**Course: Logistics and Supply Chain Management**

## Lecture 10: Supply Chain Performance Indicators

1. **Definition of performance indicators and measures**

As mentioned earlier, supply chains are generally defined as a group of organizations which are linked through various processes and activities to produce value along the chain in the form of products and services to meet consumer expectations. In this context, key performance indicators are used by organizations to manage such processes and activities.

* Supply chain performance is defined as: the ability of the supply chain to deliver the right product to the right location at the right time at the lowest logistics cost. (Zhang, H.; Okoroafo, S. C. 2015. p38)
* However; Performance measurement is defined as the process of measuring the efficiency and effectiveness of the actions taken. Where effectiveness is understood as the degree of fulfillment of customer expectations, while efficiency is a measure of the extent to which the organization's assets are used to provide a certain level of customer satisfaction, then; the performance measurement system is a set of indicators used to determine the efficiency and effectiveness of operations (Shepherd, C.; Günter, H. 2012 ).
* Key Performance Indicators are defined as measurable aspects which reflect the key factors that organizations must monitor and manage to achieve success (Nagyova, A., & Pacaiova, H. 2009). For this purpose, KPIs must be able to visualize the current scenario of the organization and its supply chain, which helps to monitor, control and evaluate processes (Maestrini, V., Luzzini, D., Maccarrone, P., & Caniato, F. (2017). To obtain relevant metrics for operations and needs, each organization creates and defines its own KPIs in terms of functional context, responsibilities, and goals.

1. **Types of supply chain indicators**

The literature on measuring supply chain performance can be divided into two phases (Zahri Thabet, 2001, p. 15):

* **The first phase**: It dates back to the pre-1980s and focused on measuring financial performance such as: sales turnover, profit, debt, rate of return on investment, number of services, and number of individuals who received services. However, it was found that these measures are not commensurate with the competencies and skills that organizations need today and are not sufficient to measure the performance of the supply chain.
* **The second phase**: Since the beginning of the nineties, interest in measuring performance has increased, which focuses on non-financial criteria while maintaining financial criteria, as a result of the shortcomings facing organizations in measuring performance on the basis of financial criteria only, because they do not provide data that helps the decision-maker in the future, where they do not perform sufficiently to improve customer satisfaction, improve quality, reduce the production cycle, and stimulate employee motivation.

Supply chain performance indicators are divided into qualitative and quantitative indicators as the following (Chan, F.T.S.; et al. 2003):

* **Qualitative indicators**: which include customer satisfaction, rapid response to customers, flexibility, supplier performance and costs, and they are used in supply chain modeling. They are represented in (Jie, Ferry. et al. 2007):

• Customer satisfaction: The customer plays an important role in supply chain performance. The customer must be satisfied with the product or service received. There are three components to customer satisfaction: customer satisfaction before the transaction, satisfaction about the transaction, and satisfaction after the transaction;

• Flexibility: the ability to adapt to its changing environment, the supply chain must be able to respond to random fluctuations in the demand pattern;

• Integration of information and materials flow: The extent to which all functions within the supply chain deliver information and materials. Information flow sharing refers to the extent to which critical and proprietary information is sent to a supply chain partner. Some elements of the quality of information sharing, such as accuracy, timing, sufficiency and credibility, must be available in the exchange of information;

• Effective Risk Management: All relationships within the supply chain contain inherent risks. The degree to which the effects of these risks are minimized must be measured.

• Supplier Performance: Through experience in dealing with suppliers, and knowing the best based on qualitative criteria such as: commitment, trust...etc. Supplier performance can be measured through the indicator (monitoring the delivery of materials on time), as supplier delivery efficiency is another measure that can help achieve chain efficiency, by dynamically determining whether a particular supplier does not meet the organization's goal (Chae, B (2009). This is important because organizations typically expect their deliveries to be more important than pricing. The quality of goods delivered is also a key indicator as it affects customer satisfaction.

* **Quantitative indicators**: they include the following:

• Cost-related indicators: cost, sales, profit, inventory investment maximization;

• Customer related indicators: product delay, sickness rate, customer response time, lead time;

• Indicators related to productivity: capacity utilization and resource utilization.

We state below how to calculate these indicators:

**A- Productivity Indicators:**

One of the widely used metrics for measuring effectiveness in manufacturing firms is; Overall equipment effectiveness (OEE). The scale was introduced by Nakajima in the 1980s to measure productivity. The tool is designed to help the organization in realizing the possible improvement points to increase the productivity of its equipment especially, loss of down time, loss of speed, and loss of quality. There are many different definitions of this indicator which consists of three main parts, availability rate (A), performance efficiency (P), and quality rate (Q). They are calculated as percentages and multiplied with each other to form the following equation (NICLAS GAMME MARTIN JOHANSSON. 2015. P:21):

**OEE = A \* P \* Q**

Where the elements of the equation are calculated as follows:

|  |  |
| --- | --- |
| ( runtime / load time) \* 100 | Availability rate A |
| Load time - downtime | Runtime |
| (theoretical cycle time \* real output) /  Runtime | Performance Efficiency (P) |
| (total production - quantity of defective production) /  total production) \* 100 | Quality Rate (Q) |

**B- Inventory Indicators:**

Inventory is one of the indicators of supply chain performance, it exists within the organization in different types and in different locations. Where inventory is classified according to location as: raw materials, materials in the manufacturing stage, supplies used in operations, and finished goods (Müller, M., 2011,). There are several indicators to measure inventory efficiency as follows:

* **Inventory Accuracy:** This indicator compares the amount of inventory on the inventory card and/or in inventory management software with the amount of physical inventory taken during a site visit. It is calculated as follows:

(Total quantity of product in inventory card or inventory management software) / (Total quantity of same product from physical inventory made during site visit)) x 100

(الكمية الإجمالية للمنتج في بطاقة المخزون أو برنامج إدارة المخزون) / (الكمية الإجمالية لنفس المنتج من المخزون المادي الذي تم إجراؤه أثناء زيارة الموقع)) × 100

(الكمية الإجمالية للمنتج في بطاقة المخزون أو برنامج إدارة المخزون) / (الكمية الإجمالية لنفس المنتج من المخزون المادي الذي تم إجراؤه أثناء زيارة الموقع)) × 100

* **Loss rate from damage, theft, and expiration**: This indicator compares damaged, lost, and expired inventory to the total inventory during the reporting period. It can be viewed by the quantity or value of the inventory. It is calculated by the formula below:

By quantity: ((Total quantity of unusable product due to loss, damage, or expiration) / (Total quantity of product available during the reporting period)) x 100

By value: ((Total value of unusable product due to loss, damage, or expiration) / (Total value of product available during the reporting period)) x 100

* **Warehouse operating cost**: This indicator compares the cost of operating a warehouse to the total value of goods managed by the warehouse during the period under review, and expresses costs as a percentage of sales. It is calculated as follows:

((Costs incurred in operating the warehouse) / (Total value of goods managed by the warehouse)) x 100

* **Inventory turnover per year**: This indicator measures the number of times the inventory goes out and is a measure of the efficiency of the operation. It is calculated as follows:

(total value issued) / (average value of inventory in the period)) = X (number of turns)

* **Storage space usage:** Storage space utilization refers to the average amount of warehouse, or storage, capacity used over a specified period of time. It is calculated by the following equation:

Total storage used/Total available storage

Storage space utilization can help managers to assess whether they should change the layout and size of the storage area, and decide which obsolete products to remove. This formula can also be used to determine whether the material flow should increase or decrease. However, it is important to realize that repositories are not necessarily optimized if they are at maximum capacity.

**C- Distribution Indicators:**

* **On time delivery** is one of the key performance indicators. According to (Chan 2003), it measures product delivery performance by observing the percentage of orders that were delivered on or before the due date (Chan, F.T. 2003).

For delivery, customers rely on timely delivery of important documents or transportation of goods. Thus, this indicator helps to anticipate future disruptions by monitoring delays and promptly searching for causes. In addition, monitoring them can check whether customers feel safe and satisfied, or whether there is a need to develop practices to enhance security. (Karl, A.A., et al. 2018) is calculated by the relationship:

(Number of orders delivered within the time period specified in the distribution plan) / (Total number of deliveries)) x 100

* **Demand Fulfillment Rate**: This indicator compares the quantity in accepted orders to the quantity delivered, including the frequency of modification of distribution orders. It is calculated by the relation:

(Total Quantity Issued / Received) / (Total Quantity of Ordered Product)) x 100

* **Percentage of orders placed as emergency orders**: This indicator measures the percentage of orders placed which were emergency orders. It is calculated as follows:

(Number of emergency orders fulfilled in the reporting period) / (Total number of orders placed in the reporting period)) x 100

* **Forecast Accuracy:** This indicator measures how to compare accurate forecasts of demand to actual consumption of the product.

Calculated by the relationship (Key Performance Indicators. <https://www.ghsupplychain.org/sites/default/files/2019-07/5>):

(expected consumption - actual consumption) / (actual consumption) x 100

**D- Human Resources Indicators:**

* **Employee turnover rate:** This indicator measures the percentage of specified supply chain employees who leave their jobs during the reporting period. It is calculated by the following formula:

(Number of supply chain employees who left their jobs during the reporting period) / (Total number of supply chain employees hired by the organization in the reporting period)) x 100

**E- Operational Indicators:**

* **Accuracy of the supply chain plan**: This indicator measures the extent to which the quantity of goods in orders submitted to suppliers matches the supply chain plan for the product under review. It is calculated as follows:

(planned orders - actual quantity) / (actual quantity) x 100

* **Purchasing Used Methods:** This indicator shows the percentage of the types of purchases made during the reporting period to evaluate the performance of the procurement process, in using a variety of procurement methods commensurate with the purchases made. It is calculated by the relation:

(Number of purchase orders placed of each type) / (Total number of purchase orders placed in the same period) x 100

**G- Transportation indicators:** they include to calculate the following:

* Transportation cost.
* The rate of packing in trucks.
* The rate of compliance with the transport plan.

**H- Other models for measuring supply chain performance**:

* **SCOR model:**

Among the tools used to measure performance of SCM, we find the SCOR model, where the measurement concept is often used in the form of the SCOR model (Supply Chain Operations Reference Model), which has been proposed by the American Supply Chain Council Association. The "SCOR" model considers supply chain activities in the form of a chain of inter-organizational operations to interact with each partner in the chain, as this model is designed to manage business operations which extend beyond the boundaries of a single organization. The indicators in this model relate to the following aspects: planning, sourcing, manufacturing, delivery, and returns. It also takes into account the effective performance attributes of: reliability, responsiveness, cost and efficiency of asset management. Below there is an explanation of these indicators (Dorota LEOŃCZUK. (2016):

* Credibility: whether the right product was delivered to the right place, in the right quantity, at the right time, with the right documentation and to the right customer;
* Responsiveness: refers to the speed with which the supply chain provides products to customers;
* Flexibility: refers to the flexibility of the supply chain to respond to market changes in demand in order to gain or maintain its competitive advantage.
* Cost: includes all costs related to operating the supply chain;
* Asset Management Efficiency: It means the efficiency of the organization in managing its resources to meet demand.
* **Scorecard Balanced**

The balanced scorecard is one of the most important means to achieve the objectives of the supply chain, where in using it the objectives which are set in each dimension stem from the organization's strategy. The organization which tries to compete by reducing the cost will be interested in the indicators of product cost, manufacturing efficiency, lack of waste, and reducing the cost of raw materials. While the organization which is trying to be proactive with new products or services, its focus will be on the ability to provide products quickly and the ability to create an atmosphere of creativity within the organization. Also, the organization which plans to expand globally will be interested in measuring the ability to enter new markets and the ability to meet the special needs of customers in each country. In this way, the balanced scorecard becomes a means to achieve the organization's strategy (Qamsi Khadra, 2010, p. 6)

The balanced scorecard consists of four aspects mediated by the strategic vision, because it is considered the starting point, and each of these dimensions is linked to the other in a causal relationship (Mohammed Awad, Suleiman, (2006), pp. 49-50):

* Financial axis: Focuses on growth strategy, profitability and risk in the view of the shareholder.
* Customer axis: Focuses on value creation strategy and customer excellence.
* The internal operations axis: focuses on the strategic priorities of the various operational processes which bring customer and shareholder satisfaction.
* Organizational training axis (learning and development): focuses on priorities and creating the appropriate atmosphere for change, creativity and development.

Many researchers also believe that the basic four dimensions of the balanced scorecard alone are not sufficient to measure and evaluate performance. For example, in 2005, Al-Jabri added two dimensions, the performance of compliance with laws and the performance of external suppliers. There are also other studies which have mixed the balanced scorecard model with other performance appraisal models.

* **Methods of multi-criteria decision making:**

Due to the difficulty of measuring and evaluating the performance of the supply chain based on several criteria using experience only, and for the purpose of speeding up and supporting the decision, organizations tended to use tools and methods of multi-criteria decision-making, which include among them the following methods (Rania Abdel Moneim, Mahmoud Ahmed Shamaa, 2003, p. 63):

* **Objective programming model**: Achieving each of the goal of time, cost and quality are critical variables in determining the efficiency of operations of supply chain activities, which can be achieved in one sentence by using programming objectives. According to Romero & Mehrdad Tamiz Carlos (1998), the programming model with goals is "a flexible and realistic mathematical methodology directed primarily to address those complex decision issues, which include taking into account several goals in addition to many variables and constraints. According & M Sang. David L Olson (1999): “The programming model with objectives is considered as one of the first scientific management methods directed at analyzing decision issues of a multi-objective nature”. Methodologically, it is concerned with searching for a solution which, as small as possible, is the absolute sum of the deviations with respect to the target values;
* **Hierarchical Analysis Process AHP**: The HAP model is one of the multi-alternative decision models, developed by Saaty Thomas, defined by Dismukes and Huang as a decision-making tool which analyzes and decomposes a complex problem into a hierarchical structure consisting of goals, sub-criteria and alternatives. The basic idea of this approach to transform Objective estimates of relative importance to a group of scores or total weights based on the provisions of the bilateral comparison, as it puts the integration of the different quantitative and qualitative measures to be collected in one comprehensive degree which expresses the classification of the alternative among a group of decision alternatives. It is used especially in the comparison between suppliers according to more than one criterion, instead of relying on the price only, such as: price, quality, delivery times, production capacity, geographical location, and others.

**3- The importance of evaluating supply chain performance:**

(Mentzer, 2003) believes that applying and improving the performance of the supply chain in the organization is beneficial in a variety of areas: \*Reducing the cost of supplies and capital costs. \*Increasing market share and sales. \*Increasing the marginal profit of the products and increasing the cash flows of the organization. \*Increasing the efficiency of manufacturing at all levels and accomplishing the work in a distinguished way.\*Enhancing customer contact and acquisition. \*Achieving operational excellence. \*And increasing the market value of the organization. (Mentzer, J.; Davis, et al., 2003)

Johnson points out that there are two dimensions to improve the performance of the supply chain, namely (Johnson, P. & Leenders, M., 2006.):

* Doing things through operational efficiency with full attention to logistics processes to achieve cost reduction, reduced stock holding time within the chain, reduced process time, diversification of products and flexibility of operations;.
* Doing the right things by raising the capabilities of the participants in the supply chain to achieve competitive advantages by penetrating new markets, or providing new products and services which allow the organization to obtain new opportunities, and make good use of these opportunities by directing all its strengths towards those opportunities.