Chapter 14

Sales and Operations Planning

Operations Management - 6th Edition

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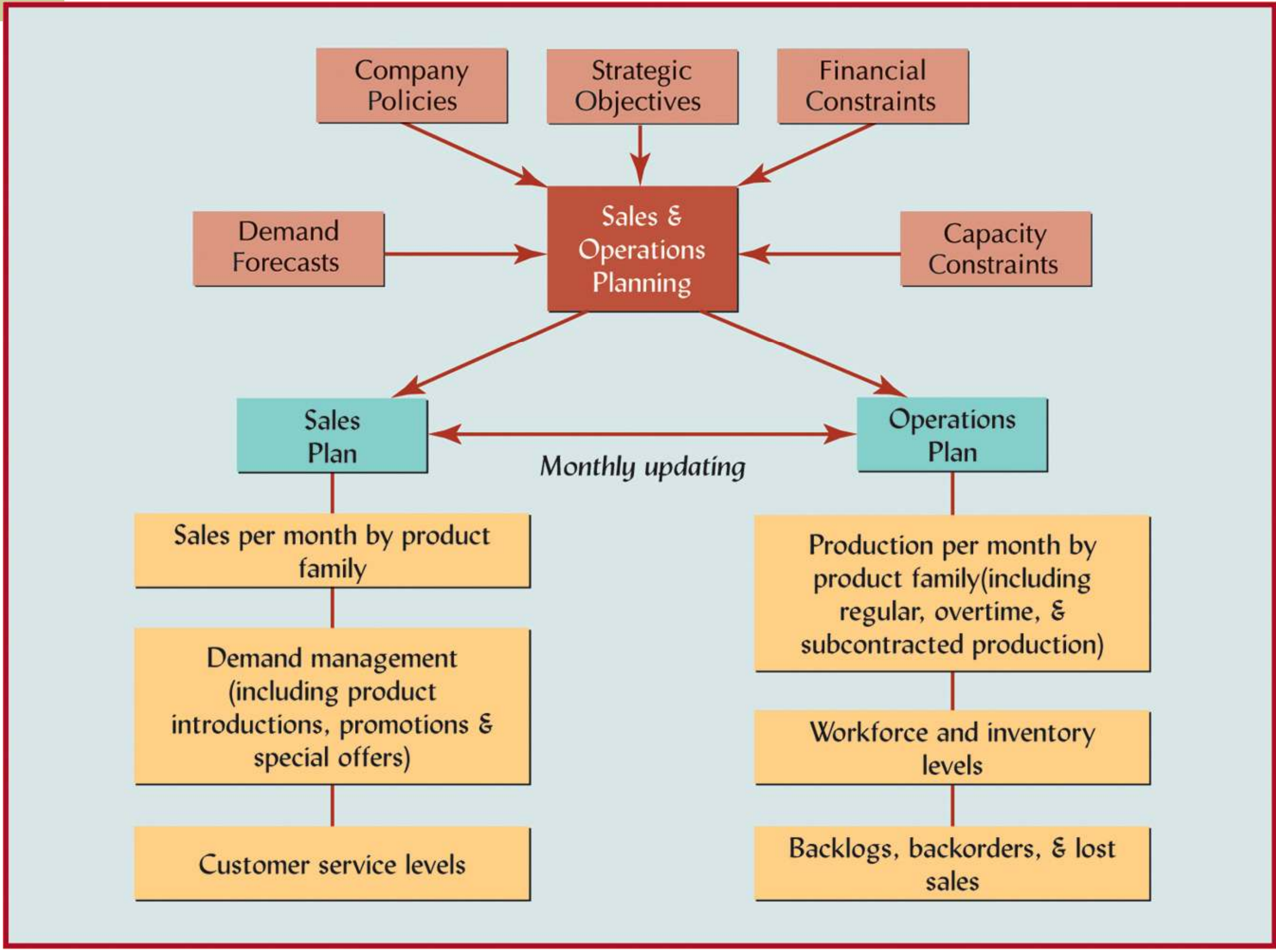
Lecture Outline

- The Sales and Operations Planning Process
- Strategies for Adjusting Capacity
- Strategies for Managing Demand
- Quantitative Techniques for Aggregate Planning
- Hierarchical Nature of Planning
- Aggregate Planning for Services

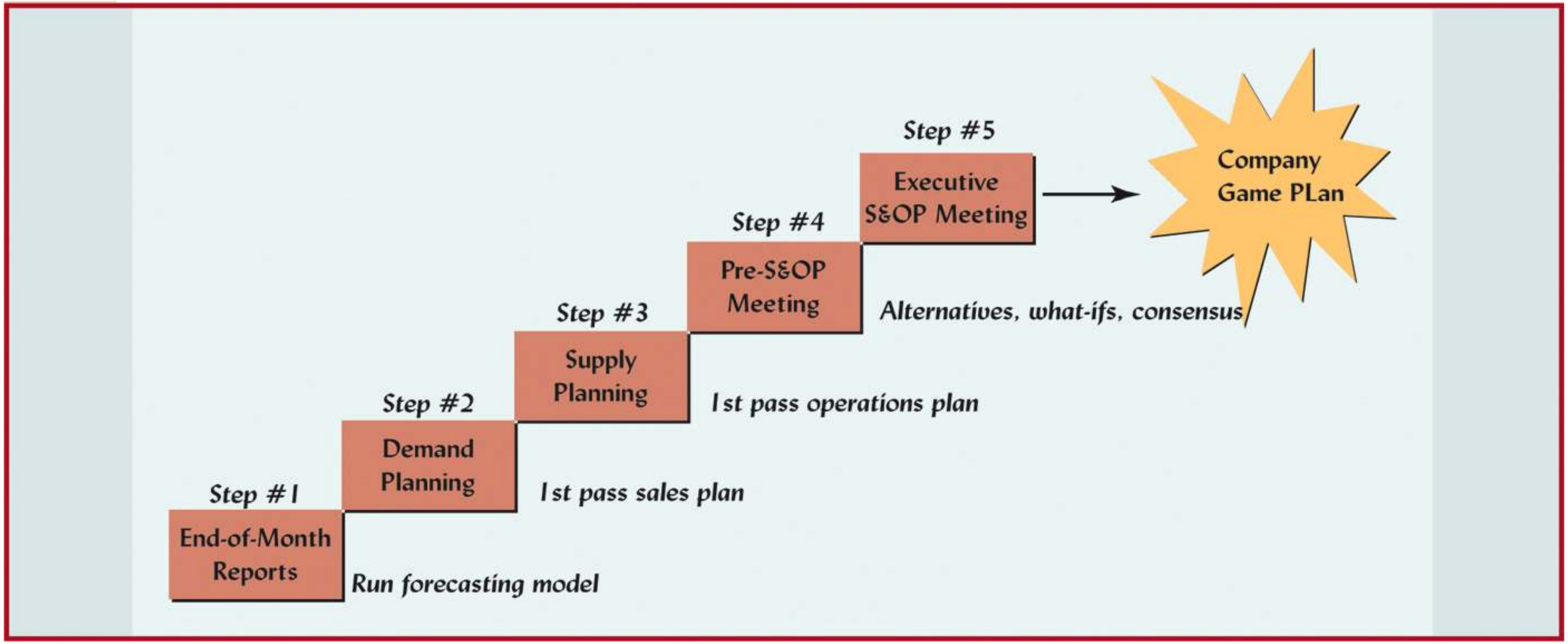
Sales and Operations Planning

- Determines the resource capacity needed to meet demand over an intermediate time horizon
  - *Aggregate* refers to sales and operations planning for product lines or families
  - *Sales and Operations planning (S&OP)* matches supply and demand
- Objectives
  - Establish a company wide game plan for allocating resources
  - Develop an economic strategy for meeting demand

Sales and Operations Planning Process



The Monthly S&OP Planning Process



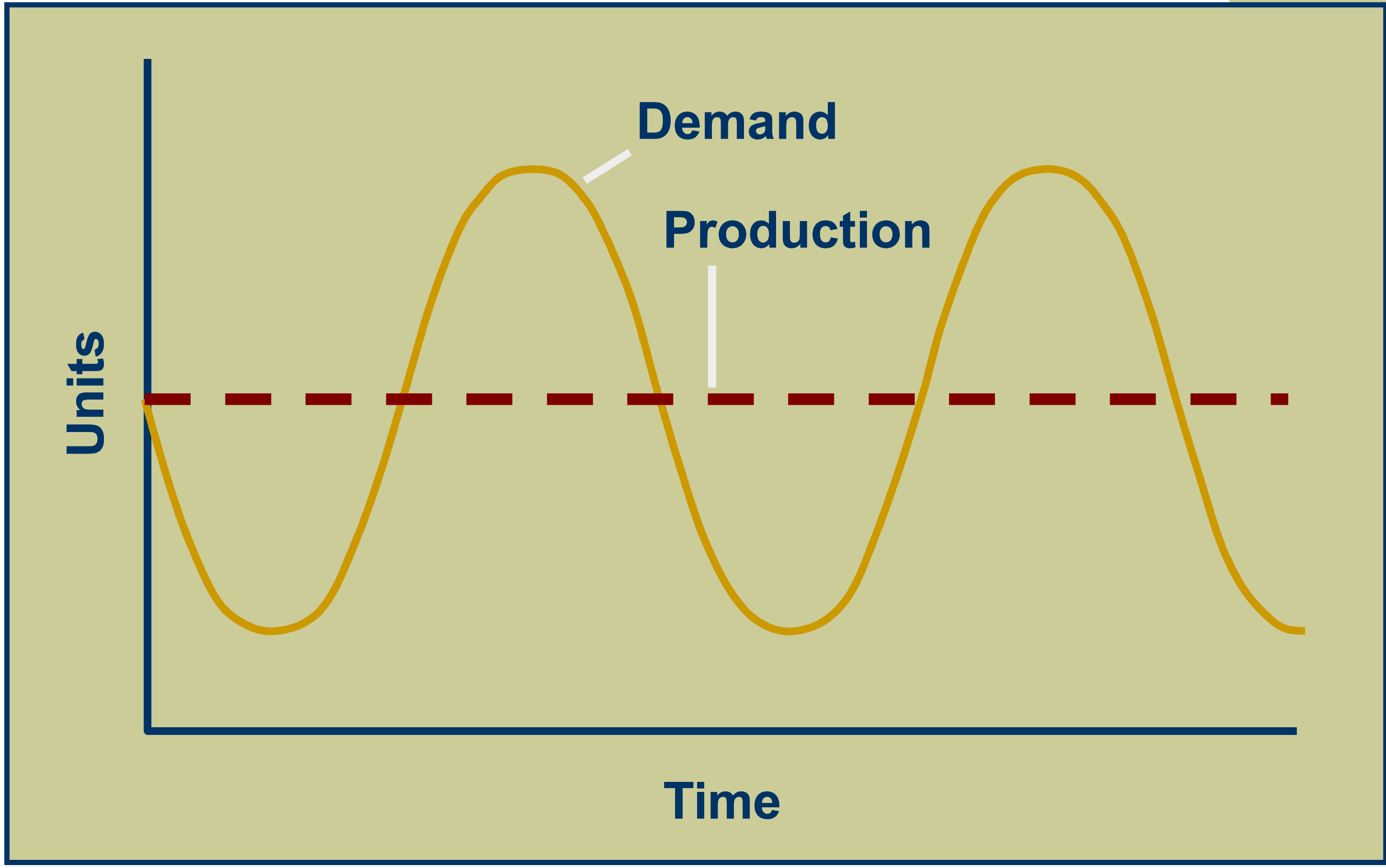
Meeting Demand Strategies

- Adjusting capacity
  - Resources necessary to meet demand are acquired and maintained over the time horizon of the plan
  - Minor variations in demand are handled with overtime or under-time
- Managing demand
  - Proactive demand management

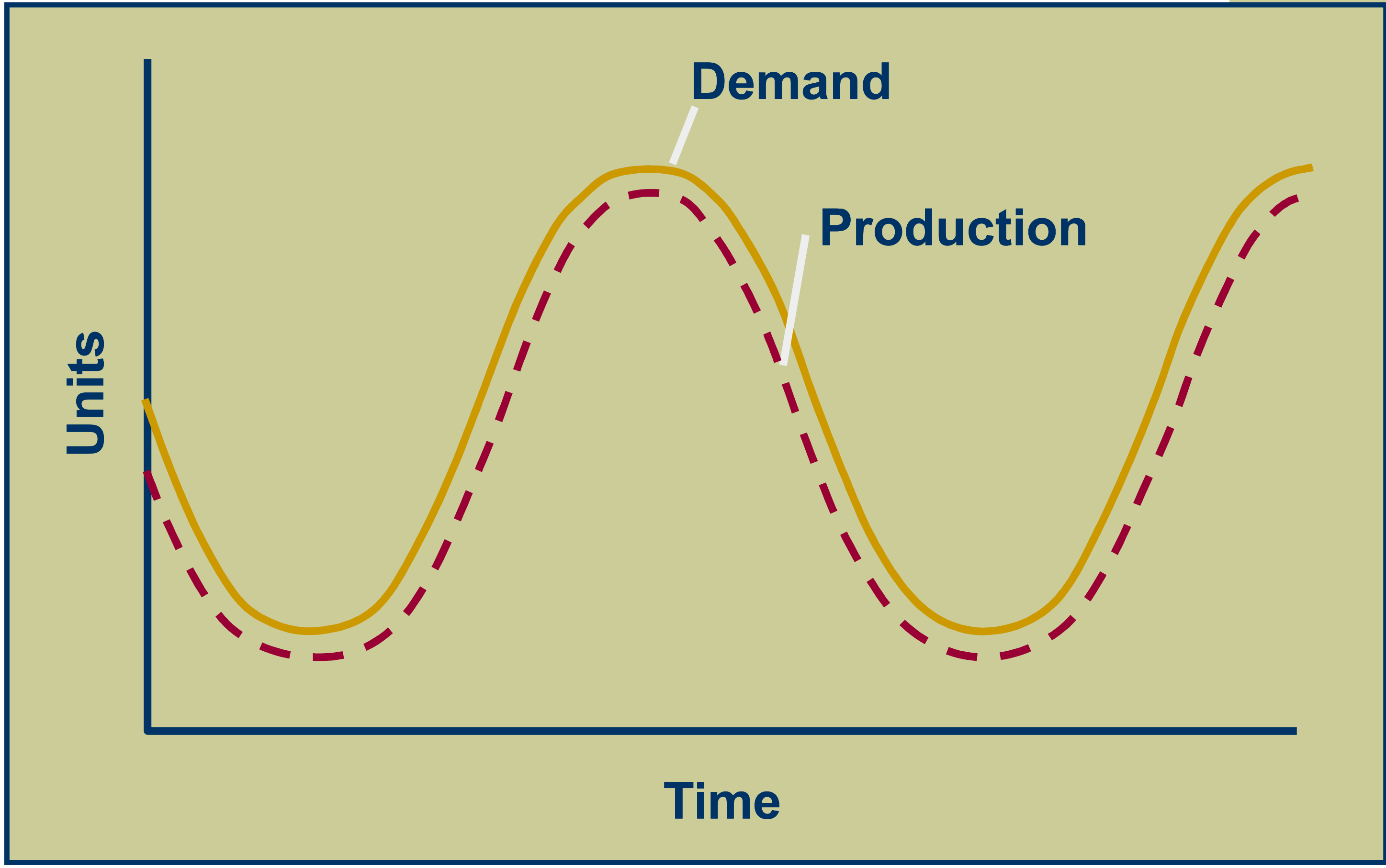
Strategies for Adjusting Capacity

- Level production
  - Producing at a constant rate and using inventory to absorb fluctuations in demand
- Chase demand
  - Hiring and firing workers to match demand
- Peak demand
  - Maintaining resources for high-demand levels
- Overtime and under-time
  - Increasing or decreasing working hours
- Subcontracting
  - Let outside companies complete the work
- Part-time workers
  - Hiring part time workers to complete the work
- Backordering
  - Providing the service or product at a later time period

Level Production



Chase Demand



Strategies for Managing Demand

- Shifting demand into other time periods
  - Incentives
  - Sales promotions
  - Advertising campaigns
- Offering products or services with counter-cyclical demand patterns
- Partnering with suppliers to reduce information distortion along the supply chain

Quantitative Techniques For AP

- Pure Strategies
- Mixed Strategies
- Linear Programming
- Transportation Method
- Other Quantitative Techniques

Pure Strategies

Example:

QUARTER	SALES FORECAST (LB)
Spring	80,000
Summer	50,000
Fall	120,000
Winter	150,000

Hiring cost = $100 per worker
Firing cost = $500 per worker
Inventory carrying cost = $0.50 pound per quarter
Regular production cost per pound = $2.00
Production per employee = 1,000 pounds per quarter
Beginning work force = 100 workers

Level Production Strategy

Level production

$$\frac{(50{,}000 + 120{,}000 + 150{,}000 + 80{,}000)}{4} = 100{,}000 \text{ pounds}$$

QUARTER	SALES FORECAST	PRODUCTION PLAN	INVENTORY
Spring	80,000	100,000	20,000
Summer	50,000	100,000	70,000
Fall	120,000	100,000	50,000
Winter	150,000	100,000	0
		400,000	140,000

Cost of Level Production Strategy

(400,000 X $2.00) + (140,00 X $.50) = $870,000

Chase Demand Strategy

QUARTER	SALES FORECAST	PRODUCTION PLAN	WORKERS NEEDED	WORKERS HIRED	WORKERS FIRED
Spring	80,000	80,000	80	0	20
Summer	50,000	50,000	50	0	30
Fall	120,000	120,000	120	70	0
Winter	150,000	150,000	150	30	0
				100	50

Cost of Chase Demand Strategy

(400,000 X $2.00) + (100 x $100) + (50 x $500) = $835,000

Level Production with Excel

Microsoft Excel - Exhibit 14.1

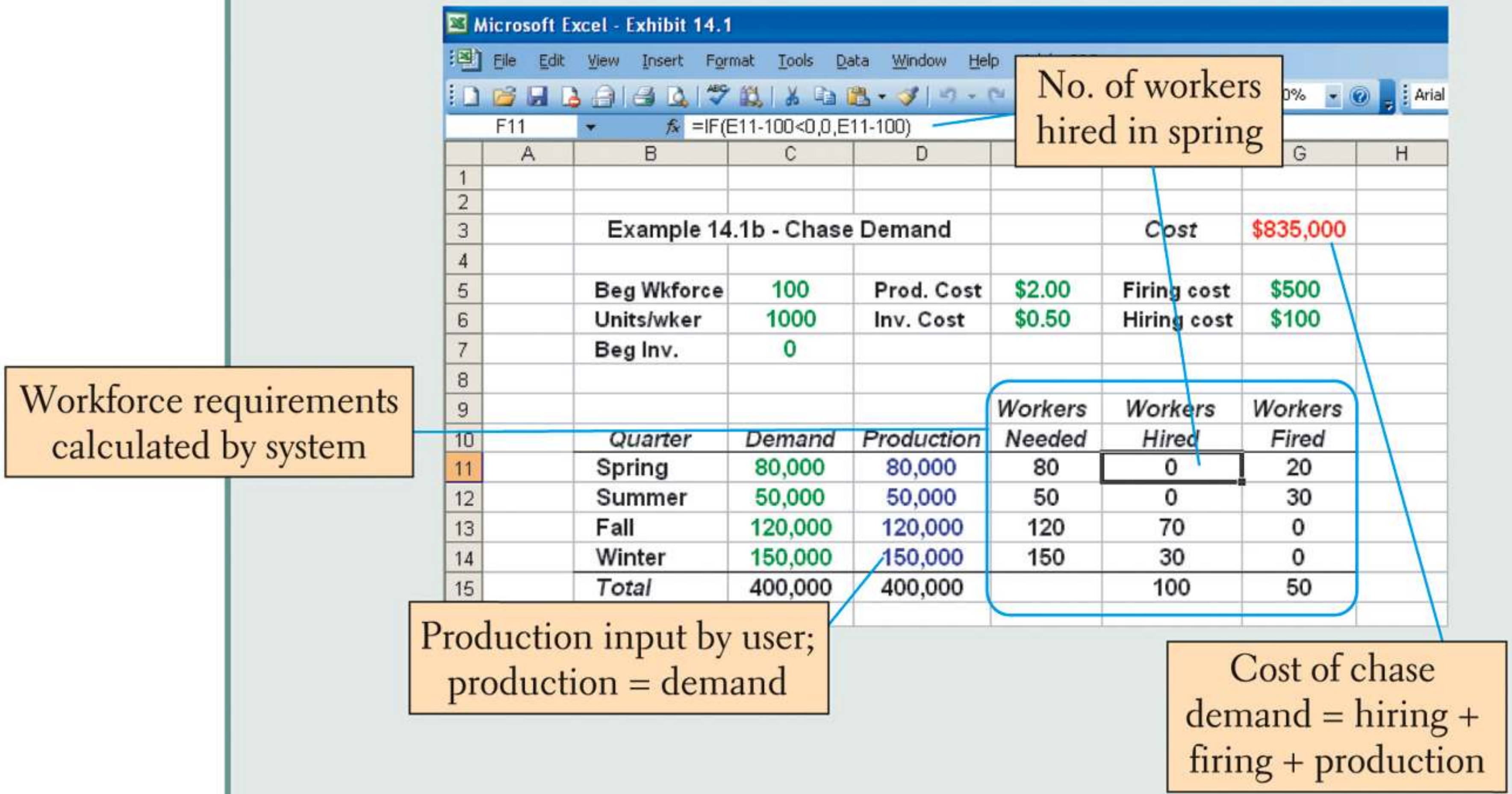
F12 =F11+E12-D12

	A	B	C	D	E	F	G	H
1								
2								
3		Example 14.1a - Level Production				Cost	$870,000	
4								
5		Beg Wkforce	100	Prod. Cost	$2.00	Firing cost	$500	
6		Units/wker	1000	Inv. Cost	$0.50	Hiring cost	$100	
7		Beg Inv.	0					
8								
9								
10			*Quarter*	*Demand*	*Production*	*Inventory*		
11			Spring	80,000	100,000	20,000		
12			Summer	50,000	100,000	70,000		
13			Fall	120,000	100,000	50,000		
14			Winter	150,000	100,000	0		
15			*Total*	400,000	400,000	140,000		
16								

Inventory at end of summer

Input by user; 400,000/4

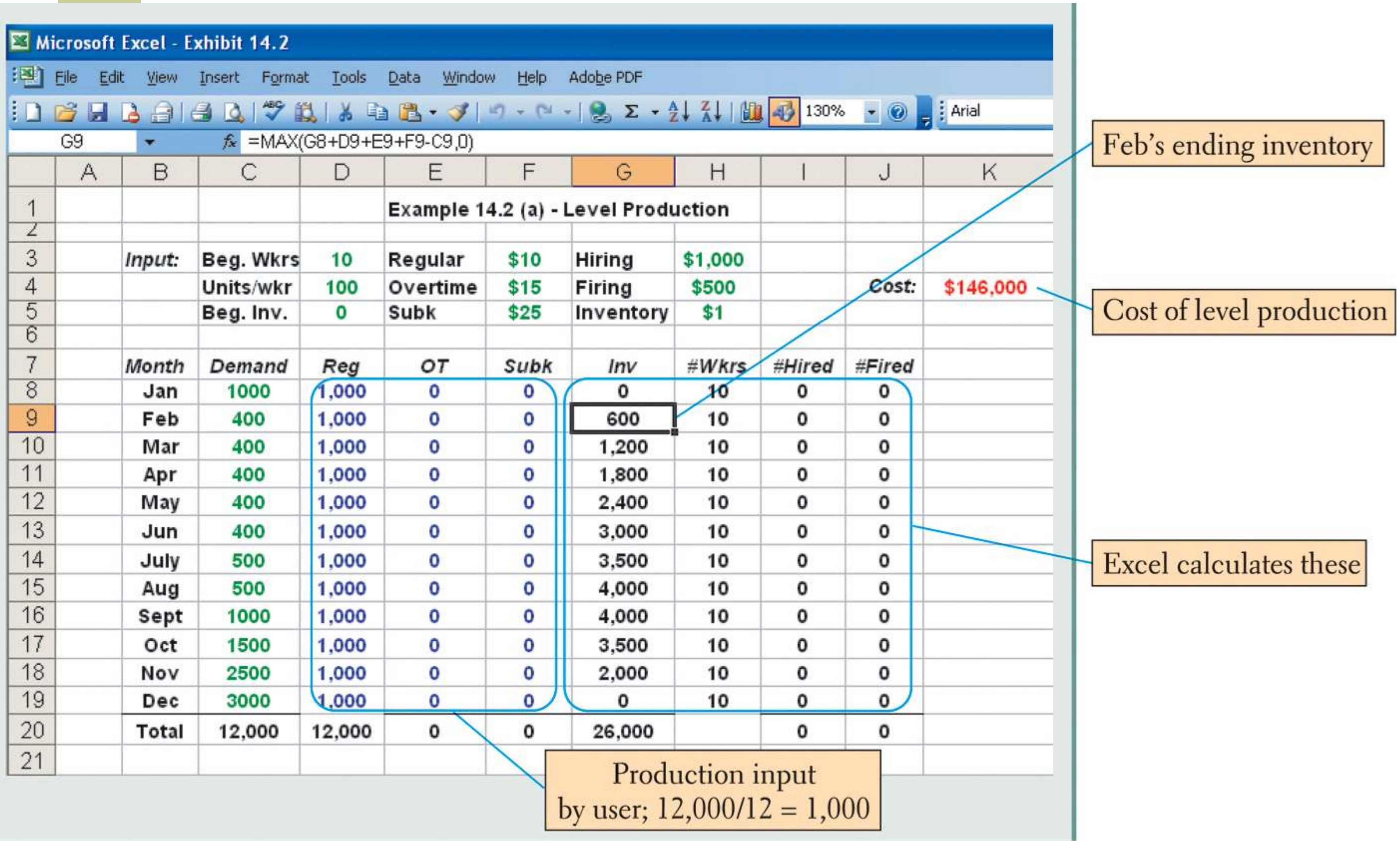
Chase Demand with Excel



Mixed Strategy

- Combination of Level Production and Chase Demand strategies
- Examples of management policies
  - no more than *x*% of the workforce can be laid off in one quarter
  - inventory levels cannot exceed *x* dollars
- Many industries may simply shut down manufacturing during the low demand season and schedule employee vacations during that time

Mixed Strategies with Excel


Microsoft Excel - Exhibit 14.2

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G9 =MAX(G8+D9+E9+F9-C9,0)

	A	B	C	D	E	F	G	H	I	J	K
1					Example 14.2 (a) - Level Production						
2											
3		*Input:*	Beg. Wkrs	10	Regular	$10	Hiring	$1,000			
4			Units/wkr	100	Overtime	$15	Firing	$500		*Cost:*	$146,000
5			Beg. Inv.	0	Subk	$25	Inventory	$1			
6											
7		*Month*	*Demand*	*Reg*	*OT*	*Subk*	*Inv*	*#Wkrs*	*#Hired*	*#Fired*	
8		Jan	1000	1,000	0	0	0	10	0	0	
9		Feb	400	1,000	0	0	600	10	0	0	
10		Mar	400	1,000	0	0	1,200	10	0	0	
11		Apr	400	1,000	0	0	1,800	10	0	0	
12		May	400	1,000	0	0	2,400	10	0	0	
13		Jun	400	1,000	0	0	3,000	10	0	0	
14		July	500	1,000	0	0	3,500	10	0	0	
15		Aug	500	1,000	0	0	4,000	10	0	0	
16		Sept	1000	1,000	0	0	4,000	10	0	0	
17		Oct	1500	1,000	0	0	3,500	10	0	0	
18		Nov	2500	1,000	0	0	2,000	10	0	0	
19		Dec	3000	1,000	0	0	0	10	0	0	
20		Total	12,000	12,000	0	0	26,000		0	0	
21											

Mixed Strategies with Excel (cont.)

Microsoft Excel - Exhibit 14.2

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I9 =MAX(H9-H8,0)

	A	B	C	D	E	F	G	H	I	J	K
1					Example 14.2 (b) - Chase Demand						
2											
3		*Input:*	Beg. Wkrs	10	Regular	$10	Hiring	$1,000			
4			Units/wkr	100	Overtime	$15	Firing	$500		*Cost:*	$149,000
5			Beg. Inv.	0	Subk	$25	Inventory	$1			
6											
7		*Month*	*Demand*	*Reg*	*OT*	*Subk*	*Inv*	*#Wkrs*	*#Hired*	*#Fired*	
8		Jan	1000	1000	0	0	0	10	0	0	
9		Feb	400	400	0	0	0	4	0	6	
10		Mar	400	400	0	0	0	4	0	0	
11		Apr	400	400	0	0	0	4	0	0	
12		May	400	400	0	0	0	4	0	0	
13		Jun	400	400	0	0	0	4	0	0	
14		July	500	500	0	0	0	5	1	0	
15		Aug	500	500	0	0	0	5	0	0	
16		Sept	1000	1000	0	0	0	10	5	0	
17		Oct	1500	1500	0	0	0	15	5	0	
18		Nov	2500	2500	0	0	0	25	10	0	
19		Dec	3000	3000	0	0	0	30	5	0	
20		Total	12,000	12,000	0	0	0		26	6	
21											

No. of workers hired in Feb.

Input by user; production = demand

Calculated by Excel

Cost of chase demand

General Linear Programming (LP) Model

- LP gives an optimal solution, but demand and costs must be linear
- *Let*
  - W_t = workforce size for period t
  - P_t =units produced in period t
  - I_t =units in inventory at the end of period t
  - F_t =number of workers fired for period t
  - H_t = number of workers hired for period t

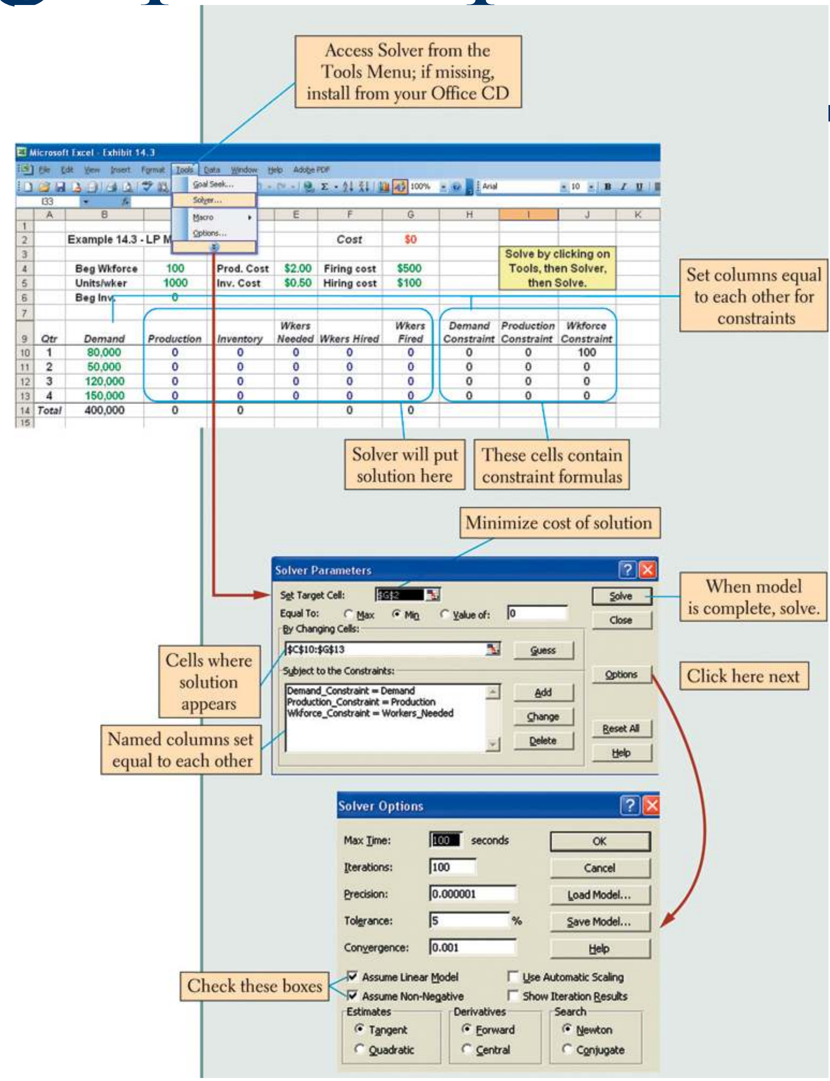
LP MODEL

Minimize $Z = \$100\,(H_1 + H_2 + H_3 + H_4)$
$+ \$500\,(F_1 + F_2 + F_3 + F_4)$
$+ \$0.50\,(I_1 + I_2 + I_3 + I_4)$
$+ \$2\,(P_1 + P_2 + P_3 + P_4)$

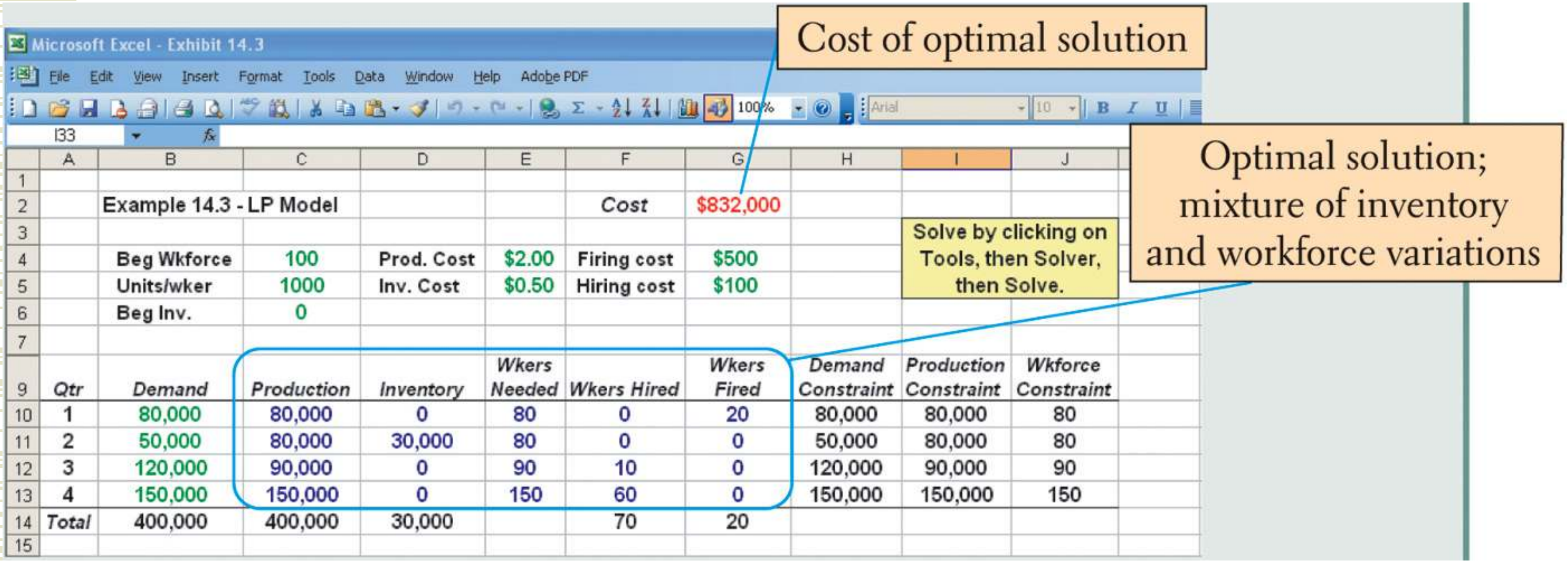
Subject to

	$P_1 - I_1 = 80{,}000$	(1)
Demand	$I_1 + P_2 - I_2 = 50{,}000$	(2)
constraints	$I_2 + P_3 - I_3 = 120{,}000$	(3)
	$I_3 + P_4 - I_4 = 150{,}000$	(4)
Production	$1000\,W_1 = P_1$	(5)
constraints	$1000\,W_2 = P_2$	(6)
	$1000\,W_3 = P_3$	(7)
	$1000\,W_4 = P_4$	(8)
	$100 + H_1 - F_1 = W_1$	(9)
Work force	$W_1 + H_2 - F_2 = W_2$	(10)
constraints	$W_2 + H_3 - F_3 = W_3$	(11)
	$W_3 + H_4 - F_4 = W_4$	(12)

Setting up the Spreadsheet



The LP Solution



Example 14.3 - LP Model — Cost: $832,000

Beg Wkforce	100	Prod. Cost	$2.00	Firing cost	$500
Units/wker	1000	Inv. Cost	$0.50	Hiring cost	$100
Beg Inv.	0				

Qtr	Demand	Production	Inventory	Wkers Needed	Wkers Hired	Wkers Fired	Demand Constraint	Production Constraint	Wkforce Constraint
1	80,000	80,000	0	80	0	20	80,000	80,000	80
2	50,000	80,000	30,000	80	0	0	50,000	80,000	80
3	120,000	90,000	0	90	10	0	120,000	90,000	90
4	150,000	150,000	0	150	60	0	150,000	150,000	150
Total	400,000	400,000	30,000		70	20			

Transportation Method

QUARTER	EXPECTED DEMAND	REGULAR CAPACITY	OVERTIME CAPACITY	SUBCONTRACT CAPACITY
1	900	1000	100	500
2	1500	1200	150	500
3	1600	1300	200	500
4	3000	1300	200	500

Regular production cost per unit	$20
Overtime production cost per unit	$25
Subcontracting cost per unit	$28
Inventory holding cost per unit per period	$3
Beginning inventory	300 units

Transportation Tableau

PERIOD OF PRODUCTION		PERIOD OF USE 1	2	3	4	Unused Capacity	Capacity
1	Beginning Inventory	300 (0)	— (3)	— (6)	— (9)		300
	Regular	600 (20)	300 (23)	100 (26)	— (29)		1000
	Overtime	(25)	(28)	(31)	100 (34)		100
	Subcontract	(28)	(31)	(34)	(37)		500
2	Regular	X	1200 (20)	— (23)	— (26)		1200
	Overtime	X	(25)	(28)	150 (31)		150
	Subcontract	X	(28)	(31)	250 (34)	250	500
3	Regular	X	X	1300 (20)	— (23)		1300
	Overtime	X	X	200 (25)	— (28)		200
	Subcontract	X	X	(28)	500 (31)		500
4	Regular	X	X	X	1300 (20)		1300
	Overtime	X	X	X	200 (25)		200
	Subcontract	X	X	X	500 (28)		500
	Demand	900	1500	1600	3000	250	

Burruss' Production Plan

PERIOD	DEMAND	REGULAR PRODUCTION	OVERTIME	SUB-CONTRACT	ENDING INVENTORY
1	900	1000	100	0	500
2	1500	1200	150	250	600
3	1600	1300	200	500	1000
4	3000	1300	200	500	0
Total	7000	4800	650	1250	2100

Using Excel for the Transportation Method of Aggregate Planning

Microsoft Excel - Exhibit 14.4

Exhibit 14.4 - The Transportation Method of Aggregate Planning

Period of Production		Period of Use 1		2		3		4		Units Produced	Capacity	Unused Capacity
	Beg. Inventory	300	0	0	3	0	6	0	9	300	300	0
1	Regular	600	20	0	23	0	26	400	29	1,000	1,000	0
	Overtime	0	25	0	28	0	31	0	34	0	100	100
	Subk	0	28	0	31	0	34	0	37	0	500	500
2	Regular	0		1,000	20	0	23	200	26	1,200	1,200	0
	Overtime	0		150	25	0	28	0	31	150	150	0
	Subk	0		350	28	0	31	0	34	350	500	150
3	Regular	0		0		900	20	400	23	1,300	1,300	0
	Overtime	0		0		200	25	0	28	200	200	0
	Subk	0		0		500	28	0	31	500	500	0
4	Regular	0		0		0		1,300	20	1,300	1,300	0
	Overtime	0		0		0		200	25	200	200	0
	Subk	0		0		0		500	28	500	500	0
	Units Produced	900		1,500		1,600		3,000		7,000	7,000	750
	Demand	900		1,500		1,600		3,000		7,000		
	Unmet Demand	0		0		0		0			Total Cost =	$153,550

Production Plan

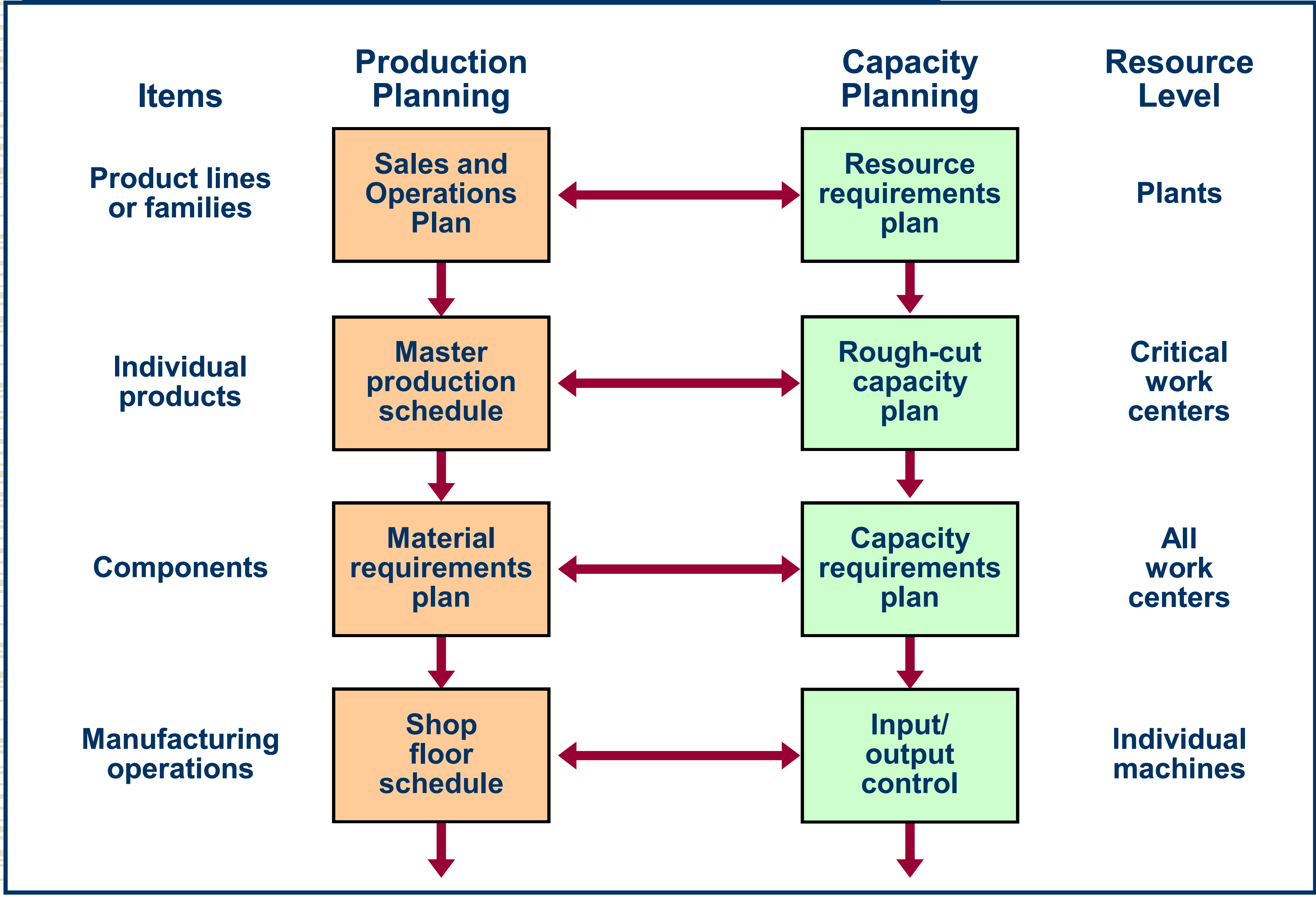
Period	Demand	Reg. Prod.	Overtime	Subk	Ending Inventory
1	900	1,000	0	0	400
2	1,500	1,200	150	350	600
3	1,600	1,300	200	500	1,000
4	3,000	1,300	200	500	0
Total	7,000	4,800	550	1,350	2,000

Total Cost = $153,550

Other Quantitative Techniques

- Linear decision rule (LDR)
- Search decision rule (SDR)
- Management coefficients model

Hierarchical Nature of Planning



- Disaggregation: process of breaking an aggregate plan into more detailed plans

Collaborative Planning

- Sharing information and synchronizing production across supply chain
- Part of CPFR (collaborative planning, forecasting, and replenishment)
  - involves selecting products to be jointly managed, creating a single forecast of customer demand, and synchronizing production across supply chain

Available-to-Promise (ATP)

- Quantity of items that can be promised to customer
- Difference between planned production and customer orders already received

AT in period 1 = (On-hand quantity + MPS in period 1) –
(CO until the next period of planned production)

ATP in period n = (MPS in period *n*) –
(CO until the next period of planned production)

- Capable-to-promise
  - quantity of items that can be produced and mad available at a later date

ATP: Example

Aggregate Production Plan

	Quarter			
Product Family	*1*	*2*	*3*	*4*
Juvenile Bikes	800	1,000	1,500	4,000

Master Production Schedule

	April	**May**	**June**	**Total**
Boys 26”	150	100	150	400
Girls 26”	100	100	100	300
Boys 20”	30	20	50	100
Girls 20”	40	20	140	200
Total	320	240	440	1000

ATP: Example (cont.)

Available-to-Promise for Girls 26" Bike

On Hand = 10	*April*	*May*	*June*	*Total*
Forecast	50	100	150	300
Customer Orders				
Master Production Schedule	100	100	100	300
Available-to-Promise				

On Hand = 10	*April*	*May*	*June*	*Total*
Forecast	50	100	150	300
Customer Orders	**70**	**110**	**50**	**230**
Master Production Schedule	100	100	100	300
Available-to-Promise				

ATP: Example (cont.)

On Hand = 10	April	May	June	Total
Forecast	50	100	150	300
Customer Orders	**70**	**110**	**50**	**230**
Master Production Schedule	100	100	100	300
Available-to-Promise	**30**	**0**	**50**	**80**

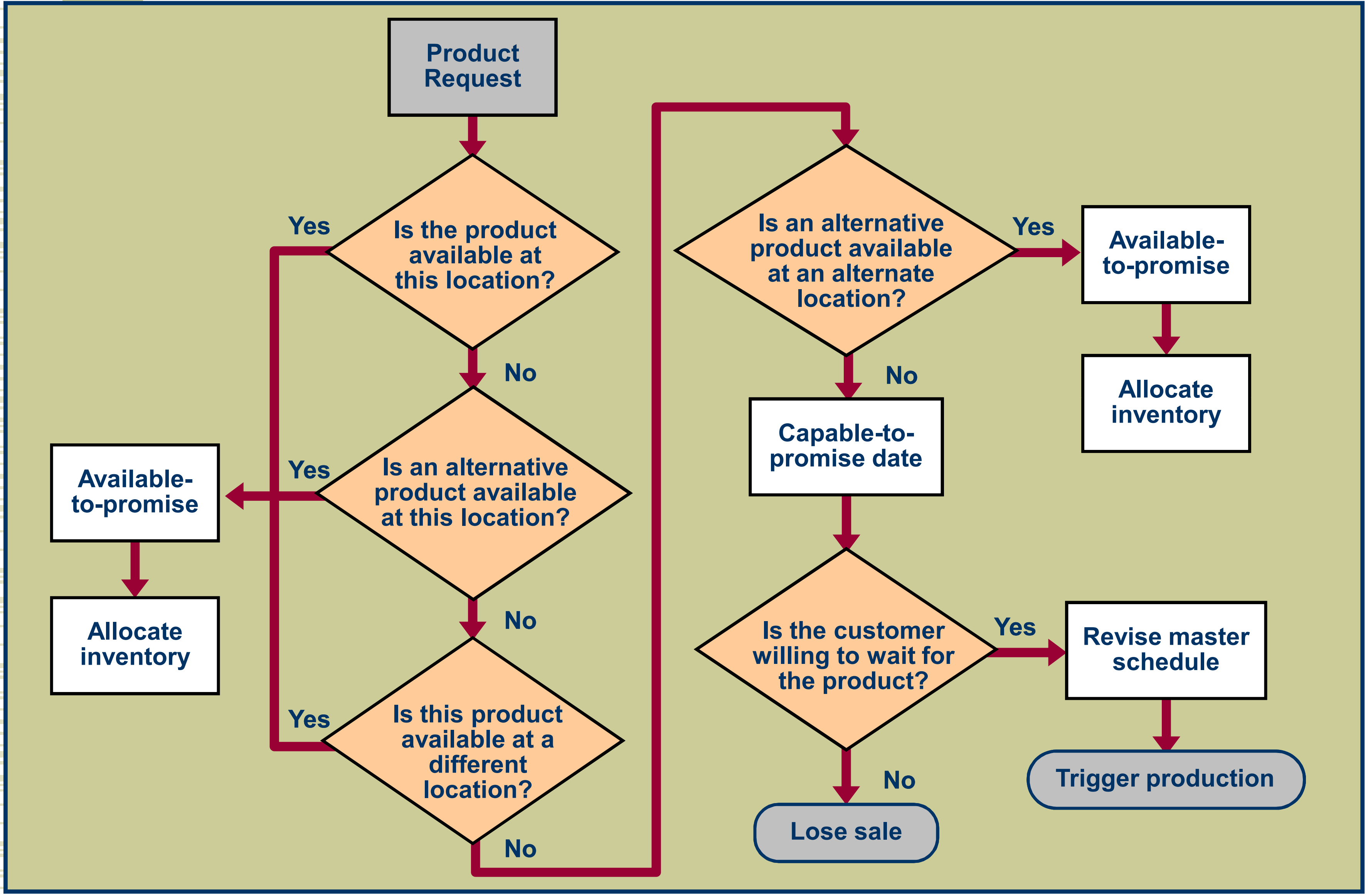
Take excess units from April

ATP in April = (10+100) – 70 = ~~40~~ = 30

ATP in May = 100 – 110 = -~~10~~ = 0

ATP in June = 100 – 50 = 50

Rule Based ATP



Aggregate Planning for Services

1. Most services cannot be inventoried
2. Demand for services is difficult to predict
3. Capacity is also difficult to predict
4. Service capacity must be provided at the appropriate place and time
5. Labor is usually the most constraining resource for services

Yield Management

Type of Problem	Type of Business	Probability of overestimating demand or no-shows, $P(N < X)$	Optimal probability of demand or no-shows $\frac{C_u}{(C_u + C_o)}$	Cost Description
Overbooking	Hotel, airlines, restaurants	N = number of no-shows X = number of overbooked rooms or seats	C_o = cost of overbooking C_u = cost of underbooking	Replacement cost Lost profit
Fare Classes	Airlines, cruise ships, passenger trains, extended stay hotels	N = number of full-fare tickets that can be sold X = seats reserved for full fare passengers	C_o = cost of overestimating full fare passengers C_u = cost of underestimating full fare passengers	Lost full-fare (Full-Fare − discounted fare)

Yield Management (cont.)

Type of Problem	Type of Business	Probability of overestimating demand or no-shows, $P(N < X)$	Optimal probability of demand or no-shows $\frac{C_u}{(C_u + C_o)}$	Cost Description
Premium seats	Stadiums, theaters	N = no. of premium tickets that can be sold X = seats reserved for premium ticket holders	C_o = cost of overestimating premium ticket sales C_u = cost of underestimating premium ticket sales	Lost regular revenue (Premium ticket − regular ticket revenue)
Single Order Quantities	Newspapers, magazines, florists, nurseries, bakeries, sale items	N = number of items that can be sold X = number of items ordered	C_o = cost of overestimating demand C_u = cost of underestimating demand	(Cost − salvage value) Lost profit

Yield Management: Example

NO-SHOWS	PROBABILITY	$P(N < X)$
0	.15	.00
1	.25	.15
2	.30	.40
3	.30	.70

.517 →

Optimal probability of no-shows

$$P(n < x) \leq \frac{C_u}{C_u + C_o} = \frac{75}{75 + 70} = .517$$

Hotel should be overbooked by two rooms