

Preface

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Good luck with your exams!

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A. Supply Chain Drivers and Metrics

In this chapter, we will link financial measures to supply chain performance of firms.

Financial measures of performance

There are several measures to measure performance of supply chains.

Return on equity: summary measure of a firm's performance.

$$ROE = \frac{\text{Net Income}}{\text{Average Shareholder Equity}}$$

Return on assets: summary measure of the return earned on each dollar invested by the firm in assets.

$$ROA = \frac{\text{Earnings before interest}}{\text{Average total assets}} = \frac{\text{Net income} + [\text{Interest expense} \times (1 - \text{Tax rate})]}{\text{Average total assets}}$$

APT: ratio measure that defines financial leverage is accounts payable turnover.

$$APT = \frac{\text{Cost of goods sold}}{\text{Accounts payable}}$$

There are three key components of asset turnover:

- **ART:** accounts receivable turnover.

$$ART = \frac{\text{Sales revenue}}{\text{Accounts receivable}}$$

- **INVT:** inventory turnover.

$$INVT = \frac{\text{Cost of goods sold}}{\text{Inventories}}$$

- **PPET:** equipment turnover.

$$PPET = \frac{\text{Sales revenue}}{PP\&E}$$

Cash-to-cash cycle (C2C): measure that measures the average amount of time from when cash enters the process as cost to when it returns as revenue.

$$C2C = -\text{weeks payable} \left(\frac{1}{APT} \right) + \text{weeks in inventory} \left(\frac{1}{INVT} \right) + \text{weeks receivable} \left(\frac{1}{ART} \right)$$

There are two measures that are not part of a firm's financial statement:

- **Markdowns:** discounts that convinces customers to buy excess inventory;
- **Lost sales:** sales that did not actualize because of the absence of products that customers wanted to buy.

Markdowns and lost sales reduce net income and cause deterioration of the supply chain.

Key drivers of supply chain performance

Drivers of the supply chain must be structured well in order to achieve the desired level of responsiveness at low costs.

There are six key drivers:

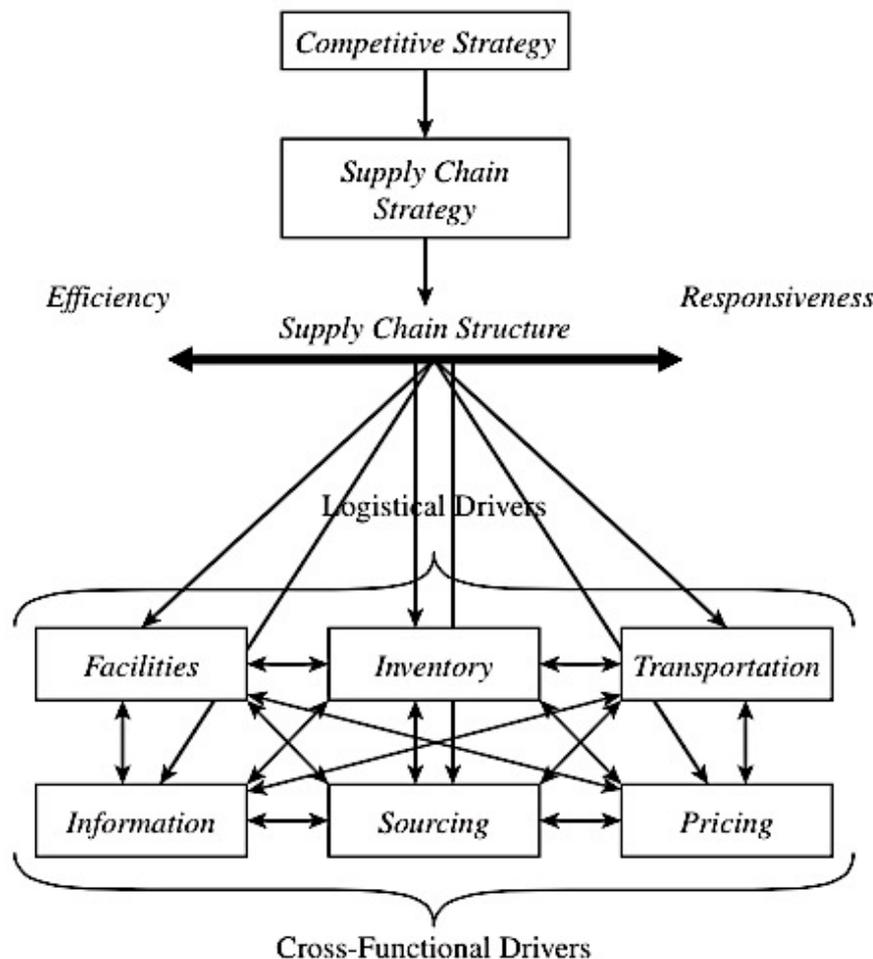
- Facilities: the location in the supply chain where products are stored, assembled, or manufactured. For instance production sites and storage sites.;
- Inventory: finished goods, raw materials, and work in process in the supply chain;
- Transportation: the process of moving inventory from location to location in the supply chain;
- Information: the data and analysis having to do with facilities, transportation, inventory, prices, costs, and customers in the supply chain;
- Sourcing: allocation of who will execute a supply chain activity;
- Pricing: how much companies will charge for services and goods that it produces in the supply chain.

It is important that these drivers interact to determine the overall supply chain performance.

Framework for structuring the key drivers

One can design a framework in order to structure the six key drivers discussed above.

Most companies begin with defining their competitive strategy. Thereafter, they decide how they will structure their supply chain strategy regarding to their efficiency and responsiveness.



A supply chain decision-making framework.
Source: Chopra, S. and P. Meindl (2016). Supply Chain Management, Strategy, Planning, and Operation, 6th Edition, Pearson Higher Education.

Facilities

When companies increase their number of facilities, they can increase responsiveness. However, this may entail costs. Though it decreases for instance transportation costs and response time. Thus, supply chains must discover the right tradeoff when they design their facilities network.

Companies make several decisions regarding facilities:

- Role: companies need to decide if production facilities will be flexible, dedicated, or both. Companies need to decide if facilities will be product focused or functional focused. Regarding warehouses and DCs, companies should decide if they will be cross-docking (inbound trucks from suppliers are unloaded) or storage facilities;
- Location: companies must decide where they will locate its facilities;
- Capacity: companies must decide what the capacity of a facility will be to perform its function or functions;
- Facility-related metrics: the above decisions affect the financial performance and the supply chain's responsiveness to customers. Managers should track several facility-related metrics that may influence supply chain performance:
 - **Capacity**: measures the highest amount that a facility can process;
 - **Utilization**: measures the part of capacity that is being used in a facility;
 - **Processing/setup/down/idle time**: measures the part of time that the facility was processing units, was setting up to process units, unavailable, or idle because there were no units to process;
 - **Production cost per unit**: measures the average production cost per unit;
 - **Quality losses**: measures the part of products lost as a result of deficiency;
 - **Theoretical flow/cycle time of production**: measures the time to process a unit without delays;
 - **Actual average flow/cycle time**: measures the average time for all units processed over a given time;
 - **Flow time efficiency**: the ratio of stated flow time to the actual average flow time;
 - **Product variety**: measures the amount of different products produced at a facility;
 - **Volume contribution of top 20 percent SKUs and customers**: measures the part of total volume that comes from the top 20 percent of SKUs or customers;
 - **Average production batch size**: measures the average products processed in a production batch;
 - **Production service level**: measures the part of production orders that are completed on time.

Inventory

Inventory in the supply chain has a big impact on the material flow time in a supply chain.

Material flow time: the time between when the material enters the supply chain and when this material exits the supply chain.

Little's law:

$$\text{Little's Law: } I = DT$$

I = inventory

D = throughput (rate at which sales occur)

T = flow time

Companies make several decisions regarding inventory:

- Cycle inventory: the amount of inventory that is used to satisfy demand of receipts of supplier shipments;
- Safety inventory: stand-by inventory when demand exceeds the expectation;
- Seasonal inventory: inventory that is build up to deal with seasonal variability in demand;
- Level of product availability: demand that is answered in time from products held in inventory;
- Inventory-related metrics: the above decisions affect the costs of goods sold, the assets held by the supply chain, the C2C cycle, and the responsiveness. Managers should track inventory-related metrics that affect supply chain performance:
 - **C2C cycle time**: metric that contains accounts payable, receivables, and inventories;
 - **Average inventory**: measures the average amount of inventory carried;
 - **Inventory turns**: measures the number of times an inventory changes in a year;
 - **Products with more than a stated number of days of inventory**: products for which a firm carries great inventory;
 - **Average replenishment batch size**: measures the average amount in each replenishment order placed;
 - **Average safety inventory**: measures the average amount of safety inventory.
 - **Seasonal inventory**: measures the amount or seasonal inventory;
 - **Fill rate**: measures the amount of orders that were met on time from inventory;
 - **Fraction of time out of stock**: measures the part of time that there was zero inventory in a SKU;
 - **Obsolete inventory**: measures the part of inventory that was older than a stated date.

Transportation

Transportation carries products from place to place. In a supply chain it affects responsiveness and efficiency.

There are several key components of transportation that companies analyse when they design their supply chain:

- Transportation network: transportation modes, locations, and routes along a product is shipped;
- Transportation mode: procedure in which a product is moved from place to place;
- Transportation-related metrics: the above components affect the costs of a good sold. Managers can track the following transportation-related metrics that affect supply chain performance:
 - **Average inbound transportation cost**: measures the cost of transporting a product into a facility;
 - **Average incoming shipment size**: measures the average number of products incoming at a facility;
 - **Average inbound transportation cost per shipment**: measures the average transportation cost of incoming products;
 - **Average outbound transportation cost**: measures the cost of transporting a product to a customer;
 - **Average outbound shipment size**: measures the average number of products outbound at a facility;
 - **Average outbound transportation cost per shipment**: measures the average transportation cost of outgoing transfer;
 - **Fraction transported by mode**: measures the part of transportation using a specific type of transportation.

Information

Useful information can advance the utilization of supply chain assets and logistics of supply chain flows to better responsiveness and reduce costs. Sharing information can increase useful information.

There are several key components of information that companies analyse to increase supply chain performance:

- Push versus pull: managers must determine which processes are part of the pull or push phase in the supply chain, because different systems require different types of information;
- Coordination and information sharing: each stage in the supply chain must share suitable information with other stages;
- Sales and operations planning: supply plan which determines the foreseen level of demand;
- Enabling technologies: technologies may share and analyse information in the supply chain. Companies should decide which technologies they are going to work with:
 - Electronic data interchange (EDI): makes transactions faster and more accurate.
 - Internet: comprises great quantity of information;
 - Enterprise resource planning (ERP): system that provides transactional tracking and global visibility of information in a company and across its supply chain;
 - Supply chain management (SCM): software that uses the information of ERP to provide analytical decisions;
 - Radio frequency identification (RFID): program that has an active or passive radio frequency tag that is applied to the item that is being tracked, and an RF reader. This can be used for instance in manufacturing to check availability of the whole bill of materials.
- Information-related metrics: a company should track the following information-related metrics that affect supply chain performance:
 - **Forecast horizon**: time that a forecast is made before the actual event;
 - **Frequency of update**: how often a forecast is updated;
 - **Forecast error**: measures the dissimilarity between the forecast and the actual demand;
 - **Seasonal factors**: measures the range at which the demand in a specific season is above or below the average over a year;
 - **Variance from plan**: the difference between the planned production and the actual demand for the products;
 - **Ratio of demand variability to order variability**: measures the standard deviation of demand and supply orders.

Sourcing

Sourcing is a process of deciding whether a task will be executed by a responsive or efficient source and secondly whether this source will be internal to the company or a third party.

There are several key sourcing decisions that are made within a firm:

- In-house or outsource: companies should decide whether a task is performed in-house or outsourced to a third party;
- Supplier selection: companies should decide which suppliers they will have for an activity;
- Procurement: companies must decide how they obtain goods and services within their supply chain;
- Sourcing-related metrics: sourcing decisions have influence on the cost of goods and accounts payable. Companies must track the following sourcing-related metrics that affect supply chain performance:
 - **Days payable outstanding**: measures the number of days amid the time that a supplier performed a supply chain activity and when it was paid for;
 - **Average purchase price**: measures the average purchase price at which a service or product was sold;
 - **Range of purchase price**: measures the change in purchase price during a given period;
 - **Average purchase quantity**: measures the average amount purchased per order;
 - **Supply quality**: measures the quality of products;
 - **Supply lead time**: measures the average time amid the time that an order is placed and when the product arrives;
 - **Percentage of on-time deliveries**: measures the part of deliveries that were on time;
 - **Supplier reliability**: measures the variability of the supplier's lead time and the delivered quantity according to plan.

Pricing

Pricing comprises the activities by which a firm determines the prices of its products and services. The prices of goods and services affect the customers' expectations and demand. Pricing influences the supply chain regarding its responsiveness and the demand profile that the supply chain tries to serve.

There are several key components of pricing decisions that influence supply chain performance:

- Pricing in economies of scale: in economies of scale, small production runs more expensive per unit than large production runs. The supervisor of the supply chain activity should decide how to price its activity according to its economy of scale;
- Low pricing versus high-low pricing: high-low pricing is the method of offering steep discounts on products every week, this causes a peak during a discount week and a drop in demand after this week. Low pricing is the method of keeping prices steady over time;
- Fixed price versus menu pricing: Fixed pricing is charging a fixed price for supply chain activities. Menu pricing is pricing taking response time or location of delivery into account;
- Pricing-related metrics: pricing affects revenues, production costs, and inventories. Companies should track the following pricing-related metrics:
 - **Profit margin**: measures the profit as a percentage of revenue;
 - **Days sales outstanding**: measures the average time between when a good is sold and when the money is received;
 - **Incremental fixed cost per order**: measures the incremental costs (i.e. changeover costs, transportation costs) that are not dependent of the size of an order;
 - **Incremental variable cost per unit**: measures the incremental costs (i.e. picking costs, variable production costs) that change with the size of an order;
 - **Average sale price**: measures the average price at which a supply chain activity was executed in a specific period;
 - **Average order size**: measures the average quantity per order;
 - **Range of sale price**: measures the minimum and maximum price per unit over a given time horizon;
 - **Range of periodic sales**: measures the minimum and maximum of the quantity sold in a given period.

A short summary, easy to remember:

Driver	Role in supply chain	Role in competitive strategy	Components of decisions	metrics
Facilities	Locations of manufacturing or storage	Economies of scale (efficiency)/ large number of facilities (responsiveness)	-Location -Capacity	-Capacity -Utilization -Time -Cost -Quality -Variety -Service level -Time efficiency
Inventory	Mismatch supply and demand Impact on flowtime and throughput	Reduce inventory (efficiency)/ inventory closer to customers (responsiveness)	- Cycle inventory -Safety inventory -Seasonal inventory	-Average inventory -Safety inventory -Seasonal inventory -Batch size -Service level -Products more than average days in inventory
Transportation	Movement between stages in the supply chain Affects facilities and inventory	Faster (responsiveness)/ slower (efficiency) Balance inventory and transportation	-Mode of transport -Route/ network -In-house/ outsource	-Inbound/ outbound transportation cost -Inbound/ outbound shipment size
Information	Connect stages in supply chain and allow coordination Crucial for daily operation	Efficient and responsive at the same time	-Push/pull -Technology (EDI/ERP)	-Forecast horizon -Forecast error -Frequency of update -Variance from plan -Seasonal factors
Sourcing	Set of business processes required Supplier selection	Affects both efficiency and responsiveness	-In-house/ outsource -Supplier evaluation and selection	-Days payable -Average purchase price -Supply quality -Supply lead time -On-time deliveries
Pricing	Amount to charge customers Use to match supply and demand	High prices/product availability (responsiveness)/ low prices/product availability (efficiency)	-Pricing/ economies of scale -Fixed prices versus menu pricing	-Profit margin -Days sales -Sale price -Order size -Periodic sales