Aggregate Planning and S&OP

OUTLINE

- **Global Company Profile:** Frito-Lay
- The Planning Process
- Sales and Operations Planning
- The Nature of Aggregate Planning
- Aggregate Planning Strategies

OUTLINE - CONTINUED

- Methods for Aggregate Planning
- Aggregate Planning in Services
- Revenue Management

LEARNING OBJECTIVES

When you complete this chapter you should be able to:

1. **Define** sales and operations planning
2. **Define** aggregate planning
3. **Identify** optional strategies for developing an aggregate plan

LEARNING OBJECTIVES

When you complete this chapter you should be able to:

4. **Prepare** a graphical aggregate plan
5. **Solve** an aggregate plan via the transportation method
6. **Understand** and solve a revenue management problem

AGGREGATE PLANNING AT FRITO-LAY

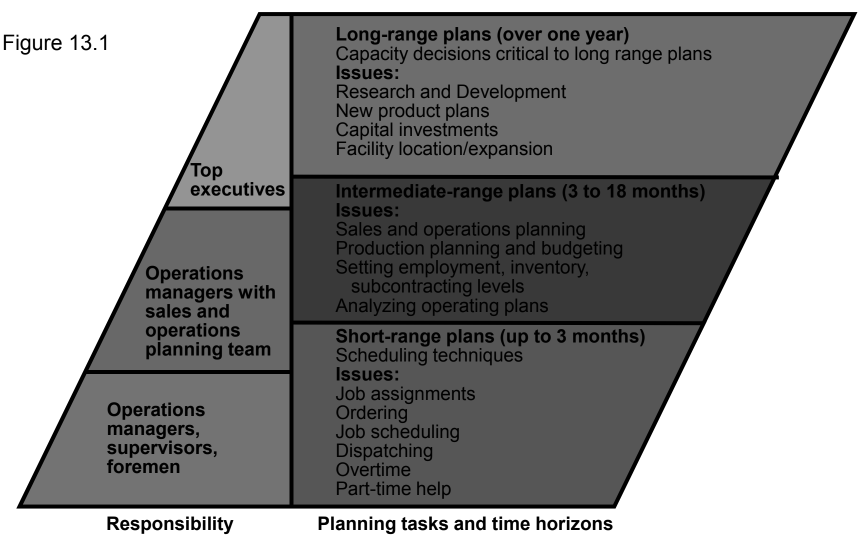
- More than three dozen brands, 15 brands sell more than \$100 million annually, 7 sell over \$1 billion
- Planning processes covers 3 to 18 months
- Unique processes and specially designed equipment
- High fixed costs require high volumes and high utilization

AGGREGATE PLANNING AT FRITO-LAY

- Demand profile based on historical sales, forecasts, innovations, promotion, local demand data
- Match total demand to capacity, expansion plans, and costs
- Quarterly aggregate plan goes to 36 plants in 17 regions
- Each plant develops 4-week plan for product lines and production runs

THE PLANNING PROCESS

Figure 13.1



SALES AND OPERATIONS PLANNING

- Coordination of demand forecasts with functional areas and the supply chain
- Typically done by cross-functional teams
- Determine which plans are feasible
- Limitations must be reflected
- Provides warning when resources do not match expectations
- Output is an **aggregate plan**

S&OP AND THE AGGREGATE PLAN

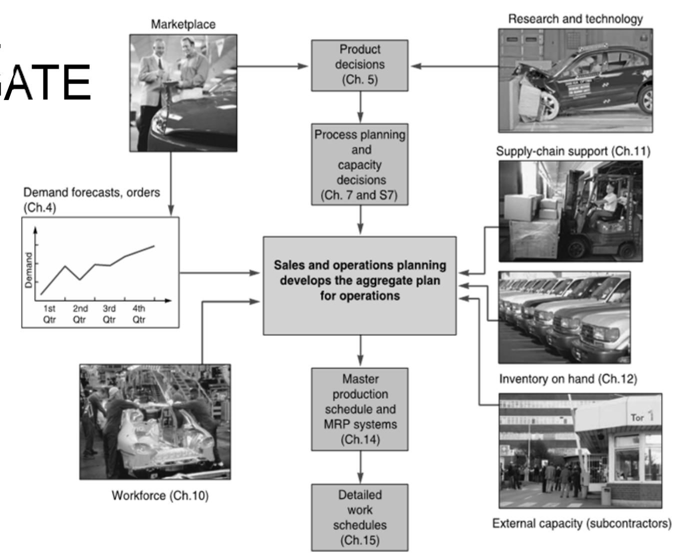


Figure 13.2

SALES AND OPERATIONS PLANNING

- Decisions must be tied to strategic planning and integrated with all areas of the firm over all planning horizons
- S&OP is aimed at
    1. The coordination and integration of the internal and external resources necessary for a successful aggregate plan
    2. Communication of the plan to those charged with its execution

SALES AND OPERATIONS PLANNING

- Requires
    - A logical overall unit for measuring sales and output
    - A forecast of demand for an intermediate planning period in these aggregate terms
    - A method for determining relevant costs
    - A model that combines forecasts and costs so that scheduling decisions can be made for the planning period

AGGREGATE PLANNING

The objective of aggregate planning is usually to meet forecast demand while minimizing cost over the planning period

AGGREGATE PLANNING

QUARTER 1		
Jan.	Feb.	March
150,000	120,000	110,000

QUARTER 2		
April	May	June
100,000	130,000	150,000

QUARTER 3		
July	Aug.	Sept.
180,000	150,000	140,000

AGGREGATE PLANNING

- Combines appropriate resources into general terms
- Part of a larger production planning system
- **Disaggregation** breaks the plan down into greater detail
- Disaggregation results in a **master production schedule**

AGGREGATE PLANNING STRATEGIES

1. Should inventories be used to absorb changes in demand?
2. Should changes be accommodated by varying the size of the workforce?
3. Should part-timers, overtime, or idle time be used to absorb changes?
4. Should subcontractors be used and maintain a stable workforce?
5. Should prices or other factors be changed to influence demand?

CAPACITY OPTIONS

1. Changing inventory levels
   - Increase inventory in low demand periods to meet high demand in the future
   - Increases costs associated with storage, insurance, handling, obsolescence, and capital investment
   - Shortages may mean lost sales due to long lead times and poor customer service

CAPACITY OPTIONS

2. Varying workforce size by hiring or layoffs
   - Match production rate to demand
   - Training and separation costs for hiring and laying off workers
   - New workers may have lower productivity
   - Laying off workers may lower morale and productivity

CAPACITY OPTIONS

3. Varying production rates through overtime or idle time
   - Allows constant workforce
   - May be difficult to meet large increases in demand
   - Overtime can be costly and may drive down productivity
   - Absorbing idle time may be difficult

CAPACITY OPTIONS

4. Subcontracting
   - Temporary measure during periods of peak demand
   - May be costly
   - Assuring quality and timely delivery may be difficult
   - Exposes your customers to a possible competitor

CAPACITY OPTIONS

5. Using part-time workers
   - Useful for filling unskilled or low skilled positions, especially in services

DEMAND OPTIONS

1. Influencing demand
   - Use advertising or promotion to increase demand in low periods
   - Attempt to shift demand to slow periods
   - May not be sufficient to balance demand and capacity

DEMAND OPTIONS

2. Back ordering during high-demand periods
   - Requires customers to wait for an order without loss of goodwill or the order
   - Most effective when there are few if any substitutes for the product or service
   - Often results in lost sales

DEMAND OPTIONS

3. Counterseasonal product and service mixing
   - Develop a product mix of counterseasonal items
   - May lead to products or services outside the company’s areas of expertise

AGGREGATE PLANNING OPTIONS

TABLE 13.1	**Aggregate Planning Options**		
OPTION	**ADVANTAGES**	**DISADVANTAGES**	**COMMENTS**
Changing inventory levels	Changes in human resources are gradual or none; no abrupt production changes.	Inventory holding cost may increase. Shortages may result in lost sales.	Applies mainly to production, not service, operations.
Varying workforce size by hiring or layoffs	Avoids the costs of other alternatives.	Hiring, layoff, and training costs may be significant.	Used where size of labor pool is large.

AGGREGATE PLANNING OPTIONS

TABLE 13.1	**Aggregate Planning Options**		
OPTION	**ADVANTAGES**	**DISADVANTAGES**	**COMMENTS**
Varying production rates through overtime or idle time	Matches seasonal fluctuations without hiring/ training costs.	Overtime premiums; tired workers; may not meet demand.	Allows flexibility within the aggregate plan.
Sub-contracting	Permits flexibility and smoothing of the firm's output.	Loss of quality control; reduced profits; loss of future business.	Applies mainly in production settings.

AGGREGATE PLANNING OPTIONS

TABLE 13.1	**Aggregate Planning Options**		
OPTION	**ADVANTAGES**	**DISADVANTAGES**	**COMMENTS**
Using part-time workers	Is less costly and more flexible than full-time workers.	High turnover/ training costs; quality suffers; scheduling difficult.	Good for unskilled jobs in areas with large temporary labor pools.
Influencing demand	Tries to use excess capacity. Discounts draw new customers.	Uncertainty in demand. Hard to match demand to supply exactly.	Creates marketing ideas. Overbooking used in some businesses.

AGGREGATE PLANNING OPTIONS

TABLE 13.1	**Aggregate Planning Options**		
OPTION	**ADVANTAGES**	**DISADVANTAGES**	**COMMENTS**
Back ordering during high-demand periods	May avoid overtime. Keeps capacity constant.	Customer must be willing to wait, but goodwill is lost.	Many companies back order.
Counter-seasonal product and service mixing	Fully utilizes resources; allows stable workforce.	May require skills or equipment outside the firm's areas of expertise.	Risky finding products or services with opposite demand patterns.

MIXING OPTIONS TO DEVELOP A PLAN

- A mixed strategy may be the best way to achieve minimum costs
- There are many possible mixed strategies
- Finding the optimal plan is not always possible

MIXING OPTIONS TO DEVELOP A PLAN

- Chase strategy
  - Match output rates to demand forecast for each period
  - Vary workforce levels or vary production rate
  - Favored by many service organizations

MIXING OPTIONS TO DEVELOP A PLAN

- Level strategy
  - Daily production is uniform
  - Use inventory or idle time as buffer
  - Stable production leads to better quality and productivity
- Some combination of capacity options, a mixed strategy, might be the best solution

METHODS FOR AGGREGATE PLANNING

- **Graphical Methods**
- Popular techniques
  - Easy to understand and use
  - Trial-and-error approaches that do not guarantee an optimal solution
  - Require only limited computations

GRAPHICAL METHODS

1. Determine the demand for each period
2. Determine the capacity for regular time, overtime, and subcontracting each period
3. Find labor costs, hiring and layoff costs, and inventory holding costs
4. Consider company policy on workers and stock levels
5. Develop alternative plans and examine their total cost

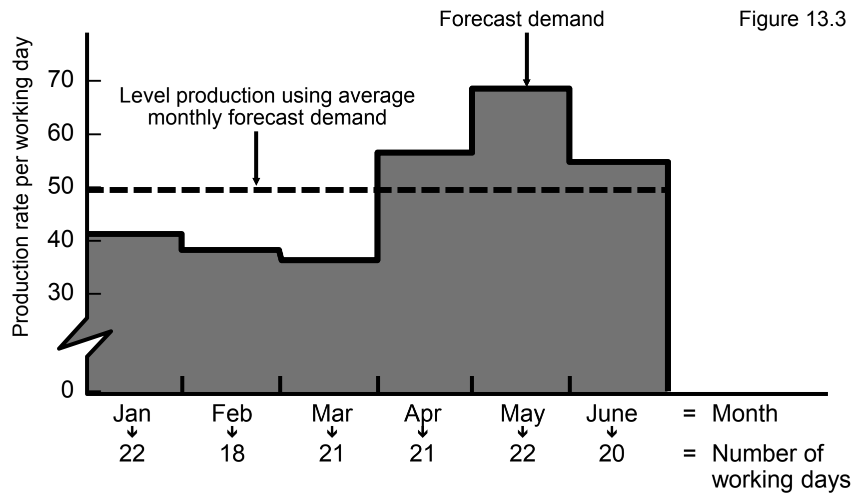
ROOFING SUPPLIER EXAMPLE 1

TABLE 13.2	**Monthly Forecasts**		
MONTH	EXPECTED DEMAND	PRODUCTION DAYS	DEMAND PER DAY (COMPUTED)
Jan	900	22	41
Feb	700	18	39
Mar	800	21	38
Apr	1,200	21	57
May	1,500	22	68
June	1,100	20	55
	6,200	124	

$$\text{Average requirement} = \frac{\text{Total expected demand}}{\text{Number of production days}}$$

$$= \frac{6{,}200}{124} = 50 \text{ units per day}$$

ROOFING SUPPLIER EXAMPLE 1



ROOFING SUPPLIER EXAMPLE 2

TABLE 13.3	**Cost Information**
Inventory carrying cost	$ 5 per unit per month
Subcontracting cost per unit	$20 per unit
Average pay rate	$10 per hour ($80 per day)
Overtime pay rate	$17 per hour (above 8 hours per day)
Labor-hours to produce a unit	1.6 hours per unit
Cost of increasing daily production rate (hiring and training)	$300 per unit
Cost of decreasing daily production rate (layoffs)	$600 per unit

Plan 1 – constant workforce

ROOFING SUPPLIER EXAMPLE 2

MONTH	PRODUCTION DAYS	PRODUCTION AT 50 UNITS PER DAY	DEMAND FORECAST	MONTHLY INVENTORY CHANGE	ENDING INVENTORY
Jan	22	1,100	900	+200	200
Feb	18	900	700	+200	400
Mar	21	1,050	800	+250	650
Apr	21	1,050	1,200	–150	500
May	22	1,100	1,500	–400	100
June	20	1,000	1,100	–100	0
					1,850

Total units of inventory carried over from one month to the next = 1,850 units

Workforce required to produce 50 units per day = 10 workers

ROOFING SUPPLIER EXAMPLE 2

COST		CALCULATIONS
Inventory carrying	$9,250	(= 1,850 units carried x $5 per unit)
Regular-time labor	99,200	(= 10 workers x $80 per day x 124 days)
Other costs (overtime, hiring, layoffs, subcontracting)	0	
Total cost	$108,450	

Total units of inventory carried over from one month to the next = 1,850 units

Workforce required to produce 50 units per day = 10 workers

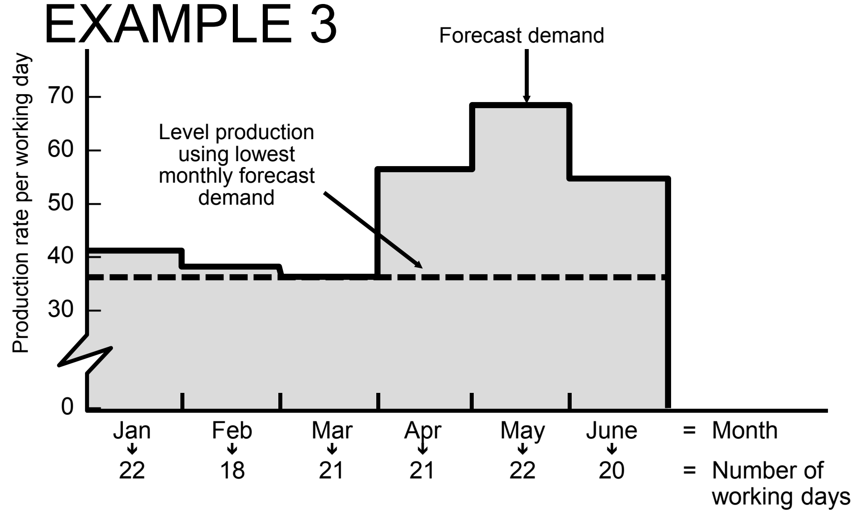
ROOFING SUPPLIER EXAMPLE 3

In-house production = 38 units per day x 124 days = 4,712 units

Subcontract units = 6,200 – 4,712 = 1,488 units

COST		CALCULATIONS
Regular-time labor	$75,392	(= 7.6 workers x $80 per day x 124 days)
Subcontracting	29,760	(= 1,488 units x $20 per unit)
Total cost	$105,152	

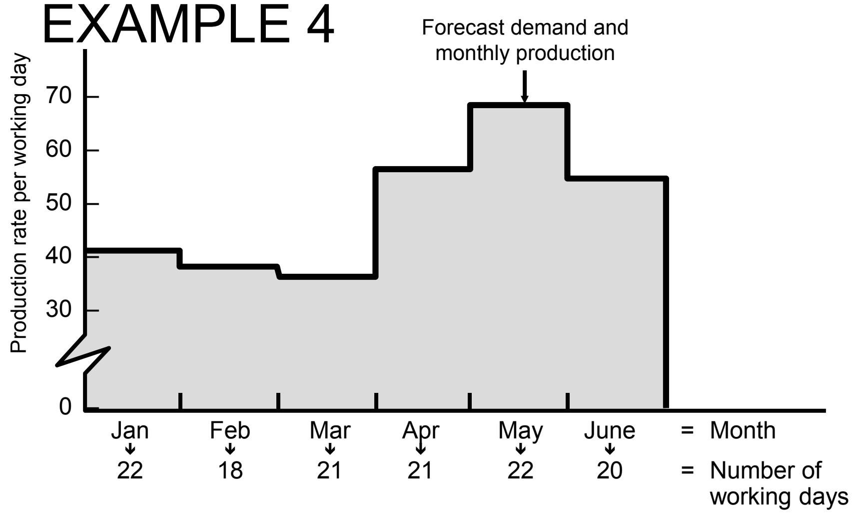
ROOFING SUPPLIER EXAMPLE 3



ROOFING SUPPLIER EXAMPLE 4

TABLE 13.4	Cost Computations for Plan 3					
MONTH	FORECAST (UNITS)	DAILY PROD RATE	BASIC PRODUCTION COST (DEMAND X 1.6 HRS/UNIT X $10/HR)	EXTRA COST OF INCREASING PRODUCTION (HIRING COST)	EXTRA COST OF DECREASING PRODUCTION (LAYOFF COST)	TOTAL COST
Jan	900	41	$ 14,400	—	—	$ 14,400
Feb	700	39	11,200	—	$1,200 (= 2 x $600)	12,400
Mar	800	38	12,800	—	$600 (= 1 x $600)	13,400
Apr	1,200	57	19,200	$5,700 (= 19 x $300)	—	24,900
May	1,500	68	24,000	$3,300 (= 11 x $300)	—	24,300
June	1,100	55	17,600	—	$7,800 (= 13 x $600)	25,400
			$99,200	$9,000	$9,600	$117,800

ROOFING SUPPLIER EXAMPLE 4



COMPARISON OF THREE PLANS

TABLE 13.5	Comparison of the Three Plans		
COST	PLAN 1	PLAN 2	PLAN 3
Inventory carrying	$ 9,250	$ 0	$ 0
Regular labor	99,200	75,392	99,200
Overtime labor	0	0	0
Hiring	0	0	9,000
Layoffs	0	0	9,600
Subcontracting	0	29,760	0
Total cost	$108,450	$105,152	$117,800

Plan 2 is the lowest cost option

MATHEMATICAL APPROACHES

- Useful for generating strategies
  - Transportation Method of Linear Programming
    - Produces an optimal plan
    - Works well for inventories, overtime, subcontracting
    - Does not work when nonlinear or negative factors are introduced
- Other Models
  - General form of linear programming
  - Simulation

TRANSPORTATION METHOD

TABLE 13.6	Farnsworth's Production, Demand, Capacity, and Cost Data		
	SALES PERIOD		
	MAR.	APR.	MAY
Demand	800	1,000	750
Capacity:			
Regular	700	700	700
Overtime	50	50	50
Subcontracting	150	150	130
Beginning inventory	100 tires		

COSTS	
Regular time	$40 per tire
Overtime	$50 per tire
Subcontracting	$70 per tire
Carrying cost	$ 2 per tire per month

TRANSPORTATION EXAMPLE

- Important points
  1. Carrying costs are $2/tire/month. If goods are made in one period and held over to the next, holding costs are incurred.
  2. Supply must equal demand, so a dummy column called "unused capacity" is added.
  3. Because back ordering is not viable in this example, cells that might be used to satisfy earlier demand are not available.

TRANSPORTATION EXAMPLE

4. Quantities in each column designate the levels of inventory needed to meet demand requirements
5. In general, production should be allocated to the lowest cost cell available without exceeding unused capacity in the row or demand in the column

TRANSP EXAMPL

SUPPLY FROM		DEMAND FOR Period 1 (Mar)	Period 2 (Apr)	Period 3 (May)	Unused Capacity (dummy)	TOTAL CAPACITY AVAILABLE (supply)
	Beginning inventory	0 100	2	4	0	100
Period 1	Regular time	40 700	42	44	0	700
	Overtime	50	52 50	54	0	50
	Subcontract	70	72 150	74	0	150
Period 2	Regular time	X	40	42	0	700
	Overtime	X	50	52	0	50
	Subcontract	X	70	72	0	150
Period 3	Regular time	X	X	40	0	700
	Overtime	X	X	50	0	50
	Subcontract	X	X	70	0	130
TOTAL DEMAND		800	1,000	750	230	2,780

Table 13.7

AGGREGATE PLANNING IN SERVICES

- Most services use combination strategies and mixed plans
- Controlling the cost of labor is critical
  1. Accurate scheduling of labor-hours to assure quick response to customer demand
  2. An on-call labor resource to cover unexpected demand
  3. Flexibility of individual worker skills
  4. Flexibility in rate of output or hours of work

FIVE SERVICE SCENARIOS

- Restaurants
  1. Smoothing the production process
  2. Determining the optimal workforce size
- Hospitals
  - Responding to patient demand
- National Chains of Small Service Firms
  - Planning done at national level and at local level

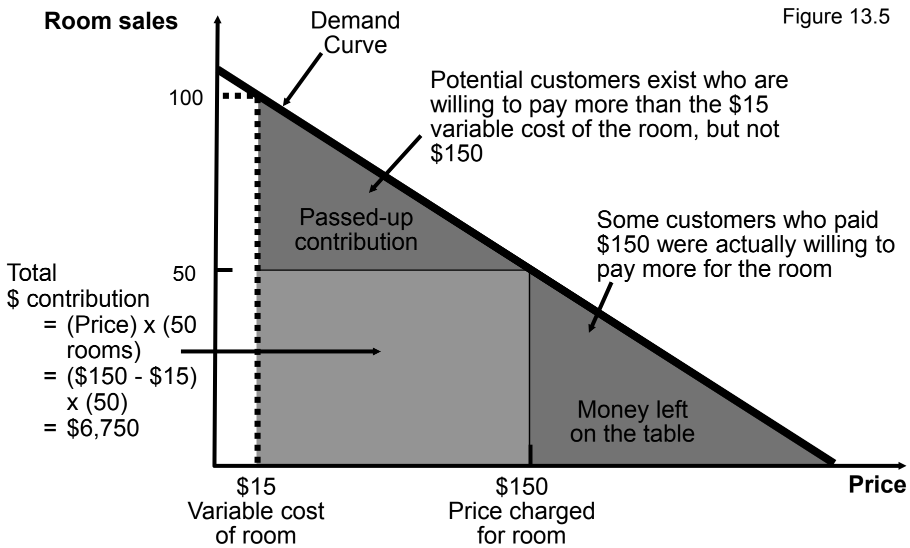
FIVE SERVICE SCENARIOS

- Miscellaneous Services
  - Plan human resource requirements
  - Manage demand
- Airline industry
  - Extremely complex planning problem
  - Involves number of flights, number of passengers, air and ground personnel, allocation of seats to fare classes
  - Resources spread through the entire system

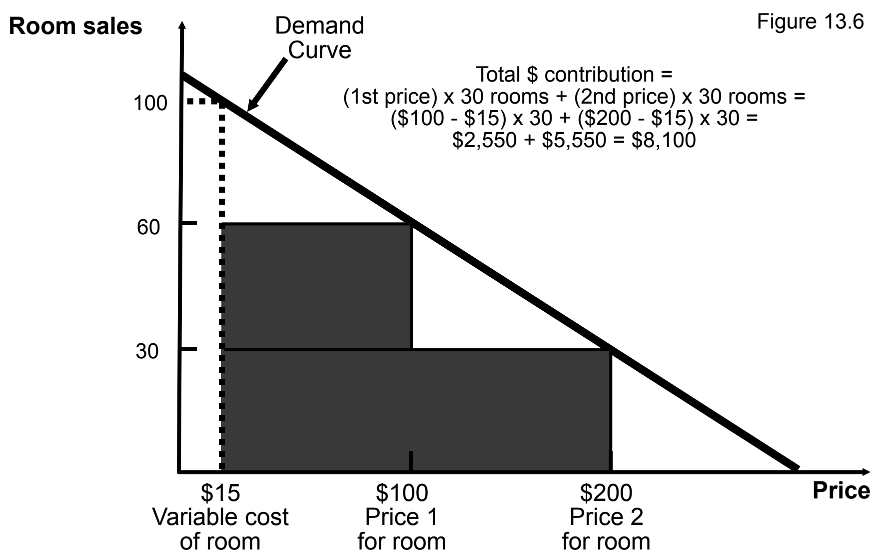
REVENUE MANAGEMENT

- Allocating resources to customers at prices that will maximize revenue
  1. Service or product can be sold in advance of consumption
  2. Demand fluctuates
  3. Capacity is relatively fixed
  4. Demand can be segmented
  5. Variable costs are low and fixed costs are high

REVENUE MANAGEMENT EXAMPLE



REVENUE MANAGEMENT EXAMPLE



REVENUE MANAGEMENT APPROACHES

- Airlines, hotels, rental cars, etc.
  - Tend to have predictable duration of service and use variable pricing to control availability and revenue
- Movies, stadiums, performing arts centers
  - Tend to have predicable duration and fixed prices but use seating locations and times to manage revenue

REVENUE MANAGEMENT APPROACHES

- Restaurants, golf courses, ISPs
  - Generally have unpredictable duration of customer use and fixed prices, may use “off-peak” rates to shift demand and manage revenue
- Health care businesses, etc.
  - Tend to have unpredictable duration of service and variable pricing, often attempt to control duration of service

MAKING REVENUE MANAGEMENT WORK

1. Multiple pricing structures must be feasible and appear logical to the customer
2. Forecasts of the use and duration of use
3. Changes in demand