

## Chapter 2

# Performance Measurement

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As supply chains continue to replace individual firms as the economic engine for creating value during the twenty-first century, understanding the relationship between supply chain management (SCM) practices and supply chain performance (SCP) becomes increasingly important.

Performance measurement is the process of quantifying the effectiveness and efficiency of action. Effectiveness is the extent to which a customer's requirements are met and efficiency measures how economically a firm's resources are utilized when providing a pre-specified level of customer satisfaction. Performance measurement systems are described as the overall set of metrics used to quantify both the efficiency and effectiveness of action (Shepherd and Gunter 2006).

There have been relatively few attempts to systematically collate measures for evaluating the performance of supply chains and integrating performance measures thereof:

- Performance measures based on strategic, operational or tactical focus (Gunasekaran et al. 2004)
- Performance measures based on reliability, responsiveness, cost and asset (Huang et al. 2005; Lai et al. 2002)
- Performance measures based on goals of supply chain (Otto and Kotzab 2003)
- Instrument to measure the collaboration in a supply chain consisting of two members, suppliers and retailers (Simatupang and Sridharan 2005)
- Assessing the performance of supplier relationships (Giannakis 2007)
- Integration of performance management process for delivery service in customer/supplier dyads (Forslund and Jonsson 2007)

### 2.1 Importance of Measurement

The role of measures and metrics in the success of an organization cannot be overstated because they affect strategic, tactical and operational planning and control. Performance measurement and metrics have an important role to play in setting

objectives, evaluating performance, and determining future courses of actions (Gunasekaran et al. 2004).

Harrington states that “If you cannot measure it, you cannot control it. If you cannot control it, you cannot manage it. If you cannot manage it, you cannot improve it”. In fact, the lack of relevant performance measures has been recognized as one of the major problems in process management and the management of supply chain (Lai et al. 2002).

The output of the processes enabled by the supply chain must be measured and compared with a set of standards. In order to be controlled, the process parameter values need to be kept within a set limit and remain relatively constant. This will allow comparison of planned and actual parameter values, and once done, the parameter values can be influenced through certain reactive measures in order to improve the performance or re-align the monitored value to the defined value (Gunasekaran et al. 2004). Many companies have not succeeded in maximizing their supply chain’s potential because they have often failed to develop the performance measures and metrics needed to fully integrate their supply chain for maximizing effectiveness and efficiency. Thus, control of processes in a supply chain is crucial in improving performance and can be achieved through measurement (Gunasekaran et al. 2004).

## 2.2 Properties of Performance Measures

There is special need to consider bellow properties in performance measurement:

- The discrete sites in a supply chain do not maximize efficiency if each pursues goals independently. They point to incomplete performance measures existing among industries for the assessment of the entire supply chain (Gunasekaran et al. 2004). Traditionally, the focus of performance measurement has been on process operations within the organizational boundaries of a firm. In the context of SCM, performance measurement involves not only the internal processes, but also requires an understanding of the performance expectation of other member firms in the supply chain, backward from the suppliers and forward to the customers. Coordination between the various parties in the supply chain is the key to its effective implementation (Lai et al. 2002).
- Measurements should be understandable by all supply chain members and should offer minimum opportunity for manipulation (Gunasekaran et al. 2004).
- Inequality does not lead to metrics that can present a clear picture of organizational performance (Gunasekaran et al. 2004).
- Companies often, have a large number of performance measures to which they continue to add based on suggestions from employees and consultants. They fail to realize that performance assessment can be better addressed using a few trivias. Actually they are not trivial, rather they are among the factors most critical to success (Gunasekaran et al. 2004).

- The metrics that are used in performance measurement and improvement should be those that truly capture the essence of organizational performance (Gunasekaran et al. 2004).
- For effective performance measurement and improvement, measurement goals must represent organizational goals and metrics selected should reflect a balance between financial and non-financial measures that can be related to strategic, tactical and operational levels of decision making and control (Gunasekaran et al. 2004).
- Traditional performance measures such as profitability are less relevant for measuring SCP because they tend to have an “individual focus” and fail to consider chain-wide areas for performance improvement. The use of integrated measures, together with non-integrated measures, motivates firms to consider chain-wide performance, rather than their own individual performance measures (Lai et al. 2002).

### 2.3 Process Management System Analysis

Performance measurement systems can be analyzed at three levels: the individual metrics; the set of measures, or performance measurement system as an entity; and the relationship between the measurement system and the internal and external environment in which it operates (Shepherd and Gunter 2006). Some of the key considerations offered for analyzing performance measurement systems in (Shepherd and Gunter 2006) are explained below:

- Individual performance measures
  - What performance measures are used?
  - What they are used for?
  - How much do they cost?
  - What benefit do they provide?
- Performance measurement system
  - Have all the appropriate elements (internal, external, financial, non-financial) been covered?
  - Have measures which relate to the rate of improvement been introduced?
  - Have measures which relate to the long-term and short-term objectives of the business been introduced?
  - Have the measures been integrated, both vertically and horizontally?
  - Do any of the measures conflict with any other?
- Relationship with internal and external environments
  - Do the measures reinforce the firm’s strategy?
  - Do the measures match the organizational culture?
  - Are they consistent with the recognition and reward structure?

- Do some measures focus on customer satisfaction?
- Do some measures focus on what the competition is doing?

Two approaches for determining SCP measures, process-oriented and goal-oriented approaches, explained in the next sections.

## 2.4 Process-Oriented Approach

Among the extant SCP conceptualizations, the supply chain operations reference model (SCOR), developed by the Supply Chain Council, provides a useful framework that considers the performance requirements of member firms in a supply chain (Lai et al. 2002). The SCOR model is a process reference model, which contains a standard description of management processes, a framework of relationships among the standard processes, standard metrics to measure process performance, management practices that produce best-in-class performance, and a standard alignment to software features and functionality (Huang et al. 2005).

The SCOR model views activities in the supply chain as a series of interlocking interorganizational processes with each individual organization consisting of five components: plan, source, make, deliver, and return. Each of these components is considered as a critical intra-organizational process in the supply chain with five measurement criteria: (1) supply chain reliability, (2) responsiveness, (3) flexibility, (4) costs, and (5) assets. The first three criteria deal with effectiveness-related (customer-facing) performance measures, while the other two are efficiency-related (internal-facing) performance measures of a firm. Customer-facing measures are concerned with how well a supply chain delivers products/services to customers, e.g. delivery performance. Internal-facing measures are concerned with the efficiency with which a supply chain operates, e.g. cash-to-cash cycle time (Lai et al. 2002).

### 2.4.1 SCOR Model Level One Performance Measure (Huang et al. 2005)

The SCOR model endorses 13 performance metrics. A company cannot be best in all 13 of the level 1 metrics, so it should wisely target its strength in several, those by which it differentiates itself in the market, while ensuring that it stays competitive in the others. In practice, most companies typically choose among 4–6 of the 13 performance metrics to focus on.

Those chosen tend to fall into five defining categories: supply chain reliability, supply chain responsiveness, supply chain flexibility, supply chain costs, and efficiency in managing assets (working and fixed capital) in the supply chain. A description of these metrics is given below:

- Delivery reliability
  - Delivery performance
  - Fill rates
  - Perfect order fulfillment
- Responsiveness
  - Order fulfillment lead times
- Flexibility
  - Supply chain response time
  - Production flexibility
- Cost
  - Cost of goods sold
  - Total SCM cost
  - Value-added employee productivity
  - Warranty/return processing costs
- Assets
  - Cash-to-cash cycle time
  - Inventory days of supply
  - Asset turns
- *Delivery performance.* The percentage of orders delivered on time with respect to the total number of orders delivered. The components of delivery performance include total number of orders received, number of orders scheduled to customer's request date, total number of orders delivered, percentage of orders delivered on time (to request date), number of orders delivered on-time to commit date, and percentage of orders delivered on-time to customer commit date. It affects the balance sheet on accounts receivable.
- *Fill rate.* Fill rate is the percentage of ship-from-stock orders shipped within 24 h of order receipt. The fill rate affects the balance on accounts receivable and is calculated as:  $(\text{number of orders filled from stock shipped within 24 h of order receipt})/(\text{total number of stock orders})$ .
- *Order fulfillment lead time.* The average actual lead time consistently achieved from customer authorization of purchase order to final installation/order completion at customer end. It affects the inventory on balance sheet. It is calculated as:  $(\text{sum of lead time required for each order fulfillment from purchase order authorization to final installation})/(\text{total number of orders})$ .
- *Perfect order fulfillment.* The percentage of orders meeting deliver performance, with complete and accurate documentation and without any shipping damage. Components of perfect order fulfillment include all items and quantities delivered on-time (using customer's definition) and documentation for packing slips, bills of lading, and invoices. It is calculated as  $(\text{total orders shipped on time and in$

full-orders without faulty documentation – orders with shipping damage)/(total orders).

- *Supply chain response time.* The time it takes the integrated supply chain to respond to abnormal (significant) change in demand. It is calculated as (order fulfillment lead time + source cycle time) and it affects the inventory on the balance sheet.
- *Production flexibility.* Production flexibility can be seen in two parts, upside flexibility and downside flexibility. Upside flexibility is the number of days required to achieve an unplanned sustainable 20% increase in production. Downside flexibility is the percentage of order reduction sustainable at 30 days prior to delivery with no inventory or cost penalties. The production flexibility is dependent upon internal manufacturing capacity, direct labor and material availability and affects inventory on balance sheet.
- *Total logistics management cost.* The sum of supply chain related costs for order management, material acquisition, inventory carrying, finance and planning, and MIS costs. It is calculated as sum of the costs.
- *Cost of goods sold.* The cost associated with buying raw materials and producing finished goods. This cost includes direct cost (labor, material) and indirect cost (overhead).
- *Value added productivity.* It is calculated as; (total product revenue – total material purchases)/total employment (in full time equivalents).
- *Warranty cost or returns processing cost.* It includes materials, labor, and problem diagnosis for product defects. A warranty cost has impact on inventory on balance sheet.
- *Cash-to-cash cycle time.* Cash-to-cash cycle time is a measure of the time required in days to convert cash paid to suppliers into cash received from customers, including the inventory required. It is calculated as (inventory days of supply + days sales outstanding-days of payables). It impacts inventory, accounts payable, accounts receivable, and total assets on the balance sheet.
- *Inventory days of supply.* Total gross value of inventory at standard cost before reserves for excess and obsolescence.
- *Asset turns.* Total turns of capital employed. It impacts inventory, accounts payable, accounts receivable, and fixed assets on the balance sheet. It is calculated as total gross product revenue divided by total net assets.

#### ***2.4.2 Measurement in Strategic, Tactical and Operational Levels (Gunasekaran et al. 2004)***

The strategic, operational and tactical levels are the hierarchies in function, wherein policies and trade-offs can be distinguished and suitable control can be exerted.

Such a hierarchy is based on the time horizon for activities and the pertinence of decisions to and influence of different levels of management. This approach

classifies indices according to its importance and has a significant role in supply chain identification.

- The *strategic level* measures influence the top level management decisions, very often reflecting investigation of broad based policies, corporate financial plans, competitiveness and level of adherence to organizational goals.
- The *tactical level* deals with resource allocation and measuring performance against targets to be met in order to achieve results specified at the strategic level. Measurement of performance at this level provides valuable feedback on mid-level management decisions.
- *Operational level* measurements and metrics require accurate data and assess the results of decisions of low level managers. Supervisors and workers are to set operational objectives that, if met, will lead to the achievement of tactical objectives.

In this section, a framework for performance measures and metrics is presented, considering the four major supply chain activities/processes (plan, source, make/assemble, and deliver).

These metrics were classified as strategic, tactical and operational to clarify the appropriate level of management authority and responsibility for performance. Some measures appear in more than one group, indicating that those measures may be appropriate at more than one management level.

#### *Plan*

- Strategic
  - Level of customer perceived value of product
  - Variances against budget
  - Order lead time
  - Information processing cost
  - Net profit vs. productivity ratio
  - Total cycle time
  - Total cash flow time
  - Product development cycle time
- Tactical
  - Customer query time
  - Product development cycle time
  - Accuracy of forecasting techniques
  - Planning process cycle time
  - Order entry methods
  - Human resource productivity
- Operational
  - Order entry methods
  - Human resource productivity

*Source*

- Strategic

There are no metrics

- Tactical

- Supplier delivery performance
- Supplier lead time against industry norm
- Supplier pricing against market
- Efficiency of purchase order cycle time
- Efficiency of cash flow method
- Supplier booking in procedures

- Operational

- Efficiency of purchase order cycle time
- Supplier pricing against market

*Make/assemble*

- Strategic

- Range of products and services

- Tactical

- Percentage of defects
- Cost per operation hour
- Capacity utilization
- Utilization of economic order quantity

- Operational

- Percentage of defects
- Cost per operation hour
- Human resource productivity index

*Deliver*

- Strategic

- Flexibility of service system to meet customer needs
- Effectiveness of enterprise distribution planning schedule

- Tactical

- Flexibility of service system to meet customer needs
- Effectiveness of enterprise distribution planning schedule
- Effectiveness of delivery invoice methods
- Percentage of finished goods in transit
- Delivery reliability performance

- Operational
  - Quality of delivered goods
  - On time delivery of goods
  - Effectiveness of delivery invoice methods
  - Number of faultless delivery notes invoiced
  - Percentage of urgent deliveries
  - Information richness in carrying out delivery
  - Delivery reliability performance

### ***2.4.3 SCP in Transport Logistics (Lai et al. 2002)***

In this section, we investigate the construct of, and develop a measurement instrument for SCP with a focus on the intermediary component, i.e. transport logistics, in a supply chain process.

Transport logistics in a supply chain is usually an intermediary that facilitates the physical flows of goods from a point of origin, i.e. shipper, to a point of destination, i.e. consignee.

The SCOR model provides a useful framework, it represents a systematic approach to measuring performance with inputs from, and outputs to, member firms in the supply chain and considers performance assessment on a supply chain-wide basis, not just on that of an individual component. Based on SCOR performance measures, three dimensions of SCP in transport logistics are identified. These are:

- Service effectiveness for shippers (SES)
- Operations efficiency for transport logistics service providers (OE)
- Service effectiveness for consignees (SEC)

SES and SEC measure how well the activities are performed to meet the requirements of shippers and consignees, respectively. OE refers to the efficiency of a transport logistics service provider in the use of resources to perform its service activities. These three dimensions of SCP in transport logistics are congruent with the critical components of supply chain success postulated in the SCOR model.

A total of 26 measurement items are generated for the measurement instrument: nine for SES, eight for OE and nine for SEC as shown below:

#### *SES*

- SES-reliability
  - Fulfill promises to shippers (e.g. time vehicle arrival; offer competitive rates)
  - Solve shippers' problem (e.g. suggest best routing)
  - Perform services for shippers right the first time
  - Provide services at the time promised to the shippers (e.g. on-time delivery to exhibition site; higher shipping frequency than rival companies)
  - Keep shippers' records accurately (e.g. correct invoice)

- SES-responsiveness
  - Tell shippers exactly when services will be performed (e.g. location and opening hours of the depots/container freight station)
  - Give prompt services to shippers (e.g. special packaging for furniture/piano, etc.)
  - Willingness to help shippers (e.g. give advice on shipping schedule or packaging; track and trace status of the cargoes shipped)
  - Timely response to shippers' requests (e.g. delivery/transshipment of the cargoes at short notice)

#### *OE*

- OE-cost
  - Reduce order management costs (e.g. minimize order handling through EDI)
  - Reduce costs associated with facilities/equipment/manpower used in providing the services (e.g. use IT to track and trace the status of shipped cargoes)
  - Reduce warehousing costs
  - Reduce transportation costs
  - Reduce logistics administration costs (e.g. build good relationships with related organizations such as customs, bureau of commodity inspection, port authority)
- OE-asset
  - Improve the rate of utilization of facilities/equipment/manpower in providing the services
  - Improve number of cash to cash cycle time (the average days required to turn a dollar investment in facilities/equipment/manpower providing the shipping services into a dollar collected from customers)
  - Improve net asset turns (working capital)

#### *SEC*

- SEC-reliability
  - Fulfill promises to consignees (e.g. advise arrival schedules; complaint handling)
  - Solve consignees' problems (e.g. provide warehousing; repackage cargoes)
  - Perform services for consignees right the first time (e.g. pack and remix cargoes)
  - Provide services at the time promised to the consignees (e.g. availability of cargoes for collection)
  - Keep consignees' records accurately (e.g. error-free records of consignees' addresses and opening hours)

- SEC-responsiveness
  - Tell consignees exactly when services will be performed (e.g. advise estimated time of arrival via fax/mail)
  - Give prompt services to consignees (e.g. advise regulations regarding discharge of overweight/over-length cargoes)
  - Willingness to help consignees (e.g. suggest inland routing)
  - Timely response to consignees requests (e.g. transshipment arrangement)

#### ***2.4.4 Taxonomy of Measure of SCP in More Detail (Shepherd and Gunter 2006)***

Since relying exclusively on cost indicators can produce a misleading picture of SCP, distinguishing between cost and non-cost measures (time, quality, flexibility and innovativeness) is important.

Measures of time and quality reflect the ability of a supply chain to deliver a high customer service, whilst flexibility and innovativeness indicate the ability to cope with rapid changes in demand or supply. Flexibility and innovativeness are considered to be important strategic drivers of supply chain development in the future (Shepherd and Gunter 2006).

So the measures were categorized according to their applicability to the five supply chain processes defined in the SCOR model (plan, source, make, deliver and return or customer satisfaction); whether they measure cost, time, quality, flexibility and innovativeness; and, whether they are quantitative or qualitative.

Consider these notations for the categories of performance measures: cost (C), time (T), quality (Q), flexibility (F), innovativeness (I), quantitative (QN), and qualitative (QL) for categories of performance measures based on (Shepherd and Gunter 2006).

##### *Plan*

- Sales C, QN
- Profit C, QN
- Return on investment (ratio of net profits to total assets) C, QN
- Rate of return on investment C, QN
- Net profit vs. productivity ratio C, QN
- Information carrying cost C, QN
- Variations against budget C, QN
- Total SCM costs C, QN
- Cost of goods sold C, QN
- Asset turns C, QN
- Value added productivity C, QN
- Overhead cost C, QN
- Intangible cost C, QN

- Incentive cost and subsidies C, QN
- Sensitivity to long-term costs C, QN
- Percentage sales of new product compared with whole sales for a period C, QN
- Expansion capability C, QN
- Capital tie-up costs C, QN
- Total supply chain response time T, QN
- Total supply chain cycle time T, QN
- Order lead time T, QN
- Order fulfillment lead time T, QN
- Customer response time T, QN
- Product development cycle time T, QN
- Total cash flow time T, QN
- Cash-to-cash cycle time T, QN
- Horizon of business relationship T, QL
- Percentage decrease in time to produce a product T, QN
- Fill rate (target fill rate achievement & average item fill rate Q, QN)
- Order entry methods Q, QN
- Accuracy of forecasting techniques Q, QN
- Autonomy of planning Q, QL
- Perceived effectiveness of departmental relations Q, QL
- Order flexibility Q, QN
- Perfect order fulfillment Q, QN
- Mix flexibility F, QN
- New product flexibility F, QN
- Number of new products launched I, QN
- Use of new technology I, QN

*Source*

- Supplier cost-saving initiatives C, QN
- Percentage of late or wrong supplier delivery C, QN
- Supplier lead time against industry norm T, QN
- Supplier's booking-in procedures T, QN
- Purchase order cycle time T, QN
- Efficiency of purchase order cycle time T, QN
- Buyer-supplier partnership level Q, QL
- Level of supplier's defect-free deliveries Q, QN
- Supplier rejection rate Q, QN
- Mutual trust Q, QL
- Satisfaction with knowledge transfer Q, QL
- Satisfaction with supplier relationship Q, QL
- Supplier assistance in solving technical problems Q, QL
- Extent of mutual planning cooperation leading to improved quality Q, QL
- Extent of mutual assistance leading in problem-solving efforts Q, QL
- Distribution of decision competences between supplier and customer Q, QL

- Quality and frequency of exchange of logistics information between supplier and customer Q, QL
- Quality of perspective taking in supply Networks Q, QL
- Information accuracy Q, QL
- Information timeliness Q, QL
- Information availability Q, QL
- Supplier ability to respond to quality problems F, QL

*Make*

- Total cost of resources C, QN
- Manufacturing cost C, QN
- Inventory investment C, QN
- Inventory obsolescence C, QN
- Work in process C, QN
- Cost per operation hour C, QN
- Capacity utilization as incoming stock level, work-in-progress, scrap level, finished goods in transit C, QN
- Inventory cost C, QN
- Inventory turnover ratio C, QN
- Inventory flow rate C, QN
- Inventory days of supply C, QN
- Economic order quantity C, QN
- Effectiveness of master production Schedule C, QN
- Number of items produced C, QN
- Warehouse costs C, QN
- Stock capacity C, QN
- Inventory utilization C, QN
- Stockout probability C, QN
- Number of backorder C, QN
- Number of stockouts C, QN
- Average backorder level C, QN
- Percentage of excess/lack of resource within a period C, QN
- Storage costs per unit of volume C, QN
- Disposal costs C, QN
- Planned process cycle time T, QN
- Manufacturing lead time T, QN
- Time required to produce a particular item or set of items T, QN
- Time required to produce new product Mix T, QN
- Inventory accuracy Q, QN
- Inventory range F, QN
- Percentage of wrong products Manufactured Q, QN
- Production flexibility F, QN
- Capacity flexibility F, QN
- Volume flexibility F, QN
- Number of tasks worker can perform F, QN

*Deliver*

- Total logistics costs C, QN
- Distribution costs C, QN
- Delivery costs C, QN
- Transport costs C, QN
- Transport costs per unit of volume C, QN
- Personnel costs per unit of volume moved C, QN
- Transport productivity C, QN
- Shipping errors C, QN
- Delivery efficiency C, QN
- Percentage accuracy of delivery C, QN
- Delivery lead time T, QN
- Frequency of delivery T, QN
- Product lateness T, QN
- Average lateness of orders T, QN
- Average earliness of orders T, QN
- Percent of on-time deliveries T, QN
- Delivery performance Q, QN
- Delivery reliability Q, QN
- Number of on-time deliveries Q, QN
- Effectiveness of distribution planning schedule Q, QL
- Effectiveness of delivery invoice methods Q, QN
- Driver reliability for performance Q, QN
- Quality of delivered goods Q, QL
- Achievement of defect-free deliveries Q, QN
- Quality of delivery documentation Q, QL
- Delivery flexibility F, QN
- Responsiveness to urgent deliveries F, QN
- Transport flexibility F, QN

*Return (customer satisfaction)*

- Warranty/returns processing costs C, QN
- Customer query time T, QN
- Customer satisfaction (or dissatisfaction) Q, QL
- Level of customer perceived value of product Q, QL
- Customer complaints Q, QN
- Rate of complaint Q, QN
- Product quality Q, QL
- Flexibility of service systems to meet particular customer needs F, QL

## 2.5 Goal-Oriented Approach

If a goal-oriented approach is used, how should the performance of SCM is measured?

In order to answer this question, we suggest distinguishing between six perspectives on SCM. Each perspective follows a particular set of goals, which consequently leads to a particular set of performance metrics. The various perspectives are systems dynamics, operations research/information technology, logistics, marketing, organization and strategy. If researchers focus on only one particular perspective, they will neglect the others. The balanced scorecard approach, with its multi-dimensional view on organizational reality, tries to overcome this boundary (Otto and Kotzab 2003).

### 2.5.1 *Six Perspectives to Measure the Performance of SCM (Otto and Kotzab 2003)*

There are six mentioned perspectives in SCP measurement, as follows:

1. *System dynamics-perspective*. This is the primary basis of the entire discussion in this field. Related contributions are still today among the most attractive ones regarding the transformation to practice.
2. *Operations research-perspective*. It can be characterized as a primarily method- or algorithm-oriented approach towards SCM. A supply chain is perceived as a resource network. SCM has to configure this network and to program the flows within the configuration according to a specific objective function based on algorithms.
3. *Logistic-perspective*. The supply chain is seen from a logistics perspective as a sequence of generic processes.
4. *Marketing-perspective*. Marketing recognized SCM in the past as a part of distribution, but recently it gained strategic importance as a potential driver for marketing's positive effect on the shareholder value. SCM is the tool to connect customers with products.
5. *Organizational-perspective*. From an organization point of view, a supply chain appears as a set of inter-organizational relationships.
6. *Strategy-perspective*. Strategy perceives SCM as a mean to vary certain competencies in a chain in order to maximize profits.

### 2.5.2 *Performance Measures of Perspectives*

Each perspective has its performance measures, which are explained below based on (Otto and Kotzab 2003):

### *System dynamics*

- *Capacity utilization*. Degree of capacity utilization.
- *Cumulative inventory level*. Volume of kept inventory along the whole chain. May be measured as “days of supply” or as a currency equivalent. Inventory may also be measured as “dwell time”, e.g. as the average number of days inventory sits idle in the pipeline compared to the average number of days it is moving.
- *Stock-outs*. Volume of stock-outs at the end user level. May be measured as a number of unsatisfied purchase orders or as the currency equivalent of the unsatisfied orders.
- *Time lags*. The length of the time lags occurring in the forwarding of demand information.
- *Time to adapt*. The time (number of days or weeks) needed to adapt to changes in demand. Supply chain adaptation is achieved as soon as all partners have accomplished their pursued operational parameters. It measures whether and how fast a supply chain manages to establish a good fit between the demand and supply patterns. “Time to adapt” measures the ability to respond rapidly to changes in demand, network design and sourcing.
- *Phantom ordering*. The volume of phantom ordering and order cancellations. They might be tracked in the manufacturers’ ERP-system.

### *Operations research*

- *Logistics costs per unit*. The percentage of the total landed costs that are consumed by the logistics processes. In this case, logistics should be defined as solely including the physical operations transport, storage and changeover.
- *Service level*. May be measured as the percentage of OTIF-orders (OTIF: on time–in full) or as a line item fill rate.
- *Time to deliver*. The time needed to move a particular inventory item from its point of storage to the customer. It may also be considered as the time required to serve the customer either by stock, assembly or make-to-order.

### *Logistics*

- *Integration*. Number of interfaces to be crossed through the processing of an order.
- *Lead times*. Lead times represent the time needed to finish a process. Lead times may be compiled for different business processes like procurement, manufacturing, or distribution.
- *Order cycle time*. The time interval between the time a customer places an order and the time he/she receives the product.
- *Inventory level*. See above.
- *Flexibility*. Flexibility may be measured as the ability to change or react with little penalty in time, effort, cost, or performance.

### *Marketing*

- *Customer satisfaction*. Customer satisfaction is a multi-dimensional construct. To measure the SCM-related fragments of customer satisfaction, it is recommended

to focus on those elements, which are driven by the physical logistical operations like the share of OTIF-orders.

- *Distribution costs per unit*. The total costs incurred to make a finished product available for a customer.
- *Market share/channel costs*. Numerical and weighted distribution: How many distribution points can be delivered and what is their market share? What are the costs to serve this marketing channel (acquisition and physical distribution)?

#### *Organization*

- *Transaction costs*. Usually defined as a bundle of costs incurred by the processes of preparing routine business conduct. This bundle includes the costs of searching business partner, monitoring the performance of agents, or adapting contracts.
- *Time to network*. The length of time needed to establish a specified particular institutional arrangement.
- *Flexibility*. For an appropriate definition of flexibility see above. The flexibility of the institutional arrangement may measure how “easily” a particular organizational set can be changed.
- *Density of relationships*. The density of a relationship is a complex conceptual phenomenon. Thus, its measurement will always be subject to the conceptual foundation.

#### *Strategy*

- *Time to network*. See above.
- *Time to market*. The time to market is the time period required to design and develop a marketable product. It measures how long it takes the business to recognize a market opportunity, to translate it into a product or service and bring it to the market. It may be measured in weeks, months or years.
- *ROI of focal organization*. Return on investment.

## **2.6 Attributes of National Logistics Systems**

The six general attributes of *World Competitive Yearbook* (Garelli 1999), i.e. infrastructure, performance, information systems, human resource, business and political environment and specific characteristics to make them more business-oriented, are shown below:

#### *Infrastructure*

- *Distribution infrastructure*. The distribution of goods and services is generally efficient/inefficient
- *Infrastructure maintenance and development*. Infrastructure maintenance and development is/is not adequately planned and financed
- *Water transportation*. Water transportation (crane handling, harbors, canals, . . . meet/does not meet business requirement

*Performance*

- *Air cargo handling*. Cargo handling throughput
- *Customs administration*. Hinders/does not hinder the efficient transit of goods
- *Process management*. Process management (quality, time to market, ... is/is not emphasize in country
- *Customer orientation*. Emphasize/does not emphasize customer satisfaction adequately

*Information system*

- *New information technology*. Implementation meets/does not meet business requirements
- *Electronic commerce*. Is/is not sufficient developed for business opportunities

*Human resource*

- *Labour regulations*. Regulations (hiring and firing practices, minimum wages, etc.) are too restrictive/are flexible enough
- *Immigration laws*. Prevent/do not prevent company from hiring foreign labor
- *Skilled labor*. Is/is not available in country's labour market
- *Industrial disputes*. Low/high working days lost per 1,000 inhabitants per year
- *Industrial relations*. Labor relations are generally hostile/productive
- *Employee training*. Is/is not high priority in companies
- *Worker motivation*. Identifies/does not identify with company objectives

*Business environment*

- *Export credits and insurance*. Are/are not available at reasonable prices for companies interested in exporting
- *Exchange rate policy*. Hinders/supports the competitiveness of enterprise
- *Cost of capital*. Hinders/does not hinder competitive business environment

*Political environment*

- *Political stability*. Risks of political instability

**Table 2.1** Value chain measure categories organized using *The Balanced Scorecard* macro level categories (Bolstorff 2006)

Balanced scorecard categories											
Customer facing			Process				Financial		Employee		
Reliability	Respon- siveness	Flexibility	Supply chain	Design chain	Customer chain	Aggregate	Profit	Growth	Perfor- mance	Develop- ment	

**Table 2.2** A draft list of value chain level 1 metrics (Bolstorff 2006)

Process model	Level 1 metrics	Balanced scored categories											
		Customer facing		Process		Financial		Employee					
		Reliability	Responsiveness	Flexibility	Supply chain	Design chain	Customer chain	Aggregate	Profit	Growth	Performance	Development	
SCOR	Performance order fulfillment	*											
CCOR	Warranty fulfillment	*											
CCOR	Service order fulfillment	*											
DCOR	Product quality	*											
SCOR	Order fulfillment cycle time		*										
DCOR	New product development cycle time		*										
CCOR	Selling process cycle time		*										
CCOR	Return process cycle time		*										
SCOR	Upside supply chain flexibility			*									
DCOR	Engineering change order flexibility			*									
DCOR	Design reuse flexibility			*									
CCOR	Total returns management cost						*						
CCOR	Total customer chain management cost						*						
CCOR	Days sales outstanding								*				
SCOR	Total supply chain management costs						*						
SCOR	Inventory days of supply						*						
DCOR	Total design chain management cost							*					

(continued)

Table 2.2 (Continued)

Process model	Level 1 metrics	Balanced scored categories										
		Customer facing			Process			Financial			Employee	
		Reliability	Responsiveness	Flexibility	Supply chain	Design chain	Customer chain	Aggregate	Profit	Growth	Performance	Development
DCOR	Total warranty cost								*			
DCOR	New product revenue								*			
SCOR	Cost of goods sold								*			
ALL	Sales, general, and administrative cost								*			
SCOR	Cash-to-cash cycle time								*			
ALL	Asset turns								*			
ALL	Return on assets								*			
ALL	Gross profit margin								*			
ALL	Operating margin								*			
ALL	Net profit margin								*			
ALL	Revenue growth									*		
ALL	Gross profit growth									*		
ALL	Operating margin growth									*		

## 2.7 Using the Balanced Scorecards to Manage SCP (Bolstorff 2006)

While SCOR provides a proven model to measure SCP, it does not include measures for the other business processes in the value chain, i.e. product design, sales, etc. One tried and true method to organize your key performance indicators is the *balanced scorecards*. The balanced scorecards has four measurement categories including customer facing; internal process; company financial; and individual employee.

Based on three value chain projects using SCOR, DCOR<sup>1</sup>, and CCOR<sup>2</sup>, this section integrate these leading practice models to manage value chain metrics.

The SCOR level 1 metrics are organized into customer-facing and internal-facing categories. The customer-facing category is further separated into three performance attributes, reliability, responsiveness, and flexibility. The internal-facing category is separated into two performance attributes, costs and assets. We can integrate categories of SCOR with the balanced scorecard organizational framework as shown in Table 2.1. Customer utilizes the SCOR customer facing categories and as you will see from the metric list in Table 2.2 broadens the scope to include more than just customer delivery performance. Process organizes metrics by value chain process and for those metrics that are a result of multiple processes an aggregate category is added. Financial has categories for both profit and growth (an important aspect of value chain improvement). Employee utilizes two categories, one focused on performance and the other focused on development.

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<sup>2</sup> Customer Chain Operations Reference.

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