

Building and Using Decision Models

Prepared by Dr. Mohamed Sleem

Subject code : FNT 631
Data Analysis

Lecture 8



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What are the components of a time series?

Answer:

- **Trend:** The long-term movement or direction in a time series, indicating overall growth or decline over a period.
- **Seasonality:** Regular and predictable patterns or cycles that repeat over a fixed period, such as daily, monthly, or annually.
- **Cyclical:** Fluctuations that occur due to economic or business cycles, often spanning several years and not of fixed duration.
- **Irregular/Random:** Unpredictable and random variations or noise in the data that do not follow any pattern and cannot be easily attributed to any known cause.

What does the Delphi Method involve?

Answer:

1. **Expert Panel:** A group of selected experts in the relevant field who provide insights and opinions.
2. **Questionnaire Rounds:** Multiple rounds of surveys conducted to gather information, with each round refining the previous responses.
3. **Anonymity:** Ensuring that the responses from the experts remain anonymous to prevent bias and influence from other panel members.
4. **Feedback:** Providing summary feedback of the responses between rounds to allow experts to reconsider and refine their views.
5. **Convergence:** The process of reaching a consensus or common agreement among the experts through iterative refinement of responses.

Name three statistical forecasting methods mentioned in the document.

Answer:

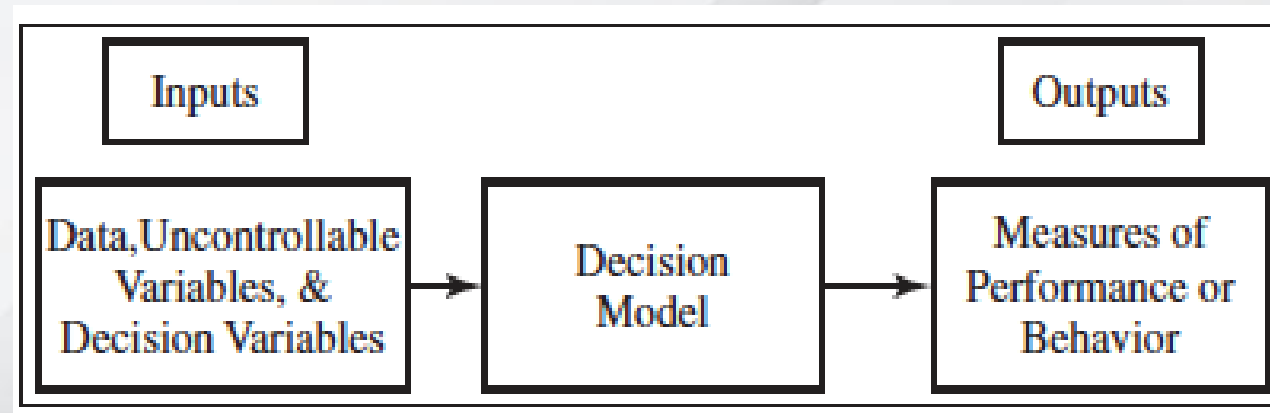
- 1. Moving Average:** A method that smooths out short-term fluctuations and highlights longer-term trends by averaging data points over a specified number of periods.
- 2. Exponential Smoothing:** A forecasting technique that applies decreasing weights to past observations, giving more significance to recent data points.
- 3. Autoregressive Integrated Moving Average (ARIMA):** A sophisticated forecasting method that combines autoregression (AR), differencing (I), and moving average (MA) to model and predict time series data.

Objectives

- Understand the components and importance of decision models in data analysis.
- Develop skills in building and using various types of decision models.
- Conduct What-If Analysis
- Learn the application of Excel tools for model analysis and optimization.
- Apply Common Mathematical Functions in Decision Models
- Explore different statistical forecasting methods and their use in decision models.
- Gain proficiency in performing what-if analysis, scenario management, and goal seeking.

Models

- A **model** is an abstraction or representation of a real system, idea, or object.
- Models could be pictures, spreadsheets, or mathematical relationships
- Models contain data, uncontrollable variables, and decision variables



Decision Models – Outsourcing Example

- Decision models are models that can be used to understand, analyze, or facilitate making a decision

	A	B
1	Outsourcing Decision Model	
2		
3	Data	
4		
5	Manufactured in-house	
6	Fixed cost	\$ 50,000
7	Unit variable cost	\$ 125
8		
9	Purchased from supplier	
10	Unit cost	\$ 175
11		
12	Model	
13		
14	Demand volume	1500
15		
16	Total manufacturing cost	\$ 237,500
17	Total purchased cost	\$ 262,500
18	Difference	\$ (25,000)
19		
20	Decision	Manufacture

	A	B
1	Outsourcing Decision Model	
2		
3	Data	
4		
5	Manufactured in-house	
6	Fixed cost	50000
7	Unit variable cost	125
8		
9	Purchased from supplier	
10	Unit cost	175
11		
12	Model	
13		
14	Demand volume	1500
15		
16	Total manufacturing cost	=B6+B7*B14
17	Total purchased cost	=B14*B10
18	Difference	=B16-B17
19		
20	Decision	=IF(B18<=0, "Manufacture", "Outsource")

Outsourcing Model

- Model components
 - F = fixed cost of in-house manufacturing
 - V = unit variable cost of in-house manufacturing
 - C = unit cost of outsourcing
 - D = demand volume
- Total Manufacturing Cost = $TMC = F + V D$
- Total outsourcing cost = $TOC = C D$.

Types of Decision Models

- **Descriptive** - describe relationships and provide information for evaluation
- **Prescriptive (optimization models)** - determine an optimal policy, that is, the best course of action that a decision maker should take to maximize or minimize some objective

Airline Pricing Model

	A	B
1	Airline Pricing Model	
2		
3	Data	
4	Airplane capacity	300
5	Fixed cost	\$ 90,000
6	Demand function	
7	slope	-2.33
8	intercept	1900
9		
10	Model	
11		
12	Revenue	
13	Unit price	\$ 500.00
14	Demand	733
15	Number of flights/day	3
16	Total Revenue	\$366,666.67
17	Cost	
18	Fixed Cost	\$270,000.00
19		
20	Profit	\$96,666.67

	A	B
1	Airline Pricing Model	
2		
3	Data	
4	Airplane capacity	300
5	Fixed cost	90000
6	Demand function	
7	slope	=-7/3
8	intercept	1900
9		
10	Model	
11		
12	Revenue	
13	Unit price	500
14	Demand	=B8+B7*B13
15	Number of flights/day	=ROUNDUP(B14/B4,0)
16	Total Revenue	=B13*B14
17	Cost	
18	Fixed Cost	=B5*B15
19		
20	Profit	=B16-B18

Model Analysis

- **What-If Analysis** – evaluate how specific combinations of model inputs that reflect key model assumptions affect model outputs (often called **sensitivity analysis**).
- Excel tools
 - Data tables
 - Scenario manager
 - Goal seek

Data Tables

- Summarizes the impact of one or two inputs on a specified output
- Excel tools
 - One-way data tables
 - Two-way data tables

One Way Data Table

	A	B	C	D	E	F	G
1	Outsourcing Decision Model						
2							
3	Data						
4							
5	Manufactured in-house						
6	Fixed cost	\$ 50,000					
7	Unit variable cost	\$ 125					
8							
9	Purchased from supplier						
10	Unit cost	\$ 175					
11							
12	Model						
13							
14	Demand volume	1500					
15							
16	Total manufacturing cost	\$ 237,500					
17	Total purchased cost	\$ 262,500					
18	Difference	\$ (25,000)					
19							
20	Decision	Manufacture					

Column
input cell

Two Way Data Table

	A	B	C	D	E	F	G	H	I	J	K
1	Outsourcing Decision Model										
2					Fixed Cost			Variable Cost			
3	Data				Manufacture	\$ 100	\$ 110	\$ 120	\$ 130	\$ 140	\$ 150
4					\$ 30,000	Manufacture	Manufacture	Manufacture	Manufacture	Manufacture	Manufacture
5	Manufactured in-house				\$ 40,000	Manufacture	Manufacture	Manufacture	Manufacture	Manufacture	Outsource
6	Fixed cost	\$ 50,000			\$ 50,000	Manufacture	Manufacture	Manufacture	Manufacture	Manufacture	Outsource
7	Unit variable cost	\$ 125			\$ 60,000	Manufacture	Manufacture	Manufacture	Manufacture	Outsource	Outsource
8					\$ 70,000	Manufacture	Manufacture	Manufacture	Outsource	Outsource	Outsource
9	Purchased from supplier				\$ 80,000	Manufacture	Manufacture	Manufacture	Outsource	Outsource	Outsource
10	Unit cost	\$ 175			\$ 90,000	Manufacture	Manufacture	Outsource	Outsource	Outsource	Outsource
11					\$ 100,000	Manufacture	Outsource	Outsource	Outsource	Outsource	Outsource
12	Model										
13											
14	Demand volume	1500									
15											
16	Total manufacturing cost	\$ 237,500									
17	Total purchased cost	\$ 262,500									
18	Difference	\$ (25,000)									
19											
20	Decision	Manufacture									

Column
input cell

Row
input cell

Scenario Manager

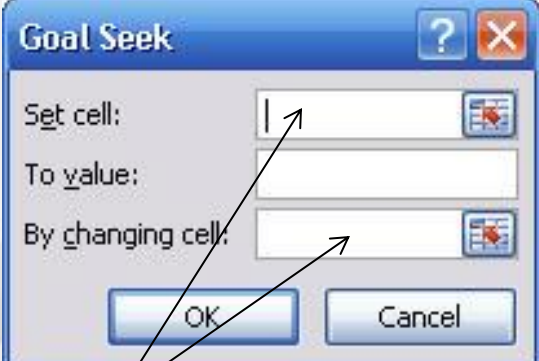
	Fixed Cost	Unit Variable Cost	Demand Volume
Best case	\$40,000	\$120	1,800
Worst case	\$60,000	\$140	1,000
Most likely case	\$55,000	\$125	1,500

Scenario Summary				
	Current Values:	Best case	Worst case	Most likely case
Changing Cells:				
\$B\$6	\$ 50,000	\$ 40,000	\$ 60,000	\$ 55,000
\$B\$7	\$ 125	\$ 120	\$ 140	\$ 125
\$B\$14	1500	1800	1000	1500
Result Cells:				
\$B\$18	\$ (25,000)	\$ (59,000)	\$ 25,000	\$ (20,000)
\$B\$20	Manufacture	Manufacture	Outsource	Manufacture
Notes: Current Values column represents values of changing cells at time Scenario Summary Report was created. Changing cells for each scenario are highlighted in gray.				

Goal Seek

- Find the value of an input that produces a known result within a spreadsheet
- Example: find the breakeven point in the outsourcing decision model

	A	B
1	Outsourcing Decision Model	
2		
3	Data	
4		
5	Manufactured in-house	
6	Fixed cost	\$ 50,000
7	Unit variable cost	\$ 125
8		
9	Purchased from supplier	
10	Unit cost	\$ 175
11		
12	Model	
13		
14	Demand volume	1500
15		
16	Total manufacturing cost	\$ 237,500
17	Total purchased cost	\$ 262,500
18	Difference	\$ (25,000)
19		
20	Decision	Manufacture



Goal Seek

Set cell:

To value:

By changing cell:

OK Cancel

Set cell is
B18;
To value = 0;
By changing
cell is B14

Optimization Models: Excel Solver

	A	B	C	D	E	F	G	H	I	J	K	
1	Airline Pricing Model											
2												
3	Data											
4	Airplane capacity	300										
5	Fixed cost	\$ 90,000										
6	Demand function											
7	slope	-2.33										
8	intercept	1900										
9												
10	Model											
11												
12	Revenue											
13	Unit price	\$ 500.00										
14	Demand	733										
15	Number of flights/day	3										
16	Total Revenue	\$366,666.67										
17	Cost											
18	Fixed Cost	\$270,000.00										
19												
20	Profit	\$96,666.67										
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												
31												
32												
33												
34												
35												

Solver Parameters

Set Objective:

To: ☒ Max ☐ Min ☐ Value Of:

By Changing Variable Cells:

Subject to the Constraints:

☐ Make Unconstrained Variables Non-Negative

Select a Solving Method:

Solving Method
Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

Buttons: Add, Change, Delete, Reset All, Load/Save, Help, Solve, Close

Solution:
Price =
\$428.57;
profit =
\$115,714.28

Tools for Model Building

- Logic and business principles
- Common mathematical functions
- Data fitting
- Spreadsheet engineering

Logic and Business Principles

- Profit = Revenue - Cost
- Revenue = (Unit price)(Quantity sold)
- Cost = Fixed cost + Unit costQuantity produced
- Quantity sold = Min(Quantity produced, Demand)
- Profit = (Unit price)Min(Quantity produced, Demand) – [Fixed cost + (Unit cost)(Quantity produced)]

Modeling Example: Gasoline Consumption

- m = miles/day driven
- d = days/month
- f = miles/gallon
- Miles driven/month = md
- Gallons consumed/month = md/f

Net Present Value

- Measures the worth of a stream of cash flows, taking into account the time value of money.
- A cash flow of F dollars t time periods in the future is worth $F(1 + i)^t$ dollars today, where i is the **discount rate**.

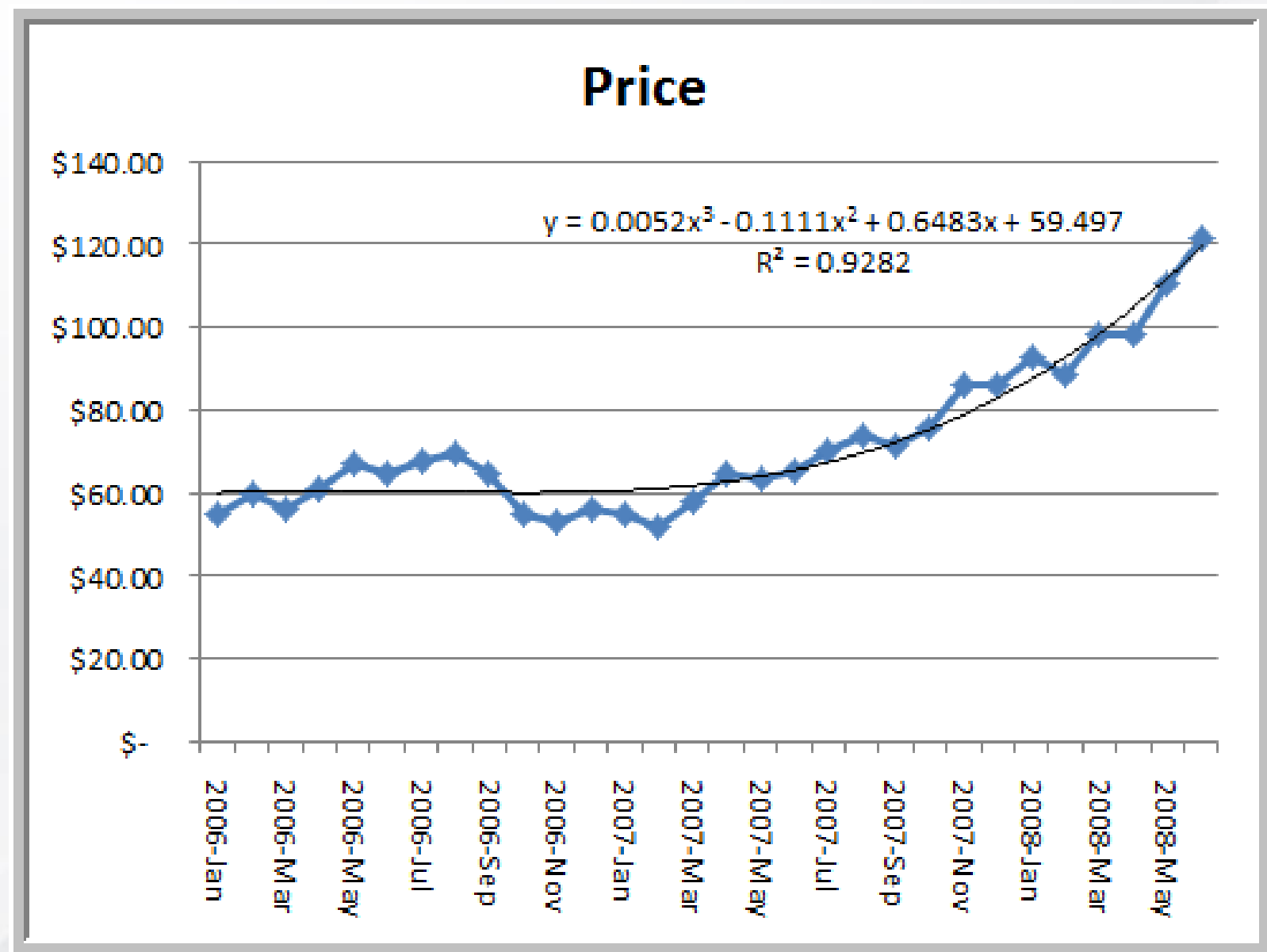
$$NPV = \sum_{t=0}^n \frac{F_t}{(1 + i)^t}$$

- Excel function $NPV(rate, value1, value2, \dots)$

Common Mathematical Functions

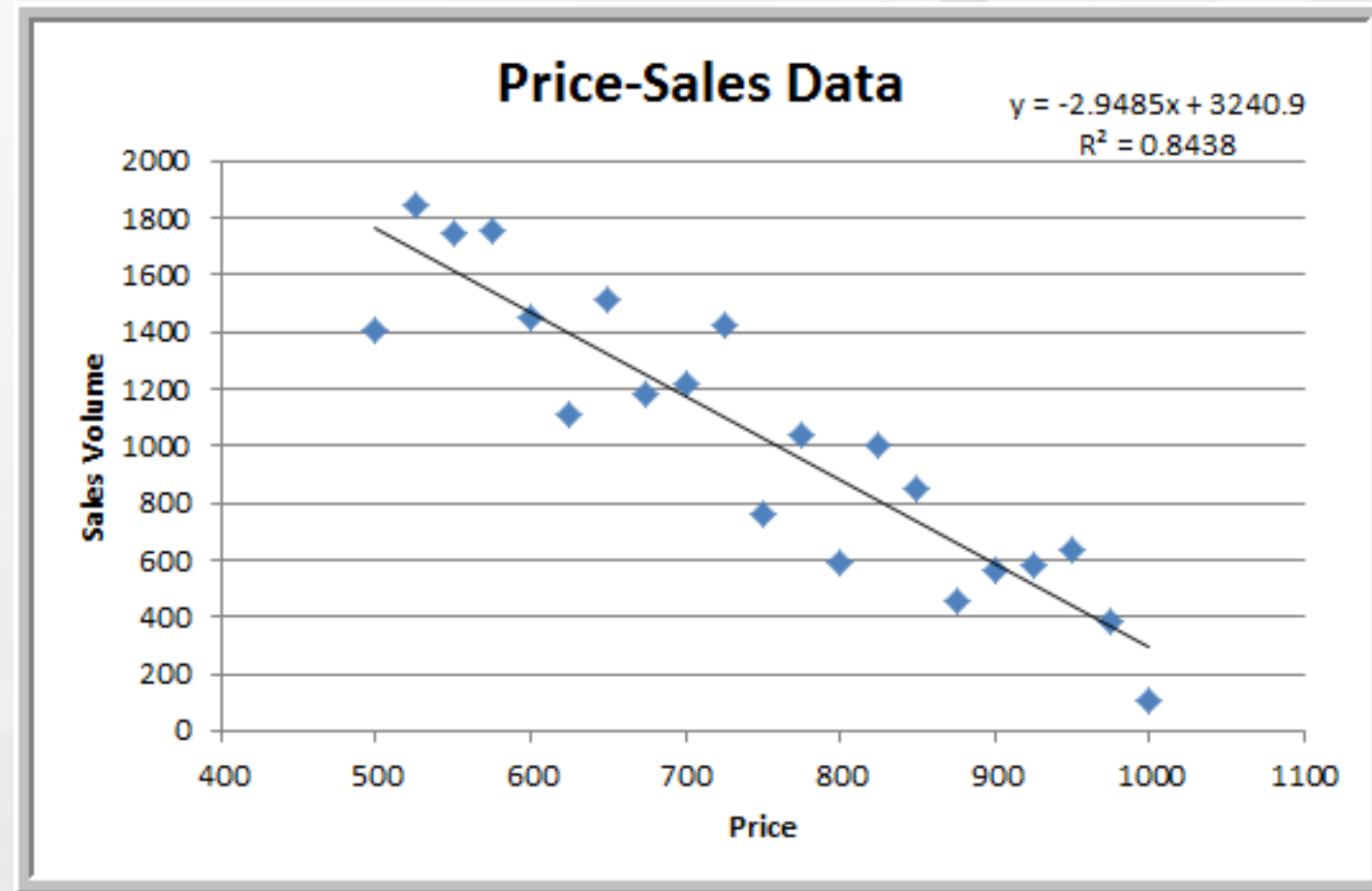
- *Linear: $y = mx + b$*
- *Logarithmic: $y = \ln(x)$*
- *Polynomial: $y = ax^2 + bx + c$ (quadratic)*
- *Power: $y = ax^b$*
- *Exponential: $y = ab^x$*

Data Fitting



Revenue Model

- Total revenue = PriceSales
 - = Price $\times$ (-2.794 Price + 3149)
 - = -2.794 Price² + 3149 Price



Spreadsheet Engineering

- Improve the design and format of the spreadsheet itself.
- Improve the process used to develop a spreadsheet.
- Inspect your results carefully and use appropriate tools available in Excel.
 - Use the Data Validation tool
 - Inspect and audit formulas

New Product Development Model

	A	B	C	D	E	F
1	Moore Pharmaceuticals					
2						
3	Data					
4						
5	Market size	2,000,000				
6	Unit (monthly Rx) revenue	\$ 130.00				
7	Unit (monthly Rx) cost	\$ 40.00				
8	Discount rate	9%				
9						
10	Project Costs					
11	R&D	\$ 700,000,000				
12	Clinical Trials	\$ 150,000,000				
13	Total Project Costs	\$ 850,000,000				
14						
15	Model					
16						
17	Year	1	2	3	4	5
18	Market growth factor		3.00%	3.00%	3.00%	3.00%
19	Market size	2,000,000	2,060,000	2,121,800	2,185,454	2,251,018
20	Market share growth rate		20.00%	20.00%	20.00%	20.00%
21	Market share	8.00%	9.60%	11.52%	13.82%	16.59%
22	Sales	160,000	197,760	244,431	302,117	373,417
23						
24	Annual Revenue	\$ 249,600,000	\$ 308,505,600	\$ 381,312,922	\$ 471,302,771	\$ 582,530,225
25	Annual Costs	\$ 76,800,000	\$ 94,924,800	\$ 117,327,053	\$ 145,016,237	\$ 179,240,069
26	Profit	\$ 172,800,000	\$ 213,580,800	\$ 263,985,869	\$ 326,286,534	\$ 403,290,156
27	Cumulative Net Profit	\$(677,200,000)	\$(463,619,200)	\$(199,633,331)	\$ 126,653,203	\$ 529,943,358
28						
29	Net Present Value	\$ 185,404,860				

New Product Development Model Formulas

	A	B	C	D	E	F
1	Moore Pharmaceuticals					
2						
3	Data					
4						
5	Market size	2000000				
6	Unit (monthly Rx) revenue	130				
7	Unit (monthly Rx) cost	40				
8	Discount rate	0.09				
9						
10	Project Costs					
11	R&D	700000000				
12	Clinical Trials	150000000				
13	Total Project Costs	=B11+B12				
14						
15	Model					
16						
17	Year	1	2	3	4	5
18	Market growth factor		0.03	0.03	0.03	0.03
19	Market size	=B5	=B19*(1+C18)	=C19*(1+D18)	=D19*(1+E18)	=E19*(1+F18)
20	Market share growth rate		0.2	0.2	0.2	0.2
21	Market share	0.08	=B21*(1+C20)	=C21*(1+D20)	=D21*(1+E20)	=E21*(1+F20)
22	Sales	=B19*B21	=C19*C21	=D19*D21	=E19*E21	=F19*F21
23						
24	Annual Revenue	=B22*\$B\$6*12	=C22*\$B\$6*12	=D22*\$B\$6*12	=E22*\$B\$6*12	=F22*\$B\$6*12
25	Annual Costs	=B22*\$B\$7*12	=C22*\$B\$7*12	=D22*\$B\$7*12	=E22*\$B\$7*12	=F22*\$B\$7*12
26	Profit	=B24-B25	=C24-C25	=D24-D25	=E24-E25	=F24-F25
27	Cumulative Net Profit	=B26-B13	=B27+C26	=C27+D26	=D27+E26	=E27+F26
28						
29	Net Present Value	=NPV(B8,B26:F26)-B13				

Single Period Purchase Decisions (Newsvendor Model)

- C = purchase cost
- R = sale price
- S = salvage value
- D = demand during a single period
- Q = quantity purchased
- Net profit = $R \times \text{Quantity Sold} + S \times \text{Surplus Quantity} - C \times Q$

Newsvendor Model Spreadsheet

	A	B
1	Newsvendor Model	
2		
3	Data	
4		
5	Selling price	18
6	Cost	12
7	Discount price	9
8		
9	Model	
10		
11	Demand	41
12	Purchase Quantity	44
13		
14	Quantity Sold	=MIN(B11,B12)
15	Surplus Quantity	=MAX(0,B12-B11)
16		
17	Profit	=B14*B5+B15*B7-B12*B6

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Newsvendor Model			Demand										
2				\$ 237.00	40	41	42	43	44	45	46	47	48	49
3	Data			40	\$ 240.00	\$ 237.00	\$ 234.00	\$ 231.00	\$ 228.00	\$ 225.00	\$ 222.00	\$ 219.00	\$ 216.00	\$ 213.00
4				41	\$ 240.00	\$ 246.00	\$ 243.00	\$ 240.00	\$ 237.00	\$ 234.00	\$ 231.00	\$ 228.00	\$ 225.00	\$ 222.00
5	Selling price	\$ 18.00		42	\$ 240.00	\$ 246.00	\$ 252.00	\$ 249.00	\$ 246.00	\$ 243.00	\$ 240.00	\$ 237.00	\$ 234.00	\$ 231.00
6	Cost	\$ 12.00		43	\$ 240.00	\$ 246.00	\$ 252.00	\$ 258.00	\$ 255.00	\$ 252.00	\$ 249.00	\$ 246.00	\$ 243.00	\$ 240.00
7	Discount price	\$ 9.00		44	\$ 240.00	\$ 246.00	\$ 252.00	\$ 258.00	\$ 264.00	\$ 261.00	\$ 258.00	\$ 255.00	\$ 252.00	\$ 249.00
8				45	\$ 240.00	\$ 246.00	\$ 252.00	\$ 258.00	\$ 264.00	\$ 270.00	\$ 267.00	\$ 264.00	\$ 261.00	\$ 258.00
9	Model			46	\$ 240.00	\$ 246.00	\$ 252.00	\$ 258.00	\$ 264.00	\$ 270.00	\$ 276.00	\$ 273.00	\$ 270.00	\$ 267.00
10				47	\$ 240.00	\$ 246.00	\$ 252.00	\$ 258.00	\$ 264.00	\$ 270.00	\$ 276.00	\$ 282.00	\$ 279.00	\$ 276.00
11	Demand	41		48	\$ 240.00	\$ 246.00	\$ 252.00	\$ 258.00	\$ 264.00	\$ 270.00	\$ 276.00	\$ 282.00	\$ 288.00	\$ 285.00
12	Purchase Quantity	44		49	\$ 240.00	\$ 246.00	\$ 252.00	\$ 258.00	\$ 264.00	\$ 270.00	\$ 276.00	\$ 282.00	\$ 288.00	\$ 294.00
13														
14	Quantity Sold	41												
15	Surplus Quantity	3												
16														
17	Profit	\$ 237.00												

Monte Carlo Simulation

- The process of generating random values for uncertain inputs in a model, computing the output variables of interest, and repeating this process for many trials in order to understand the distribution of the output results.

Overbooking Decisions

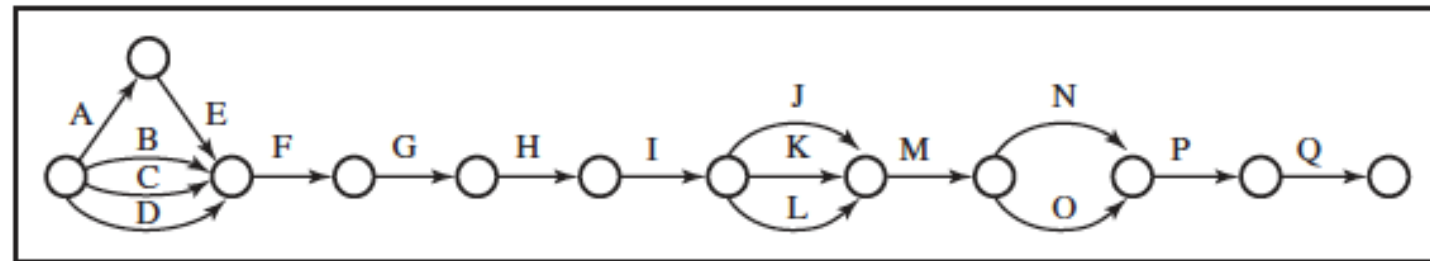
	A	B
1	Hotel Overbooking Model	
2		
3	Data	
4		
5	Rooms available	300
6	Price	\$120
7	Overbooking cost	\$100
8		
9	Model	
10		
11	Reservation limit	300
12	Customer demand	290
13	Reservations made	290
14	Cancellations	15
15	Customer arrivals	275
16	Overbooked customers	0
17		
18	Net revenue	\$33,000

	A	B
1	Hotel Overbooking Model	
2		
3	Data	
4		
5	Rooms available	300
6	Price	120
7	Overbooking cost	100
8		
9	Model	
10		
11	Reservation limit	300
12	Customer demand	290
13	Reservations made	=MIN(B11,B12)
14	Cancellations	15
15	Customer arrivals	=B13-B14
16	Overbooked customers	=MAX(0,B15-B5)
17		
18	Net revenue	=MIN(B15,B5)*B6-B16*B7

Project Management

TABLE 9.1 Activity and Time Estimate List

	Activity	Predecessors	Activity Time
A	Select steering committee	—	15
B	Develop requirements list	—	50
C	Develop system size estimates	—	20
D	Determine prospective vendors	—	3
E	Form evaluation team	A	7
F	Issue request for proposal	B,C,D,E	6
G	Bidders conference	F	1
H	Review submissions	G	36
I	Select vendor short list	H	6
J	Check vendor references	I	6
K	Vendor demonstrations	I	32
L	User site visit	I	4
M	Select vendor	J,K,L	3
N	Volume-sensitive test	M	15
O	Negotiate contracts	M	18
P	Cost-benefit analysis	N,O	2
Q	Obtain board of directors approval	P	5



Spreadsheet Model

	A	B	C	D	E	F	G	H
1	Becker Consulting Project Management Model							
2								
3		<i>Activity</i>	<i>Early</i>	<i>Early</i>	<i>Latest</i>	<i>Latest</i>		<i>On Critical</i>
4	<i>Activity</i>	<i>Time</i>	<i>Start</i>	<i>Finish</i>	<i>Start</i>	<i>Finish</i>	<i>Slack</i>	<i>Path?</i>
5	A	15.00	0.00	15.00	28.00	43.00	28.00	0
6	B	50.00	0.00	50.00	0.00	50.00	0.00	1
7	C	20.00	0.00	20.00	30.00	50.00	30.00	0
8	D	3.00	0.00	3.00	47.00	50.00	47.00	0
9	E	7.00	15.00	22.00	43.00	50.00	28.00	0
10	F	6.00	50.00	56.00	50.00	56.00	0.00	1
11	G	1.00	56.00	57.00	56.00	57.00	0.00	1
12	H	36.00	57.00	93.00	57.00	93.00	0.00	1
13	I	6.00	93.00	99.00	93.00	99.00	0.00	1
14	J	6.00	99.00	105.00	125.00	131.00	26.00	0
15	K	32.00	99.00	131.00	99.00	131.00	0.00	1
16	L	4.00	99.00	103.00	127.00	131.00	28.00	0
17	M	3.00	131.00	134.00	131.00	134.00	0.00	1
18	N	15.00	134.00	149.00	137.00	152.00	3.00	0
19	O	18.00	134.00	152.00	134.00	152.00	0.00	1
20	P	2.00	152.00	154.00	152.00	154.00	0.00	1
21	Q	5.00	154.00	159.00	154.00	159.00	0.00	1
22								
23	Project completion time			159.00				

Model Formulas

	A	B	C	D	E	F	G	H
1	Becker Consulting I							
2								
3		Activity	Early	Early	Latest	Latest		On Critical
4	Activity	Time	Start	Finish	Start	Finish	Slack	Path?
5	A	15	0	=C5+B5	=F5-B5	=E9	=F5-D5	=IF(G5<0.0001,1,0)
6	B	50	0	=C6+B6	=F6-B6	=E10	=F6-D6	=IF(G6<0.0001,1,0)
7	C	20	0	=C7+B7	=F7-B7	=E10	=F7-D7	=IF(G7<0.0001,1,0)
8	D	3	0	=C8+B8	=F8-B8	=E10	=F8-D8	=IF(G8<0.0001,1,0)
9	E	7	=D5	=C9+B9	=F9-B9	=E10	=F9-D9	=IF(G9<0.0001,1,0)
10	F	6	=MAX(D6,D7,D8,D9)	=C10+B10	=F10-B10	=E11	=F10-D10	=IF(G10<0.0001,1,0)
11	G	1	=D10	=C11+B11	=F11-B11	=E12	=F11-D11	=IF(G11<0.0001,1,0)
12	H	36	=D11	=C12+B12	=F12-B12	=E13	=F12-D12	=IF(G12<0.0001,1,0)
13	I	6	=D12	=C13+B13	=F13-B13	=MIN(E14,E15,E16)	=F13-D13	=IF(G13<0.0001,1,0)
14	J	6	=D13	=C14+B14	=F14-B14	=E17	=F14-D14	=IF(G14<0.0001,1,0)
15	K	32	=D13	=C15+B15	=F15-B15	=E17	=F15-D15	=IF(G15<0.0001,1,0)
16	L	4	=D13	=C16+B16	=F16-B16	=E17	=F16-D16	=IF(G16<0.0001,1,0)
17	M	3	=MAX(D14,D15,D16)	=C17+B17	=F17-B17	=MIN(E18,E19)	=F17-D17	=IF(G17<0.0001,1,0)
18	N	15	=D17	=C18+B18	=F18-B18	=E20	=F18-D18	=IF(G18<0.0001,1,0)
19	O	18	=D17	=C19+B19	=F19-B19	=E20	=F19-D19	=IF(G19<0.0001,1,0)
20	P	2	=MAX(D18,D19)	=C20+B20	=F20-B20	=E21	=F20-D20	=IF(G20<0.0001,1,0)
21	Q	5	=D20	=C21+B21	=F21-B21	=D21	=F21-D21	=IF(G21<0.0001,1,0)
22								
23		Project completion time		=D21				

Model Assumptions, Complexity, and Realism

- All models reflect assumptions used by the modeler.
- Assumptions simplify models and make them easier to manipulate and solve
- Assumptions should be as realistic as necessary to make models useful but not overly complex
- Assumptions should be clearly stated and documented

Example: Retirement Planning

	A	B	C	D	E
1	Retirement Plan Model				
2					
3	Data				
4	Retirement contribution (% of salary)	8%			
5	Employer match	35%			
6	Annual salary increase	4%			
7	Annual return on investment	8%			
8					
9	Model		Employee	Employer	
10		Age Salary	Contribution	Contribution	Balance
11		25 \$ 50,000	\$4,000	\$1,400	\$5,400
12		26 \$ 52,000	\$4,160	\$1,456	\$11,448
13		27 \$ 54,080	\$4,326	\$1,514	\$18,204
14		28 \$ 56,243	\$4,499	\$1,575	\$25,735
15		29 \$ 58,493	\$4,679	\$1,638	\$34,111
16		30 \$ 60,833	\$4,867	\$1,703	\$43,410
17		31 \$ 63,266	\$5,061	\$1,771	\$53,715
18		32 \$ 65,797	\$5,264	\$1,842	\$65,119
19		33 \$ 68,428	\$5,474	\$1,916	\$77,719
20		34 \$ 71,166	\$5,693	\$1,993	\$91,622
21		35 \$ 74,012	\$5,921	\$2,072	\$106,945
22		36 \$ 76,973	\$6,158	\$2,155	\$123,814
23		37 \$ 80,052	\$6,404	\$2,241	\$142,364
24		38 \$ 83,254	\$6,660	\$2,331	\$162,745
25		39 \$ 86,584	\$6,927	\$2,424	\$185,115
26		40 \$ 90,047	\$7,204	\$2,521	\$209,650
27		41 \$ 93,649	\$7,492	\$2,622	\$236,536
28		42 \$ 97,395	\$7,792	\$2,727	\$265,977
29		43 \$ 101,291	\$8,103	\$2,836	\$298,195
30		44 \$ 105,342	\$8,427	\$2,950	\$333,428
31		45 \$ 109,556	\$8,764	\$3,068	\$371,934
32		46 \$ 113,938	\$9,115	\$3,190	\$413,994
33		47 \$ 118,496	\$9,480	\$3,318	\$459,911
34		48 \$ 123,236	\$9,859	\$3,451	\$510,013
35		49 \$ 128,165	\$10,253	\$3,589	\$564,656
36		50 \$ 133,292	\$10,663	\$3,732	\$624,224

	A	B	C	D	E
1	Retirement Plan Model				
2					
3	Data				
4	Retirement contribution (% of salary)	0.08			
5	Employer match	0.35			
6	Annual salary increase	0.04			
7	Annual return on investment	0.08			
8					
9	Model		Employee	Employer	
10		Age Salary	Contribution	Contribution	Balance
11	25	50000	=B11*\$B\$4	=\$B\$5*C11	=C11+D11
12	26	= B11*(1+\$B\$6)	=B12*\$B\$4	=\$B\$5*C12	=E11*(1+\$B\$7) + C12+D12
13	27	= B12*(1+\$B\$6)	=B13*\$B\$4	=\$B\$5*C13	=E12*(1+\$B\$7) + C13+D13
14	28	= B13*(1+\$B\$6)	=B14*\$B\$4	=\$B\$5*C14	=E13*(1+\$B\$7) + C14+D14

- **Decision Models:** Representations used to analyze and facilitate decision-making processes, including descriptive and prescriptive (optimization) models.
- **What-If Analysis:** Evaluates how specific combinations of model inputs affect model outputs, often referred to as sensitivity analysis.
- **Excel Tools:** Includes data tables, scenario manager, and goal seek to analyze model outcomes and optimize decisions.
- **Common Mathematical Functions:** Linear, logarithmic, polynomial, power, and exponential functions used in decision models.
- **Monte Carlo Simulation:** Generates random values for uncertain inputs in a model, computes output variables, and repeats the process to understand output distributions.
- **Spreadsheet Engineering:** Involves improving spreadsheet design, development process, and using tools like data validation to ensure accurate results.

Review Questions

1. What is a decision model?
2. What are the key tools in Excel for performing what-if analysis?
3. What is the purpose of Monte Carlo Simulation in decision models?



Thank You