

Quantitative Supply Chain Decisions Driving Your Business

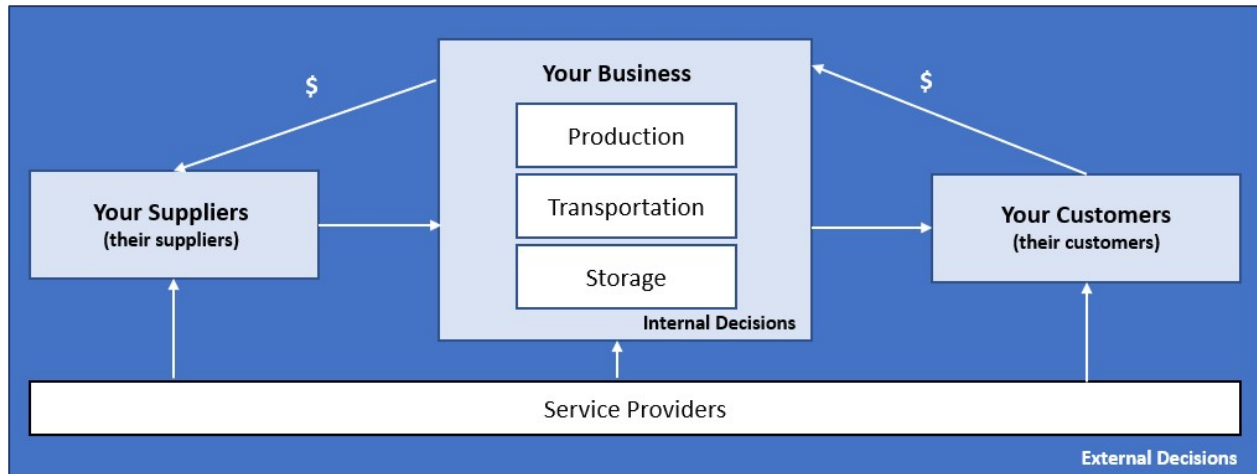
**Are you actively making these decisions or just
continuing with how things have always been done?**

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Supply Chain Management

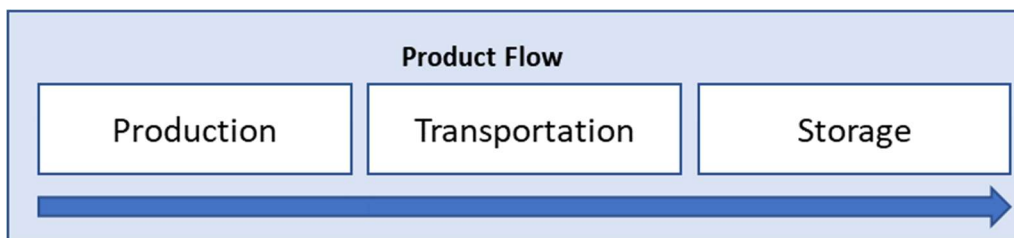
Supply chain management involves the flow of products, information and money from suppliers (and their suppliers) through a company to its customers (and their customers) with the purpose of serving customers and maximizing profit.



Decisions driving supply chain management can be separated into internal and external decisions. Internally, your business is making decisions around the logistics of producing, transporting and storing your product. Externally, your business is making decisions on how it will interact with others (suppliers, customers, partners, service providers, etc.) to support the business. This paper will focus on the internal quantitative supply chain decisions.

Key Internal Supply Chain Decisions

Internal supply chain management decisions revolve around how you produce, transport and store your product. These are your internal logistics decisions and often involve significant quantitative analysis to optimize. Often organizations do not perform the required analysis as their business evolves rather, they continue with their processes as they have always been done.



There are eight key internal logistics decisions that are made by any business which creates a product and moves their product to their customers. We will review the information required to make the best choice for each of these decisions.

Production

1. Location and number of facilities

An organization must decide where to produce and in how many locations. This is a costly and strategic decision, and is based on the location and distance from both your customers and your suppliers, the cost of labor and utilities in different locations, economies of scale and risks that come from having multiple locations or selecting specific locations.

Each of these variables need to be analyzed and understood. As organizations grow often these decisions are initially made without significant review. For example, if an organization grows through acquisition, new facilities are incorporated into the existing network. To optimize, you need to analyze each facility of the network and determine the correct number of locations and where they should be located, including existing locations or considering new, candidate locations.

2. Product Design

In addition to location, an important logistical decision is production strategy. The way a company decides how to manufacture their products has important implications for location, transportation and inventory storage. The production strategy is largely realized at the product design and development stage. Possible strategies include:

- *Highly standardized products* – high volume, low variation
- *Mass customization* – customized products on standardized modules
- *Postponement* – standard products, customized later in the supply chain closer to the customer
- *Push/pull* – Push items are inventory items often with long lead times, pull items are sub-assemblies built from inventory items that are pulled as production is required
- *Mix model production* – allows for production of various products on one production line
- *Job shop* – ultimate flexibility, each product is different and may follow a different flow through the plant

Each strategy has positive and negative impacts, often trading flexibility for cost.

Transportation

Transportation costs are by far the largest of all supply chain costs. Facility location will have a significant impact on transportation costs, but even once the locations are determined, we can still look to minimize transportation cost by minimizing the distance products are moved via optimal routing.

3. Routing Vehicles

Vehicle routing at its core is minimizing the cost, time or distance to serve your customers. Depending on the business, you might need one vehicle per customer

because your product or customer orders are large and require a full truck. In this situation, finding the optimal (minimum cost) route per customer is relatively simple.

If your average customer order size is smaller and multiple orders are grouped together, then the optimal routing becomes more complicated. You are still trying to minimize the cost, time or distance to serve your customers, but there are additional variables and constraints to consider: capacity of vehicles, time windows for customers to receive orders, and backhaul – is there anything the vehicle can pick up and bring back to the factory or warehouse. Once incorporated an optimization model can determine the lowest cost route that meets all of the business constraints.

4. Transportation Mode

There are different modes of transportation (ship, rail, tractor-trailer (full truck or less-than-truckload), box-truck, van, plane) that come with different tradeoffs. Each mode has a level of speed and flexibility. As speed and flexibility increases, so does the cost of the transportation.



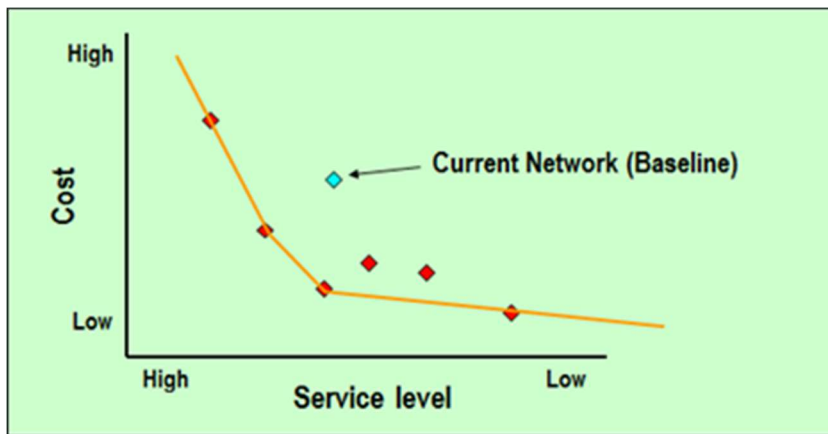
It is important to analyze your business and the transportation needs – cheaper isn't always better in this situation. If your product has a high inventory value and obsolescence happens relatively quickly, then you likely would not want to use slow modes of transportation but could consider flying your goods. Rail is often a very affordable mode of transportation, but again if you need to have flexibility or multiple stops for your products this might not be the best choice.

Storage

5. Location and number of facilities

This decision is similar to the decision around production locations and number of facilities. The main difference is that storage is not adding value to the product, so the key things to balance are cost and customer service. Additional storage locations typically increase both cost and customer service.

Defining customer service expectations is key to determining the correct storage network. For example, if you can deliver to a customer in 3 or 4 days and meet their expectations, your storage needs will vary significantly from a business whose customers expect their product in one day. Below is a summary of potential storage locations (each diamond is a potential site) with their cost and service level. The locations above the line are less efficient – either costing more or providing a lower service level than the locations on the line.



Ultimately the decision is choosing between cost and customer service. Any location on the line could be a good choice, but how you balance the tradeoff will vary depending on your business.

6. Type of facility

When building or buying an inventory storage site it is important to plan its purpose. The purpose will impact location select, layout, and racking or shelving design.

- *Direct-to-Consumer* – order-fulfillment facilities, high volume of small single item pick orders
- *B2B warehouse* – large multiple pallet orders
- *Crossdock Warehouse* – breakdown pallets from suppliers into boxes for individual stores
- *Value Added Provider* – final customization or packaging provided at storage location just prior to shipping
- *Retail Store* – not always considered a storage location, but it does hold inventory

When considering your network on storage locations, it is important to note that each location may not just serve one purpose. You could have a warehouse that is both direct-to-consumer, but also fills B2B orders.

We worked with an organization whose business grew to support exactly these two different situations. They had large national accounts buying pallets of specific items. These same items were being sold in single unit direct-to-consumer orders, which had to be fulfilled from the same warehouse. To support this, we created multiple locations in their warehouse for these same items. On one side of the warehouse was the national accounts section which held pallets of these products. On the other side of the warehouse were narrow-aisle racks which held smaller volume of these products but supported a quick and easy picking process to enable fast fulfillment of small customer orders.

7. Inventory levels

Similar to number and location of storage facility, inventory levels require the decision of cost versus customer service. Holding more inventory will support higher service levels. The more inventory that you hold, the more likely you will be to have the product in stock when a customer wants it. But there is a cost to holding inventory. The cost is more than just the financial holding cost of having a product which you have already paid for sitting in your warehouse. The more inventory you hold, the higher your chance for that product to turn obsolete, break, or be lost before you are able to sell it.

There are mathematical formulas to determine the correct level of inventory to hold, when to reorder and how much to order. The key inputs for determining your optimal inventory are:

- *Forecasted demand (and forecast error)*
- *Lead Time*
- *Inventory holding cost* –the cost of handling or warehousing, and the cost of damage or obsolescence
- *Cost of Product*
- *Order or Setup Cost* – machine set up or ordering cost (inclusive of shipping)
- *Target Service Level* – what percentage of the time do you want the product in stock when a customer orders **Target service level is the decision that needs to be balanced with cost.** A higher service level will result in a higher level of inventory.

8. Packaging

The final consideration is packaging. Packaging can dramatically reduce storage and product costs, but must be weighed against consumer perception. Examples of interesting storage involve wine and deodorant. A connoisseur of wine would never consider buying boxed wine. However, the bag and box design stores more wine in a smaller space, keeps the wine fresh because it does not let air in (which oxidizes the wine ruining the flavor), and is less expensive to ship (cardboard weighs less than glass). However, glass bottles still are preferred in most countries. Therefore, we need to balance cost with consumer perception. Even the most dedicated supply chain manager would likely not show up to a party with a box of wine!

Another famous packaging story involves one of the great supply chain companies in the world, Wal-mart. A buyer at Wal-mart realized that deodorant, which was packaged in the plastic container and then in small printed boxes, was unnecessarily double-packaged. She demanded that the cardboard boxes be eliminated, and all product information be printed directly on the plastic container. This buyer may be responsible for saving more trees than any human in our entire history.

Summary

There are several key decisions driving the internal logistics of your supply chain through production, transportation and storage. These decisions are quantitative in nature and require significant data analysis to get right. Ensure your business is actively making these decisions, especially as your business and the markets evolve rather than continuing with the status quo.