Lesson 16 – Aggregate Planning

refers to intermediate range planning covering 2 to 24 months … a “big picture” look at planning aimed at balancing capacity and demand

Forecast, Production Plan and Inventory

Recall from the forecasting presentation, future demand is forecasted,

<table>
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<th>8 Month Forecast</th>
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<tbody>
<tr>
<td>Forecast Demand</td>
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then a manufacturing production plan is developed,

resulting in an inventory plan

which can be evaluated against financial objectives.

Aggregate Planning Horizon

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<th>Short Range</th>
<th>Intermediate Range</th>
<th>Long Range</th>
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<tbody>
<tr>
<td>Group level forecast</td>
<td>Decision Areas</td>
<td>Staff Planning</td>
<td>Production planning</td>
</tr>
<tr>
<td>Aggregate planning</td>
<td>Master production scheduling</td>
<td>Purchasing (material and equipment)</td>
<td>Distribution</td>
</tr>
</tbody>
</table>
Lesson 16 – Aggregate Planning

Planning Sequence

Corporate strategies and policies
Economic, competitive, and political conditions
Aggregate demand forecasts

Business Plan
Establishes long range production and capacity strategies

Aggregate Plan
Establishes intermediate range production capacity for product groups

Master schedule
Establishes short range schedules for specific products

Aggregate Planning

Aggregate Planning is a planning process which establishes a company-wide game plan for allocating resources (people, equipment, etc.) and economically meeting demand. It

- Matches market demand to company resources
- Expresses intermediate range demand, resources, and capacity in general terms – product groups or families of products rather than at the detail product level (e.g. televisions vs 21", 27", 32", etc.)
- Allows planners more time to deal with short range and day-to-day issues
- Provides information to allow for flexibility ... because of forecast inaccuracy intermediate plans do not have to be “locked in” too soon

Aggregate Planning Objectives

The overriding objective of Aggregate Planning is to consider company policies and management inputs related to operations, distribution & marketing, materials, accounting & finance, engineering and human resources to

- Minimize costs & maximize profits
- Maximize customer service
- Minimize inventory investment
- Minimize changes in production rates
- Minimize changes in work-force levels
- Maximize utilization of plant and equipment
Managerial Inputs To Aggregate Planning

- Operations
  - Current machine capacities
  - Plans for future capacities
  - Work-force capacities
  - Current staffing level

- Distribution & Marketing
  - Customer needs
  - Demand forecasts
  - Competition behavior

- Materials
  - Supplier capabilities
  - Storage capacity
  - Materials availability

- Accounting & Finance
  - Cost data
  - Financial condition of firm

- Engineering
  - New products
  - Product design changes
  - Machine standards

- Human Resources
  - Labor-market conditions
  - Training capacity

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The process of Aggregate Planning:
1. Use the company forecast to determine demand for each period.
2. Determine capacities (regular time, overtime, subcontracting, etc) for each period.
3. Identify company or departmental policies that are pertinent (employment policies, safety stock policies, etc.)
4. Determine unit costs for regular time, overtime, subcontracting, holding inventories, layoffs, and other relevant costs.
5. Develop alternatives with cost for each.
6. If satisfactory plans emerge select the one that best satisfies objectives; otherwise, continue with the previous step.

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Aggregate Planning Process

1. Determine requirements for planning horizon.
2. Identify alternatives, constraints, and costs.
3. Prepare prospective plan for planning horizon.
4. Is the plan acceptable?
   - Yes: Implement and update the plan.
   - No: Move ahead to the next planning session.
5. Implement and update the plan.
6. Move ahead to the next planning session.
7. Is the plan acceptable?
   - Yes: Implement and update the plan.
   - No: Move ahead to the next planning session.
Lesson 16 – Aggregate Planning

**Strategies for meeting uneven supply & demand**

**Level capacity** - maintain a level (steady rate) of production output while meeting variations in demand – use inventory to absorb fluctuations in demand.

**Effect Of “Level Output Strategy”**

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<tr>
<th>Planning Period</th>
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<tbody>
<tr>
<td>Forecasted Demand</td>
<td>10</td>
<td>8</td>
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<tr>
<td>Production Plan</td>
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<tr>
<td>Inventory Position</td>
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</table>

A level output strategy – make the same amount each period.

Inventory is used to “buffer” the difference in capacity and demand.

Can you think of some advantages/disadvantages of this strategy?

**Chase demand** - match production capacity to demand by adjusting capacity to the demand for the period.
Effect Of “Chase Demand Strategy”

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</table>

A chase demand strategy – production is adjusted to meet demand

Can you think of some advantages/disadvantages of this strategy?

Strategies for meeting uneven supply & demand

**Demand Options** ... when capacity and demand are not the same
- Pricing can be adjusted to affect demand (e.g. lower rates in off season)
- Promotions (e.g. advertising, consumer marketing campaigns)
- Back Orders - shift demand to another period by taking orders in one period and promising deliver in a future period when capacity is available (may not create a satisfied customer)
- New demand - create a new need for capacity by producing a product during slack times to utilize resources (e.g. snow blower company produces leaf blowers in off season)

**Capacity Options** ... when capacity and demand are not the same
- Hire or lay-off workers (may create morale and employment problems)
- Use overtime or under-time
- Part-time workers
- Manage capacity with inventory (e.g. let inventories build during periods of low demand or deplete during periods of high demand)
- Subcontract temporary capacity
Simple tables or worksheets can be developed to evaluate demand, aggregate group level production plans and inventory. We will look at some examples to illustrate the concept of aggregate planning. The assumptions for these examples simplify the computations but can be easily modified to “real situations”.

Aggregate Planning – Informal Techniques

Aggregate Planning assumptions
- No allowances are made for holidays, different number of workdays
- Cost is a linear function composed of unit cost & number of units
- Plans are feasible (e.g. sufficient inventory storage space is available, subcontractors are available to produce quantity and quality of products, changes in output can be made as needed)
- Cost figures can be reasonably estimated and are constant for the planning horizon
- Inventories are built and drawn down at a uniform rate and output occurs at a uniform rate through out

Aggregate Planning – formula’s

- Number of workers in period = Number of workers at end of the previous period + Number of new workers at the start of a period - Number of laid-off workers at the start of a period
- Inventory at the end of a period = Inventory at the end of the previous period + Production in the current period - Amount used to satisfy demand in the current period
- Average Inventory for a period = (Beginning Inventory + Ending Inventory) / 2
- Cost for a period = Output Cost + Hire/Lay-off Cost + Inventory Cost + Backorder Cost where Output Cost = Regular Time Cost + Overtime Cost + Subcontractor Cost
How To Calculate Costs …

Regular Costs
- Output cost = Regular cost per unit * Quantity of regular output
- Overtime cost = Overtime cost per unit * Overtime quantity
- Subcontract cost = Subcontract cost per unit * Subcontract quantity

Hire-Layoff Costs
- Hire cost = Cost per hire * Number hired
- Lay-off cost = Cost per lay-off * Number laid off

Inventory Costs
- Carrying cost per unit * Average inventory

Back Order Costs
- Back order cost per unit * Backorder quantity

Aggregate Planning - Example

Example 1: Planners for a company that makes several models of tractors are about to prepare an aggregate plan that will cover 6 periods. The have assembled the following cost information ($):

Output Costs
- Regular time 2 per tractor
- Overtime 3 per tractor
- Subcontract 6 per tractor

Inventory Costs
- 1 per tractor on average inventory

Back Order Costs 5 per tractor per period

The forecasted demand by period is:

<table>
<thead>
<tr>
<th>Planning Period</th>
<th>1</th>
<th>2</th>
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<th>5</th>
<th>6</th>
<th>Total</th>
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<tbody>
<tr>
<td>Forecasted Demand</td>
<td>200</td>
<td>200</td>
<td>300</td>
<td>400</td>
<td>500</td>
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</table>

They now want to evaluate a plan that calls for a steady rate of regular-time output.

They intend to start with 0 inventory on hand in the first period.

Prepare an aggregate plan and determine its cost for a level output rate of 300 units per period with 15 workers.
Example 2: After reviewing the plan the planners need to develop an alternative based on the news that one of the regular time workers has decided to retire. Rather than replace that person they would rather stay with a smaller workforce and use overtime to make up for the lost output. The maximum overtime output is 40 units.

First the regular time output of 300 units per 15 people must be adjusted for 14 people. Therefore 300/15*14 = 280 = adjusted regular time output for 14 people.
Lesson 16 – Aggregate Planning

We are 120 tractors short. Where do we manufacture them?

Why did we put manufacture them here? Does manufacturing them in other periods produce a lower cost? Total cost of plan is $4,640.

Notice the backorder cost in period 5.

Example 3: A third option is to use temporary workers rather than overtime to fill in for the retiring worker.

Suppose that it costs an additional $100 to hire and train a temporary worker and that a temporary worker can produce 15 tractors per period.

First of all, 120 units are needed to replace the retired worker’s output (see output from Example 2).

Therefore, 120/15 = 8 means that 8 temporary worker periods are needed to create the 120 units.

Noting that periods 4 and 5 have the heaviest demand, using 4 temporary workers during those periods seems reasonable. This means that we only have to hire 4 temporary workers for two months.
Why is the hire/train cost only $400?
Total cost of plan is $4,860

Notice the backorder cost in period 5
Notice the hire/layoff cost in period 6

The aggregate plan can not be used for production because it is at the group level rather than the individual product level.

The aggregate plan must be broken down into specific product requirements so that specific labor skills, materials, and inventory plans can be determined. (e.g. 21” TV’s take different parts than 27” TV’s)

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### Master Scheduling Process

**Inputs**
- Beginning Inventory
- Forecast
- Customer Orders

**Outputs**
- Projected Inventory
- Master Production Schedule
- Available To Promise (uncommitted inventory)

3 inputs and 3 outputs

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### Inputs To Master Scheduling

<table>
<thead>
<tr>
<th>Planning Period</th>
<th>1</th>
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<tr>
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<tr>
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<tr>
<td>Projected On Hand Inventory</td>
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</tbody>
</table>

Projected demand is calculated based on the customer orders and forecast.

Projected Demand = max (forecast, orders)

How can customer orders be more than forecast?

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### Outputs Of Master Scheduling

Therefore, the Projected Inventory Position (previous inventory position - projected demand) without any production can be calculated and is shown below.

<table>
<thead>
<tr>
<th>Planning Period</th>
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<td></td>
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<tr>
<td>Projected Demand</td>
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<td>40</td>
<td>40</td>
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<tr>
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<td>30</td>
<td>30</td>
<td>30</td>
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</table>

How can customer orders be more than forecast?
If the lot size for this item is 70 units, we can now build the Master Production Schedule. We add our first lot in week/day 3 because this is the first negative inventory position. We then update our Projected Inventory Position.

<table>
<thead>
<tr>
<th>Planning Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<td>Projected Demand</td>
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<tr>
<td>Projected On Hand Inventory</td>
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<td>Master Production Schedule (MPS)</td>
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</table>

We add our next lot in week/day 5 because this is the next negative inventory position. We then update our Projected Inventory Position.

<table>
<thead>
<tr>
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We add our next lot in week/day 7 because this is the next negative inventory position. We then update our Projected Inventory Position.

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We add our next lot in week/day 9 because this is the next negative inventory position. We then update our Projected Inventory Position, and have completed the second output of the master scheduling process, the Master Production Schedule.

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We are now ready to compute our final output of the master scheduling process, the Available to Promise (ATP) or uncommitted inventory. This is inventory which is available to sell and is extremely important to customer service. The ATP is calculated for weekday 1, 3, 6, 7 and 8.

Think about how Land's End may use the ATP!

The ATP is calculated for weekday 1 by the following:

\[ \text{Week 1 ATP} = \text{Beginning inventory} \times \text{sum of committed inventory (customer orders) until the first master scheduled lot} \]

\[ = 64 \times (33 + 20) = 11 \]

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The ATP is calculated for week/day 3 by the following:

\[ \text{Week 3 ATP} = \text{MPS for week/day 3} - \text{sum of committed inventory (customer orders until the next master scheduled lot)} \]

\[ = 70 - (10 + 4) = 56 \]

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The ATP is calculated for week/day 5 by the following:

\[ \text{Week 5 ATP} = \text{MPS for week/day 5} - \text{sum of committed inventory (customer orders until the next master scheduled lot)} \]

\[ = 70 - 2 = 68 \]

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The ATP is calculated for week/day 7 by the following:

\[ \text{Week 7 ATP} = \text{MPS for week/day 7} - \text{sum of committed inventory (customer orders until the next master scheduled lot)} \]

\[ = 70 - 0 = 70 \]

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Outputs Of Master Scheduling

The ATP is calculated for week/day 8 by the following:

\[
\text{Week 8 ATP} = \text{MPS for week/day 8} - \text{sum of committed inventory (customer orders) until the next master scheduled lot} \\
= 70 - 0 = 70
\]

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You can see by these calculations that changes to a Master Schedule can be disruptive, particularly those in the first few weeks/days of a schedule. It is difficult to rearrange schedules, materials plans, and labor plans on a short notice. For these reasons, many schedules have varying degrees of changes that are allowed. Time fences are created to indicate the level of change if any that will be considered.

### Planning Period

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### Hierarchical Planning Process

- **Items**
  - Product lines or families
  - Individual products
  - Components
  - Manufacturing operations

- **Production Planning**
  - Aggregate Production Plan
  - Master Production Schedule
  - Material Requirements Plan
  - Shop Floor Schedule

- **Capacity Planning**
  - Resource Requirements Plan
  - Rough-Cut Capacity Plan
  - Capacity Requirements Plan
  - Input/Output Control

- **Resource Level**
  - Plants
  - Critical work centers
  - All work centers
  - Individual machines

### Homework

- Read and understand all material in the chapter.
- Discussion and Review Questions
- Recreate and understand all classroom examples
- Exercises on chapter web page