Operations & Supply Planning
PGDM 2018-20

Sales and Operations Planning

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Matching Supply with Demand

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Typical executive staff meeting

President: This shortage situation is terrible. When will we ever get our act together? Whenever business is good, we run out of product and our customer service is lousy.

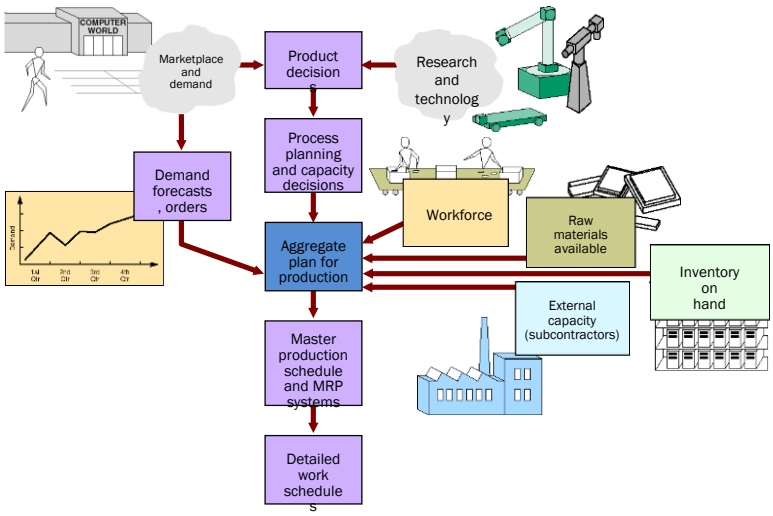
VP Operations: I'll tell you when. When we start to get some decent forecasts from the Sales Department…

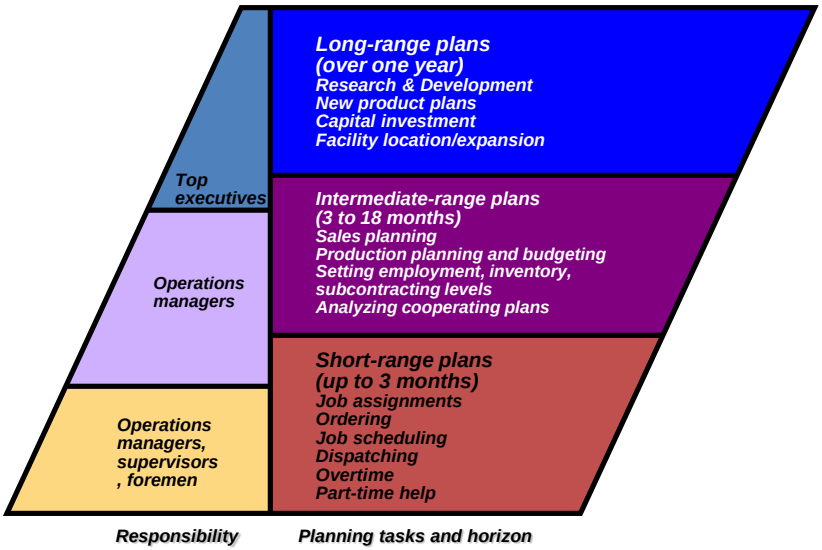
VP Sales (interrupting) : Wait a minute. We forecasted this upturn.

VP Operations: … in time to do something about it. Yeah, we got the revised forecast…four days after the start of the month. By then it was too late

VP Sales: I could have told you months ago. All you had to do was ask!

VP Finance: I'd like to be in on those conversations. We've been burned more than once by building inventories for a business upturn that doesn't happen. Then we get stuck with tons of inventory and run out of cash!





Aggregate Operations Planning

- Amount of resources to be committed in each period
- Rate at which goods and services need to be produced in each period
- Inventory to be carried forward from one period to the next
- Is in terms of standardized aggregate units

The Aggregate Operations Plan

- Main purpose: Specify the optimal combination of
  - Production rate (units completed per unit of time)
  - Workforce Level (number of workers)
  - Inventory on Hand (inventory carried from previous period)
- Product group or broad category (Aggregation)
- This planning is done over an intermediate range planning period of 3 to18 months

Problem statement

Given the demand forecast F_t for each period t in the planning horizon that extends over T periods, determine the production level P_t, inventory level It and workforce level W_t for periods t = 1, 2, 3, … T that minimize the relevant costs over the planning horizon.

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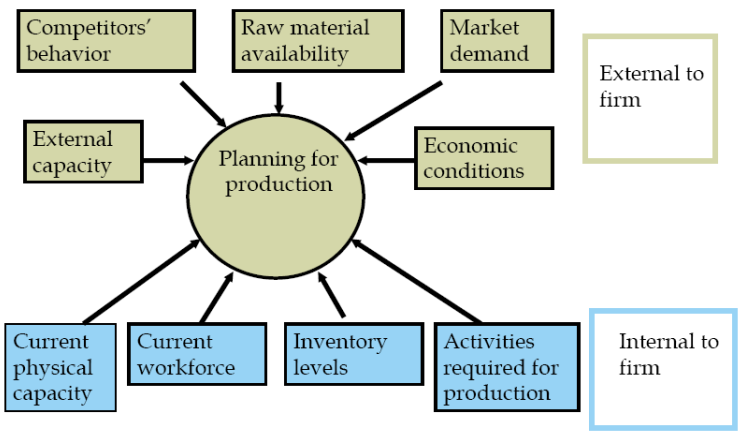
Relevant costs

- Basic production costs
- Cost associated with changes in the production rate
- Inventory holding costs
- Backorder costs
- Shortage costs

Inputs to the production planning system



Why do you need an Aggregate Planning

- Demand Fluctuations
- Capacity Fluctuations
- Difficulty level of altering operation rates
- Benefits of multi-period planning

Managing Demand

- Reservation systems
- Influencing demand
  - Promoting off peak demand
  - Backordering
  - Counter seasonal product or service mixings
- Overbooking

Managing Supply

- Inventory based adjustments
  - Build inventory during lean periods
  - Backorder/Stock out/backlog
- Capacity Adjustment
  - Hiring/laying off workers
  - Varying shifts
  - Varying working hours
- Capacity augmentation alternatives
  - Sub-contract
  - Add new capacity
  - De-bottleneck

Other ways of managing supply

- Increasing customer participation
- Creating adjustable capacity
- Sharing capacity
- Cross training employees
- Using part time employees

Basic Strategies for AOP

Level Strategy

Chase Strategy

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Level strategy

- Daily production is uniform
- Use inventory or idle time as buffer
- Stable production leads to better quality and productivity

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Chase strategy

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

Mixed Strategy

- 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

Demand and Working Days							
	January	February	March	April	May	June	Totals
Demand forecast	1,800	1,500	1,100	900	1,100	1,600	8,000
Number of working days	22	19	21	21	22	20	125

Costs	
Materials	$100.00/unit
Inventory holding cost	$1.50/unit/month
Marginal cost of stockout	$5.00/unit/month
Marginal cost of subcontracting	$20.00/unit ($120 subcontracting cost less $100 material savings)
Hiring and training cost	$200.00/worker
Layoff cost	$250.00/worker
Labor hours required	5/unit
Straight-time cost (first eight hours each day)	$4.00/hour
Overtime cost (time and a half)	$6.00/hour

Inventory	
Beginning inventory	400 units
Safety stock	25% of month demand

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Aggregate Planning – JC Company

	January	February	March	April	May	June
Beginning inventory	400	450	375	275	225	275
Demand forecast	1,800	1,500	1,100	900	1,100	1,600
Safety stock (.25 × Demand forecast)	450	375	275	225	275	400
Production requirement (Demand forecast + Safety stock − Beginning inventory)	1,850	1,425	1,000	850	1,150	1,725
Ending inventory (Beginning inventory + Production requirement − Demand forecast)	450	375	275	225	275	400

January ending inventory becomes February beginning inventory.

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Evaluate Alternative Plans

Produce to exact monthly production requirements by varying workforce size

Produce to meet expected average demand by maintaining a constant workforce

Produce to meet the minimum expected demand using a constant workforce and subcontract to meet additional requirements

Produce to meet expected demand for all but the first two months using a constant workforce and use overtime to meet additional output requirements

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Plan 1: Exact Production; Vary Workforce

PRODUCTION PLAN 1: EXACT PRODUCTION; VARY WORKFORCE

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	TOTAL
Production requirement (from Exhibit 19.3)	1,850	1,425	1,000	850	1,150	1,725	
Production hours required (Production requirement × 5 hr./unit)	9,250	7,125	5,000	4,250	5,750		
Working days per month	22	19	21	21			
Hours per month per worker (Working days × 8 hr./day)	176	152	168	168	176		
Workers required (Production hours required/Hours per month per worker)	53	47	30	26	33	54	
New workers hired (assuming opening workforce equal to first month's requirement of 53 workers)	0	0	0	0	7	21	
Hiring cost	$0	$0	$0	$0	$1,400	$4,200	$5,600
Workers lai	0	6	17	4	0	0	
Layoff cost	$0	$1,500	$4,250	$1,000	$0	$0	$6,750
Straight-tim required	$37,000	$28,500	$20,000	$17,000	$23,000	$34,500	$160,000
						Total cost	$172,350

Production exactly matches requirements.

Workers are added or reduced as needed.

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Plan 2: Constant Workforce; Vary Inventory and Stockout

Number of workers is set to meet average demand over the time horizon. This then determines production rate and inventory/backorders.

PRODUCTION PLAN 2: CONSTANT WORKFORCE; VARY INVENTORY AND STOCKOUT

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	TOTAL
Beginning inventory	400	8	−276	−32	412	720	
Working days per month	22	19	21	21	22	20	
available (Working days hr./day × 40 workers)*	7,040	6,080	6,720	6,720	7,040	6,400	
(Production hours unit)	1,408	1,216	1,344	1,344	1,408	1,280	
(from Exhibit 19.3)	1,800	1,500	1,100	900	1,100	1,600	
(Beginning inventory + tion − Demand forecast)	8	−276	−32	412	720	400	
its short × $5)	$0	$1,380	$160	$0	$0	$0	$1,540
Exhibit 19.3)	450	375	275	225	275	400	
Units excess (Ending inventory − Safety stock) only if positive amount	0	0	0	187	445	0	
Inventory cost (Units excess × $1.50)	$0	$0	$0	$281	$668	$0	$948
Straight-time cost (Production hours available × $4)	$28,160	$24,320	$26,880	$26,880	$28,160	$25,600	$160,000
						Total cost	$162,488

Plan 3: Constant Low Workforce; Subcontract

Workforce sized to meet minimum demand (April).

PRODUCTION PLAN 3: CONSTANT LOW WORKFORCE; SUBCONTRACT

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	TOTAL
Production requirement (from Exhibit 19.3)	1,850	1,425	1,000	850	1,150	1,725	
Working days per month	22	19	21	21	22	20	
Production hours available (Working days × 8 hr./day × 25 workers)*	4,400	3,800	4,200	4,200	4,400	4,000	
Actual production (Production hours available/5 hr. per unit)	880	760	840	840	880	800	
Units subcontracted (Production requirement − Actual production)	970	665	160	10	270	925	
Subcontracting cost (Units subcontracted × $20)	$19,400	$13,300	$3,200	$200	$5,400	$18,500	$60,000
Straight-time cost (Production hours available × $4)	$17,600	$15,200	$16,800	$16,800	$17,600	$16,000	$100,000
						Total cost	$160,000

*Minimum production requirement. In this example, April's minimum of 850 units. Number of workers required for April is (850 × 5)/(21 × 8) = 25.

Demand over minimum is met with subcontracting.

Plan 4: Constant Workforce; Overtime

Demand in the first two months is high, so overtime is used to compensate. Then, inventory can be built for high demand in June.

PRODUCTION PLAN 4: CONSTANT WORKFORCE; OVERTIME

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	TOTAL
Beginning inventory	400	0	0	177	554	792	
Working days per month	22	19	21	21	22	20	
Production hours available (Working days × 8 hr./day × 38 workers)*	6,688	5,776	6,384	6,384	6,688	6,080	
Regular shift production (Production hours available/5 hr./unit)	1,338	1,155	1,277	1,277	1,338	1,216	
Demand forecast (from Exhibit 19.3)	1,800	1,500	1,100	900	1,100	1,600	
Units available before overtime (Beginning inventory + Regular shift production − Demand forecast). This number has been rounded to the nearest integer.	−62	−345	177	554	792	408	
Units overtime	62	375	0	0	0	0	
Overtime cost (Units overtime × 5 hr./unit × $6/hr.)	$1,860	$10,350	$0	$0	$0	$0	$12,210
Safety stock (from Exhibit 19.3)	450	375	275	225	275	400	
Units excess (Units available before overtime − Safety stock) only if positive amount	0	0	0	329	517	8	
Inventory cost (Units excessive × $1.50)	$0	$0	$0	$494	$776	$12	$1,281
Straight-time cost (Production hours available × $4)	$26,752	$23,104	$25,536	$25,536	$26,752	$24,320	$152,000
						Total cost	$165,491

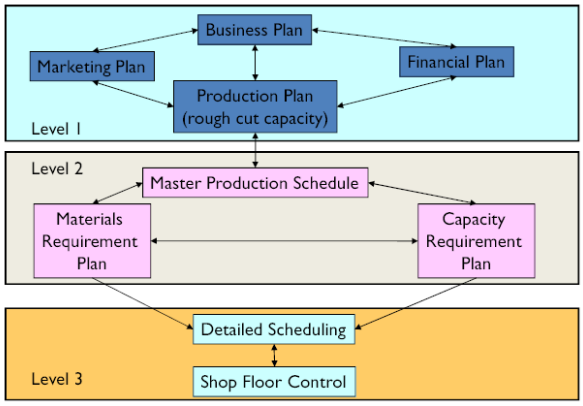
*Workers determined by trial and error. See text for explanation.

Plan Comparison

Comparison of Four Plans

COSTS	PLAN 1: EXACT PRODUCTION; VARY WORKFORCE	PLAN 2: CONSTANT WORKFORCE; VARY INVENTORY AND STOCKOUT	PLAN 3: CONSTANT LOW WORKFORCE; SUBCONTRACT	PLAN 4: CONSTANT WORKFORCE; OVERTIME
Hiring	$ 5,600	$ 0	$ 0	$ 0
Layoff	6,750	0	0	0
Excess inventory	0	948	0	1,281
Shortage	0	1,540	0	0
Subcontract	0	0	60,000	0
Overtime	0	0	0	12,210
Straight time	160,000	160,000	100,000	152,000
	$172,350	$162,488	$160,000	$165,491

Hierarchical Approach to Production Planning



Business Planning Exercise

- Business plan is strategic in nature and addresses the following questions:
  - Should we meet the projected demand entirely or a portion of the projected demand?
  - What are the implications of this decision on the overall competitive scenario and the firm's standing in the market?
  - How is this likely to affect the operating system and planning in other functional areas of the business such as marketing and finance?
  - What resources should we commit to meet the chosen demand during the planning horizon?
  - Aggregate production planning seeks to translate business plans to operational decisions

Yield Management

- **Yield management:** the process of allocating the right type of capacity to the right type of customer at the right price and time to maximize revenue or yield
  - Can be a powerful approach to making demand more predictable
- Has existed as long as there has been limited capacity for serving customers
- Its widespread scientific application began with American Airlines' computerized reservation system (SABRE)

Yield Management Most Effective When…

1. Demand can be segmented by customer
2. Fixed costs are high and variable costs are low
3. Inventory is perishable
4. Product can be sold in advance
5. Demand is highly variable

Yield Management at a Hotel

- Hotels offer one set of rates during the week and another set during the weekend
- The variable costs associated with a room are low in comparison to the cost of adding rooms to the property
- Available rooms cannot be transferred from night to night
- Blocks of rooms can be sold to conventions or tours
- Potential guests may cut short their stay or not show up at all

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Operating Yield Management Systems

- Pricing structures must appear logical to the customer and justify the different prices
- Must handle variability in arrival or starting times, duration, and time between customers
- Must be able to handle the service process
- Must train employees to work in an environment where overbooking and price changes are standard occurrences that directly impact the customer
- The essence of yield management is the ability to manage demand

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Price/Service Duration Matrix: Positioning of Selected Service Industries

		Price	
		Fixed	Variable
Duration	Predictable	Movies Stadiums/arenas Convention centers	Hotels Airlines Rental cars Cruise lines
	Unpredictable	Restaurants Golf courses Internet service providers	Continuing care hospitals

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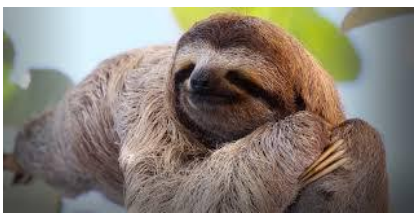
What you think you are!

What you should be!

What you could be!

THANK YOU



What you are!

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