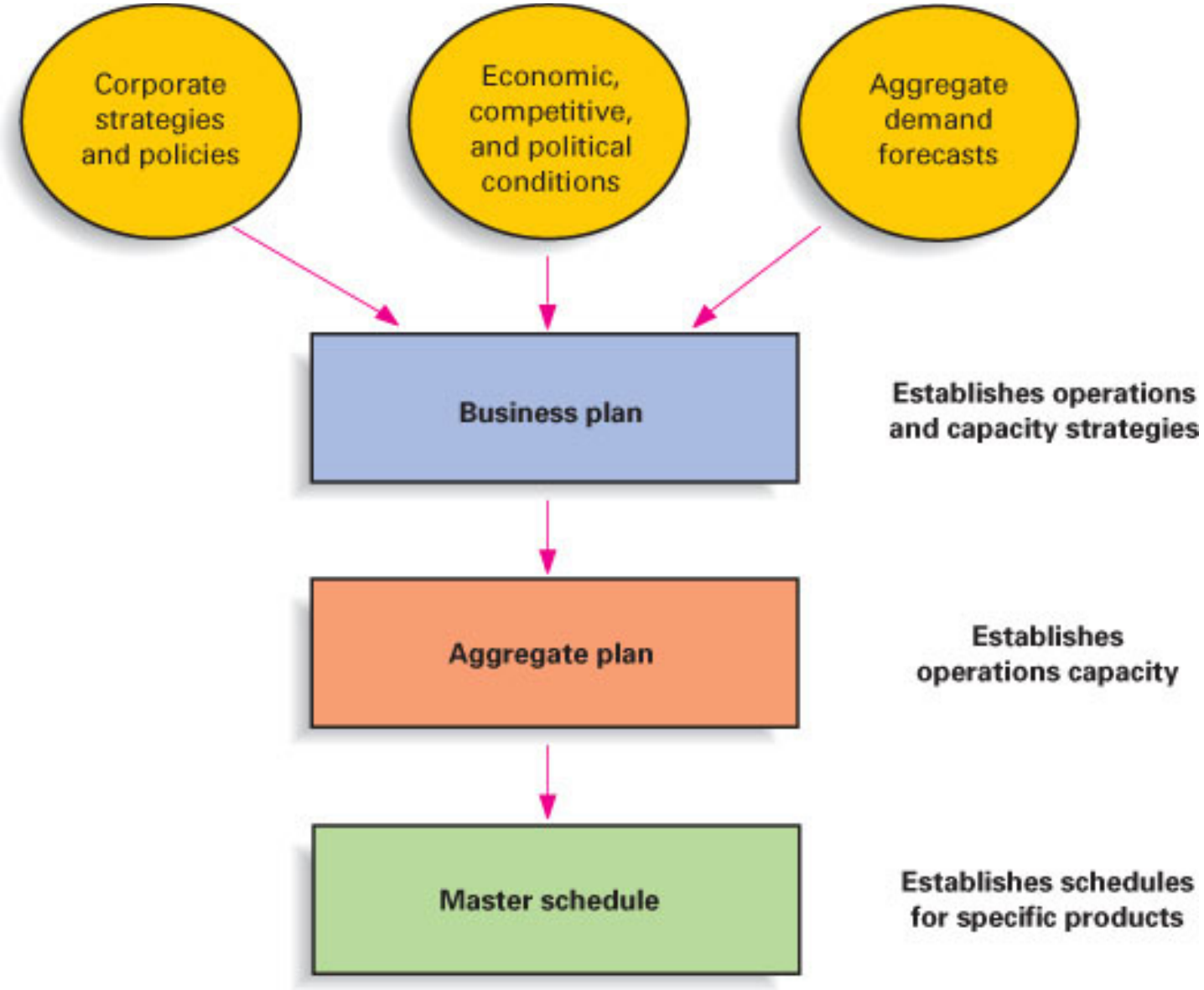
Aggregate Planning

Chapter 13

Intermediate Planning in Perspective

Overview of planning levels

Planning Sequence



The Concept of Aggregation

An Overview of Aggregate Planning

Demand and Capacity

Inputs to Aggregate Planning

Aggregate planning inputs and outputs

Inputs	Outputs
Resources	Total cost of a plan
Workforce/production rates	Projected levels of
Facilities and equipment	Inventory
Demand forecast	Output
Policies on workforce changes	Employment
Subcontracting	Subcontracting
Overtime	Backordering
Inventory levels/changes	
Back orders	
Costs	
Inventory carrying cost	
Back orders	
Hiring/firing	
Overtime	
Inventory changes	
Subcontracting	

Demand and Capacity Options

Demand Options

Pricing (the degree of price elasticity for the product or service)

Promotion

Back Orders

New Demand

Capacity Options

Hire and lay off workers

Overtime/Slack time

Part time workers

Inventories

Subcontracting

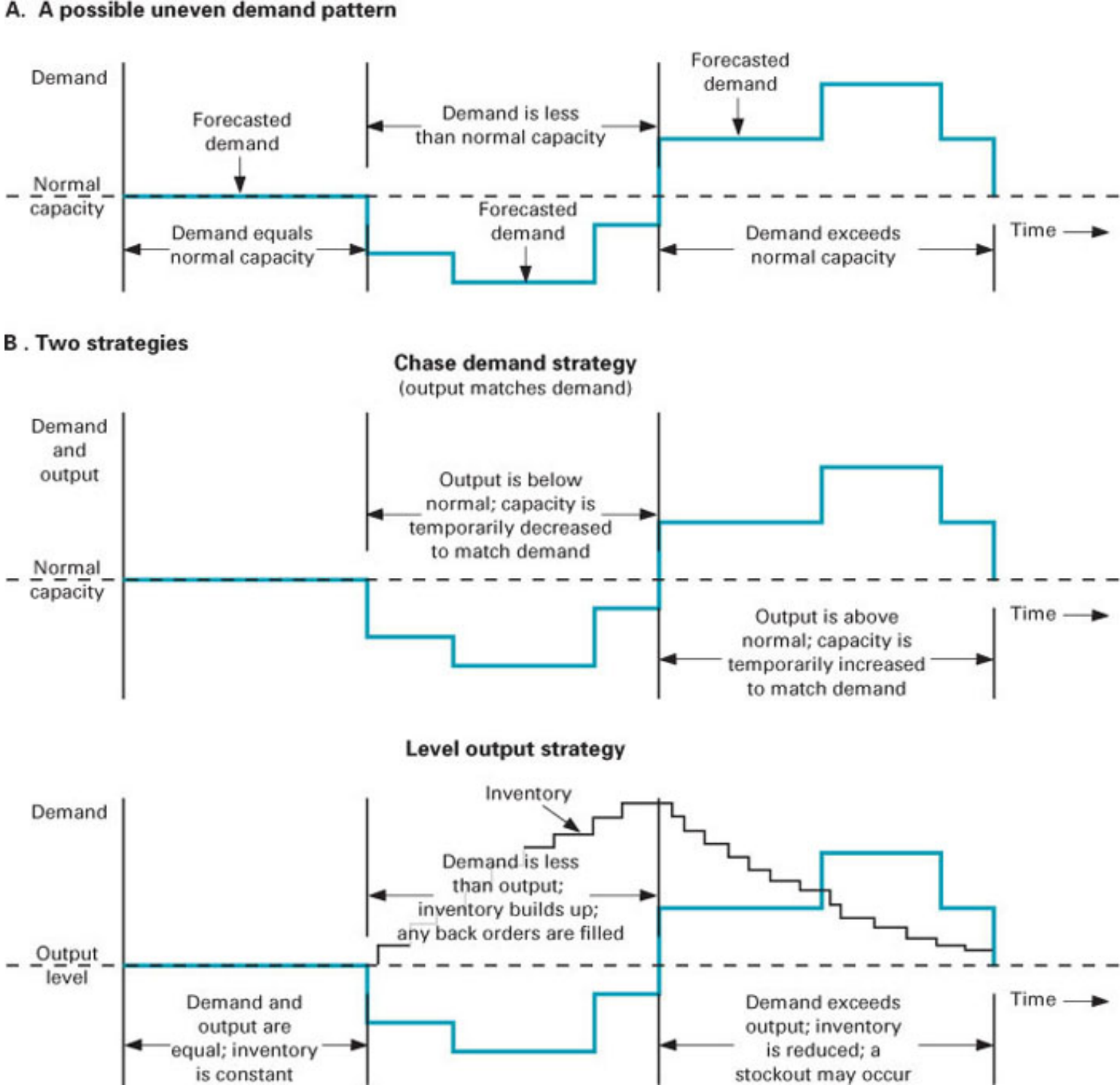
Basic Strategies for Meeting Uneven Demand

- Maintain a level workforce.
- Maintain a steady output rate.
- Match demand period by period.
- Use a combination of decision variables.

level capacity strategy maintaining a steady rate of regular time output while meeting variations in demand by a combination of options.

chase demand strategy matching capacity to demand; the planned output for the period is set equal to the expected demand for the period.

A varying demand pattern and a comparison of a chase demand strategy versus a level strategy



Choosing a Strategy

Two important factors are **company policy** and **costs**

Comparison of reactive strategies

Chase approach

Capacities (workforce levels, output rates, etc.) are adjusted to match demand requirements over the planning horizon.

Advantages: Investment in inventory is low, Labor utilization is kept high

Disadvantage: The cost of adjusting output rates and/or workforce levels

Level approach

Capacities (workforce levels, output rates, etc.) are kept constant over the planning horizon.

Advantage: Stable output rates and workforce levels

Disadvantages: Greater inventory costs, Increased overtime and idle time, Resource utilizations that vary over time

Techniques for Aggregate Planning

Informal trial-and-error techniques

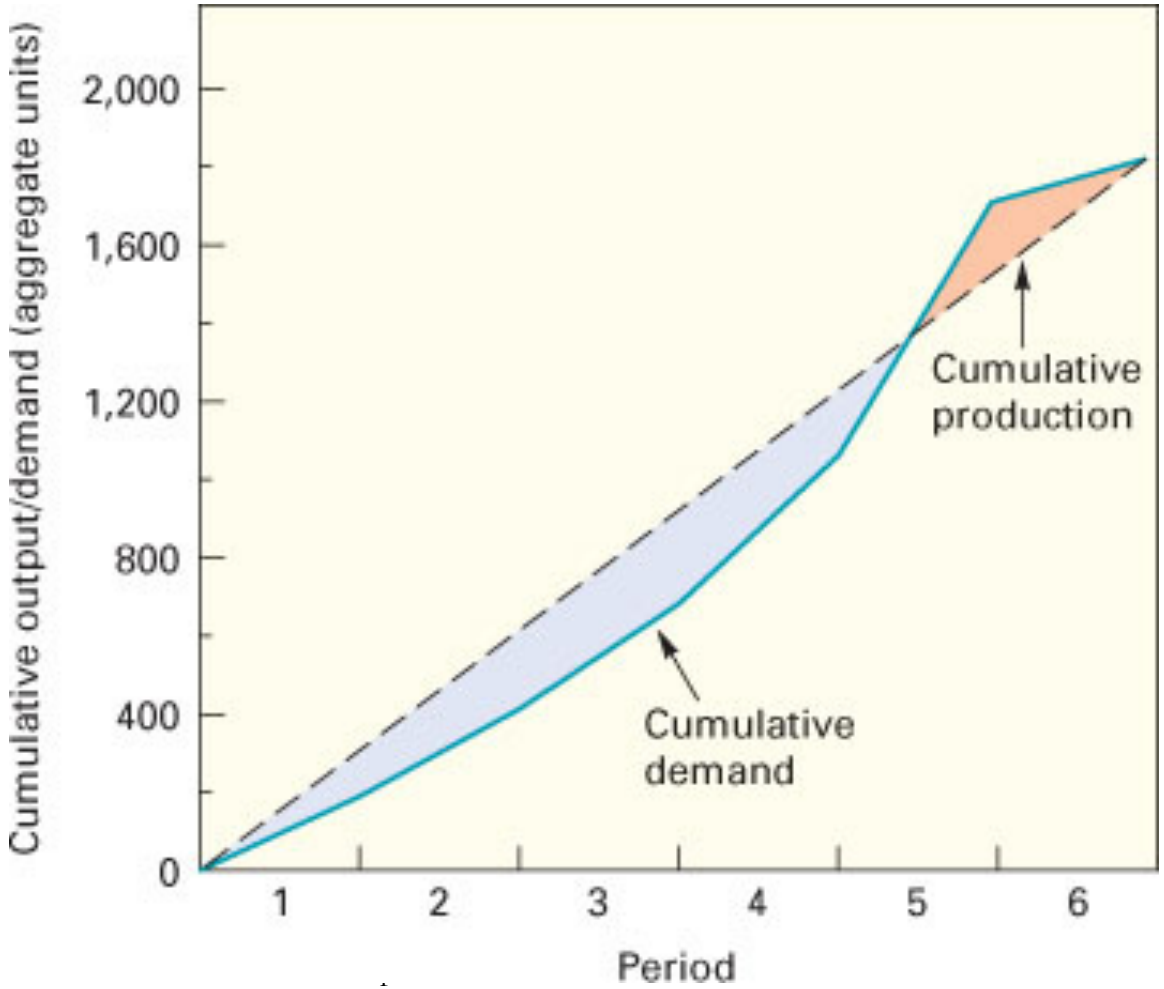
A general procedure for aggregate planning consists of the following steps:

1. Determine demand for each period.
2. Determine capacities (regular time, overtime, subcontracting) for each period.
3. Identify company or departmental policies that are pertinent (e.g., maintain a safety stock of 5 percent of demand, maintain a reasonably stable workforce).
4. Determine unit costs for regular time, overtime, subcontracting, holding inventories, back orders, layoffs, and other relevant costs.
5. Develop alternative plans and compute the cost for each.
6. If satisfactory plans emerge, select the one that best satisfies objectives. Otherwise, return to step 5.

Period	1	2	3	4	5		Total
Forecast							
Output							
Regular time							
Overtime							
Subcontract							
Output – Forecast							
Inventory							
Beginning							
Ending							
Average							
Backlog							
Costs							
Output							
Regular							
Overtime							
Subcontract							
Hire/Lay off							
Inventory							
Back orders							
Total							

Trial-and-Error Techniques Using Graphs and Spreadsheets

A cumulative graph



Example

Planners for a company that makes several models of skateboards are about to prepare the aggregate plan that will cover six periods. They have assembled the following information:

They now want to evaluate a plan that calls for a steady rate of regular-time output, mainly using inventory to absorb the uneven demand but allowing some backlog. Overtime and subcontracting are not used because they want steady output. They intend to start with zero inventory on hand in the first period. Prepare an aggregate plan and determine its cost using the preceding information. Assume a level output rate of 300 units (skateboards) per period with regular time (i.e., 1,800÷6 = 300). Note that the planned ending inventory is zero. There are 15 workers, and each can produce 20 skateboards per period.

Period	1	2	3	4	5	6	Total
Forecast	200	200	300	400	500	200	1,800

Costs

- Output
  - Regular time = $2 per skateboard
  - Overtime = $3 per skateboard
  - Subcontract = $6 per skateboard
- Inventory = $1 per skateboard per period on average inventory
- Back orders = $5 per skateboard per period

Period	1	2	3	4	5	6	Total
Forecast	200	200	300	400	500	200	1,800
Output							
Regular	300	300	300	300	300	300	1,800
Overtime	—	—	—	—	—	—	
Subcontract	—	—	—	—	—	—	
Output – Forecast	100	100	0	(100)	(200)	100	0
Inventory							
Beginning	0	100	200	200	100	0	
Ending	100	200	200	100	0	0	
Average	50	150	200	150	50	0	600
Backlog	0	0	0	0	100	0	100
Period	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
Costs							
Output							
Regular	$600	600	600	600	600	600	$3,600
Overtime	—	—	—	—	—	—	
Subcontract	—	—	—	—	—	—	
Hire/Lay off	—	—	—	—	—	—	
Inventory	$ 50	150	200	150	50	0	$ 600
Back orders	$ 0	0	0	0	500	0	$ 500
Total	$650	750	800	750	1,150	600	$4,700

Example

After reviewing the plan developed in the preceding example, planners have decided to develop an alternative plan. They have learned that one person is about to retire from the company. Rather than replace that person, they would like to stay with the smaller workforce and use overtime to make up for the lost output. The reduced regular-time output is 280 units per period. The maximum amount of overtime output per period is 40 units. Develop a plan and compare it to the previous one.

Period	1	2	3	4	5	6	Total
Forecast	200	200	300	400	500	200	1,800
Output							
Regular	280	280	280	280	280	280	1,680
Overtime	0	0	40	40	40	0	120
Subcontract	—	—	—	—	—	—	
Output – Forecast	80	80	20	(80)	(180)	80	0
Inventory							
Beginning	0	80	160	180	100	0	
Ending	80	160	180	100	0	0	
Average	40	120	170	140	50	0	520
Backlog	0	0	0	0	80	0	80
Costs							
Output							
Regular	$560	560	560	560	560	560	$3,360
Overtime	0	0	120	120	120	0	$ 360
Subcontract	—	—	—	—	—	—	
Hire/Lay off	—	—	—	—	—	—	
Inventory	40	120	170	140	50	0	$ 520
Back orders	$0	0	0	0	400	0	$ 400
Total	$600	680	850	820	1,130	560	$4,640

Mathematical Techniques

Linear programming

Transportation notation for aggregate planning

Period		Period 1	Period 2	Period 3	. . .	Ending inventory period n	Unused capacity	Capacity
	Beginning inventory	0	h	$2h$	. . .	$(n-1)h$	0	I_0
1	Regular time	r	$r+h$	$r+2h$	. . .	$r+(n-1)h$	0	R_1
	Overtime	t	$t+h$	$t+2h$	. . .	$t+(n-1)h$	0	O_1
	Subcontract	s	$s+h$	$s+2h$	. . .	$s+(n-1)h$	0	S_1
2	Regular time	$r+b$	r	$r+h$	. . .	$r+(n-2)h$	0	R_2
	Overtime	$t+b$	t	$t+h$	. . .	$t+(n-2)h$	0	O_2
	Subcontract	$s+b$	s	$s+h$	. . .	$s+(n-2)h$	0	S_2
3	Regular time	$r+2b$	$r+b$	r	. . .	$r+(n-3)h$	0	R_3
	Overtime	$t+2b$	$t+b$	t	. . .	$t+(n-3)h$	0	O_3
	Subcontract	$s+2b$	$s+b$	s	. . .	$s+(n-3)h$	0	S_3
	Demand				. . .			Total

r = Regular production cost per unit

t = Overtime cost per unit

s = Subcontracting cost per unit

h = Holding cost per unit period

b = Backorder cost per unit per period

n = Number of periods in planning horizon

Example

Given the following information set up the problem in a transportation table and solve for the minimum-cost plan:

	PERIOD		
	1	2	3
Demand	550	700	750
Capacity			
Regular	500	500	500
Overtime	50	50	50
Subcontract	120	120	100
Beginning inventory	100		
Costs			
Regular time	$60 per unit		
Overtime	$80 per unit		
Subcontract	$90 per unit		
Inventory carrying cost	$1 per unit per month		
Back-order cost	$3 per unit per month		

Transportation solution

Supply from		Demand for: Period 1	Period 2	Period 3	Unused capacity (dummy)	Total capacity available (supply)
Period	Beginning inventory	0 100	1	2	0	100
1	Regular time	60 450	61 50	62	0	500
	Overtime	80	81 50	82	0	50
	Subcontract	90	91 30	92	0 90	120
2	Regular time	63	60 500	61	0	500
	Overtime	83	80 50	81	0	50
	Subcontract	93	90 20	91 100	0	120
3	Regular time	66	63	60 500	0	500
	Overtime	86	83	80 50	0	50
	Subcontract	96	93	90 100	0	100
Demand		550	700	750	90	2,090

Simulation models

Technique	Solution Approach	Characteristics
Spreadsheet	Heuristic (trial and error)	Intuitively appealing, easy to understand; solution not necessarily optimal
Linear programming	Optimizing	Computerized; linear assumptions not always valid
Simulation	Heuristic (trial and error)	Computerized models can be examined under a variety of conditions

Aggregate Planning in Services

- Services occur when they are rendered.
- Demand for service can be difficult to predict.
- Capacity availability can be difficult to predict.
- Labor flexibility can be an advantage in services.

Disaggregating the Aggregate Plan

Moving from the aggregate plan to a master schedule

Disaggregating the aggregate plan

Aggregate plan

Month	Jan.	Feb.	Mar.
Planned output*	200	300	400

*Aggregate units

Master schedule

Month	Jan.	Feb.	Mar.
Planned output*			
Push	100	100	100
Self-propelled	75	150	200
Riding	25	50	100
Total	200	300	400

*Actual units

Master Scheduling

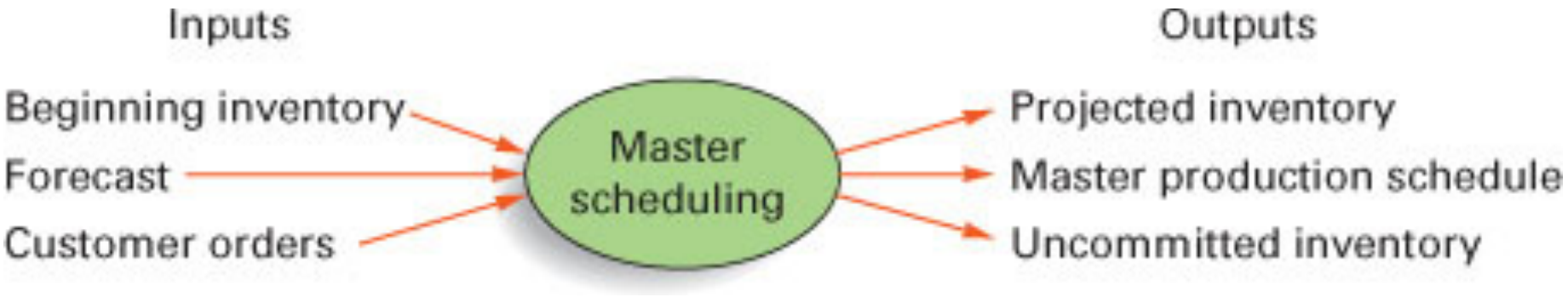
- The duties of the master scheduler generally include
- Evaluating the impact of new orders.
- Providing delivery dates for orders.
- Dealing with problems:

  Evaluating the impact of production delays or late deliveries of purchased goods.

  Revising the master schedule when necessary because of insufficient supplies or capacity.

  Bringing instances of insufficient capacity to the attention of production and marketing personnel so that they can participate in resolving conflicts.

The Master Scheduling Process



Weekly forecast requirements for industrial pumps.

	June				July			
	1	2	3	4	5	6	7	8
Forecast	30	30	30	30	40	40	40	40

Eight-week schedule showing forecasts, customer orders, and beginning inventory

Beginning inventory 64	June				July			
	1	2	3	4	5	6	7	8
Forecast	30	30	30	30	40	40	40	40
Customer orders (committed)	33	20	10	4	2			

Projected on-hand inventory is computed week by week until it becomes negative

Beginning inventory: 64

	June				July			
	1	2	3	4	5	6	7	8
Forecast	30	30	30	30	40	40	40	40
Customer orders (committed)	33	20	10	4	2			
Projected on-hand inventory	31	1	−29					

Customer orders are larger than forecast in week 1; projected on-hand inventory is 64 − 33 = 31

Forecast is larger than customer orders in week 2; projected on-hand inventory is 31 − 30 = 1

Forecast is larger than customer orders in week 3; projected on-hand inventory is 1 − 30 = −29

Determining the MPS and projected on-hand inventory

Week	Inventory from Previous Week	Requirements*	Net Inventory before MPS		(70) MPS		Projected Inventory
1	64	33	31				31
2	31	30	1				1
3	1	30	−29	+	70	=	41
4	41	30	11				11
5	11	40	−29	+	70	=	41
6	41	40	1				1
7	1	40	−39	+	70	=	31
8	31	40	−9	+	70	=	61

*Requirements equals the larger of forecast and customer orders in each week.

Projected on-hand inventory and MPS are added to the master schedule

	June				July			
64	1	2	3	4	5	6	7	8
Forecast	30	30	30	30	40	40	40	40
Customer orders (committed)	33	20	10	4	2			
Projected on-hand inventory	31	1	41	11	41	1	31	61
MPS			70		70		70	70

The available-to-promise inventory quantities have been added to the master schedule

	June				July			
64	1	2	3	4	5	6	7	8
Forecast	30	30	30	30	40	40	40	40
Customer orders (committed)	33	20	10	4	2			
Projected on-hand inventory	31	1	41	11	41	1	31	61
MPS			70		70		70	70
Available-to-promise inventory (uncommitted)	11		56		68		70	70

Time fences in an MPS