%
9					
10	**Find the Interest Rate**		Annual		NPV
11	**(the Internal Rate of**	Year	Returns		Calculations
12	**Return-IRR)**	1	$ 120.00		$109.09
13	**that yields an NPV**	2	$ 130.00		$118.18
14	**of $0**	3	$ 140.00		$127.27
15		4	$ 150.00		$136.36
16		5	$ 160.00		$145.45
17		6	$ 152.00		$138.18
18		7	$ 144.40		$131.27
19		8	$ 137.18		$124.71
20		9	$ 130.32		$118.47
21		10	$ 123.80		$112.55
22					
23			The NPV	Solutions:	$261.55
24					

Decision Analysis with Decision Tables and Decision Trees

- **Decision Tables** – a tabular representation of the decision situation (alternatives)
- Investment example:
  - **Goal:** maximize the yield after one year
  - **Yield** depends on the status of the economy (the **state of nature**)
    - Solid growth
    - Stagnation
    - Inflation

Decision Table – Investment Example: Possible Situations

1. If **solid growth** in the economy, bonds yield 12%; stocks 15%; time deposits 6.5%
2. If **stagnation**, bonds yield 6%; stocks 3%; time deposits 6.5%
3. If **inflation**, bonds yield 3%; stocks lose 2%; time deposits yield 6.5%

Decision Table Investment Example: Decision Table

- Payoff decision variables (alternatives)
- Uncontrollable variables (states of economy)
- Result variables (projected yield)
- **Tabular representation:**

Table 6.3 Investment Problem Decision Table Model

State of Nature (Uncontrollable Variables)

Alternative	**Solid Growth (%)**	**Stagnation (%)**	**Inflation (%)**
Bonds	12.0	6.0	3.0
Stocks	15.0	3.0	–2.0
CDs	6.5	6.5	6.5

Decision Table Investment Example: Treating Uncertainty

- Optimistic approach vs. pessimistic approach
- Treating Risk/Uncertainty:
  - Use known probabilities (calculate **expected values**)
  - Solid growth 0.5
  - Stagnation 0.3
  - Inflation 0.2
- Multiple goals: yield, safety, and liquidity

Table 6.4 Multiple Goals

Alternative	Yield (%)	Safety	Liquidity
Bonds	8.4	High	High
Stocks	8.0	Low	High
CDs	6.5	Very high	High

Decision Trees

- Graphical representation of relationships
  - Can be induced (driven) from data [data mining]
  - Can be driven from experts [knowledge-driven]
- Multiple criteria approach
- Demonstrates complex relationships
- Cumbersome, if many alternatives exist
- Many tools exist:
  - Mind Tools Ltd., mindtools.com
  - TreeAge Software Inc., treeage.com
  - Palisade Corp., palisade.com

Simulation

- Simulation is the “appearance” of reality
- It is often used to conduct what-if analysis on the model of the actual system
- It is a popular DSS technique for conducting experiments with a computer on a comprehensive model of the system to assess its dynamic behavior
- Often used when the system is too complex for other DSS techniques

Major Characteristics of Simulation

- **Imitates** reality and captures its richness both in shape and behavior
  - “Represent” versus “Imitate”
- Technique for **conducting experiments**
- **Descriptive**, not normative tool
- Often to “solve” [i.e., analyze] very complex systems/problems
- Simulation should be used only when a numerical optimization is not possible

Simulation Example

- A model of a supermarket
- OBJ -- hire the least-cost combination of checkout clerks & baggers that keeps checkout line length < predetermined limit 95% of the time
- Decide -- how many checkout counters to open?

  -- how many baggers to hire (for optimum profit)
- Decision variables?
- Uncontrollable variables?
- Data needed?

Simulation Example *con't*

- Decision variables
  - number of open checkout counters
  - number of baggers
- State(Uncontrollable) variables
  - number of shoppers in the supermarket
  - number of shoppers at each open checkout counters
- Data needed/obtained
  - arrival rate statistics
  - statistics on distribution of shopping times
  - checkout process statistics

Application Case 6.7

Simulating Effects of Hepatitis B Interventions

Questions for Discussion

1. Explain the advantage of OR methods such as simulation over clinical trial methods in determining the best control measure for Hepatitis B.
2. In what ways do the decision and Markov models provide cost-effective ways of combating the disease?
3. Discuss how multidisciplinary background is an asset in finding a solution for the problem described in the case.

Advantages of Simulation

- The theory is fairly straightforward
- Great deal of time compression
- Experiment with different alternatives
- The model reflects manager's perspective
- Can handle wide variety of problem types
- Can include the real complexities of problems
- Produces important performance measures
- Often it is the only DSS modeling tool for non-structured problems

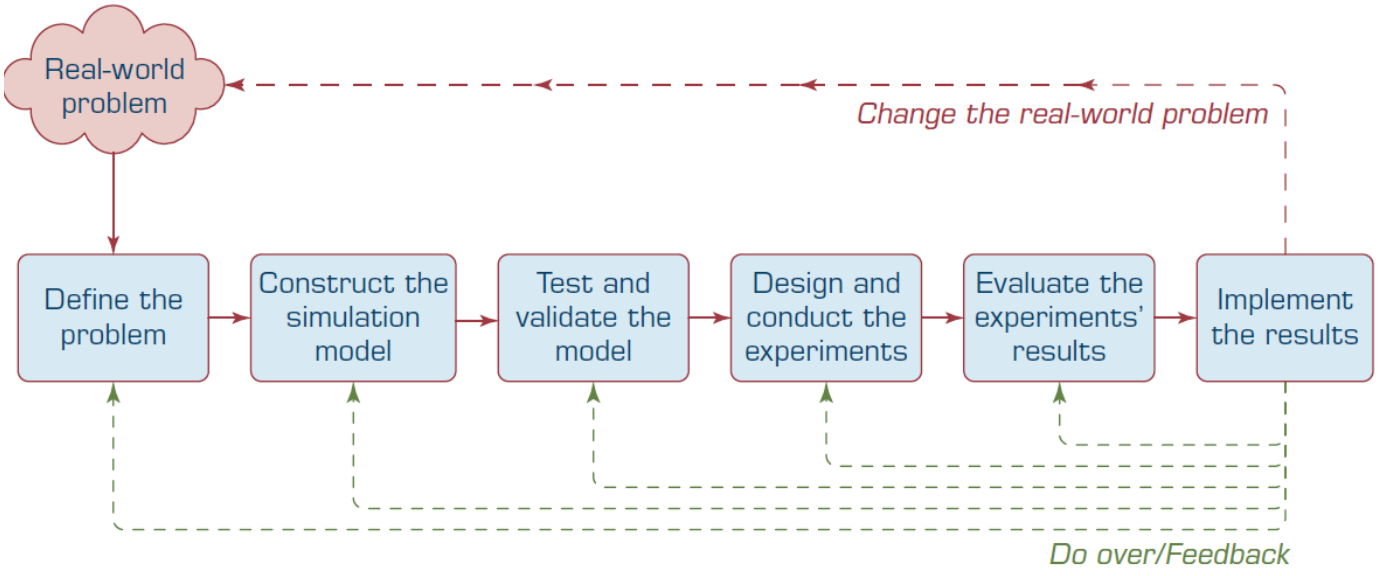
Disadvantages of Simulation

- Cannot guarantee an optimal solution
  - It is a descriptive model that can help develop prescriptive outcomes
- Time-demanding and costly construction process
- Cannot transfer solutions and inferences to solve other problems (models are problem specific)
- So easy to explain/sell to managers, may lead to overlooking analytical/optimal solutions
- Software may require special skills/experience

Simulation Methodology

Model Development Steps:

1. Define problem
2. Construct the model
3. Test and validate model
4. Design experiments
5. Conduct experiments
6. Evaluate results
7. Implement solution



Simulation Types

- **Stochastic vs. Deterministic Simulation**
  - Uses probability distributions
- **Time-dependent vs. Time-independent Simulation**
  - **Monte Carlo Simulation** $\left(X = A + B\right)$

    [A, B, and X are all probability distributions]
- **Discrete Event vs. Continuous Simulation vs. Agent-Based Simulation**
- **Simulation Implementation**
  - Visual Simulation and/or Object-Oriented Simulation

Application Case 6.8

Cosan Improves Its Renewable Energy Supply Chain Using Simulation

Questions for Discussion

1. What type of supply chain disruptions might occur in moving the sugar cane from the field to the production plants to develop sugar and ethanol?
2. What types of advanced planning and prediction might be useful in mitigating such disruptions?

Visual Interactive Simulation (VIS)

- Visual interactive modeling (VIM), also called **Visual Interactive Simulation** or **Visual Interactive Problem Solving**
- Goal is to address conventional simulation modeling inadequacies
- Uses computer graphics and animation
- Often integrated with RFID and GIS
- Allows for interactive/immersive sensitivity analysis
- Virtual reality
- Immersive presence

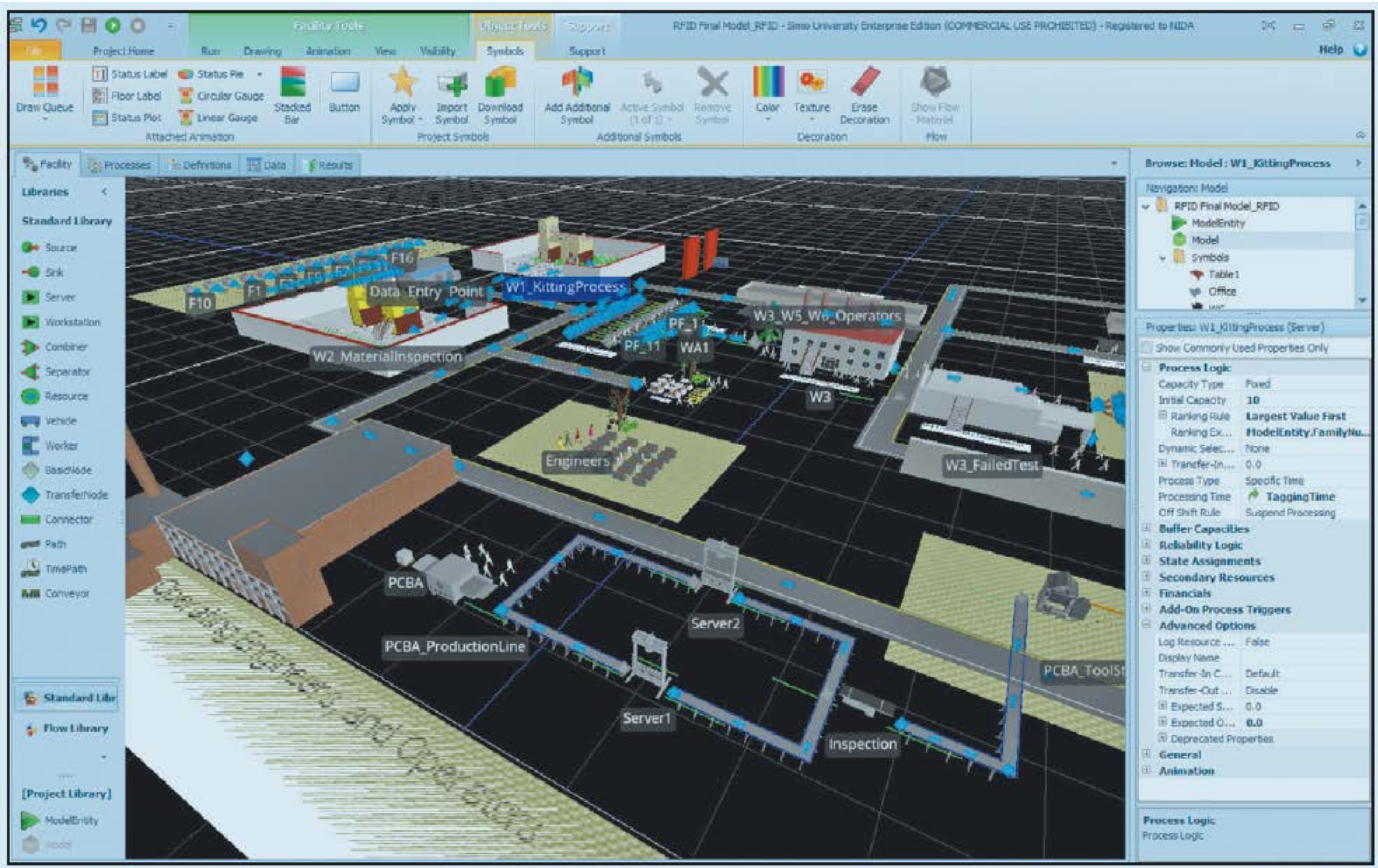
Application Case 6.9 (1 of 5)

Improving Job-Shop Scheduling Decisions through RFID: A Simulation-Based Assessment

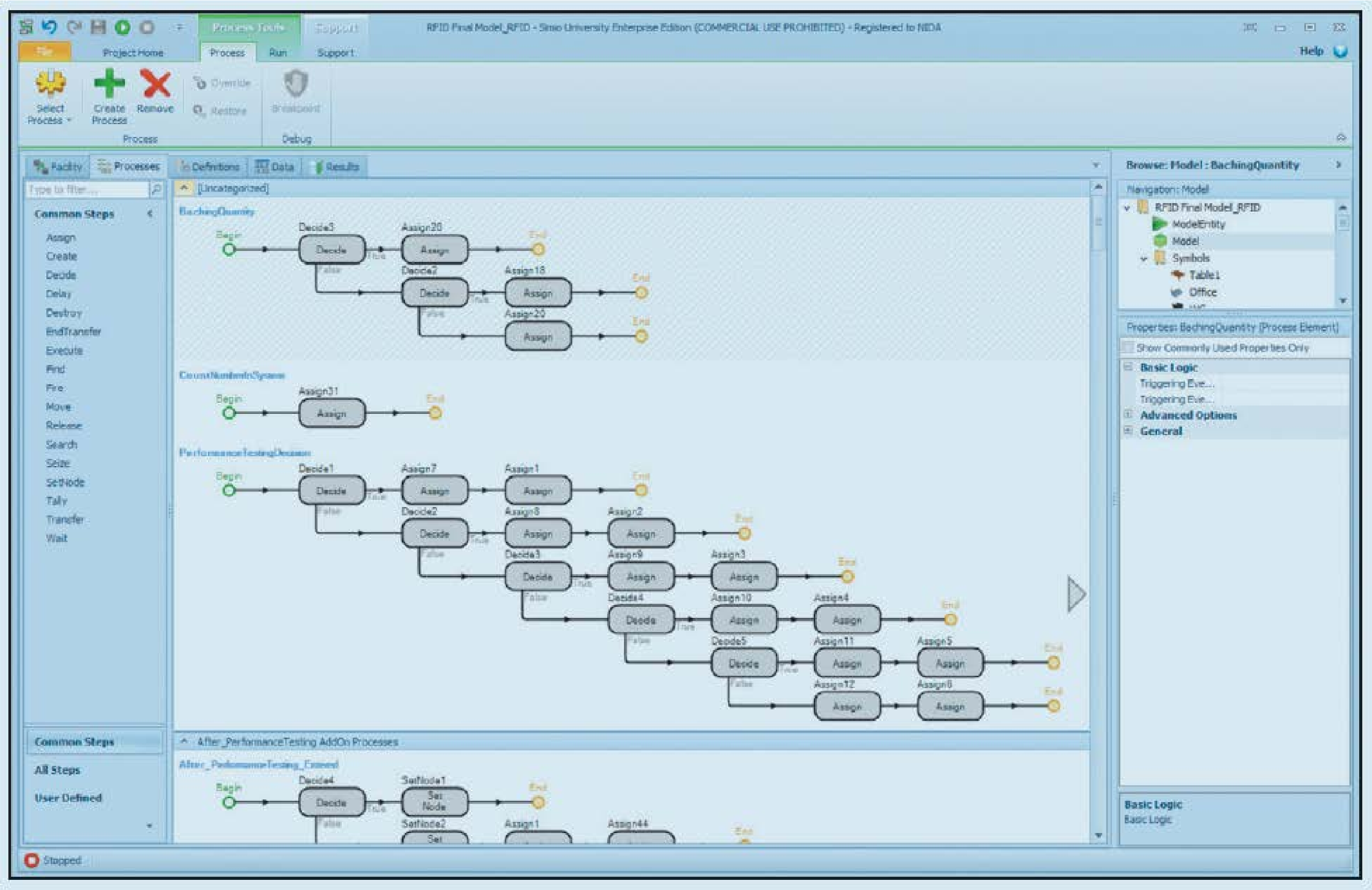
Questions for Discussion

1. In situations such as what this case depicts, what other approaches can one take to analyze investment decisions?
2. How would one save time if an RFID chip can tell the exact location of a product in process?
3. Research to learn about the applications of RFID sensors in other settings. Which one do you find most interesting?

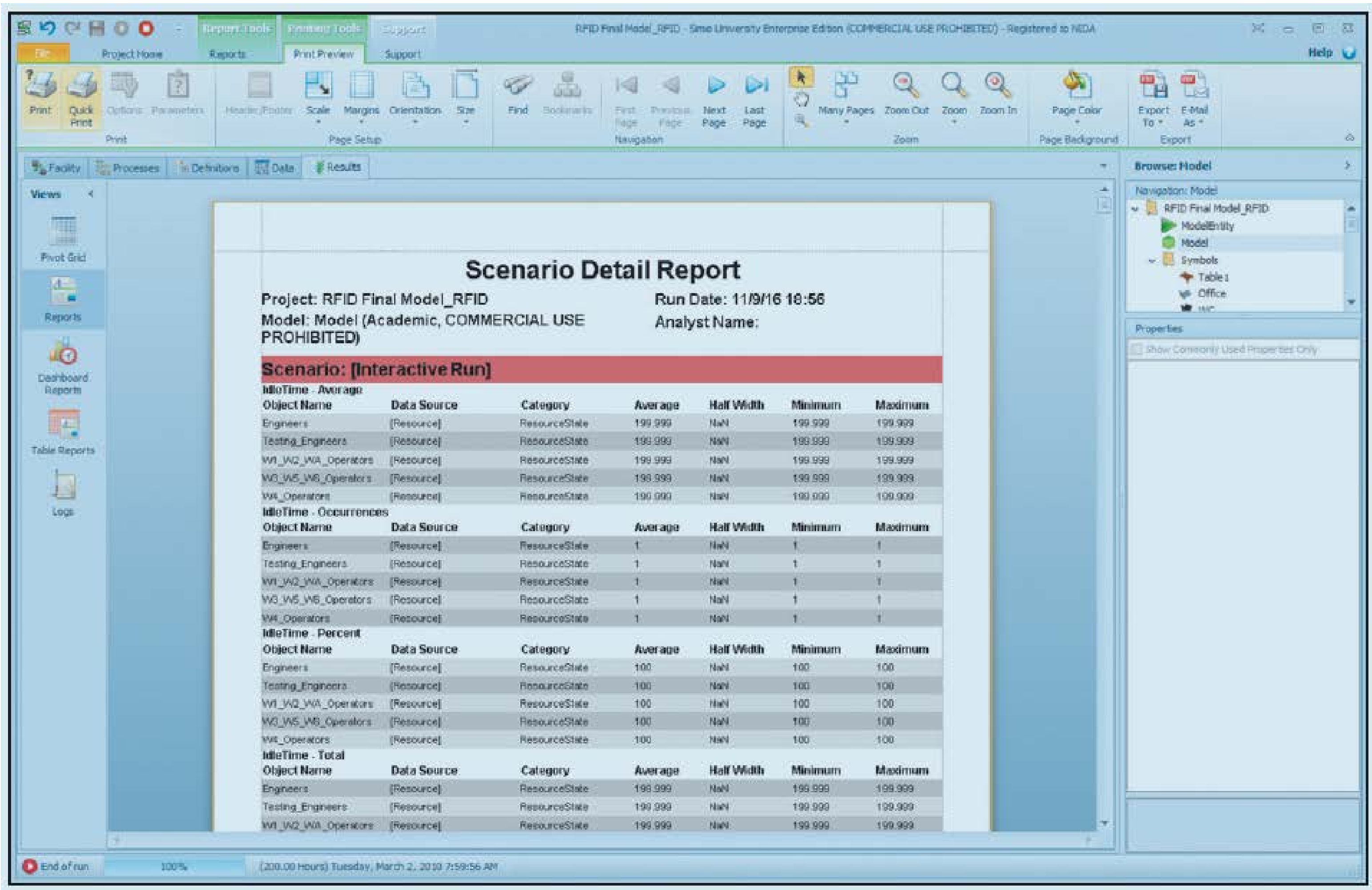
Application Case 6.9 (2 of 5)



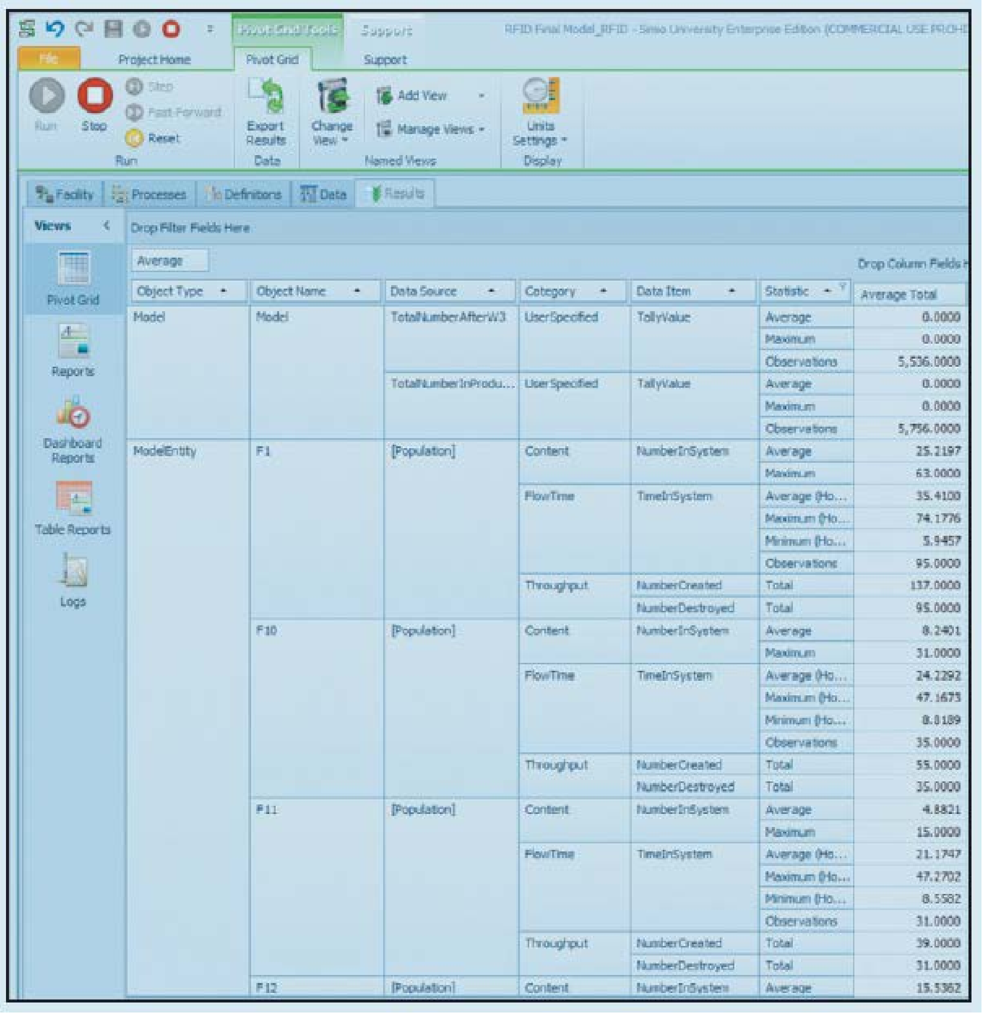
Application Case 6.9 (3 of 5)



Application Case 6.9 (4 of 5)



Application Case 6.9 (5 of 5)



Simulation Software

- A comprehensive list can be found at
  – orms-today.org/surveys/Simulation/Simulation.html
- **Simio** LLC, simio.com
- SAS Simulation [SAS OR], sas.com
- Lumina Decision Systems, lumina.com
- Oracle Crystal Ball, oracle.com
- Palisade Corp., palisade.com
- Rockwell Software, arenasimulation.com …