

Supply chain Management

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Lecture 8

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PMG 660

Aggregate Planning in a Supply Chain



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Learning Objectives

After reading this chapter, you will be able to:

- 1. Identify the decisions that are best solved by aggregate planning.**
- 2. Understand the importance of aggregate planning as a supply chain activity.**
- 3. Describe the information needed to produce an aggregate plan.**
- 4. Explain the basic trade-offs to consider when creating an aggregate plan.**

The role of aggregate planning in a supply chain

In this chapter, we discuss how the aggregate planning methodology is used to make decisions about production, outsourcing, inventory, and backlogs in a supply chain.

We identify the information required to produce an aggregate plan and outline the basic trade-offs that must be made to create an optimal aggregate plan.

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Imagine a world in which manufacturing, transportation, warehousing, and even information capacity are all limitless and free. Imagine lead times of zero, allowing goods to be produced and delivered instantaneously. In this world, there would be no need to plan anticipation of demand, because whenever a customer demands a product, the demand would be instantly satisfied. In this world, aggregate planning plays no role.

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In the real world, however, capacity has a cost, and lead times are often long. Therefore, companies must make decisions regarding capacity levels, production levels, outsourcing, and promotions well before demand is known.

A company must anticipate demand and determine, in advance of that demand, how to meet it.

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Should a company invest in a plant with large capacity that is able to produce enough to satisfy demand even in the busiest months?

Or should a company build a smaller plant but incur the costs of holding inventory built during slow periods in anticipation of demand in later months?

These are the types of questions that aggregate planning helps companies answer.

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Aggregate planning is a process by which a company determines ideal levels of capacity, production, subcontracting, inventory, stockouts, and even pricing over a specified time horizon. The goal of aggregate planning is to satisfy demand while maximizing profit. Aggregate planning, as the name suggests, solves problems involving aggregate decisions rather than stock-keeping unit (SKU)-level decisions.

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For example, aggregate planning determines the total production level in a plant for a given month, but it does so without determining the quantity of each individual SKU that will be produced. This level of detail makes aggregate planning a useful tool for thinking about decisions with an intermediate time frame of between roughly 3 and 18 months. In this time frame, it is too early to determine production levels by SKU, but it is also generally too late to arrange for additional capacity. Therefore, aggregate planning answers the question, "How should a firm best utilize the facilities that it currently has?"

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The aggregate planner's main objective is to identify the following operational parameters over the specified time horizon:

Production Rate: the number of units to be completed per unit time (such as per week or per month)

Workforce: the number of workers/units of capacity needed for production

Overtime: the amount of overtime production planned

Machine Capacity Level: the number of units of machine capacity needed for production

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Subcontracting: the subcontracted capacity required over the planning horizon

Backlog: demand not satisfied in the period in which it arises but carried over to future periods

Inventory on Hand: the planned inventory carried over the various periods in the planning horizon .

The aggregate plan serves as a broad blueprint for operations and establishes the parameters within which short-term production and distribution decisions are made. The aggregate plan allows the supply chain to alter capacity allocations and change supply contracts

The aggregate planning problem

The objective of the aggregate plan is to satisfy demand in a way that maximizes profit for the firm. We can state the aggregate planning problem formally as follows:

Given the demand forecast for each period in the planning horizon, determine the production level, inventory level, and capacity level (internal and outsourced) for each period that maximizes the firm's profit over the planning horizon.

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To create an aggregate plan, a company must specify the planning horizon for the plan.

A planning horizon is the time period over which the aggregate plan is to produce a solution-usually between 3 and 18 months.

A company must also specify the duration of each period within the planning horizon (e.g., weeks, months, or quarters). In general, aggregate planning takes place over months or quarters.

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Next, a company specifies key information required to produce an aggregate plan and to make the decisions for which the aggregate plan will develop recommendations. This information and the recommendations are specified for a generic aggregate planning problem in this section.

The model we propose in the next section is flexible enough to accommodate situation-specific requirements.

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An aggregate planner requires the following information:

- Demand forecast F_r for each Period t in a planning horizon that extends over T periods
- Production costs
- Labor costs, regular time (\$/hour), and overtime costs (\$/hour)
- Cost of subcontracting production (\$/unit or \$/hour)
- Cost of changing capacity; specifically, cost of hiring/laying off workforce (\$/worker) and cost of adding or reducing machine capacity (\$/machine)

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- Labor/machine hours required per unit
- Inventory holding cost (\$/unit/period)
- Stockout or backlog cost (\$/unit/period)
- Constraints
 - Limits on overtime
 - Limits on layoffs
 - Limits on capital available
 - Limits on stockouts and backlogs
 - Constraints from suppliers to the enterprise

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Using this information, a company makes the following determinations through aggregate planning:

Production Quantity from Regular time, Overtime, and Subcontracted Time:

used to determine number of workers and supplier purchase levels

Inventory Held: used to determine the warehouse space and working capital required

Backlog/Stockout Quantity: used to determine customer service levels

Workforce Hired/Laid Off used to determine any labor issues likely to be encountered

Machine Capacity Increase/Decrease: used to determine if new production equipment should be purchased or idled

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The quality of an aggregate plan has a significant impact on the profitability of a firm.

A poor aggregate plan can result in lost sales and lost profits if the available inventory and capacity are unable to meet demand. A poor aggregate plan may also result in a large amount of excess inventory and capacity, thereby raising costs. Therefore, aggregate planning is a very important tool in helping a supply chain maximize profitability.

Aggregate planning strategies

The aggregate planner must make trade-offs among **capacity, inventory, and backlog costs**. An aggregate plan that increases one of these costs typically results in reduction of the other two.

In this sense, the costs represent a trade-off-to lower inventory cost, a planner must increase capacity cost or delay delivery to the customer. Thus the planner trades inventory cost for capacity or backlog cost. Arriving at the most profitable combination of trade-offs is the goal of aggregate planning.

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Given that demand varies over time, the relative level of the three costs leads to one of them being the key lever the planner uses to maximize profits.

- **If the cost of varying capacity is low, a company may not need to build inventory or carry backlogs.**
- **If the cost of varying capacity is high, a company may compensate by building some inventory and carrying some backlogs from peak demand periods to off-peak demand periods.**

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In general, a company attempts to use a combination of the three costs to best meet demand. Therefore, the fundamental trade-offs available to a planner are among

- **Capacity (regular time, overtime, subcontracted)**
- **Inventory**
- **Backlog/lost sales because of delay**

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There are essentially three distinct aggregate planning strategies for achieving balance between these costs. These strategies involve trade-offs among capital investment, workforce size, work hours, inventory, and backlogs/lost sales.

Most strategies that a planner actually uses are a combination of these three and are referred to as tailored strategies. The three strategies are as follows.

Aggregate planning strategies types



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1. Chase strategy-using capacity as the lever: With this strategy, the production rate is synchronized with the demand rate by varying machine capacity or hiring and laying off employees as the demand rate varies. In practice, achieving this synchronization can be very problematic because of the difficulty of varying capacity and workforce on short notice. This strategy can be expensive to implement if the cost of varying machine or labor capacity over time is high.

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It can also have a significant negative impact on the morale of the workforce.

The chase strategy results in low levels of inventory in the supply chain and high levels of change in capacity and workforce. It should be used when the cost of carrying inventory is very high and costs to change levels of machine and labor capacity are low.

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2. Time flexibility from workforce or capacity strategy-using utilization as the lever:

This strategy may be used if there is excess machine capacity (i.e., if machines are not used 24 hours a day, seven days a week). In this case the workforce (capacity) is kept stable but the number of hours worked is varied over time in an effort to synchronize production with demand.

A planner can use variable amounts of overtime or a flexible schedule to achieve this synchronization.

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Although this strategy does require that the workforce be flexible, it avoids some of the problems associated with the chase strategy, most notably, changing the size of the workforce.

This strategy results in low levels of inventory but with lower average machine utilization. It should be used when inventory carrying costs are relatively high and machine capacity is relatively inexpensive.

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3. Level strategy-using inventory as the lever:

With this strategy, a stable machine capacity and workforce are maintained with a constant output rate. Shortages and surpluses result in inventory levels fluctuating over time. In this case, production is not synchronized with demand. Either inventories are built up in anticipation of future demand or backlogs are carried over from high- to low-demand periods.

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Employees benefit from stable working conditions. A drawback associated with this strategy is that large inventories may accumulate and customer orders may be delayed.

This strategy keeps capacity and costs of changing capacity relatively low. It should be used when inventory carrying and backlog costs are relatively low.

Aggregate planning using linear programming

As we discussed earlier, the goal of aggregate planning is to maximize profit while meeting demand. Every company, in its effort to meet customer demand, faces certain constraints, such as the capacity of its facilities or a supplier's ability to deliver a component.

A highly effective tool for a company to use when it tries to maximize profits while being subjected to a series of constraints is linear programming. Linear programming finds the solution that creates the highest profit while satisfying the constraints that the company faces.

The role of IT in aggregate planning



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Aggregate planning is arguably the supply chain area in which information technology has been used the most.

The earliest IT supply chain products were aggregate planning modules, often called factory, production, or manufacturing planning. Some of the early modules focused only on obtaining a feasible production plan subject to constraints arising from demand and available capacity.

The role of it in aggregate planning



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These classic solutions generally formulated the aggregate planning problem as a linear program (LP) to get a production schedule of products to be made in each period of time.

Today, some planning modules incorporate nonlinear optimization to account for the fact that not all constraints or reasonable objective functions are linear functions.

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However, given the large amount of data considered in producing aggregate plans, which can render nonlinear problems computationally prohibitive, and the ability to create linear approximations of nonlinear functions, linear programming is often the best way to solve these problems.

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Supply chain planning modules today often combine both production planning and inventory planning. The supply chain planning module uses the output of the forecasting module as a constraint in setting up the production schedule and inventory levels. These production schedules and inventory levels are used by the execution system for the actual production of the goods and the setting of inventory levels throughout the supply chain. Given the complexity of the problem, aggregate planning modules can add significant value even for small companies.

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There are a number of dimensions along which IT can add value in the aggregate planning realm:

- **The ability to handle large problems**
- **The ability to handle complex problems (through either nonlinear optimization or linear approximations)**
- **The ability to interact with other core IT systems such as inventory management and sourcing**

Implementing aggregate planning in practice

1. Think beyond the enterprise to the entire supply chain. Most aggregate planning today takes only the enterprise as its breadth of scope. However, many factors outside the enterprise throughout the supply chain can affect the optimal aggregate plan dramatically. Therefore, avoid the trap of thinking only about your enterprise when planning. Work with downstream partners to produce forecasts, with upstream partners to determine constraints, and with any other supply chain entities that can improve the quality of the inputs into the aggregate plan.

Implementing aggregate planning in practice

The plan is only as good as the quality of the inputs. So using the supply chain to increase the quality of the inputs will greatly improve the quality of the aggregate plan.

Also make sure to communicate the aggregate plan to all supply chain partners who will be affected by it.

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2. Make plans flexible, because forecasts are always wrong. Aggregate plans are based on forecasts of future demand.

Given that these forecasts are always wrong to some degree, the aggregate plan needs to have some flexibility built into it if it is to be useful. By building flexibility into the plan, when future demand changes, or other changes occur such as increases in costs, the plan can adjust appropriately to handle the new situation.

3. Rerun the aggregate plan as new data emerge.

As we have mentioned, aggregate plans provide a map for the next 3 to 18 months. This does not mean that a firm should run aggregate plans only once every 3 to 18 months. As inputs such as demand forecasts change, managers should use the latest values of these inputs and rerun the aggregate plan. By using the latest inputs, the plan will avoid sub optimization based on old data and will produce a better solution.

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4. Use aggregate planning as capacity utilization increases.

Surprisingly, many companies do not create aggregate plans and instead rely solely on orders from their distributors or warehouses to determine their production schedules. These orders are driven either by actual demand or through inventory management algorithms.

If a company has no trouble meeting demand efficiently this way, then the lack of aggregate planning may not harm the company significantly.

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However, when utilization becomes high and capacity is an issue, relying on orders to set the production schedule can lead to capacity problems. When utilization is high, the likelihood of producing for all the orders as they arrive is very low. Planning needs to be done to best utilize the capacity to meet the forecasted demand.

Therefore, as capacity utilization increases, it becomes more important to perform aggregate planning.



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Reference

Supply chain management

Strategy, Planning, and Operation

By: Sunil Chopra,.-3rd ed.

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