Global supply chain management and performance measurement

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1 Introduction

Fast ongoing changes in global business environment have introduced new kinds of challenges and opportunities to the manufacturing companies. In the wide internet survey conducted in the spring 2011 the Finnish manufacturing companies named intensifying global competition and unstable demand as the two most influential drivers in business environment. In the same survey supply chain management was named the most important success factor for the companies for the next ten years. The success of the companies in the global environment depends highly on supply chain efficiency and its capabilities to provide value to the customers. Supply chains are usually complex entities containing huge amount of external and internal resources which make management and development work challenging. (TTY, VTT 2011)

Especially large companies have distributed their manufacturing resources into the global value chains. This enables companies to access to the new markets, technology, research and highly qualified labour. The main challenges regarding the increased geographical distribution are additional costs because of the distance (geography, structure and management), pressure on the flexibility and responsiveness as well as need of more efficient and extensive communication systems. (Johansen 2010)

A possibility to decrease the effects of unstable and weakly predictable demand in the global environment is to postpone the differentiation of the product as late as possible in the supply chain. Postponement (also delayed differentiation) enables among others to follow JIT principles, to reduce end-product inventory and to make forecasting easier.

Performance measurement of the entire supply chain and its processes is essential when managing and developing the supply chain. Performance measurement metrics enable evaluating and control the performance of the resources, provide information for internal needs and external stakeholders’ purposes as well as enables continuous improvement of the performance.

This literature review presents some relevant principles of the supply chain management and strategies. In the second part (section 3) there is introduced performance measurement and the measuring principles in the supply chain environment.
2 Supply chain management and strategies

Intensifying global competition, short life cycles of the products and increased customer expectations have forced the companies to invest and focus their attention on their supply chains. Together with continuous advances in communication and transportation technologies, this has motivated the continuous evolution of supply chain and of effective managing techniques. (Simchi-Levi et al. 2008)

Supply chain is a combination of processes, functions, activities, relationships and pathways along which products, services, information and financial transactions move in and between companies. The supply chain consist suppliers, manufacturing centers, warehouses, distribution centers and sales offices. Complexity of the supply chains makes the development and managing challenging. (Gattorna 2006, Simchi-Levi et al. 2008)

Simchi-Levi et al. (2008) define the supply chain management as follows:

“Supply chain management is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize systemwide costs while satisfying service level requirements”

Supply chain management means managing of the series of activities concerning the planning, coordinating and controlling movement of materials, parts and products from the suppliers to the customer. This includes the management of material, information and financial flows in the supply chain. The decisions are made at strategic, tactical and operational levels throughout the supply chain. A summary of the decisions made at these levels written by Simchi-Levi et al. (2008) is presented in the table 1. (Chandra & Grabis 2007, Simchi-Levi et al. 2008)

<table>
<thead>
<tr>
<th>Decision-making level</th>
<th>Timeline</th>
<th>Type of Decision Made</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic</td>
<td>Long lasting effect ~3 to 10 years</td>
<td>Investment on plants and capacities. Make or buy decisions. Introduction of new products. Decisions regarding product design. Creation of a logistics network and material flow through it.</td>
</tr>
<tr>
<td>Tactical</td>
<td>~3 months to 2 years</td>
<td>Purchasing and production policies to be implemented. Inventory policies to use. Transportation strategies to be adopted.</td>
</tr>
<tr>
<td>Operational</td>
<td>Day-to-Day</td>
<td>Scheduling of resources. Routing. Lead time quotations.</td>
</tr>
</tbody>
</table>

Table 1. Decision-making levels in supply chains (Simchi-Levi et al. 2008)
According several contributions in the literature (e.g. Christopher 1998, Sillanpää 2010) a network of companies to which interdependent organizations have linked up can be regarded as a supply chain. Typically supply chain is described as a chain that produces products or services and delivers them from suppliers to customers. But in reality, in most cases supply network would be more appropriate term to describe a supply chain. The networks can consist of company’s partners, various suppliers, distributors and clients. In the figure 1 there is an example of the supply network visualization. (Christopher 1998, Sillanpää 2010, Slack & Lewis 2008)

Figure 1. Supply network (Slack & Lewis 2008).
2.1 Supply chain integration

Supply chain integration means the co-operation between various functions in the supply chain. The key processes that can be integrated across the supply chain are: customer relationship management, customer service management, demand management, order fulfilment, manufacturing flow management, procurement and product development. In some cases it might be sufficient to integrate only one of these processes. (Sillanpää 2012)

The supply chain integration can be defined as (Sillanpää 2012):

*the degree to which an organisation strategically collaborates with its partners and manages intra- and inter-organisational processes in order to achieve efficient and effective flows of products, services, information, money and decisions.*

The supply chain integration can be divided into supply and demand integration. According de Treville (2004), supply integration includes just-in-time (JIT) delivery, reduction of the supplier base, evaluating suppliers based on quality and delivery performance, establishing long-term contracts with suppliers, and the elimination of paperwork. Demand integration includes increased access to demand information throughout the supply chain to permit rapid and efficient delivery, coordinated planning, and improved logistics communication. (de Treville et al. 2004)

2.2 Order penetration point

Order penetration point (OPP) or decoupling point is the point in the manufacturing chain where the product is marked to be delivered to a specific customer. The point divides the production into upstream and downstream. Upstream from the OPP the material flow is managed according forecasts and plans. The production is pull-oriented and based on stock levels. Downstream from the OPP the flow is directed by the order from the client. (Sillanpää 2010, Olhager 2003)

The position of the OPP defines the manufacturing strategy in the supply chain. Different manufacturing strategies such as make-to-stock (MTS), assemble-to-order (ATO), make-to-order (MTO) and engineer-to-order (ETO) relate to the position of the OPP (figure 2). In the figure 2 dotted lines illustrate the production activities that are forecast driven, and the straight lines illustrate customer order driven activities. (Olhager 2003)

![Figure 2](image)

*Figure 2.* Different product delivery strategies relate to different positions of order penetration point. (Olhager 2003)
Shifting of OPP has to be strategically motivated. According Olhager (2003) shifting the OPP forward has two major driving forces (Olhager 2003):
- reduce the delivery lead time to customers, and
- increase the manufacturing efficiency, e.g. by optimising the bottleneck operation.

The negative effects of shifting the OPP forward are (Olhager 2003):
- Rely more on forecasts (risk of obsolescence)
- Reduce product customisation (to maintain WIP and inventories levels)
- Increase work-in-process (due to more items being forecast-driven)

According Olhager (2003) shifting the OPP backward has following major driving forces (Olhager 2003):
- Increasing the degree of product customisation
- Reduce the reliance on forecasts
- Reduce or eliminate WIP buffers
- Reduce the risk of obsolescence of inventories

The negative effects of shifting the OPP backward are (Olhager 2003):
- Longer delivery lead times and reduced delivery reliability (if production lead times are not reduced)
- Reduced manufacturing efficiency (due to reduced possibilities to process optimisation).

### 2.3 Agile supply chain

The agility in the field of manufacturing and supply chains has numerous definitions in the literature. The agility is typically related to the flexibility and responsiveness. Christopher (2000) presents a relevant definition of agility (Christopher 2000):

> Agility is a business-wide capability that embraces organizational structures, information systems, logistics processes, and, in particular, mindsets. A key characteristic of an agile organization is flexibility...Agility might, therefore, be defined as the ability of an organization to respond rapidly to changes in demand, both in terms of volume and variety.

Agile organisations are also seen to benefit from the unexpected changes in business environment. Shang & Sharifi (2000) defines the agility as following (Shang & Sharifi 2000):

> The paradigm is primarily concerned with the ability of enterprises to cope with unexpected changes, to survive unprecedented threats from the business environment, and to take advantage of changes as opportunities.

According Shang & Sharifi (2000) the concept of agility comprises two main factors:
- Responding to changes (anticipated or unexpected) in proper ways and due time.
- Exploiting changes and taking advantage of changes as opportunities.

Harrison & van Hoek (2008) presented a supply chain based definition to the agility (Harrison & Van Hoek 2008):

*Agility is a supply-chain-wide capability that aligns organizational structures, information systems, logistics processes and, in particular, mindsets.*

Main idea of agility in the context of supply chain is responsiveness. Agile supply chain has shorter lead times and seeks to be demand-driven. According Christopher (2000) the agile supply chain is
- Market sensitive: closely connected to end-user trends
- Virtual: relies on shared information across all SC partners
- Network-based: gains flexibility by using the strengths of specialist players
- Process aligned: has a high degree of process inter-connectivity between the network members.

### 2.4 Lean supply chain

Lean philosophy derived mostly from the Toyota Production System (TPS) and identified as Lean in the 1990. Lean focuses on delivering value to the customer with less work. The basic principles of lean can be expressed by the 4P model (figure 3) introduced by Liker (2004). The base part of the 4P model, philosophy, means that the management decisions should be based on long-term philosophy. The process means the eliminating waste from the processes for example by creating flow by using pull system and standardising tasks. People and partners means respecting, developing and challenging people, teams and suppliers. And finally problem solving means continuous learning and improvement. (Liker 2004)
Lean supply management focuses on developing a value stream to eliminate all waste. According Christopher (2006) lean concept work well when demand is relatively stable and predictable and where variety is low. Agility, on the contrary, focuses primarily on responsiveness and it is seeking to match supply and demand in turbulent and unpredictable markets. (Sillanpää 2010, Christopher 2006)

2.5 Designing global operations networks

The operations network has a great impact on a company’s performance and profitability. The business environment is global and often there is situation where the company’s operations network (manufacturing, distribution, sourcing) needs to be restructured or expanded. Designing the network is a complex task and multiple factors have to be taken into account when making the decisions. According Blomqvist & Laiho (2012) there are at least three categories of company targets which may lead to the need to redesign operations networks: 1) Improvement of competitiveness through an improved utilization of the global network and global resources 2) Improved competitiveness through more focused, differentiated resource combinations (improved fit). 3) International expansion to reach new markets, customer groups or new geographical areas. (Blomqvist & Laiho 2012)

Designing operations networks includes strategic decisions which need careful preparation and planning. Company’s operations strategy should be aligned with the corporate and business strategy. Within supply chains the structure and the strategy of the network need to be also aligned with the markets. Demand (predictable/volatile), product (standard/special)
and supply lead-times (long/short) have to be taken in account. (Blomqvist & Laiho 2012, Christopher & Towill 2002)

Long-term strategic decisions like location, make or buy, plant focus and plant role, technology as well as planning and control systems are essential when designing the operations network. Blomqvist & Laiho (2012) presented the factors that affect the decisions. They divided the direct factors to
- operating environment,
- market requirements,
- demand,
- product and
- cost.

Operating environment is discussed for example by Ferdows (1997). He named three main strategic reasons for the factory location: access to low-cost production, access to skills and knowledge, and proximity to markets. Proximity to markets can be defined by location close to specific key customers, location at (or close to) the current main markets and/or location at (or close to) the expected future markets. Proximity to suppliers and other resources is another important aspect. Closer personal co-operations as well as short and flexible logistics connections can make the supplier relationship more effective. By access to skills and knowledge Ferdows means the know-how accumulated in certain areas or clusters like Southern China for electronics, Taiwan for semiconductors, Silicon Valley for software and Italian hydraulic valley for such competence.

Market requirements can be expressed by quality, cost, and delivery requirements. Essential questions in understanding the market requirement are: who the customers are; what they buy, when, where and how often their purchases occur; why they buy, that is, what benefits they seek; and how they buy i.e. what their buying process is. About the demand it is important to understand is it predictable or volatile, is there some trends in the demand and what causes the trends (e.g. seasonal demand). Considering the product itself two main aspects that influence to the ideal setup of an operations network are volumes and variability. Third aspect is the stability of the product: How fast does the technology change with this product? How often do we bring new product versions into the market? Are all our products standard or do we customize them according to customer needs? Modularity and postponement make it possible to create the variants closer to the customer, thus the high flexibility requirements need to be applied only to end part of the chain. The postponement strategies are discussed more in the chapter 2.6. (Blomqvist & Laiho 2012, Christopher & Towill 2002)

Finally, an important factor that have to be always taken in account: cost. In some cases the cost may be the major driving force and all of the factors discussed earlier affect the costs, but it should be remembered that it is not the only factor. For example, lost opportunity of not being able to open a new market due to inadequate operations network cannot easily be evaluated as cost. In practise, all costs that are needed in order to make the product available in a given location have to be taken in account. The costs affecting the location decision are, for example, cost to acquire land and build the facility, costs of labor, taxes and utilities as well as the cost to transport the materials to the facility, and move finished product from the facility. (Vonderembse & White 1996, Blomqvist & Laiho 2012).
Blomqvist & Laiho (2012) presented also the factors that limit the decisions about operations network design. They divide those to business strategy and competitive approach, current capabilities, risk management, sustainability and service content. The limiting factors may rule out some of alternatives or make some alternatives less appealing. Useful tools which may help in the decision making are presented for example by Blomqvist & Laiho (2012). (Blomqvist & Laiho 2012)

2.6 Postponement

In many markets the customers are demanding their orders be fulfilled more quickly and at the same time they are demanding highly customized products and services. It is very challenging task for the companies to offer customized products and services for the customers rapidly and at the same time reduce costs. The key to mass-customize effectively is to postpone the differentiating of the product for a customer until the latest possible point in the supply chain. In the literature this is handled using several different terms such postponement, late customization and delayed (product) differentiation. Mass-customization and postponement enables to exploit the benefits of economies of scale and scope through product and process standardization and customization. The idea of postponement is to supply desirable products to customers at a relatively low cost and in a responsive way. The benefits of postponement include following JIT principles, reducing end-product inventory and making forecasting easier. (Feitzinger & Lee, 1997, Cheng et al. 2010, Lee & Tang 1997)

2.6.1 Principle

The delayed differentiation can be seen as moving the order penetration point (OPP) closer to end of the supply chain. The idea of mass-customization and OPP is illustrated in the figure 4. The OPP is the point where the product is assigned to a specific customer. In mass customization the standard parts of the product that are produced with mass-production process and the independent modules that are produced by separate production lines should be combined with small and simple series of incorporating tasks after the order penetration point. This requires that the product and its architecture are designed for efficient mass customization. (Mattila 2012, Olhager, J. 2003, Feitzinger and Lee 1997)
Figure 4. Idea of mass-customization and OPP. (Mattila 2012)

A simple example of postponement presented by Ulrich & Eppinger (2008) is illustrated in figure 5. There are three different versions of the printer, each adapted to a different electrical power standard in three different geographic regions. The supply chains consist of three basic activities: assembly, transportation and packaging. In scenario A all the three versions are differentiated during the assembly and then transported and packaged. In scenario B, the assembly is divided into two stages, most of the product is assembled in the first stage, after transportation the assembly is completed and finally the product is packed. The components included into power conversion module is assembled after transportation, thus the product is differentiated near the end of the supply chain. (Ulrich & Eppinger 2008)
Delayed differentiation may provide remarkable reductions in the cost of operating the supply chain, primarily through reductions in inventory requirements. Especially for the innovative products, demand for the different versions of the product is unpredictable. To offer high product availability with reasonably low order lead time, the inventory may need to locate near the end of the supply chain. For the printers, transportation by ship between production and distribution sites may take several weeks. To respond the fluctuating demand effectively, substantial inventory must be held after transportation. The amount of inventory required is the function of the magnitude of the variability in demand. Delayed differentiation enables reductions in the cost of inventories because there is less fluctuation in demand of basic elements of the products (e.g. the platform) than for the differentiating components. In many cases demand of different versions is somewhat correlated: when demand for one version high, it is possible that the demand for other version is low. (Ulrich & Eppinger 2008)
Postponement can be divided into form, time and place postponement. Form and time postponement refer to delaying some customization until customer order is received. Place postponement means the positioning of inventories upstream or downstream. (Chen et al. 2010, Yang & Burns 2003)

### 2.6.2 Product and process design for postponement

Feitzinger & Lee (1997) presented three organizational design principles that form the basic building blocks of an effective mass-customization program:

- A product should be designed so that it consists of independent modules that can be assembled into different forms of the product easily and inexpensively.
- Manufacturing processes should be designed so that they, too, consist of independent modules that can be moved or rearranged easily to support different distribution network designs.
- The supply chain network – the positioning of inventory and the location, number and architecture of manufacturing and distribution facilities – should be designed to provide two capabilities. First, it should be able to supply the basic product to the facilities performing the customization in a cost effective manner. Second, it must have flexibility and responsiveness to take an individual customer’s orders and deliver the finished, customized goods quickly. (Feitzinger & Lee 1997)

By simultaneous design of products, processes and supply chain for mass customization a company can optimize costs and provide fast and effective service. Decisions concerning the distribution network are trade-offs between costs and service level. On the other hand centralized distribution network, using one distribution center or warehouse to serve multiple regions, typically offer the advantage of low costs. On the other hand decentralized network provide usually improved service to the customers. The factors affecting the design of operations network is handled already in the chapter 2.5. (Feitzinger & Lee 1997)

Feitzinger & Lee 1997 presented an example of distribution network design. The company selling many product options benefits a little from having many distribution centers around the world if the center's perform only distribution and warehousing tasks. But if the company redesigns its products and processes into modules so that the final customization is performed on receipt of a customer order, the economics change radically. It is then more cost effective to have distribution centers, each of which stocks basic products and performs the final customization of the products. Another advantage of postponing the light manufacturing processes to distribution centers around the world is that the company can comply the local content rules and to respond to the customer orders more quickly around the world. In this way, a company can concentrate manufacturing of critical parts in a few sites to achieve economies of scale and maintain a local manufacturing presence at the same time. (Feitzinger & Lee 1997)

Ulrich & Eppinger (2008) named two main design principles that need to be taken in account when the differentiation is postponed: 1. the differentiating elements of the product must be concentrated in a few chunks, 2. the product and the production process must be designed so that the differentiating chunks can be added to the product near the end of the supply chain. (Ulrich & Eppinger 2008)
2.7 Value added logistics (VAL)

Value added logistics means the combination of logistical and light industrial activities to finalize a product performed by a logistics provider. Preferably, these finalizing activities are done as late as possible in the logistics chain before sending the product to its final destination. The activities can be divided according to the amount of value added to the product or service:

- Low-end VAL activities normally add only low value to the product (e.g., labelling, making the product country- or customer-specific, adding manuals and parts, creating new assortments of goods or breaking bulk)
- High-end VAL activities normally add high value to the product (e.g. final assembly, instruction/training, repairs and recommissioning, blending/mixing of granular products or liquids, sterilization) (ESCAP & KMI 2007)

Postponement, which was discussed in the previous chapter, is an important concept associated with value added logistics. Logistics provider can carry out postponed manufacturing activities like final assembly of the product in a distribution center or a warehouse after the customer order is placed. Postponement activities can be also performed in order to avoid or reduce import taxes. In some countries the import taxes for components are lower than for total final products. (ESCAP & KMI 2007)

Vervoed (1999) handled value added logistics services performed in regional distribution centers. He presented development steps of VAL (figure 6). VAL developed around the value added production. In the next step more and more information travelled through the hub. When these are combined and expanded it ends up as value added services. (Vervoed 1999)
<table>
<thead>
<tr>
<th>Logistics Information hub</th>
<th>Value Added Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>As much information as possible via hub</td>
<td>Customer clearance, insurance, invoicing, fiscal representative, etc.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Distribution Hub</th>
<th>Value Added Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>As much goods as possible via hub</td>
<td>Assembly, packaging, labeling, repair and maintenance</td>
</tr>
</tbody>
</table>

**Figure 6.** Development steps of VAL according Vervoed (1999).
3 Supply chain performance measurement

It is important to measure the performance of the complete supply chain and the individual processes. The performance measurement system should be based on the strategy, value drivers and important goals of the companies and the whole supply chain.

Performance measurement provides information for management and decision makers, enable identifying the success and potential of management strategies and facilitating the understanding of the situation. In addition performance measurement assists in directing management attention, revising company goals, and re-engineering business processes. SC performance measurement is helpful in the continuous improvement of SCM. (Chan 2003)

According Melnyk et al. (2004) the performance metrics have three basic functions: control, communication and improvement. Control means that the metrics enable managers and workers to evaluate and control the performance of the resources. The performance is communicated for internal needs and external stakeholders' purposes by the metrics. Improvement means the possibility to identify the gaps between performance and expectations and to indentify the areas where the development work is needed. (Melnyk et al. 2004)

Gunasekaran et al. (2001) stated that there is a great need of study measures and metrics in the context of following reasons:

1. Lack of balanced approach. The importance of financial and non-financial measures have been realised, but typically the companies have failed to create the balance between those. Financial performance measurements are important for strategic decisions and external reporting, and non-financial measures handle more day-to-day control of manufacturing and distribution operation.

2. Lack of understanding on deciding on the number of metrics to be used. Quite often the companies have a large number of performance measures to which they keep on adding based on suggestions of employees and consultants. Many times the performance measurement can be better addressed using a good few metrics.

3. Lack of clear distinction between metrics at strategic, tactical, and operational levels. Metrics that are used in performance measurement influence the decisions to be made at strategic, tactical, and operational levels. Using a classification based on these three levels, each metric can be assigned to a level where it would be most appropriate.

3.1 Purpose of performance measurement

The information from the performance measurement is needed especially in top management level, but also several kinds of SCM measures are needed at every management and operational level. The management’s main interest is to know how efficient the SMC is. Also several management levels are interested in knowing about SCM capability and performance. Performance measuring is also essential when the SC is developed. Performance measurement provides information on how effective the development work has been. In manufacturing companies performance measurement provides information for the monitoring, control, evaluation and feedback functions for operations management. When implementing and executing a new business strategy, the performance measurement provides important feedback about the improvement. Good performance measurement system also

Gunasekaran & Kobu (2007) presented following purposes of a performance measurement system:
- identifying success
- identifying whether customer needs are met
- better understanding of processes
- identifying bottlenecks, waste, problems and improvement opportunities
- providing factual decisions
- enabling progress
- tracking progress
- facilitating a more open and transparent communication and co-operation.

3.2 Designing and developing the performance measurement metrics

The performance measurement metrics should be designed and developed separately for each case. The measurement system should reinforce the firm’s strategy as well as guide the organisation to improve customer and shareholder satisfaction and competitiveness. When designing and developing the supply chain performance metrics, the strategy and goals of entire supply chain need to be understood. The network should pursue shared goals and avoid sub-optimization. (Neely et al. 1995, Stadtler H. & Kilger C. 2008)

Stadtler H. & Kilger (2008) presented some important issues when assessing the supply chain performance:
- **Definition of indicators.** As the supply chains consist of several companies and functions, a common definition of all the measures is obligatory. The indicators should be understood and applied in the same way in every entity of the chain.
- **Perspective on indicators.** The two partners in supply chain may have a different perspective to the measures depending on their role in the chain. For example, a supplier may want to calculate the order fill rate based on the order receipt date and the ship date. The customer, on the other hand, might want to calculate it based on the requested date and the receipt date at the customer’s warehouse. This will lead different results with respect to an agreed order fill rate. The both parties should agree on one perspective.
- **Capturing of data.** The data have to be captured in a consistent way throughout the supply chain. The units should be consistent and the reliable and up-to-date data should be available in adequate systems for the supply chain partners.
- **Confidentiality.** Confidentiality need to be kept in mind when the supply chain consists of more than one company. The individual companies might not want to give complete information about their internal processes and the targets to their partners.

According Ghalayini (1996) performance measurement system should have the following characteristics (Ghalayini & Noble 1996):
- a clearly defined set of improvement areas and associated performance measures that are related to company strategy and objectives
- stresses the role of time as a strategic performance measure
- allows dynamic updating of the improvement areas
- links the areas of improvement and performance measurement to the factory shop floor
- is used as an improvement tool rather than just a monitoring and controlling tool
- considers process improvements efforts as a basic integrated part of the system
- utilizes any improvements in performance (i.e. going beyond just achieving improvement and actively planning for the utilization of benefits from an overall company perspective)
- uses historical data of the company to set improvement objectives and to help achieve such objectives
- guards against sub-optimization
- provides practical tools that could be used to achieve all of the above.

Wisner (1991) presented nine-steps for developing a performance measurement metrics (Wisner & Fawcett 1991):

1. Clearly define the firm’s mission statement.
2. Identify the firm’s strategic objectives using the mission statement as a guide (profitability, market share, quality, cost, flexibility, dependability, and innovation).
3. Develop an understanding of each functional area’s role in achieving the various strategic objectives.
4. For each functional area, develop global performance measures capable of defining the firm’s overall competitive position to top management.
5. Communicate strategic objectives and performance goals to lower levels in the organization. Establish more specific performance criteria at each level.
6. Assure consistency with strategic objectives among the performance criteria used at each level.
7. Assure the compatibility of performance measures used in all functional areas.
8. Use the performance measurement system to identify competitive position, locate problem areas, assist the firm in updating strategic objectives and making tactical decisions to achieve these objectives, and supply feedback after the decisions are implemented.
9. Periodically re-evaluate the appropriateness of the established performance measurement system in view of the current competitive environment.

Thakkar (2009) proposed some features for the performance metrics used in SC performance measurement (Thakkar et al. 2009):

- measurement system should have the capability to capture the essence of organizational performance
- measurement system should ensure an appropriate assignment of metrics to the areas where they would be most appropriate
- minimum deviations should exist between the organizational goals and measurement goals
- metrics should reflect an adequate balance between financial and nonfinancial measures
- measures should reflect their clear linkages with various levels of decision making such as strategic, tactical, and operational level.

Neely (1995) proposed that the system can be analysed by exploring issues such as (Neely et al. 1995):

- Have all the appropriate elements (internal, external, financial, nonfinancial) been covered?
- Have measures which relate to the rate of improvement been introduced?
- Have measures which relate to both the long- 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 one another?

If the measures are not aligned to the network strategy and goals, it may happen that one supply chain entity pursue a conflicting goal. For example, when the company increases the inventory turn rate by reducing safety sock, it could affect negatively to the downstream partners’ delivery performance. (Stadtler & Kilger 2008)

Performance measures can vary between company locations. The same measurement system is not necessarily suitable for all sites thus the metrics should be formed for each site separately. The measurement system has to be continually reviewed and revised as the circumstances and the competition situation changes. In addition the measures should be simple and easy to use, should provide fast feedback and should stimulate continuous improvement rather than simply monitor. (Maskell 1991)

3.3 Supply performance measurement approaches

Several different approaches for the supply chain measurement have been introduced in the literature. In following chapters some of these approaches are presented.

3.3.1 A framework for measuring the performance of a supply chain

Gunasekaran et al. (2001) presented a framework for measuring the performance of a supply chain. They divided the SC performance measures into financial and non-financial measures. In addition they used three measurement levels (strategic, tactical and operational) as well as four SC activities/operations (plan, source, make/assembly and deliver) to form the measurement framework. The performance metrics proposed by Gunasekaran et al. (2001) are presented in the table 1.
<table>
<thead>
<tr>
<th>Level</th>
<th>Performance metrics</th>
<th>Financial</th>
<th>Non-financial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic</td>
<td>Total supply chain cycle time</td>
<td>x</td>
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<tr>
<td></td>
<td>Total cash flow time</td>
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<td>x</td>
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<tr>
<td></td>
<td>Customer query time</td>
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<tr>
<td></td>
<td>Level of customer perceived value of product</td>
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<tr>
<td></td>
<td>Net profit vs. productivity ratio</td>
<td>x</td>
<td></td>
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<tr>
<td></td>
<td>Rate of return on investment</td>
<td>x</td>
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<tr>
<td></td>
<td>Range of product and services</td>
<td>x</td>
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<tr>
<td></td>
<td>Variations against budget</td>
<td>x</td>
<td></td>
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<tr>
<td></td>
<td>Order lead time</td>
<td>x</td>
<td></td>
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<tr>
<td></td>
<td>Flexibility of service systems to meet particular customer needs</td>
<td>x</td>
<td></td>
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<tr>
<td></td>
<td>Buyer-supplier partnership level</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Supplier lead time against industry norm</td>
<td>x</td>
<td></td>
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<tr>
<td></td>
<td>Level of supplier's defect free deliveries</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delivery lead time</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delivery performance</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Tactical</td>
<td>Accuracy of forecasting techniques</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Product development cycle time</td>
<td>x</td>
<td></td>
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<tr>
<td></td>
<td>Order entry methods</td>
<td>x</td>
<td></td>
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<tr>
<td></td>
<td>Effectiveness of delivery invoice methods</td>
<td>x</td>
<td></td>
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<tr>
<td></td>
<td>Purchase order cycle time</td>
<td>x</td>
<td></td>
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<tr>
<td></td>
<td>Planned process cycle time</td>
<td>x</td>
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<tr>
<td></td>
<td>Effectiveness of master production schedule</td>
<td>x</td>
<td></td>
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<tr>
<td></td>
<td>Supplier assistance in solving technical problems</td>
<td>x</td>
<td></td>
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<tr>
<td></td>
<td>Supplier ability to respond to quality problems</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supplier cost saving initiatives</td>
<td>x</td>
<td></td>
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<tr>
<td></td>
<td>Supplier's booking in procedures</td>
<td>x</td>
<td></td>
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<tr>
<td></td>
<td>Delivery reliability</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Responsiveness to urgent deliveries</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Effectiveness of distribution planning schedule</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Operational</td>
<td>Cost per operation hour</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Information carrying cost</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Capacity utilisation</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total inventory as:</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Incoming stock level</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Work-in-progress</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Scrap level</td>
<td></td>
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<tr>
<td></td>
<td>- Finished goods in transit</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supplier rejection rate</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Quality of delivery documentation</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Efficiency of purchase order cycle time</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frequency of delivery</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>
Driver reliability for performance | x
Quality of delivered goods | x
Achievement of defect free deliveries | x

Gunasekaran et al. (2004) presented the improved framework for supply chain measurement. The framework is based on a theoretical framework discussed by Gunasekaran et al. (2001) and on the empiric analysis, in which selected British companies were asked which of the metrics are most important for their business. The framework and the measures are presented in the Table 3. (Gunasekaran et al. 2004)

Table 3. Supply chain performance metrics framework (Gunasekaran et al. 2004).

<table>
<thead>
<tr>
<th>Supply chain activity/process</th>
<th>Strategic</th>
<th>Tactical</th>
<th>Operational</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plan</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of customer perceived value of product</td>
<td>Customer query time</td>
<td>Order entry methods</td>
<td></td>
</tr>
<tr>
<td>Variances against budget</td>
<td>Product development cycle time</td>
<td>Human resource productivity</td>
<td></td>
</tr>
<tr>
<td>Order lead time</td>
<td>Accuracy of forecasting techniques</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information processing cost</td>
<td>Planning process cycle time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net profit Vs productivity ratio</td>
<td>Order entry methods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total cycle time</td>
<td>Human resource productivity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total cash flow time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product development cycle time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Source</strong></td>
<td>Supplier delivery performance</td>
<td>Efficiency of purchase order cycle time</td>
<td></td>
</tr>
<tr>
<td>Supplier lead time against industry norm</td>
<td>Supplier pricing against market</td>
<td>Supplier pricing against market</td>
<td></td>
</tr>
<tr>
<td>Supplier pricing against market</td>
<td>Effiency of cash flow method</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency of purchase order cycle time</td>
<td>Supplier booking in procedures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency of cash flow method</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplier booking in procedures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Make/Assemble</strong></td>
<td>Range of products and services</td>
<td>Percentage of defects</td>
<td>Percentage of Defects</td>
</tr>
<tr>
<td>Percentage of defects</td>
<td>Cost per operation hour</td>
<td>Cost per operation hour</td>
<td></td>
</tr>
<tr>
<td>Cost per operation hour</td>
<td>Capacity utilization</td>
<td>Human resource productivity index</td>
<td></td>
</tr>
<tr>
<td>Capacity utilization</td>
<td>Utilization of economic order quantity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilization of economic order quantity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Deliver</strong></td>
<td>Flexibility of service system to meet customer needs</td>
<td>Flexibility of service system to meet customer needs</td>
<td>Quality of delivered goods</td>
</tr>
</tbody>
</table>
3.3.2 Balanced scorecard

Several contributions in the literature is dealing with the adaptation of Balanced scorecard (BSC) to measure supply chains (e.g., Brewer & Speh 2000, Bullinger et al. 2002, Thakkar et al. 2006, Mehrjerdi 2009). Kaplan and Norton (1992) presented the BSC to measure the company performance from four perspectives: customer, internal business, financial, and innovation and learning. Basic idea of BSC is to maintain a balance between short term and long term objectives, between financial and non-financial measures, between lagging and leading indicators and between internal and external performance. The BSC also facilitates to focus on the most critical measures by limiting the number of measures used. The BSC perspectives and the links are presented in the figure 7. (Kaplan & Norton 1992, Sillanpää 2010).
Customer perspective evaluate on how the company add value for the customers. The customer estimates the value through time, quality, performance, service and cost. In BSC the company have to set goals for these value adding elements and translate these into specific measures. Customer based measures have to be translated into a measures of what the company have to do internally to meet its customers’ expectations. Customer value derives from processes, decisions and actions in the organisation. Internal business perspective focuses on these elements. Objective of the financial perspective is to measure financial success. Goals in this area are deals typically with profitability, growth, and shareholder value. Finally, innovation and learning perspective evaluates on how the company can continue to improve and create the value in the future. (Kaplan & Norton 1992)

In the adaptations proposed for the supply chain measurement both original four perspectives and new perspectives have been used. Bhagwat and Sharma (2007) introduced their BSC approach for the supply chain measurement. They have used the original four
perspectives for the goal setting. The measures they proposed for the SC measuring is presented in the table 4. (Bhagwat & Sharma 2007)

**Table 4. Example of the balanced scorecard measures for supply chain. (Bhagwat & Sharma 2007)**

<table>
<thead>
<tr>
<th>Customer perspective:</th>
<th>Internal business perspective:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer query time</td>
<td>Total supply chain cycle time</td>
</tr>
<tr>
<td>Level of customer perceived value of product</td>
<td>Total cash flow time</td>
</tr>
<tr>
<td>Range of products and services</td>
<td>Flexibility of service systems to meet particular customer needs</td>
</tr>
<tr>
<td>Order lead time</td>
<td>Supplier lead time against industry norms</td>
</tr>
<tr>
<td>Flexibility of service systems to meet particular customer needs</td>
<td>Level of supplier’s defect free deliveries</td>
</tr>
<tr>
<td>Buyer–supplier partnership level</td>
<td>Accuracy of forecasting techniques</td>
</tr>
<tr>
<td>Delivery lead time</td>
<td>Product development cycle time</td>
</tr>
<tr>
<td>Delivery performance</td>
<td>Purchase order cycle time</td>
</tr>
<tr>
<td>Effectiveness of delivery invoice methods</td>
<td>Planned process cycle time</td>
</tr>
<tr>
<td>Delivery reliability</td>
<td>Effectiveness of master production schedule</td>
</tr>
<tr>
<td>Responsiveness to urgent deliveries</td>
<td>Capacity utilization</td>
</tr>
<tr>
<td>Effectiveness of distribution planning schedule</td>
<td>Total inventory cost as:</td>
</tr>
<tr>
<td>Information carrying cost</td>
<td>o Incoming stock level</td>
</tr>
<tr>
<td>Quality of delivery documentation</td>
<td>o Work-in-progress</td>
</tr>
<tr>
<td>Driver reliability for performance</td>
<td>o Scrap value</td>
</tr>
<tr>
<td>Quality of delivered goods</td>
<td>o Finished goods in transit</td>
</tr>
<tr>
<td>Achievement of defect free deliveries</td>
<td>Supplier rejection rate</td>
</tr>
<tr>
<td>Supplier rejection rate</td>
<td>Efficiency of purchase order cycle time</td>
</tr>
<tr>
<td>Supplier ability to respond to quality problems</td>
<td>Frequency of delivery</td>
</tr>
</tbody>
</table>

Financial perspective:  
- Customer query time  
- Net profit vs. productivity ratio  
- Rate of return on investment  
- Variations against budget  
- Buyer–supplier partnership level  
- Delivery performance  
- Supplier cost saving initiatives  
- Delivery reliability  
- Cost per operation hour  
- Information carrying cost  
- Supplier rejection rate  

Innovation and learning perspective:  
- Supplier assistance in solving technical problems  
- Supplier ability to respond to quality problems  
- Supplier cost saving initiatives  
- Supplier’s booking in procedures  
- Capacity utilization  
- Order entry methods  
- Accuracy of forecasting techniques  
- Product development cycle time  
- Flexibility of service systems to meet particular customer needs  
- Buyer–supplier partnership level  
- Range of products and services  
- Level of customer perceived value of product  

**3.3.3 Supply chain operations reference (SCOR)**

Another well known approach for the SC measurement is Supply chain operations reference (SCOR), which is used in various industries around the world. The Supply-Chain Council, which is a global organization of firms interested in SCM, introduced

Theeranuphattana (2008) lists the benefits that the SCOR model offers for users:
- standard descriptions of management processes that make up the SC
- a framework of relationships among the standard processes
- standard metrics to measure process performance
- management practices that produce best-in-class performance
- standard alignment to software features and functionality that enable best practices.

In the SCOR model the metrics are linked with five management processes: plan, source, make, deliver, and return. The SCOR model contains hundreds of performance metrics that are divided under five core supply chain performance attributes (Supply-Chain Council 2010):

- **Reliability**: The Reliability attribute addresses the ability to perform tasks as expected. Reliability focuses on the predictability of the outcome of a process. Typical metrics for the reliability attribute include: on-time, the right quantity, the right quality. The SCOR KPI (level 1 metric) is Perfect Order Fulfillment. Reliability is a customer-focused attribute.

- **Responsiveness**: The Responsiveness attribute describes the speed at which tasks are performed. Examples include cycle-time metrics. The SCOR KPI is Order Fulfillment Cycle Time. Responsiveness is a customer-focused attribute.

- **Agility**: The Agility attribute describes the ability to respond to external influences and the ability to change. External influences include: Non-forecasted increases or decreases in demand; suppliers or partners going out of business; natural disasters; acts of (cyber) terrorism; availability of financial tools (the economy); or labor issues. The SCOR KPIs include Flexibility and Adaptability. Agility is a customer-focused attribute.

- **Costs**: The Cost attribute describes the cost of operating the process. It includes labor costs, material costs, and transportation costs. The SCOR KPIs include Cost of Goods Sold and Supply Chain Management Cost. These two indicators cover all supply chain spend. Cost is an internally-focused attribute.

- **Assets**: The Asset Management Efficiency (“Assets”) attribute describes the ability to efficiently utilize assets. Asset management strategies in a supply chain include inventory reduction and in-sourcing vs. outsourcing. Metrics include: inventory days of supply and capacity utilization. The SCOR KPIs include: Cash-to-Cash Cycle Time and Return on Fixed Assets. Asset Management Efficiency is an internally-focused attribute.

In addition the metrics are divided under three levels. Level 1 metrics are strategic metrics, also called key performance indicators (KPIs). Level 2 serve as diagnostics for the level 1 metrics and help to identify the root cause or causes of a performance gap for a level 1 metric. Level 3 metrics serve as diagnostics for level 2 metrics. (Supply-Chain Council
The structure of SCOR metrics and example metrics are presented in the appendix 1. (Supply-Chain Council 2010)

### 3.3.4 Measuring approaches for the manufacturing industry

Sillanpää (2010) introduced several different approaches for the supply chain measurement in his doctoral thesis. Many approaches use the following four SC operations to divide the metrics: plan, source, make and deliver. The fifth operation that is used less is return or customer satisfaction. Furthermore, the supply chains should be measured in different levels, typically the levels are strategic, tactical and operational. According Sillanpää (2010) the supply chain should be measured using different kind of approaches. Sillanpää concludes the literature review by proposing the following principal approaches for SC performance measurement:

- management approach
- time based approaches
- quantitative and qualitative measures

Management approach refers to the three management levels: strategic, tactical and operational. Strategic level measures performance for needs of top management and the measures are usually corporate level performance measures. The tactical level measure performance against targets and collect feedback from mid-management level. Operational level metrics collect the data mainly for low level management. (Gunasekaran et al. 2004)

The time-based measuring is used widely in the supply chain performance measuring. Time is also identified as the one source of competitive advantage. Time is easy to measure and it is stable and accurate. Every management level is of interest for time measurement of supply chain. For example, lead-time, order cycle time, time-to-market etc. are relevant for every level. (Sillanpää 2010)

In some approaches the measures are divided into quantitative and qualitative (e.g. Chan 2003, Beamon 1998). According Chan (2003) quantitative measures are cost and resource utilization, and qualitative measures are quality, flexibility, visibility, trust and innovativeness. (Chan 2003)

### 3.4 Typical key performance indicators for Supply Chains

In the literature there is vast amount performance indicators suggested for the supply chains. Stadtler & Kilger proposed some performance indicators that are applicable in most settings. They present these as key performance indicators (KPI). The KPIs are introduced in the following paragraphs. They are grouped into four categories: delivery performance, supply chain responsiveness, assets and inventories, and costs. (Stadtler & Kilger 2008)

**Delivery performance**

- Service level (event oriented α-service level, quantity-oriented β-service level, γ-service level)
Supply chain responsiveness
- Planning cycle time

Assets and inventories
- Asset turns
- Inventory turns
- Inventory age

Costs
- Cost of goods sold
- Value-added employee productivity
- Warranty cost

3.5 Challenges for supply chain performance measurement

Supply chain performance measurement has been studied since the concept of SCM was founded. Many researchers have stated that the SC is complicated to measure because the SCM is a huge concept and it has so many approaches and different meanings. According Gunasekaran et al. (2001) there are three fundamental challenges in measuring supply chains. First, the lack of a balanced approach in integrating financial and non-financial measures. Secondly, the lack of system thinking, in which a SC must be viewed as a whole entity and the measurement system should span the entire SC. And thirdly, the loss of the SC context. (Sillanpää 2010, Gunasekaran et al. 2001).

Lönnqvist et al. (2006) handled the general problems in performance measurement. The problems related to measuring relates to validity, reliability, relevance and practicality of the metrics. Important questions are also what returns and costs should take in account, what values should be used in measurements, how to allocate (for example the costs) and are the data in information systems exact enough. (Lönnqvist et al. 2006)

The measurement systems and the metrics that the company uses can be defective in many ways. The systems can, for example, contain too few or too many metrics. The metrics can also measure wrong things, so that they are not essential relative to development. Some metrics can be difficult to interpret or the metrics can be unreliable. (Lönnqvist et al. 2006)

Both management’s and the employees’ commitment to the measuring is highly important in order to use measurement effectively. The organisational culture has to encourage using the metrics and the metrics should not be inconsistent with the organisational culture. (Lönnqvist et al. 2006)
4 Summary

This literature review introduced first the concept supply chain management, some relevant strategies (especially postponement strategy) and basics of operations network design. The second part handled the performance measurement of the supply chains.

Supply chains are usually complex entities that aims to deliver the materials, parts and products from the suppliers to the end users. The management of supply chain means planning, coordinating and controlling the material, information and financial flows. The decisions are made at strategic, tactical and operational levels throughout the supply chain.

The position of the order penetration point (OPP) is an important strategic question. Basically the actions before the OPP are forecast driven and the actions after the OPP customer order driven. Shifting the OPP forward reduce the delivery lead time to customers and increase the manufacturing efficiency. Advantages of shifting the OPP backwards are among others increase of the degree of product customisation, reduce of the reliance on forecasts and reduce or eliminate of the WIP buffers.

Agile supply chain aims to respond to changes in proper ways and due time as well as exploit changes and taking advantage of changes as opportunities. Lean supply management focuses on developing a value stream and eliminating waste. According Christopher (2006) lean concept work well when demand is relatively stable and predictable and where variety is low. Agility, on the contrary, focuses primarily on responsiveness and it is seeking to match supply and demand in turbulent and unpredictable markets.

Mass-customization and postponement of the product differentiation are effective way to supply desirable products to customers at a relatively low cost and in a responsive way. The delayed differentiation can be seen as moving the order penetration point (OPP) closer to end of the supply chain. By simultaneous design of products, processes and supply chain for mass customization a company can optimize costs and provide fast and effective service. Decisions concerning the distribution network are trade-offs between costs and service level. The benefits of postponement include following JIT principles, reducing end-product inventory and making forecasting easier.

Performance measurement of the processes and the complete supply chain are important for many reasons. Performance measurement among others provides information for management and decision makers, enable identifying the success, assists in directing management attention, revising company goals, and re-engineering business processes. The performance metrics have three basic functions: control, communication and improvement.

The performance measurement metrics have to be designed separately for each company and supply chain. The performance measurement system should be based on the strategy, value drivers and important goals of the companies and the whole supply chain. There is several different approaches for the supply chain performance measurement. Many approaches divide the metrics into the following SC operations: plan, source, make and deliver. In addition return or customer satisfaction is also used. Many contributors in the literature state that supply chains should be measured in different levels, typically the levels are strategic, tactical and operational. The performance metrics should be carefully selected and they should capture the essence of organizational performance. Many times it is better to use a
few good performance measures rather than a large number of measures that are more difficult to handle as a one entity.
References


Appendix 1: SCOR metrics (Supply-Chain Council 2010)

<table>
<thead>
<tr>
<th>Supply Chain Reliability</th>
<th>Supply Chain Responsiveness</th>
<th>Supply Chain Agility</th>
</tr>
</thead>
<tbody>
<tr>
<td>RL.1.1 - Perfect Order Fulfillment</td>
<td>RS.1.1 - Order Fulfillment Cycle Time</td>
<td>AG.1.1 - Upside Supply Chain Flexibility</td>
</tr>
<tr>
<td>RL.2.1 - % of Orders Delivered In Full</td>
<td>RS.2.1 - Source Cycle Time</td>
<td>AG.2.1 - Upside Flexibility (Source)</td>
</tr>
<tr>
<td>RL.3.33 - Delivery Item Accuracy</td>
<td>RS.3.8 - Authorize Supplier Payment Cycle Time</td>
<td>AG.2.2 - Upside Flexibility (Make)</td>
</tr>
<tr>
<td>RL.3.35 - Delivery Quantity Accuracy</td>
<td>RS.3.35 - Identify Sources of Supply Cycle Time</td>
<td>AG.2.3 - Upside Flexibility (Deliver)</td>
</tr>
<tr>
<td>RL.2.2 - Delivery Performance to Customer Commit Date</td>
<td>RS.3.107 - Receive Product Cycle Time</td>
<td>AG.2.4 - Upside Return Flexibility (Source)</td>
</tr>
<tr>
<td>RL.3.32 - Customer Commit Date Achievement Time Customer Receiving</td>
<td>RS.3.122 - Schedule Product Deliveries Cycle Time</td>
<td>AG.2.5 - Upside Return Flexibility (Deliver)</td>
</tr>
<tr>
<td>RL.3.34 - Delivery Location Accuracy</td>
<td>RS.3.125 - Select Supplier and Negotiate Cycle Time</td>
<td>AG.1.2 - Upside Supply Chain Adaptability</td>
</tr>
<tr>
<td>RL.2.3 - Documentation Accuracy</td>
<td>RS.3.139 - Transfer Product Cycle Time</td>
<td>AG.2.6 - Upside Adaptability (Source)</td>
</tr>
<tr>
<td>RL.3.31 - Compliance Documentation Accuracy</td>
<td>RS.3.140 - Verify Product Cycle Time</td>
<td>AG.2.7 - Upside Adaptability (Make)</td>
</tr>
<tr>
<td>RL.3.43 - Other Required Documentation Accuracy</td>
<td>RS.2.2 - Make Cycle Time</td>
<td>AG.2.8 - Upside Adaptability (Deliver)</td>
</tr>
<tr>
<td>RL.3.45 - Payment Documentation Accuracy</td>
<td>RS.3.33 - Finalize Production Engineering Cycle Time</td>
<td>AG.2.9 - Upside Return Adaptability (Source)</td>
</tr>
<tr>
<td>RL.3.50 - Shipping Documentation Accuracy</td>
<td>RS.3.49 - Issue Material Cycle Time</td>
<td>AG.2.10 - Upside Return Adaptability (Deliver)</td>
</tr>
<tr>
<td>RL.2.4 - Perfect Condition</td>
<td>RS.3.101 - Produce and Test Cycle Time</td>
<td>AG.1.3 - Downside Supply Chain Adaptability</td>
</tr>
<tr>
<td>RL.3.12 - % Of Faultless Installations</td>
<td>RS.3.114 - Release Finished Product to Deliver Cycle Time</td>
<td>AG.2.11 - Downside Adaptability (Source)</td>
</tr>
<tr>
<td>RL.3.24 - % Orders/Lines Received Damage Free</td>
<td>RS.3.123 - Schedule Production Activities Cycle Time</td>
<td>AG.2.12 - Downside Adaptability (Make)</td>
</tr>
<tr>
<td>RL.3.41 - Orders Delivered Damage Free Conformance</td>
<td>RS.3.128 - Stage Finished Product Cycle Time</td>
<td>AG.2.13 - Downside Adaptability (Deliver)</td>
</tr>
<tr>
<td>RL.3.42 - Orders Delivered Defect Free Conformance</td>
<td>RS.3.142 - Package Cycle Time</td>
<td>AG.1.4 - Overall Value at Risk (VAR)</td>
</tr>
<tr>
<td>RL.3.55 - Warranty and Returns</td>
<td>RS.2.3 - Deliver Cycle Time</td>
<td>AG.2.14 - Supplier’s/Customer’s/Product’s Risk Rating</td>
</tr>
<tr>
<td></td>
<td>RS.3.16 - Build Loads Cycle Time</td>
<td>AG.2.15 - Value at Risk (Plan)</td>
</tr>
<tr>
<td></td>
<td>RS.3.18 - Consolidate Orders Cycle Time</td>
<td>AG.2.16 - Value at Risk (Source)</td>
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<td>RS.3.46 - Install Product Cycle Time</td>
<td>AG.2.17 - Value at Risk (Make)</td>
</tr>
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<td>RS.3.51 - Load Product &amp; Generate Shipping Documentation Cycle Time</td>
<td>AG.2.18 - Value at Risk (Deliver)</td>
</tr>
<tr>
<td></td>
<td>RS.3.95 - Pack Product Cycle Time</td>
<td>AG.2.19 - Value at Risk (Return)</td>
</tr>
<tr>
<td></td>
<td>RS.3.96 - Pick Product Cycle Time</td>
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<tr>
<td></td>
<td>RS.3.102 - Receive &amp; Verify Product by Customer Cycle Time</td>
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<tr>
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<td>RS.3.110 - Receive Product from Source or Make Cycle Time</td>
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<tr>
<td></td>
<td>RS.3.111 - Receive, Configure, Enter, &amp; Validate Order Cycle Time</td>
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<tr>
<td></td>
<td>RS.3.116 - Reserve Resources and Determine Delivery Date Cycle Time</td>
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<tr>
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<td>RS.3.117 - Route Shipments Cycle Time</td>
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<tr>
<td></td>
<td>RS.3.120 - Schedule Installation Cycle Time</td>
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<tr>
<td></td>
<td>RS.3.124 - Select Carriers &amp; Rate Shipments Cycle Time</td>
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<td>RS.3.126 - Ship Product Cycle Time</td>
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<td>RS.2.4 - Delivery Retail Cycle Time</td>
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<td>RS.3.17 - Checkout Cycle Time</td>
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<td>RS.3.32 - Fill Shopping Cart Cycle Time</td>
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<tr>
<td></td>
<td>RS.3.34 - Generate Stocking Schedule Cycle Time</td>
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<tr>
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<td>RS.3.97 - Pick Product from Backroom Cycle Time</td>
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<td>RS.3.109 - Receive Product at Store Cycle Time</td>
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<tr>
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<td>RS.3.129 - Stock Shelf Cycle Time</td>
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</tr>
</tbody>
</table>
### Supply Chain Costs

- **CO.1.1** - Supply Chain Management Cost
- **CO.2.1** - Cost to Plan
  - **CO.3.104** - Cost to Plan (Deliver)
  - **CO.3.105** - Cost to Plan (Make)
  - **CO.3.106** - Cost to Plan (Return)
  - **CO.3.107** - Cost to Plan (Source)
  - **CO.3.108** - Cost to Plan Supply Chain
- **CO.3.115** - Cost to Receive Product
- **CO.3.126** - Cost to Schedule Product Deliveries
- **CO.3.137** - Cost to Transfer Product
- **CO.3.138** - Cost to Verify Product
- **CO.2.2** - Cost to Source
- **CO.3.27** - Cost to Authorize Supplier Payment
- **CO.3.111** - Cost to Source
- **CO.3.127** - Cost to Verify Product
- **CO.2.3** - Cost to Make
- **CO.2.4** - Cost to Deliver
- **CO.3.163** - Order Management Costs
- **CO.3.200** - Order Delivery Costs
- **CO.2.5** - Cost to Return
- **CO.3.131** - Cost to Source Return
- **CO.2.7** - Cost to Source Return
- **CO.3.178** - Risk Mitigation Costs (Deliver)
- **CO.3.179** - Risk Mitigation Costs (Make)
- **CO.3.180** - Risk Mitigation Costs (Plan)
- **CO.3.181** - Risk Mitigation Costs (Return)
- **CO.3.182** - Risk Mitigation Costs (Source)
- **CO.1.2** - Cost of Goods Sold
  - **CO.2.140** - Direct Labor Cost
  - **CO.2.141** - Direct Material Cost
  - **CO.2.155** - Indirect Cost Related to Production

### Supply Chain Asset Management

- **AM.1.1** - Cash-to-Cash Cycle Time
- **AM.2.1** - Days Sales Outstanding
- **AM.2.2** - Inventory Days of Supply
  - **AM.3.45** - Inventory Days of Supply (Finished Goods)
  - **AM.3.16** - Inventory Days of Supply (Raw Material)
- **AM.3.17** - Inventory Days of Supply (WIP)
- **AM.3.23** - Recycle Days of Supply
- **AM.3.28** - Percentage Defective Inventory
- **AM.3.37** - Percentage Excess Inventory
- **AM.3.44** - Percentage Unserviceable MRO
  - **AM.2.2** - Days Payable Outstanding
- **AM.2.5** - Supply Chain Fixed Assets
- **AM.3.11** - Fixed Asset Value (Deliver)
- **AM.3.18** - Fixed Asset Value (Make)
- **AM.3.20** - Fixed Asset Value (Plan)
- **AM.3.34** - Fixed Asset Value (Return)
- **AM.3.27** - Fixed Asset Value (Source)
- **AM.1.2** - Return on Supply Chain Fixed Assets
- **AM.2.6** - Accounts Payable (Payables Outstanding)
- **AM.2.7** - Accounts Receivable (Sales Outstanding)
- **AM.2.8** - Inventory