Developing key performance indicators for supply chain: an industry perspective

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Abstract
Purpose – Measuring or monitoring supply chain performance reveals the gap between planning and execution and helps companies to identify potential problems and areas for improvement. However, it is recognized that developing key performance indicators (KPIs), or metrics, is very challenging and a set of practical guidelines is not readily available for companies and supply chain management (SCM) practitioners. This paper seeks to offer a practical approach to performance measurement and to present a list of essential KPIs.
Design/methodology/approach – This paper offers insights from industry in the area of supply chain performance measurement and a practical approach to developing performance metrics.
Findings – The experience from, and the review of, industry standards and best practices in supply chain performance measurement suggest that "less is better" as to developing performance metrics. Companies should focus on only a small list of KPIs which are critical for their operations management, customer service, and financial viability. Potential KPIs should be developed for each of the supply chain operations-reference (SCOR) model's four meta-processes (plan, source, make, and delivery) and need to be hierarchically grouped such as primary and secondary metrics.
Practical implications – The paper offers a background of why performance measurement is necessary for SCM success, pragmatic guidelines for designing and implementing performance metrics, and critical KPIs with the definition, examples, and computation mechanism.
Originality/value – Despite the importance of performance measurement for successful SCM, many companies wonder how to put performance metrics in place and make them work in practice. This paper offers an industry-oriented, practical approach to performance measurement in SCM contexts and proposes key performance metrics which can be easily adapted for different businesses.

Keywords Supply chain management, Performance measurement (quality), Quality indicators

Paper type Viewpoint

Introduction

The success of supply chain management (SCM) depends on, among other things, the closed-loop of planning and execution in regard to the process of minimizing possible gaps between planning and execution. In practice, it is impossible to remove such gaps entirely from one's supply chain. This is because the future cannot be fully known and decision-makers develop various operational plans under high uncertainty. Those in industry recognize this critical in operation and production planning (Vollmann *et al.*, 2005). Thus, monitoring how planning and execution are synchronized is critical for operational performance and SCM success. In this regard, SCM performance measurement or monitoring is the term for a set of metrics and processes related to assessing and evaluating how accurate the planning is and how well the execution is carried out.

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Despite its importance, however, putting performance measurement in place has always been a daunting task. Because of such reasons as the lack of incentives and top management support as well as an organizational culture unfavorable to performance measurement, developing a performance measurement tool set (also known as key performance indicators (KPIs) or metrics) involves a rather complicated process and can be very challenging for ordinary businesses (see Shepherd and Gunter, 2006; Aramyan *et al.*, 2007; Lambert and Pohlen, 2001; Lapide, 2000; Chan and Qi, 2003). A typical firm already has a certain number of KPIs such as return on investment for assessing its financial performance, but supply chain related KPIs have not been widely adopted and businesses are typically uninformed of them. Companies often find that there is a lack of practical guidelines on how to develop KPIs. This seems to be in contrast to the fast adoption of various SCM related technologies and other best practices for the past decade.

We respond to this need by offering practical guidelines for developing metrics and proposing a list of metrics which are essential for a firm's operations management, customer service, and financial viability. The paper also explains the importance of defining roles and responsibilities (R&R) of organizational units and members to make KPIs work in practice. The next section first sketches the process of SCM planning and execution and positions performance measurements in this context.

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Supply chain planning and execution

SCM planning takes supply and demand information and generates a synchronized sales and production plan. SCM execution takes this enterprise-level plan and carries out such activities as source, production, and delivery, which ultimately generate revenues. More specifically, the planning covers demand management (DM) and master production planning (MPP). Most companies use software for planning. Depending on the complexity of the planning, the range of software being used is very broad: from spreadsheets to advanced planning and scheduling (APS) from software vendors like SAP, i2, and Oracle. DM offers forecast and sales orders to MPP. MPP uses the demand information and generates monthly, weekly, and daily master production plans, considering production capacity and raw material availability. Also, MPP can be designed to produce such outputs as available-to-promise (ATP) for the sales/marketing unit, production quantities for the manufacturing unit, and material purchasing plan for the purchasing unit. Then, SCM execution follows. Upon availability of the information from the planning stage, business units either take action or execute the MPP. To illustrate, the sales unit offers delivery promising to customers, the production unit manufactures the targeted amount of products, and the purchasing unit releases purchase orders (PO) to suppliers for material sourcing. Likewise, various types of software, ranging from spreadsheet to advanced execution tools such as warehouse management and logistics system, are available (Figure 1).

There is always a time gap between the planning and execution and unexpected events often occur during the execution. As a consequence, there is always a gap between what was planned and what is actually done. But, for higher SCM performance companies and their members need to make continuous efforts (or adaptations) to close the gap. Performance metrics or KPIs offer the overall visibility of supply chain and help to assess the accuracy of supply/demand plan (e.g. forecast accuracy), and the execution performance (e.g. actual sales versus forecast plan). KPIs reveal the gap between plan and execution and offer opportunities to identify and correct potential problems. From a systems perspective, feedback is necessary for every system or organism's survival. Performance measurement or monitoring plays the role of feedback in one's supply chain.

Developing performance measurement: general guidelines

Most companies without APS or other advanced SCM software in place typically do not have a formal method of monitoring their SCM performance. In this situation the review and discussion of performance metrics are not on the agenda of monthly and weekly sales and operations planning (S&OP). Some companies have very little understanding of how to define KPIs for their supply/demand chain and set up the structure of people's roles and responsibilities relevant to performance measurement. One particular framework – the Supply Chain Operations-Reference (SCOR) model – becomes useful as it comes to develop supply chain performance metrics. According to the model, a company's supply chain would be represented by four meta-level processes: plan, source, production, and delivery. In practice, this high-level view of SCM processes can be useful for identifying potential KPIs. Figure 2 shows such metrics. For example, monitoring the "plan-related" processes would need such metrics as forecast accuracy and MPP cycle time.

However, developing key metrics becomes a daunting task, considering that listing potential supply chain related KPIs itself appears to be inexhaustible (Lapide, 2000; Hoffman, 2004; Gunasekaran *et al.*, 2001; Shepherd and Gunter, 2006). For example, an AMR research report contains about 45 supply chain KPIs, a report from ASCET lists almost 100 KPIs, and academic papers also suggest a large number of KPIs. Choosing the right number of key KPIs is a challenge to many companies (Lapide, 2006). Unlike a general perception that more is better, in supply chain performance measurement "less is better": companies should start with a small number of KPIs which are absolutely necessary to monitor the meta-level processes (plan, source, make, and delivery) which they can successfully manage and operate.

In addition, companies can benefit from having those selected KPIs layered or hierarchically organized. There are several possible approaches. One ways is to hierarchically group KPIs as top tier, mid-level, and ground level, as suggested by AMR (Hofman, 2004). The top-tier metrics, such as demand forecast accuracy, show a high-level view of how a company's overall supply chain is doing. The other two lower-level metrics that are connected to the top-tier metrics are designed to diagnose detailed reasons for underperformance of the top-tier metrics. Another way is

Figure 1 Supply chain planning and execution

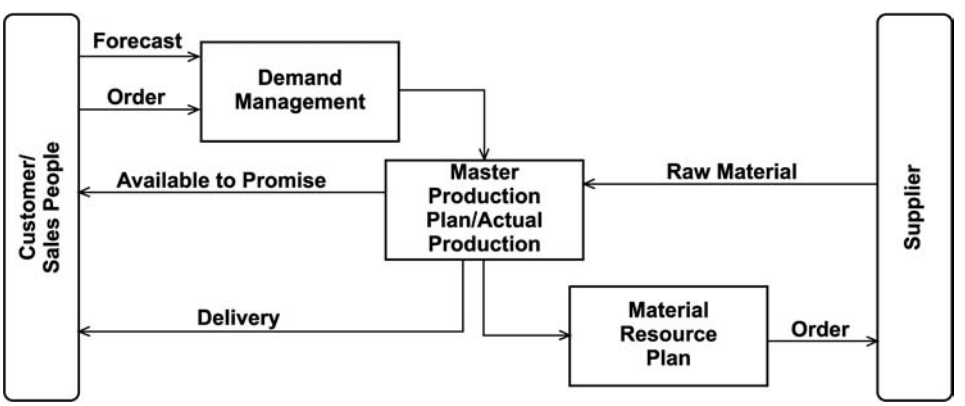
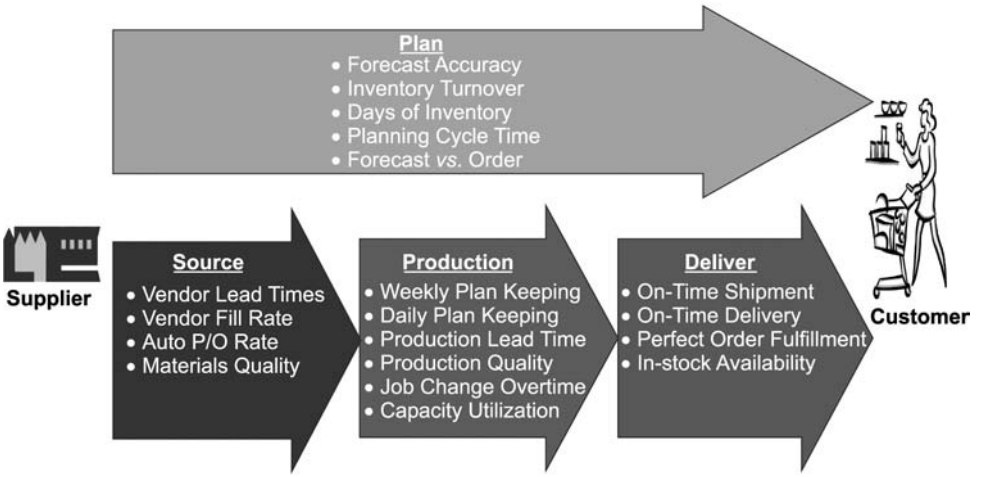


Figure 2 Exemplar supply chain KPIs



through three levels – strategic (e.g. total cycle time), tactical (e.g. delivery reliability), and operational (e.g. capacity utilization) – which can be best dealt with by the appropriate management level (Gunasekaran *et al.* 2001). For easy and fast implementation, we recommend two layers – primary and secondary. The primary metrics (e.g. forecast accuracy, on time delivery) represent a company's overall supply chain performance, which should be regularly monitored by the top management and the middle management responsible for demand and supply management. The secondary metrics are potential indicators of why the primary metrics are high or low and offer a detailed view of supply chain.

Proposed KPIs

The metrics presented here adopt the SCOR model's four meta-level processes and are grouped hierarchically as primary and secondary KPIs. Also, the key assumption is that a company's supply chain relies on both forecasting and order information, rather than order only, meaning that both push-based and pull-based planning are likely present. In today's typical manufacturing setting, where sales and production activities are globally operated, one's supply chain most likely needs forecasting as well as order information in order for advanced sourcing of raw materials and inventory management (see Figure 3).

Planning

Planning is a vitally important aspect of all activities of supply chain, including source, make, and delivery. From a performance standpoint, in particular, it is important to monitor the activities such as demand forecasting, planning cycle of MPP and S&OP, and inventory and distribution requirement planning.

Primary – forecast accuracy

The role of forecasting in a supply chain is well known (Moon *et al.*, 2000). Generally, supply chain planning relies on forecast data, which becomes the basis for its production, material sourcing, inventory management, and all other activities in one's supply chain. There are two primary ways of forecasting future demand. One is to use extant forecasting methods/techniques such as moving average and simple exponential smoothing. This approach relies on historical data and mathematical models, which are often available through APS. The other approach regularly takes demand forecasting data from salespeople (or units) who may (or may not) utilize the mathematical forecasting models and receive sales and demand information from customers. Recently, more companies are adopting "consensus forecasting" in which forecasting is done "collaboratively" among different groups of people ranging from salespeople to business or sales managers and, as a result, a single number forecasting is available for MPP. Forecast accuracy can be computed by min. (amount of sales, amount of forecasting)/max. (amount of sales, amount of forecasting) per each sales person, each sales subsidiary, each product, and each product category.

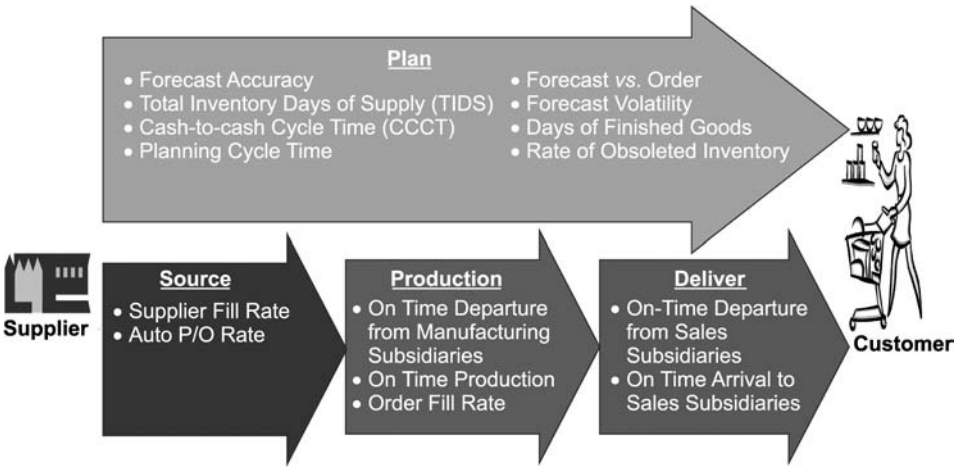
Primary – planning cycle time

Today there is increasing pressure to make planning cycle time as short as possible, from monthly and quarterly to weekly (and even daily). This need comes partly from fast-changing external environments (e.g. shorter product life cycle), demand of better customer service, and high uncertainty in supply chain. In general, companies well known for their advanced supply chain capabilities tend to have a shorter planning cycle time than others. Short planning cycle time would be a good indicator of fast responsiveness and high adaptability of supply chain. For this reason, short planning cycle time is much desirable. To measure planning cycle time, it is necessary to figure out how regularly S&OP is being performed. In the 1980s when the practice began, most companies had quarterly or monthly S&OP meetings for balancing demand and supply. This generally meant that forecasting data was collected and formally reviewed quarterly or monthly and then production and material purchase plans followed. In this case, planning cycle time is considered to be a month or a quarter. On the other hand, more high-performance companies today are conducting S&OP on a weekly basis (or more often). As a result, the planning cycle time becomes shorter.

Primary – total inventory days of supply (TIDS)

TIDS has been considered one of the most important KPIs by companies for the past several decades. In the past the goal had been to minimize the amount of inventories within a

Figure 3 Proposed supply chain metrics



company. But now the effort is to minimize total inventories within one's supply chain network. There are several methods for computing TIDS. One general approach is to divide the dollar value of total finished goods for a particular month by the daily average of costs of goods sold (= the month's costs of goods sold divided by 30 days). The inventory days of raw materials can be similarly computed and added to the inventory days of finished goods for TIDS (= days of finished goods + days of raw materials). The frequency of calculating TIDS varies among the companies. Traditionally, the computation was done for the yearly TIDS but now the monthly TIDS is much desirable.

Primary – cash-to-cash cycle time (CCCT)
CCCI is widely used to figure out the financial efficiency of a supply chain. As a composite metric it is expected to offer a comprehensive view of one's supply chain (Vollmann *et al.*, 2005). CCCT is the amount of time a company takes to recover its financial investment for purchasing. It can be computed according to an equation (inventory days + days of account receivable − days of account payable); the shorter the CCCT, the more working capital available. Some companies such as Dell are known to have a negative CCCT. In order for a short CCCT, it is necessary to alleviate the overall inventory level while extending days of account payable and reducing days of account receivable (see Farris and Hutchison, 2002)

Secondary – forecast volatility
Demand forecast should reflect real customer demands as much as possible and deliver accurate market information to the upstream supply chain (e.g. production and sourcing). However, the behavior of salespeople characterized by forecast volatility, known as the degree of changing forecasting amount weekly, can result in serious challenges to production and material sourcing. For example, salespeople of a consumer electronics company may be expected to enter forecasting amounts per product and per customer into DM system. A common practice is that each week salespeople make predictions for the eight to 16-week rolling period. In the first week, a salesperson predicted to sell 200 units of Product No. 1 to customer A in the eighth week. However, in the second or later week he may change that forecast amount to 50 and in the sixth or seventh week he may increase his forecast from 50 to 300. While these forecasting changes may be due to real changes in market demand, in practice, this high magnitude of changes in the forecasting makes it very difficult for the production and purchasing departments to develop the MPP and MRP. Thus, forecast volatility needs to be as low as possible for the stability of the supply chain. The computation can use the method of standard deviation.

Secondary – forecast vs order
Forecast accuracy, one of the most widely used metrics for supply chains computed by comparing the amount forecasted with the amount actually sold. Thus, high forecast accuracy demands the operational excellence in all four meta-level processes. For instance, the sale unit predicted 1,000 units of a major product for the fifth week and brought an order of 1,000 units of the same product for the same week. Thus, forecast vs order is perfect. However, if the purchasing unit does not make an accurate amount of raw materials ready for the 1,000 units, the production and delivery will fail to meet the sales unit's original demand. As a result, forecast accuracy becomes low. Therefore, the synchronization of demand and supply management plays an important role in forecast accuracy. For this reason, it is often difficult to evaluate the sale department/unit through forecasting accuracy. Rather, forecast vs order is an alternative metric to evaluate the sale unit. In general, low forecast vs order is a good indicator of low forecast accuracy. If forecast vs order is high but forecast accuracy is relatively low, this would be indicating some potential problems with manufacturing and material purchasing.

Secondary – days of finished goods at sales subsidiaries and manufacturing subsidiaries
When sales and manufacturing operation is going global, as it is in many companies, it is critical to know the inventory level at each of the subsidiaries that could be used in order to understand potential problems relevant to the total inventory days of supply and others.

Secondary – rate of obsolete inventory
Along with days of finished goods at sales subsidiaries, it is important to measure the obsolete inventory level at each sales subsidiary. Obsolete inventory generally refers to those having been at a sales subsidiary for more than a certain period (e.g. 60 days). These slow moving or excess inventories

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generally mean high inventory carrying cost and the disposal of such inventories comes as a huge challenge. Overall, obsolete inventories are the main source of increasing the full cost of inventory. Regularly monitoring the obsolete inventory level allows companies to deal with it in a more proactive way and reduces the overall cost of inventory.

Source

The sourcing function in the upstream supply chain is becoming more important today because there is high demand for a supply chain to be more customer-oriented and, as a result, the supply chain needs to be adaptable to market demand. On the other hand, the complexity of material sourcing is higher than before since companies are adopting global sourcing strategies these days. Supplier delivery performance should be the primary focus.

Primary – supplier fill rate

The primary KPI for the sourcing function is supplier fill rate, which measures a supplier's reliability in delivering materials. To properly evaluate this metric, two considerations need to be made. First, supplier fill rate must be measured item-by-item since a purchasing order contains multiple line items. Second, when a simple way to measure supplier fill rate is for one to compare the actual delivery date with the requested date of delivery then it is necessary to determine whether a far advanced delivery should also be considered to be a "hit" or not. A practical approach is incorporating the allowance period in the computation, considering each line item has a different order lead time, presumably stored in ERP as the master data. For example, assuming that a line item has its order lead-time as 30 days and was scheduled to be delivered by October 15, but the actual delivery was made on October 17. The simple approach mentioned earlier would consider this delivery as late and this lowers the supplier fill rate. But, when an allowance period (e.g. 10 percent of the order lead time) is considered, this particular delivery is counted as a hit. From this approach, a delivery made on October 5 would be considered as an imperfect delivery since it was done too early.

Secondary – rate of automatic PO release

For vendors to satisfy the material needs of their customers, it is necessary for them to receive accurate purchasing information, including amount of materials, due date, and others in a systematic way. Today material requirement planning (MRP) system is widely used. In practice, planners do not review the output of MRP. Instead MRP automatically releases POs to vendors. Related to this, a system and rule-based approach to MRP has been emphasized due to the increasing complexity of MPP and detailed material planning. In addition, a plan by MRP should be based on a globally optimized MPP generated such systems as APS and ERP's production module, and thus a regular, automatic release of purchase orders by MRP to vendors is better for streamlining supply chain than the traditional, manual-based release of purchase orders by purchasing personnel. Thus, higher automatic PO release rate is a good indicator of how systematic the process of raw material purchasing is.

Make

There are many potential metrics (e.g. capacity utilization, manufacturing lead time) relevant to the production or "make" activities. Among them, the key metrics should focus on how well (e.g. on time) manufacturing subsidiaries (or factories) and ODM/OEM companies supply products to their sales subsidiaries and/or distributors.

Primary – on time departure from manufacturing subsidiaries and ODM/OEM

One key KPI in the manufacturing area is the level of on-time product departure from manufacturing subsidiaries. Each manufacturing subsidiary is operated with so-called shipment plan. A consumer electronics manufacturer would have a number of its own production facilities in different countries and at the same time may have one or more original design manufacturers (ODM) or original equipment manufacturers (OEM). This manufacturer generally releases a production plan for each of its manufacturing facilities, for example on a weekly basis, but not to its ODM or OEM. Rather, the company tends to release a shipment plan to both manufacturing facilities and ODM/OEM. Thus, it is important to keep track of the performance (plan vs. result) of shipment by each manufacturing subsidiary and ODM/OEM. The computation can be done by dividing the number of shipment cases on time by total number of shipment cases.

Secondary – on time production

For better performance of on time departure, on time production (OTP) must first take place. OTP is the measure of planned production versus actual production. This can be monitored daily, weekly, and monthly. For instance, a company that releases a daily production plan should monitor actual production daily. Since, in most companies, the production data is available through ERP or manufacturing execution systems (MES), the monitoring becomes relatively easy. The performance monitoring should target for each manufacturing subsidiary (or factory).

Secondary – order fill rate

Order fill rate is another relevant metric for evaluating manufacturing performance. There are various ways to measure order fill rate. One general approach is to compare customer's requested date of delivery (RDD) with the date of delivery committed by the company's order management system (OMS) which could be part of ERP or APS. Like supplier fill rate, an allowance of certain days could be considered. For example, a customer places an order with RDD of October 10. If the available to promise (ATP) date generated by ERP or APS is no later than October 17 (for instance, with the allowance period of seven days), this case is considered a "hit."

Delivery

Fast and reliable product delivery is important for customer satisfaction and sales. But, as companies are going global, the on-time product delivery becomes more complex and challenging than ever. Suggested below are the metrics based on the assumption that a company has a global operation and, for sales and delivery of products to local customers, maintains sales subsidiaries (or has distributors) in major countries or regions.

Primary – on time departure from sales subsidiary to customers (OTD)

It is often difficult for a manufacturing company to figure out the actual time of arrival (ATA) of its products to end customers. While estimated time of arrival (ETA) information is available since delivery lead time by different transportation

mechanisms is managed by information systems (e.g. ERP) as the master data, the ATA data may not be available. Unlike world-class retailers (e.g. Best Buy, Dixons Group) that would collect the ATA data and offer order tracking information to customers, most manufacturers do not have adequate systems in place to collect the ATA data from its distribution channels (retailers, distributors) and/or end customers. Therefore, the sales subsidiary-level and company-level delivery performance can be measured by how many ordered items are shipped on time from sales subsidiaries. This metric should be monitored as frequently as possible, typically once per week. This periodic monitoring helps avoid the situation of products being out of stock at distribution channels and also helps to increase customer service.

Secondary – on time arrival to sales subsidiary from manufacturing subsidiary or ODM/OEM

In order to improve on time departure from sales subsidiary to customers (OTD) and properly evaluate sales subsidiaries using that metric, it is necessary to have a record of on time arrival (OTA) to sales subsidiaries (or distribution centers) from manufacturing subsidiaries and ODM/OEMs. This metric is greatly affected by logistics capability and the accuracy of the logistics-related master data such as transportation lead-time.

Roles and responsibilities

Finally, for the proposed performance metrics to work properly, among other things such as systems, master data, and processes (Yang *et al.*, 2007), the roles and responsibilities (R&R) of organizational members and units or teams need to be clearly defined and communicated enterprise-wide on a regular basis. Table I is an exemplar R&R chart, showing the link between business units and the proposed KPIs.

In addition, the targeting level of each KPI should be set and updated periodically. Also it is necessary to consider a group of cross-functional people (maybe called "Operation Strategy" or S&OP Team) which leads the S&OP meeting and oversees the entire supply chain operation, ranging from demand planning to supply network designs. This cross-functional group should play the key role in performance measurement by monitoring the proposed metrics, figuring out the root causes of issues with low-performing metrics, communicating with the units and people responsible, and further developing strategies for continuous improvement and adaptation.

Table I Roles and responsibilities

Business unit	Proposed KPIs
Sales and marketing	Forecast versus order Forecast volatility Inventory days of supply at sales subsidiaries
Production	On time departure from manufacturing subsidiaries and ODM/OEM Production plan versus result Inventory days of (finished goods) supply at manufacturing subsidiaries Inventory days of raw material supply On time arrival to sales subsidiaries (or distribution centers) from manufacturing subsidiaries and ODM/OEM
Purchasing	Supplier fill rate Automatic PO rate
Operation strategy	Forecast accuracy Planning cycle Inventory days of supply Cash-to-case cycle

Conclusion

Every system or organism uses feedback for continuous learning and adaptation. The role of performance metrics or KPIs is the feedback in one's supply chain. Monitoring KPIs reveals the gap between plan and execution and helps to identify and correct potential problems and issues. This paper presented a practical approach to supply chain performance measurement by offering guidelines for designing metrics and proposing key metrics for SCOR model's four meta-level processes: plan, source, make, and delivery. The suggested design guidelines and KPIs are derived from a set of industry standards and best practices in performance measurement and companies can benefit from adopting or adjusting them to their specific environments. For the success of performance metrics, finally, companies need to nurture organizational infrastructures, particularly roles and responsibilities (R&R).

References

Aramyan, L., Lansink, A., Vorst, J. and Kooten, O. (2007), "Performance measurement in agri-food supply chains: a case study", *Supply Chain Management: An International Journal*, Vol. 12 No. 4, pp. 304-15.

Chan, F. and Qi, H. (2003), "An innovative performance measurement method for supply chain management", *Supply Chain Management: An International Journal*, Vol. 8 No. 3, pp. 209-23.

Farris, M. and Hutchison, P. (2002), "Cash-to-cash: the new supply chain management practice", *International Journal of Physical Distribution & Logistics Management*, Vol. 32 No. 4, pp. 288-98.

Gunasekaran, A., Patel, C. and Tirtiroglu, E. (2001), "Performance measures and metrics in a supply chain environment", *International Journal of Operations & Production Management*, Vol. 21 Nos 1/2, pp. 71-87.

Hoffman, D. (2004), *The Hierarchy of Supply Chain Metrics: Diagnosing Your Supply Chain Health*, AMR Research, Boston, MA.

Lambert, D. and Pohlen, T. (2001), "Supply chain metrics", *International Journal of Logistics Management*, Vol. 12 No. 1, pp. 1-19.

Lapide, L. (2000), "What about measuring supply chain performance?", *ASCET*, Vol. 2 No. 15, pp. 287-97.

Moon, M., Mentzer, J. and Thomas, D. (2000), "Customer demand planning at lucent technologies", *Industrial Marketing Management*, Vol. 29 No. 1, pp. 19-26.

Shepherd, C. and Gunter, H. (2006), "Measuring supply chain performance: current research and future directions", *International Journal of Productivity and Performance Management*, Vol. 55 Nos 3/4, pp. 242-58.

Vollmann, T., Berry, B., Whybark, D. and Jacobs, F. (2005), *Manufacturing Planning and Control for Supply Chain Management*, McGraw-Hill, Boston, MA.

Yang, H., Choi, B., Park, H., Suh, M. and Chae, B. (2007), "Supply chain management six sigma: a management innovation methodology at the Samsung Group", *Supply Chain Management: An International Journal*, Vol. 12 No. 2, pp. 88-95.

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