Systemic Assessment of SCOR for Modeling Supply Chains

Vijay Kasi,
Center for Process Innovation, Georgia State University
vkasi@gsu.edu .

Abstract

The recent introduction of Supply Chain Operations Reference (SCOR) approach for modeling supply chains has been positively received by practitioners and consultants. SCOR is perceived to provide a simple though powerful standard for modeling supply chains. As SCOR is emerged from a practitioner's perspective, comparatively less little academic attention has been paid to SCOR to date. This paper aims to address one aspect of SCOR while at the same time providing a short overview of its concepts and use. Specifically, we examine SCOR from a methodological perspective, by adopting a systems development framework and using a socio-technical lens as a basis for assessment. To effect such an assessment, a fictitious timing instrument manufacturing company supply chain case (TimeWise) is used to create the context for developing and assessing SCOR approach. It was found that SCOR was strong on technical dimensions such as modeling process and techniques but weak on the social dimensions. The contribution of the paper includes an overview of SCOR and a systemic assessment of a method to develop a SCOR model in order to highlight the strengths and limitations of the approach and to guide future research in this domain.

1. Introduction and background

Organization change and improvement remain important and prominent themes within the practitioner and academic research community for the past several decades. Researchers have proposed various theories to examine the important characteristics of organization change. One of the popular theories includes Leavitt's socio-technical approach to produce organization change [17]. Process-oriented approaches have dominated since the nineties, of all the approaches to effect organization change. Some of the initiatives to effect organization change includes: Business process redesign, business process re-engineering, process innovation, business process modeling and total quality management.

Supply chains are gaining prominence of all the business processes[7, 10, 14]. This prominence has generated a considerable interest and research in supply chain modeling [2, 19]. For instance, the Supply Chain Council, a consortium of supply chain companies, introduced the Supply Chain Operation Reference (SCOR) model for modeling supply chains. This model has gained widespread use among industry practitioners and consultants.

The paper organization is as follows: This section provides an introduction to supply chains, models, modeling approaches and modeling assessments. The following section introduces the SCOR approach for modeling supply chains. The framework for evaluation forms the basis for the third section of the paper. Section four presents a case study of TimeWise. Section five then examines the SCOR approach for modeling supply chains based on the assessment framework. Finally, in section six some conclusions and recommendations are made.

1.1. Supply chain and supply chain modeling

A supply chain consists of a network of business entities such as suppliers, manufacturers, distributors and retailers interconnected by material flow, information flow and financial flow [7]. Supply chains are business processes [13]. Davenport [8] defines a business process as a set of related tasks and activities with inputs and outputs to achieve a common business objective. Supply chains can be seen as a set of activities (e.g. manufacturing, distribution) with inputs (e.g. raw materials) and outputs (e.g. finished goods) to achieve a common business objective (low cost, customer satisfaction, etc.).

There are many challenges associated with improving an existing supply chains process. First, supply chains have been hitherto seen as unique and have lacked standard definitions and terminology; i.e., the terminology used to describe supply chains has varied across functions, organizations and industries. Second, supply chains (in part as a consequence of standard definitions) lack standardized metrics. This has hampered attempts to improve supply chains and prevented organizations from comparing themselves to others. Lack of standard definitions also prevent companies to employ best practices from other successful companies. Third, decisions regarding the design (or re-design) of supply chains involve trade offs among these metrics -- efforts to achieve one often cause problems to the other such as total cost reduction and increased customer satisfaction.

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Fourth, the preceding problem compounds itself when looking across a multi-company supply chain – a more holistic (or systemic) approach would improve the supply chains due to various dependencies within the across the supply chain partners. Finally, the knowledge required to improve the supply chains increases exponentially with the scope (i.e. number of tiers) of the supply chain.

1.2. Models and modeling approaches

A model is an abstract representation of the real world that reduces complexity and represents only the details necessary for a specific purpose [15, 27]. Modeling is widely used to represent supply chains to improve the efficiency and effectiveness of supply chains [2, 13, 19]. People have developed models using various approaches and methods to understand, analyze and improve supply chains [3, 7, 11, 22, 25]. Various approaches to model supply chains have strengths and weaknesses as widely discussed in the literature [2, 11, 27]. Some of the popular classifications of models in the literature include: analytic and simulation models and descriptive and normative models.

1.2.1. Analytic and simulation models: Analytical models typically represent supply chains in the form of symbolic/logical (mathematical) formulations (equations). This treatment allows usage of optimization techniques such as linear programming to design solutions that improve the supply chains. Although analytical modeling approaches are useful for parts of supply chains, increasing the scope of the supply chain increases the complexity of the model. The application of this approach to supply chain modeling can be found in [1, 5, 18].

Simulation models are dynamic representations of supply chains executed step-wise within a computer program. Transactions, events and time can be readily included in the simulation model to assess how the performance changes over time. A simulation model can easily capture the dynamic nature of supply chains. A simulations can also better handle the complexity involved in supply chains. Broadly speaking, two kinds of simulation models exist: discrete-event simulation models and continuous simulation models. Simulation approaches have been very successful in modeling and improving supply chains in industry even though such approaches have been out of favor with the general academic community for some time. Examples where simulation has been successfully used for simulating supply chains are [16, 21, 25, 26, 28].

1.2.2. Descriptive and normative models: Descriptive models are models where the real world is simply "described". A descriptive modeling technique limits the types of objects, relationships and properties to be perceived, but does not limit the modeler in how he/she goes about mapping these concepts to the domain of investigation In short, the descriptive modeler can freely choose and name the objects perceived, their relationships (and names) and which properties to capture. As such, descriptive models offer a great deal of freedom and flexibility to the modeler.

Normative models restrict how the system being investigated can be represented. It forces the modeler to select from a pre-specified set of object and relationship instances and essentially map the perceived system into this pre-specified set. This substantially reduces the freedom (and variety) of models produced. However, it produces models that can, at a minimum, be compared. And since everyone is working from the same set, it makes possible the notions of common metrics, prescriptions of "better" models (e.g. best-practice models or sub-models). It also substantially reduces representational complexity. However, normative models are difficult to develop as they require agreement across a relatively broad set of modelers of such systems. Normative models are also referred to as Process reference models in some business process literature [24].

1.3 Modeling assessments

With the proliferation of models and modeling approaches, problem arises with the confidence on the effectiveness of all models and approaches. Thus researchers have come up with meta models to specify how a modeling approach ought to be. Thus a modeling approach can be assessed based on a relevant meta model. In addition to identifying the strengths and limitations of a particular modeling approach, meta models also help to identify the critical elements and missing elements in a model or a modeling approach. These modeling assessments are helpful to choose a right modeling approach depending on the purpose of modeling.

When choosing a modeling approach, Davis lays importance on matching the modeling approaches and the situations, precisely the uncertainty of the situation and the extent of uncertainty the modeling approach can handle [9]. Checkland considers the ability of the modeling approach to address the unstructured or ill structured situation to be an important factor for choosing a modeling approach [6]. Nielsen in his work focuses on modeling approach's answer to domain of use, conditions of use and consequences of use before choosing a modeling approach [20].

Jayaratna proposed NIMSAD framework (Normative Information Model based Systems Analysis and Design) for evaluation of modeling approaches. He identifies three elements that modeling approach need to address:

Problem domain, Methodology user and methodology process* [15]. This framework has been adapted and extended in this paper as can be found in section three of the paper.

2. Supply chain operations reference (SCOR) model

Supply Chain operations reference (SCOR) is a modeling approach that provides standard guidelines for companies. These standard guidelines help to examine the configuration of their supply chains, identify and measure metrics in the supply chain. In addition SCOR helps to adopt best practices where deemed appropriate [23] and thus SCOR can be classified as a Normative modeling approach based on previously discussed classification. SCOR has been continually evolving through work by the Supply Chain Council (SCC) since Version 1.0 was published, and the latest to their additions is Version 6.0.

- 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 features and functionality.

Business process reengineering concepts capture the "as-is" state of the process and derive the desired "to-be" future state. Benchmarking concepts quantify the operational performance of similar companies and establish internal targets based on "best in class" results. Best practices analysis characterizes the management practices and software solutions that result in "best in class" performance. Thus SCOR combines all these three concepts into a cross functional framework. SCOR has been warmly greeted by the industry. This success of SCOR has led to the development of various tools for building models using SCOR.

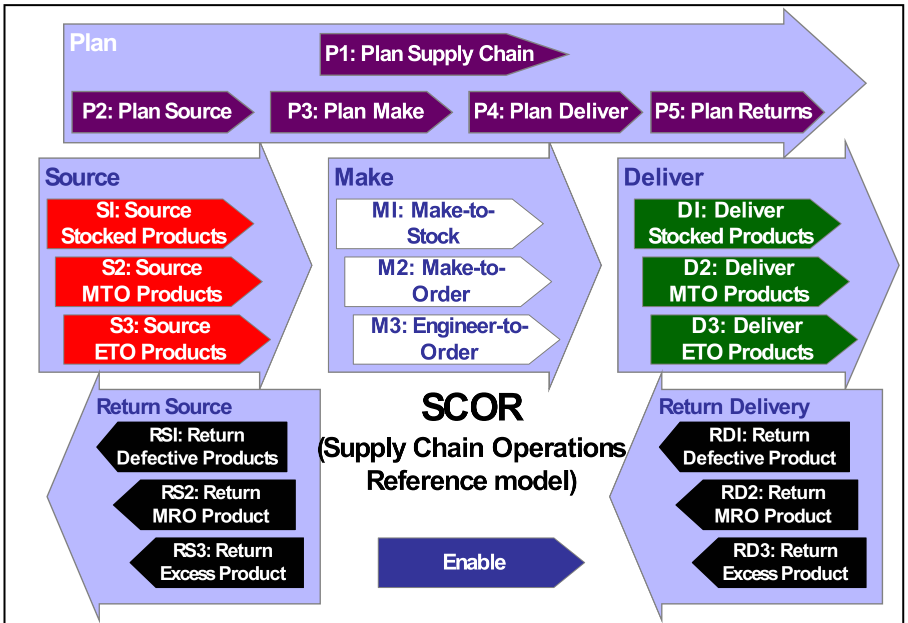

Figure 1: SCOR Approach

SCOR Methodology falls under the classification of normative models, where it provides standard definitions of measures and procedure for calculating the metrics. SCOR thus, provides a common language for communication. SCOR is a process reference model which combines the concepts of business process reengineering, benchmarking and best practices. Thus SCOR as a process reference model contains:

- Standard descriptions of management practices

2.1. SCOR scope

The SCOR model has been developed to define all business activities associated with the supply chain [12, 23]. It spans: all customer interactions (order entry through paid invoice), all physical material transactions (supplier's supplier to customer's customer, including equipment, supplies, spare parts, bulk product, software, etc.) and all market interactions (from the understanding of aggregate demand to the fulfillment of each order). It does not attempt to describe every business process or activity. Specifically, the Model does not address: sales and marketing (demand generation), product development, research and development, and some elements of post-delivery customer support [12, 23].

* Jayaratna considers methodology as explicit structuring of actions to arrive at final model. For the paper we consider a methodology same as modeling approach

Table 1: Performance Attributes

Performance Attribute	Performance Attribute Definition	Level 1 Metric
Supply Chain Delivery Reliability	The performance of the supply chain in delivering: the correct product, to the correct place, at the correct time, in the correct condition and packaging, in the correct quantity, with the correct documentation, to the correct customer.	Delivery Performance
		Fill Rates
		Perfect Order Fulfillment
Supply Chain Responsiveness	The velocity at which a supply chain provides products to the customer.	Order Fulfillment Lead Times
Supply Chain Flexibility	The agility of a supply chain in responding to marketplace changes to gain or maintain competitive advantage.	Supply Chain Response Time
		Production Flexibility
Supply Chain Costs	The costs associated with operating the supply chain.	Cost of Goods Sold
		Total Supply Chain Management Costs
		Value-Added Productivity
		Warranty / Returns Processing Costs
Supply Chain Asset Management Efficiency	The effectiveness of an organization in managing assets to support demand satisfaction. This includes the management of all assets: fixed and working capital.	Cash-to-Cash Cycle Time
		Inventory Days of Supply
		Asset Turns

2.2. SCOR processes

The SCOR model consists of five basic processes plan, source, make, deliver and return. In addition to these basic processes, there are three process types or categories, Enable, Planning and Execute. The SCOR modeling approach starts with the assumption that any supply chain process can be represented as a combination of the five basic processes plan, source, make, deliver and return. The plan process balances the demand and supply to best meet the sourcing, manufacturing and delivery requirements. The source process procures goods and services to meet planned or actual demand. The Make process transforms product to a finished state to meet planned or actual demand. The Deliver process provide finished goods and services to meet planned or actual demand, typically including order management, transportation management and distribution management. The return process is associated with returning or receiving returned products for any reason.

2.3. SCOR levels

SCOR is a based on hierarchical modeling. The first level represents the core management processes and the metrics and measures corresponding to the management processes. The three types of processes are represented in level two of the model. The plan process types are represented as P2, P3. P4 and P5 for plan source, plan make, plan deliver and plan return. The basic source makes, deliver and return have variants like make to stock, make to order and engineer to order. Thus the process type execute have the three variants of these processes. Each of the core process has an enable process as indicated.

Each of the level 2 process elements is further detailed in level 3 of the model. The level 3 consists of process elements and the input measures, parameters and output metrics associated with it. For example a level 2 process element S1 represents a Source stocked product. Thus it is a source process with the level 2 variant or the make to stock strategy. SCOR defines five level 3 process elements for this level 2 process as indicated in the figure. Each process element has a set of inputs and outputs as indicated in the figure. SCOR presents the best practices at both level 2 and level3. SCOR defines its scope only until level 3 processes. For the sake of implementation the model has to be taken further down into lower level of detail. The level 4 represents the tasks associated with a process element. Process element D1.2 is received enter and validate order. The tasks that may be associated with these process elements are to receive order, enter order, check credit and validate price. These tasks are dependent on the individual company or industry. This level of detail is necessary for implementation purposes [12, 23].

2.4. SCOR measures

SCOR defines metrics and measures in addition to the structured vocabulary of definitions of supply chain processes, the SCC also defined a set of measures that one can use to evaluate processes at each level of the process hierarchy [12, 23]. The metrics cater to various goals different companies might have. Thus choice of measures and metrics to depend on the company's strategy and focus and it is upon the company to choose the metrics they desire. The SCOR model thus instead of dictating strategy, defines a measure at a high level. The SCOR model calculates the measures based on precise formulae for each measure defined by a standard definition.

The SCOR methodology defines a dictionary of all the definitions of terms and measures to standardize across all domains. The metrics are calculated at each level of the model [12, 23]. The performance attributes and measures are measured in four different categories namely delivery reliability, responsiveness and flexibility, assets and costs.

In the next section, we develop the framework for evaluating SCOR.

3. Framework for assessment

The proposed assessment is termed as systemic assessment borrowing the term from Checkland's soft systems' and system's thinking tradition [6]. Systemic represents the holistic perspective, thus the modeling approach is assessed by examining it in the context of problem domain and organization. Jayaratna's NIMSAD framework is another instance of systemic assessment applicable for information systems development methodologies [15]. Jayaratna defines systemic assessment as the critical enquiring process using the notion of systems for defining systems that are considered as relevant to the situation of concern. Jayaratna's NIMSAD framework is further elaborated to develop this framework for assessing SCOR.

A good modeling approach guides the model building addressing and incorporating the various elements of this framework. If the modeling approach fails to identify the right variables for building the model, then the whole process of analysis and implementation is bound to fail. Similarly, if a modeling approach doesn't consider the business strategy while deriving the solution, then it may not produce the desired change in the company. Thus this framework serves as a normative guide to look into what an ideal modeling approach should address. Thus this gives us a good guide to strengths and limitations of a modeling approach. This helps us to identify the stages where caution has to be exercised while using a modeling approach.

Based on Leavitt's socio-technical model (see Figure 2), four elements are important for successful organizational change namely: Structure, Actors, Tasks, Technology and the interactions between them [17]. Jayaratna's NIMSAD framework is based on three elements: 1) Problem domain or the situation of concern 2) Methodology user 3) Methodology process. Aligning NIMSAD framework to Leavitt's diamond: Structure element in Leavitt's model represents the organization where the change is to be effected; problem domain element in Jayaratna's framework is exactly dealing with organization where model is being developed. The second element in Leavitt's model, Actors is being represented in Jayaratna's model as Methodology user. The third element in Leavitt's model, Task is represented in Jayaratna's framework as Modeling Process. The fourth element, Technology is not represented in Jayaranta's framework, except part of it accounted in modeling process element.

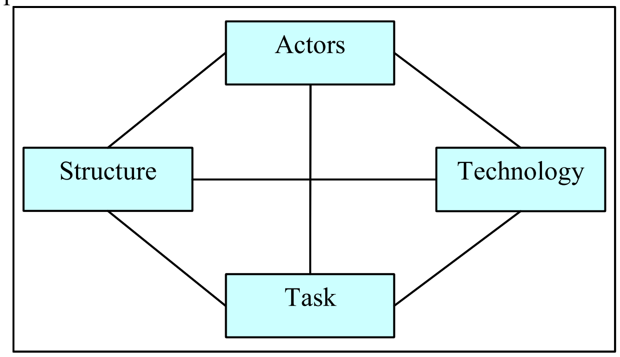

Figure 2: Leavitt's Model

Framework includes the fourth element, "Modeling tools and techniques" (See Figure 3) to correspond to the Leavitt's model. Each element of assessment is detailed below:

3.1. Problem domain

The purpose of a model is to understand, analyze and solve problems in the problem domain. Thus the modeling approach should consider the problem situation in a problem domain. Model should be developed after considering the views of problem owners or the people. The problem situation can be ill structured situations, semi-structured or highly structured situation. It is not necessary that all modeling approaches apply to all kinds of situations. Modeling approach should capture the problem situation from consideration of various problem owners.

3.2. Methodology user (Modeler)

Methodology users or the modelers are the people who use the methodology in the problem domain to bring about changes to the situation by defining problems, designing solutions and implementing the designed solutions. A methodology user (modeler) plays an important role in the success of a modeling approach. Each modeler may have different value sets, experiences and abilities. Each modeler may have a different mental construct formed by their beliefs, value sets etc. The modeling approach should account for the bias of the modeler in the process of model development.

3.3. Modeling process

The modeling process includes the process of problem formulation, model building, solution designing and solution implementing. A modeling approach should assist modeler for each step of the model building process. The modeling approach should assist in deriving the boundary conditions, identifying and formulating the

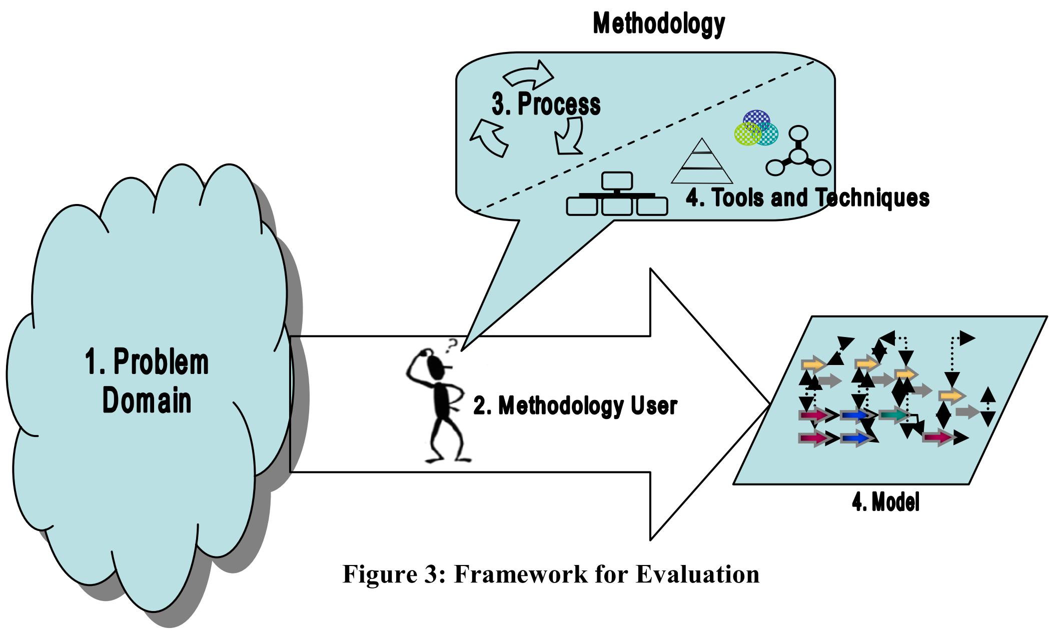

Figure 3: Framework for Evaluation

problems. A model is developed to understand and analyze the present situation apart from designing solution to improve the present situation. A modeling approach thus should assist to derive a "to-be" model and also means to implement this "to-be" model in the organization.

3.4. Modeling techniques

A modeling approach provides tools, notations and techniques for developing a model. The suitability of these tools, notations and techniques for developing the model should be an important factor for a modeling approach. These tools, notations and techniques should aid the ease of building the model and facilitate the extent of understanding of the model. The techniques should also be suitable to represent a specific domain which is being modeled. Supply chains being the domain of interest, the tools, techniques and notations provided by the modeling approach should suitable for supply chains. The typical elements of supply chains include the entities such as suppliers, manufacturer, distributors and customers. The products and information has to flow from one entity to others. There are many metrics that need to be calculated at various stages and phases. The tools and notation provided by the modeling approach should be suitable to represent supply chains, analyze the performance and design the solutions to improve the performance of supply chains.

This section presented the four elements of the framework chosen to evaluate SCOR model. The next section describes the case study of TimeWise, for which the SCOR model was developed.

4. A case study with TimeWise

TimeWise manufactures a line of sophisticated timing instruments used in commercial and military vehicles. The company started out manufacturing three different products: blue sapphire, black diamond and grey pearl for its two established customers. TimeWise has its set four suppliers and three customers. The company was still in the growth phase and it was one of the good companies in the timing instrument industry. TimeWise was able to accurately forecast the demand 90% of the time. The company followed a make-to-order strategy as their lead time allowed this. The competition was not threatening. Desired metrics such as order fill rate, cost of sales and most importantly net profit on sales were looking good. The company followed its own standard terminology for calculating the metrics. The company remained self content and unconcerned about how the outside world would calculate the same metrics.

As the global competition increased, the customers started to bargain for price concessions. The competition forced TimeWise to reduce their prices. The customers also demanded personalized products from TimeWise. Responding to these requests, TimeWise added two more products to their product line. TimeWise could acquire two new customers because the company increased the number of products. Now, they have four customers and nine products in their product lines. The company expecting an increase in sales volume doubled its employees apart from acquiring two new suppliers. The competition also forced TimeWise to shorten lead times. In order to be able to respond more quickly to customer, TimeWise piled on their inventory. So competition caused TimeWise not only to shorten lead times but also reduce errors. TimeWise needed to improve the efficiency of supply chain processes on demand as well as supply side. On the supply side, an early order from supplier required handling and storage and thus increased costs. If TimeWise ordered late, they disrupted replenishment and caused a stock out. On the demand side, the company needed to increase the delivery speed, responsiveness, and cost efficiencies while decreasing the order lead time. TimeWise, in the end piled up a lot of inventory. Inventory being a surrogate from inefficiency, drastically reduced the performance of TimeWise.

TimeWise realized that it needed to improve its processes but remained unsure about how and where to improve. TimeWise decided to use a normative model for modeling its supply chains and to see what improvements to make to its supply chain to increase efficiency, and effectiveness of the supply chain. TimeWise decided to use SCOR approach for modeling its supply chain to improve it. TimeWise followed the SCOR model as prescribed in SCC's SCOR Version 6.0 and followed the steps specified in [4, 12].

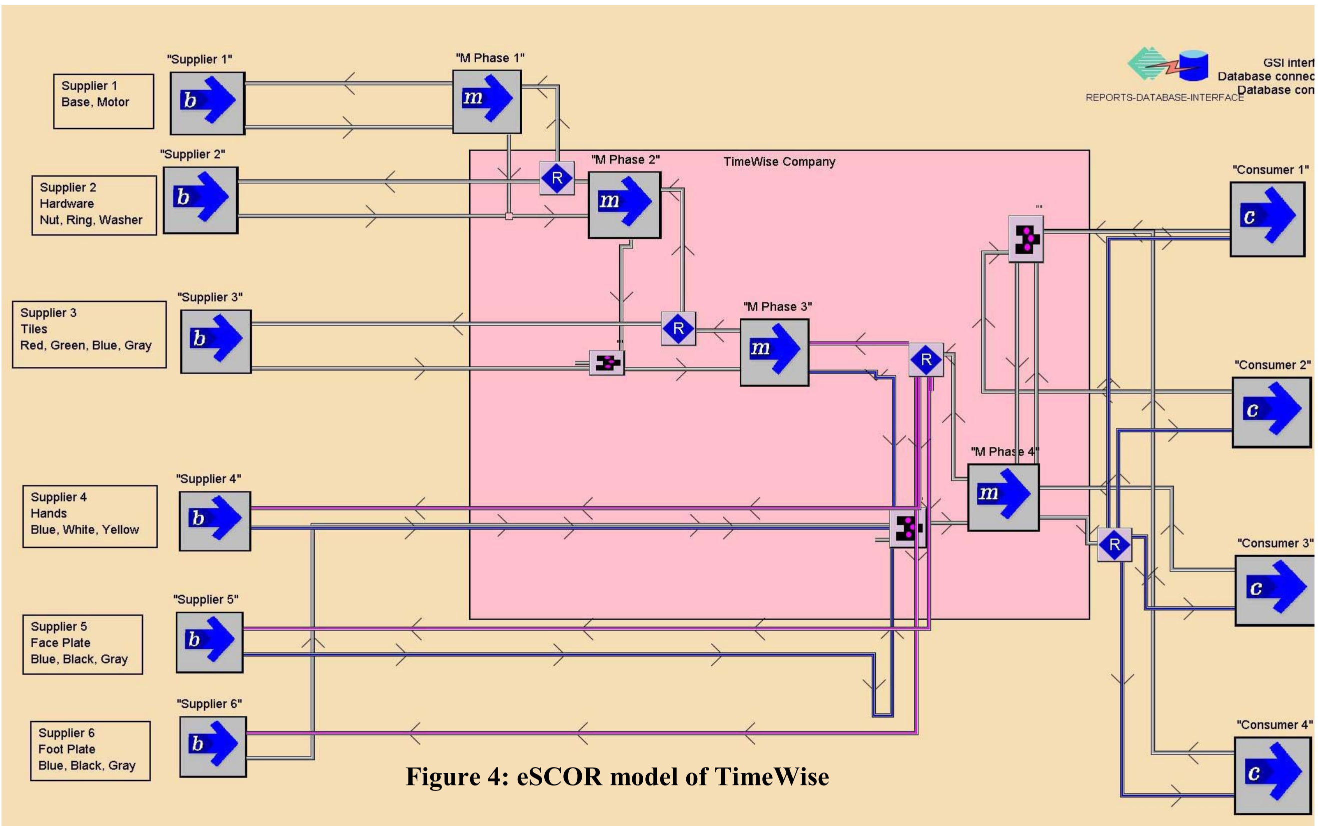

Figure 4: eSCOR model of TimeWise

The company first performed SWOT analysis to identify the key strengths and issues within the company. The SCOR team developed the “As-Is” model of the supply chain, using the standard SCOR notations and terminology. The scope of the model included the suppliers on supply side and TimeWise’s customers on the demand side. SCOR has five broad performance measures: supply chain reliability, responsiveness, flexibility, costs and asset management efficiency. The business strategy of TimeWise decided the desired outcomes of the company and thus the modeling process. Table 2 represents the “as-is” and “to-be” process (“to-be” is based on business strategy). SCOR Version has the best practices listed from all the SCC members which are listed in SCOR Version 6.0. TimeWise, based on its “to-be" model, identified the following changes: cycle time reduction, smaller batch size, reduction of number of parts to build product (using modular products) and reduction of production cycle time.

Table 2: Competition Model

Competition Model		
	Performance Vs Competition	
Performance Attributes	AS-IS	TO-BE
Supply Chain Reliability	Advantage	Advantage
Responsiveness	Advantage	Superior
Flexibility	Parity	Parity
SC Management Costs	Parity	Advantage
SC Asset Utilizations	Parity	Advantage

Superior, Advantage, Parity

TimeWise, identified the concepts of lean production (pull based model) from the best practice analysis available in SCOR. SCOR best practices also suggested the use of Kanban cards[†]. Figure 4 shows the SCOR model of TimeWise developed using eSCOR (a simulation tool to build SCOR model).

5. Evaluation and discussion of SCOR modeling approach

The evaluation of SCOR modeling approach is based on existing studies on SCOR and personal experience in modeling TimeWise supply chain using SCOR. The examined studies on SCOR include: (1) Supply chain council's SCOR version 6.0 (2) Bolstroff and Rosenbaum's book titled "Supply chain excellence" on the use of SCOR [4] and (3) Paul Hermon's paper titled "Introduction to SCOR methodology" in Business process trends (BPT), a popular domain for practitioners. The framework of evaluation discussed in section three was used to evaluate SCOR. Framework consists of four elements: problem domain, methodology user, modeling process and modeling techniques.

The problem domain consists of three aspects: Assumption of the situation, problem owners and problem situation as perceived by the company. SCOR can be applicable to situations where the problems are not exactly known. SCOR helps in identifying the areas where the company is performing well and the areas where the company needs to tighten. SCOR does not consider the multiple view of the problem owners explicitly. Soft systems methodology for example would consider the views of multiple problem owners in developing the model. SCOR does not have explicit steps to understand the problems situation. Bolstroff and Rosenbaum suggest preparing Business context summary to understand the problem situation [4]. A business context summary may include Strategic background, financial performance and SWOT analysis of the company. This helps in the SCOR team to understand the companies needs and the corporate strategy [4]. Davenport, in his book on "Process Innovation" stresses the importance on creating process vision and defining business strategy before reengineering the process [8]. This suggests that SCOR needs some explicit steps to understand the problem situation.

Methodology user element is the most difficult to evaluate. Most modeling approaches fail to address this element explicitly and instead try to avoid this problem by detailing specific steps that the modeler has to take in the process of developing the model. Soft systems methodology suggests developing multiple rich pictures to account for this which may not be a feasible approach every time. A good composition of SCOR team and active involvement of all the participants in the process of model development could be a reasonable guard towards this.

The modeling process includes: problem formulation, solution design and implementation. SCOR emphasizes the notion of benchmarking and best practices. By defining standard measures and metrics, SCOR allows one to benchmark the companies' performance against other companies' performance. Thus, SCOR assists in problem formulation. The best practices that are built into SCOR are another helpful resource for solution designing that does not exist in many other modeling approaches. "To-be" model can identify the areas where company needs to improve. SCOR does not deal with implementation of the solution into the supply chain. SCOR model, being a generic model applicable for all supply chains can be part of the reason why SCOR does not devise any strategies for implementation issues.

6. Conclusion

The paper adopts socio-technical systemic assessment of the SCOR approach for modeling supply chains. The SCOR approach has been developed by practitioners and consultants. Research community has paid little attention to SCOR until now. This paper introduces SCOR concepts and approach for modeling supply chains to the research community. This paper also examines SCOR from methodological perspective by adopting systems development framework and using a socio-technical lens as a basis for assessment.

The SCOR was examined using four elements of the framework: problem domain, methodology user,

[†] Kanban card is a pull signaling system, used for lean production. It enables a controlled flow of work by releasing materials only when the customer demands them.

modeling process and modeling techniques. It was found that SCOR is strong on modeling process and modeling techniques. These two represent the technical dimensions in the discussed socio-technical model. SCOR is relatively weak on addressing the issues in problem domain and does not take into account the limitations of methodology user. These two dimensions represent the social dimension of Leavitt's socio-technical model. Thus it can be said that SCOR is strong on the technical dimensions and relatively weak on the social dimensions. Leavitt's organizational change model emphasizes the importance of the social dimension for effective organizational change [17], thus SCOR needs to be strengthened on this dimension.

SCOR's core strengths lies in its ability to define standard measures and metrics. These standard measures and metrics enable SCOR to identify and apply best practices to various supply chains. Thus further research should look into strengthening SCOR along the social dimension. This includes steps involving people within the company, getting opinion from multiple people within the company etc.

One of the main purpose of this article is to introduce SCOR to the research community by providing an overview of concepts and techniques of the methodology. This article also provides an overall high level evaluation of SCOR to guide further research in this area.

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