

Research note

A review and analysis of supply chain operations reference (SCOR) model

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Abstract

Research on supply chain management can be broadly classified into three categories, namely, operational, design, and strategic. While many analytical and numerical models have been proposed to handle operational and design issues, formal models for strategic planning are scarce. The supply chain operations reference (SCOR) model, developed by the Supply Chain Council, is a strategic planning tool that allows senior managers to simplify the complexity of supply chain management. It is firmly rooted in industrial practices and is poised to become an industrial standard that enables next-generation supply chain management. This paper gives a brief introduction to the SCOR model, analyzes its strength and weakness, and discusses how it can be used to assist managers for strategic decision making.

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1 Introduction

The concept of supply chain management (SCM) can be traced back to just before the 1960s. Increased study of the field began in the 1980s, with a dramatic increase in the publication rate since 1990. SCM research can be classified into three categories:

- (1) *Operational*: This area is concerned with the daily operation of a facility such as a plant or distribution center to ensure that the most profitable way to fulfill customer order is executed. Examples include inventory management (Cachon and Zipkin, 1997) and production, planning, and scheduling (Lederer and Li, 1997). The focus is to develop mathematical tools that aid in the efficient operation of the supply chain as a whole. Also included are the development of software and better manufacturing methods and technologies (Slats *et al.*, 1995).
- (2) *Design*: Design of the supply chain focuses on the location of decision spots and the objectives of the chain (Mourits and Evers, 1995). Four categories of models are found in the literature: (1) deterministic analytical models (Cohen and Lee, 1989), (2) stochastic analytical models (Lee *et al.*, 1993), (3) economic models (Christy and Grout, 1994), and (4) simulation models (Towill, 1991). A good design should integrate various elements of the supply chain and strive for optimization of the entire chain rather than individual entities. Information sharing and its control play a vital role in integration, which requires highly coordinated efforts of both engineers and managers (Lee *et al.*, 1997).
- (3) *Strategic*: Strategic decisions are made by business managers, which requires understanding the dynamics of a supply chain and development of objectives for the whole chain (Gopal, 1992). This task also includes critical evaluation of alternative supply chain configurations and partnerships, and the determination of opportunities that can enhance the competitiveness of the firm as a part of the supply chain or the network of supply chains.



Many analytical and numerical models, stemming from conventional business and engineering principles, have been proposed to handle supply chain operational and design issues (Chopra and Meindl, 2001). In contrast, models for strategic decisions, which need to deal with the entire supply chain as a whole, are scarce. Based on our survey, the most promising model for supply chain strategic decision making is the supply chain operations reference (SCOR) model developed by the Supply Chain Council (SCC). This paper briefly reviews the SCOR model, analyzes its strength and weakness, and proposes some enhancements.

2 SCOR model

Figure 1 schematically illustrates the supply chain infrastructure based on the SCOR model. According to SCC (1999), SCOR model integrates the well-known concepts of business process re-engineering, benchmarking, and process measurement into a cross-functional framework, which contains:

- standard descriptions of management processes;

- a framework of relationships among the standard processes;
- standard metrics to measure process performance;
- management practices that produce best in class performance; and
- standard alignment to software features and functionality.

The four distinct processes for the SCOR model are:

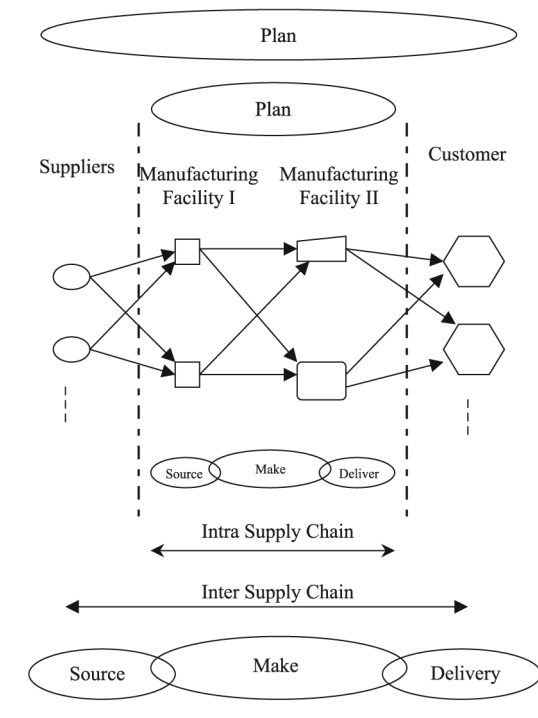
- (1) source;
- (2) make;
- (3) deliver; and
- (4) plan.

These processes are defined in increasing levels of details beginning with a description of the overall process. The processes are further divided into process elements, tasks, and activities. Each basic supply chain is a “chain” of source, make, and deliver execution process. Each interaction of two execution processes (source-make-deliver) is a “link” in the supply chain. Planning sits on top of these links and manages them.

The SCOR model contains three levels of process detail. Level I is the top level that deals with process types. Level II is the configuration level and deals with process categories. Level III is process element level and is the lowest level in the scope of the SCOR model. Table I gives the SCOR model configuration toolkit. The SCOR model endorses 12 performance metrics. The SCOR model levels II and III supporting metrics are keys to these 12 level I metrics, which fall into four categories and are shown in Table II.

By providing a complete set of supply chain performance metrics, industry best practices, and enabling systems’ functionality, the SCOR model allows firms to perform very thorough fact based analyses of all aspects of their current supply chain. With its inception in 1996 by SCC, the model is still in its infancy and might need a strategy to become accepted as an industry standard.

Figure 1 The SCOR model-based supply chain infrastructure



3 Analysis

A major objective of the SCOR model is to improve alignment between marketplace and

Table I The SCOR model configuration toolkit

	Process category			
	Supply chain operations reference model (SCOR) processes			
	Plan	Source	Make	Deliver
Process type				
Planning	P1	P2	P3	P4
Execution		S1-S3	M1-M3	D1-D3
Infrastructure	P0	S0	M0	D0

Notes: P0 - Plan infrastructure; P1 - Plan supply chain; P2 - Plan source; P3 - Plan make; P4 - Plan deliver; S0 - Source infrastructure; S1 - Source stocked products; S2 - Source make-to-order products; S3 - Source engineer-to-order products; M0 - Make infrastructure; M1 - Make-to-stock; M2 - Make-to-order; M3 - Engineer-to-order; D0 - Deliver infrastructure; D1 - Deliver stocked products; D2 - Deliver made-to-order products; D3 - Deliver engineered-to-order products

the strategic response of a supply chain, on the premise that the better the alignment, the better the bottom-line performance. The problem in the past has been that different metrics were used to measure the performance at different levels. Market researchers and corporate strategists use entirely different language to describe the marketplace and supply chain activities. The strength of the SCOR model is that it provides a standard format to facilitate communication. It is a useful tool for the upper management of a firm to design and reconfigure its supply chain to achieve desired performance. Specific advantages of the SCOR model have been widely publicized by the SCC and will not be repeated here. Rather, we focus on discussing the weakness of the SCOR model and how it can be enhanced to facilitate

management decision making in a changing environment.

3.1 Change management

Just as humans change their behavior in different situation or environments, so do companies and markets. The major factor driving the need for change management is the accelerating change in technologies, mainly in the field of information technology. The rapid growth in Internet awareness among the customer base requires a strong change management strategy. We recommend that change management be included as an element in the plan supply chain (P1) process category of the SCOR model, since managing change deals with management of any of the nodes of a supply chain.

The first issue to be addressed in change management is market analysis. The market is the structure, conditions and forces for change in a given industry, all of which shape a range of customer buying behaviors. Developing an intimate relationship with customers is essential to the success of a firm. The most effective way to develop a close customer relationship is by understanding customer buying behaviors and designing and sustaining a supply chain tailored to deliver value to each customer segment. Customer segments may typically include the cost conscious buyers, the time sensitive payers and those with specialized requirements, among others. Sometimes, circumstances move customers from one segment to another in an instant. Market analysis is the key input to the future strategic decisions of the SCOR model and should receive proper attention.

Table II SCOR model level I performance metrics

Delivery reliability
Delivery performance
Fill rate
Order fulfillment lead time
Perfect order fulfillment
Flexibility and responsiveness
Supply chain responsiveness
Production flexibility
Cost
Total logistics management cost
Value-added employee productivity
Warranty costs
Assets
Cash-to-cash cycle time
Inventory days of supply
Asset turns

The second issue to be addressed is integration to synchronization. To be successful in a highly dynamic marketplace, firms can no longer afford to compete as individual entities. Rather they need to compete as networks or chains of trading partners. It is now common wisdom for firms to identify potential partners and develop the kinds of organizational and technological capabilities that facilitate seamless flows of goods and information between their organizations. As networks of supply chains compete with each other, the SCOR model needs to provide a working platform for them. These networks are bound to be dynamic. The SCOR model's strategy should be to strive to synchronize these alliance dynamics. This kind of synchronization requires a very high level of flexibility and agility in the SCOR model strategy itself.

The third issue concerns the use of network modeling tools to support change management decisions. Network modeling tools are software tools that can explain the dynamics of supply chain relative to one's firm. They apply sophisticated computer modeling techniques to determine the impact of business scenarios on a firm's operations and costs. When used effectively, they significantly contribute to enhancing supply chain decision making and eventually supply chain profitability, especially in a changing environment. However, these tools are costly and complex, requiring specialized database building and manipulation tools, expertise in computer programming systems and the skills to decipher the optimizer outputs and error codes. There are also compatibility issues since different firms might use different network optimization tools. These issues can be addressed efficiently if network modeling tools can be integrated with the SCOR model.

3.2 Network optimization using SCOR performance metrics

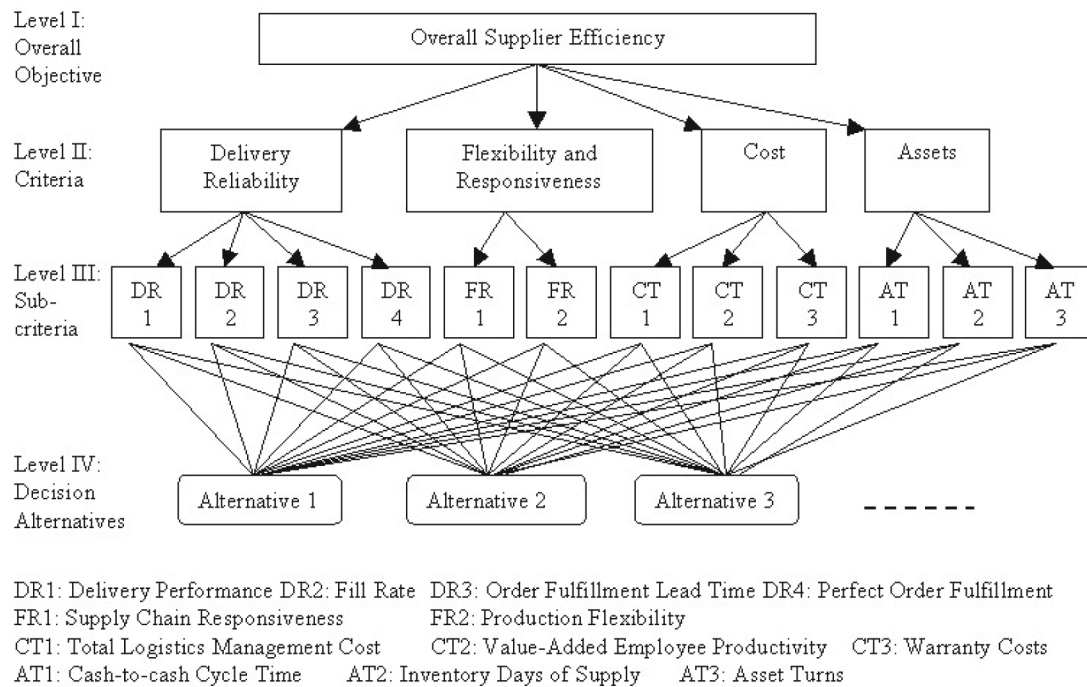
Network modeling tools use optimization techniques to generate optimal solutions with respect to one or a set of objective functions while satisfying certain constraints. From a user perspective, the optimization techniques used, whether they are traditional operations research methods (such as linear programming or dynamic programming) or emerging

computational intelligence techniques (such as genetic algorithms), are irrelevant in decision making. Rather, determining the right objective function(s) is the most important task. Naturally, management of a firm wants to optimize their supply chain performance. However, this objective is not quantifiable and cannot be used by network modeling tools to generate a solution. As previously mentioned, SCOR provides 12 performance metrics. The question is "can these 12 metrics be used to derive a quantifiable supply chain performance measure?"

There are two ways of handling multiple objectives in classical optimization, namely, weighted sum and preemptive optimization. The weighted sum approach requires determination of relative importance of different performance metrics; while the preemptive approach requires determination of absolute priority. In both cases, decisions are made without considering the available solutions. In supply chain decision making, e.g. supplier selection, a firm usually has a number of alternatives. Intuitively, a more appropriate objective function can be developed if the performance of these alternatives can be measured and taken into consideration. There exists such a method, namely, the analytical hierarchy process (AHP) proposed by Saaty (1980). AHP involves the following steps:

- *Problem decomposition and hierarchy construction.* The top level of the hierarchy is the overall objective, say, overall supply chain efficiency. The next level are the criteria. When using SCOR model, there are four criteria, namely, the four categories of performance metrics including: delivery reliability, flexibility and responsiveness, cost, and assets. Below this level are the sub-criteria, which will be the 12 SCOR performance metrics.
- *Determine alternatives.* The decision alternatives, e.g. different suppliers under consideration, are constructed and added to the lowest level of the hierarchy. Figure 2 shows such a hierarchy.
- *Pair-wise comparison.* Pair-wise comparison aims at determining the relative importance of the elements in each level of the hierarchy. It starts from the second level and ends at the lowest level. The decision

Figure 2 Network optimization using AHP and SCOR metrics



- maker needs to express his/her preference between each pair of the elements.
- *Weight calculation.* Mathematical normalization methods are used to calculate the priority weights for each level.
- *Consistency check.* A consistency ratio (CR) is calculated. If it is greater than 10 per cent, then the decision maker is not consistent in making the pair-wise comparison. He/she should review the comparison and make adjustment.
- *Hierarchical synthesis.* The calculated priority weights at different hierarchy levels are integrated to allow overall evaluation of the alternatives.
- *Determine priority for all alternatives.* The alternative with the highest overall priority weight is chosen.

AHP was developed to reflect the way people naturally behave and think. It is a decision making tool that can help describe the general decision operation by decomposing a complex problem into a multi-level hierarchic structure of objectives, criteria, sub-criteria and alternatives. AHP's hierarchic structure reflects the natural tendency of the human mind to sort elements of a system into different levels and to group like elements in each level, which can

facilitate decision maker's easy understanding from a human factor point of view. The SCOR model is also a hierarchical model that consists of different process levels. The performance metrics it uses are also hierarchical in nature. Therefore, it seems natural to apply AHP with SCOR metrics to construct an overall objective function (overall supply chain efficiency) for network optimization. Although it seems unlikely that SCC should endorse a certain network optimization/decision making technique, the introduction of an overall supply chain efficiency measure will be beneficial to industrial practitioners.

3.3 Decision making using analytical hierarchy process

It should be pointed out that there is a debate on the rigor of using AHP for decision making. While we believe the use of AHP with the SCOR model is valid, it is necessary to examine the issues raised by AHP opponents to justify our belief. The first issue is regarding the axiomatic foundation of AHP. Belton and Gear (1984) argued that AHP lacked a firm theoretical basis and an axiomatic approach compared to multi-attribute utility theory (MAUT), hence it was a flawed theory in analyzing decisions. Saaty (1986) then

provided theorems to prove that AHP was based on an axiomatic theory. Dyer (1990) questioned the validity of Saaty's axioms. Saaty (1990), together with Harker and Vargas (1990), defended their standpoints that the axioms of AHP are different from that of traditional utility theory, and they are valid. It appears to us that if one agrees that AHP is a different approach from MAUT, then its axiomatic validity should not be questioned. This is a matter of opinion and should not hinder the applicability of AHP in decision making.

A more serious problem under debate is rank reversal. Belton and Gear (1984) criticized that any addition of alternatives caused a rank reversal in AHP. Harker and Vargas (1987) and Saaty (1986) defended the attack by indicating that:

... the rank reversal was because Belton and Gear applied MAUT weights on the AHP derived eigen vectors to derive the rankings, which is an incorrect method. If the AHP method of deriving the ranked preferences were followed, then the rank reversal would not have occurred. The weights that are considered to be equal in MAUT have to be transformed in AHP to preserve not only the preference but also the ratio among the values.

Saaty (1990) further pointed out that:

... with the absolute measurement of the AHP, there can never be reversal in the rank of the alternatives by adding or deleting other alternatives.

Dyer (1990) pointed out that a static set of AHP weights can lead to arbitrary rankings when multiple alternatives (e.g. multiple suppliers) are selected at one time. For example, suppose there are three suppliers A, B and C, in order of their AHP weighting preference. Now if A is selected first, it is possible that the AHP weightings of B and C might change if A were no longer included in the set of paired comparisons. Saaty (1990) pointed out that Dyer (1990) built certain expectations about AHP, because he assumed that there is a unique way to deal with decision problems, more or less along the traditional lines of utility theory largely reflected in his own work. Saaty (1990) also indicated two flaws in Dyer's (1990) logic. The first one is to do with change in criteria weights and rank reversal, and the second one is about the

axioms and outcomes of AHP and MAUT. Harker and Vargas (1990) argued that the axioms of AHP provided by Saaty (1986) are different from those of traditional utility theory, and they indicated the reason for rank reversal is because the alternatives depend on what alternatives are considered, hence, adding or deleting alternatives can lead to change in the rank.

Many researchers are still working on the rank reversal problem using sensitivity analysis. So far, no definite conclusion has been made. In our opinion, the rank reversal problem occurs under certain conditions, some of which are created manually that do not occur (or can be easily dealt with) in real life, e.g. adding exact copies of alternatives. Nonetheless this is a problem that any users of AHP should recognize and pay attention to. We believe the use of AHP with SCOR performance metrics will not cause the rank reversal problem because of the following reasons:

- The set of criteria and sub-criteria to be compared, which are SCOR model level I performance metrics, does not change. Therefore, there is no multiple choice to cause rank reversal.
- SCOR performance metrics use absolute measurements, so the addition and/or deletion of alternatives will not cause any reversal ranks.

4 Conclusion

The SCOR model provides a common supply-chain framework, standard terminology, common metrics with associated benchmarks, and best practices. It can be used as a common model for evaluating, positioning, and implementing supply-chain application software. It is in its growing stage of life cycle and enjoys a leverage to become an industry standard. This paper argued that the SCOR model should consider change management and discussed issues related to the use of SCOR performance metrics for decision making. It is intended to serve as a catalyst for SCC to further enhance the SCOR model and eventually succeed in making it an industry standard.

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