

A Framework for Supply Chain Design

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1. Abstract

The choice of reference processes during the design phase is of utmost importance for a supply chains' overall performance. Nonetheless practical experience gained in consulting projects provides numerous examples of unaligned processes. Thus the research project to be presented in this paper is aimed at establishing an easy to use framework for aiding decision makers faced with this problem and at providing a solution for this classical optimization problem in supply chain management.

For this purpose the widely applied and accepted SCOR model was enhanced. In a first step the Level 2 processes already implemented in SCOR were analyzed. Thereafter, adjustments were made to Level 2 of the SCOR model if deemed necessary. The resulting model makes it possible to distinguish between the important processes covered in literature and established in companies clearly and thus increases the ability to model supply chains in a meaningful way.

Corresponding Level 3 processes were then allotted to each Level 2 process. While providing a first indication of the expenses for each Level 2 process, sensible combinations of these processes were revealed as well. Ongoing work is targeting Level 4 processes as a source for a better understanding of Level 2 expenditures. Still an example of standardized Level 4 processes for Source is given.

Matching Logistic Performance Indicators which will allow a holistic optimization of the supply chain are currently being developed. These indicators' values will be strongly dependent on the chosen Level 2 processes. Based on these logistic performance indicators the overall supply chain performance can be evaluated as well as the impact of strategic logistic measures. Thus the enhanced process model and the matching indicators will form a framework for optimizing the supply chain configuration and strategy.

2. Keywords: Supply Chain Management, Supply Chain Design, SCOR

3. Introduction

Since the early 1990s increasing importance has been attributed to the concepts of supply chain design and supply chain management in manufacturing practice and research. Main reason is the necessity to maintain and increase the competitiveness in a globally challenging environment. Thereafter a lot of frameworks and tools for improving a Supply Chain have been discussed in business literature ([1-4]).

In this paper, we will first introduce the Supply Chain Operations Reference Model, otherwise known as the SCOR model [5]. Based on identified limits and weaknesses we will then go on to explain how the SCOR model can be expanded further increasing its proven practical relevance. Using the example of the Source process the procedure and the resulting extensions to SCOR will be described in detail. In doing so it will become clear how a supply chain can be designed with the assistance of this extended model. In conclusion, a suitable Logistic Performance Measures System (LPMS) currently being developed at the Institute of Production Systems and Logistics (IFA) will be introduced. The LPMS has to be a fundamental component of the framework which is to be developed.

4. SCOR Model

The Supply Chain Operations Reference Model has established itself internationally in research as well in the industrial setting as a cross-industry standard for depicting supply chain management processes (see e.g., [6-8]). In 1996, the Supply Chain Council (SCC), a non-profit organization whose membership currently comprises over 1000 enterprises, first introduced the SCOR model. Since then the model, which is used for describing supply chains and their inherent business processes, has been developed continually. The current Version 9.0 was released in April 2008 [5].

The SCOR model is arranged hierarchically and defines the supply chain core management processes Source, Make, Deliver and Return in three different levels of detail as well as an overall process referred to as Plan. In conjunction with concepts of process engineering, benchmarking, and best practice analyses the standard process definitions form a cross-functional framework for Supply Chain Management. Homogenous, comparable and assessable process models of supply chains from the supplier's supplier to the customer's customer can thus be created (see figure 1).

The five primary management processes are [5]:

- (1) *Plan*, which contains all planning processes for coordinating the supply and aggregated demand of the entire supply chain, e.g., the planning and distribution of resources and capacities,
- (2) *Source*, which includes the procurement (or sourcing) processes for acquiring goods and services in order to satisfy a planned or current demand as well as the management of supply sources,
- (3) *Make*, which comprises the planning and execution of processes for transforming the supplied goods and services into the required output,
- (4) *Deliver*, which describes the processes for supplying the customers with the finished products and services including the accompanying processes of managing stores, orders and transport, and
- (5) *Return*, which consists of the processes for handling the return of defective products, maintenance cases and surplus stock to suppliers or through customers.

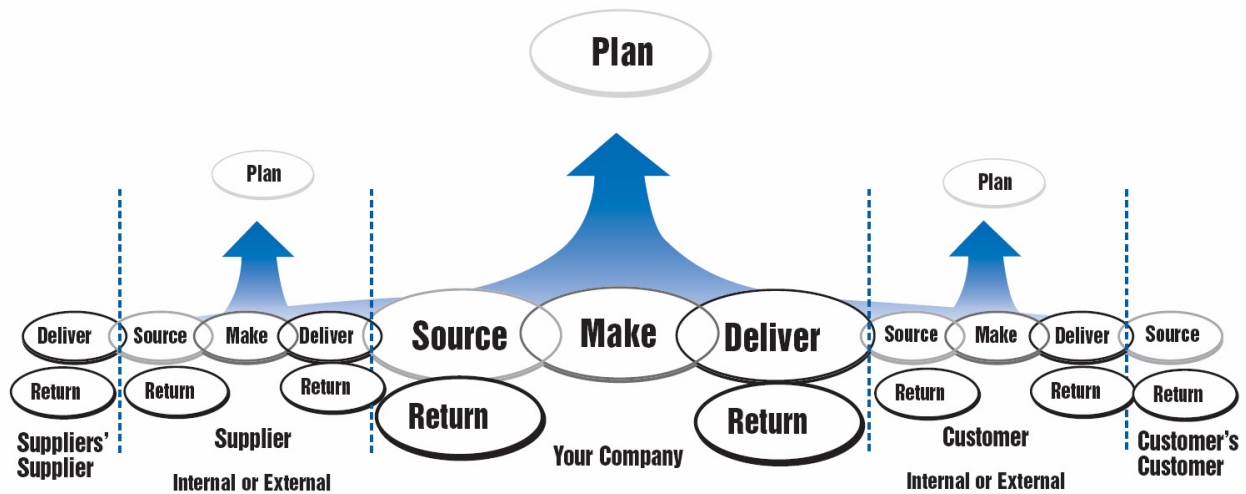


Figure 1. Scope of SCOR [5]

In order to generate a differentiated modelling of the processes with the help of the SCOR model, it is essential to clearly distinguish the five primary management processes along the lines of the product related execution logic. In this context, the process categories Make-to-Stock, Make-to-Order and Engineer-to-Order are differentiated on the Level 2 of the SCOR model, the so-called Configuration Level. Moreover, since version 6.0 of the SCOR model, the basic management process Deliver also contains the category Retail Product. Through the combination of core processes and process categories as well their subsequent sequential linking, the SCOR model supports the modelling of various supply chain configurations. Each of these configurations is usually characterized by a process category. For example, a Make-to-Stock supply chain configuration can be built from the core processes Source, Make and Deliver, which are in the basic Make-to-Stock form. On Level 3 of the SCOR model, the Process Element Level, the process categories are elaborated in more detail through the individual process elements.

In addition to the process reference model, the SCOR model also provides standard terminology and metrics for benchmarking the supply chain. On each level, these key figures are allotted to five Performance Attributes, defined by the SCC as follows [5]:

- (1) *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.
- (2) *Responsiveness*. The speed at which a supply chain provides products to the customer.
- (3) *Agility*. The agility of a supply chain in responding to marketplace changes to gain or maintain competitive advantage.
- (4) *Costs*. The costs associated with operating the supply chain.
- (5) *Assets*. The effectiveness of an organization in managing assets to support demand satisfaction. This includes the management of all assets: fixed and working capital.

Reliability, Responsiveness and Flexibility are customer oriented metrics (Customer-Facing), where as Cost and Assets are the enterprise's internal metrics (Internal-Facing). Level 1 of the SCOR model (version 9.0) contains ten Strategic Metrics which evaluate the entire performance of the supply chain and are assigned to various Performance Attributes. The key figures for Level 2 focus on the process categories, and those for Level 3 on the process elements. The metrics for a lower level can be aggregated to the next level.

5. Enhancement of the SCOR model — Standard Process Models

The SCOR model initially provides an as universal as possible description of a supply chain and an evaluation of it within the context of benchmarking. Nonetheless, the process categories described in Level 2 of the SCOR model do not allow a clear depiction of the processes which occur in the field. In particular, the interfaces between the supply chain firms, i.e., the link between the deliver process of the previous enterprise with the source process of the following company, are not sufficiently distinguished. In sourcing for example, the SCOR model only differentiates three process categories Source Stocked Product, Source Make-to-Order Product and Source Engineer-to-Order Product. In the industrial practice, however, these process categories can exist in extremely different forms. The SCOR process Source Stocked Product can be concerned with sourcing according to the consignment concept as well as inventory sourcing. Although these are represented in the SCOR model by an identical process, in the field these two strategies are clearly distinguishable with regards to the type and extent of the process steps and therefore, also as to their impact on the supply chain, e.g., on the logistic performance and logistic costs [9-10].

An additional weakness of the SCOR model are the, to some extent, not exactly demarcated core processes source, make and deliver within the enterprise. Despite the fact that clearly allocating the process elements to the core processes is a basic condition for evaluating the supply chain, it is not always possible to do so. On account of these weakness within the SCOR model, suitable and practical reference process models were developed based on the SCOR model (see figure 2). For the core process Source for example, six standard sourcing models have been defined including Inventory Sourcing, Standard Parts Management and Consignment Concept [9-11].

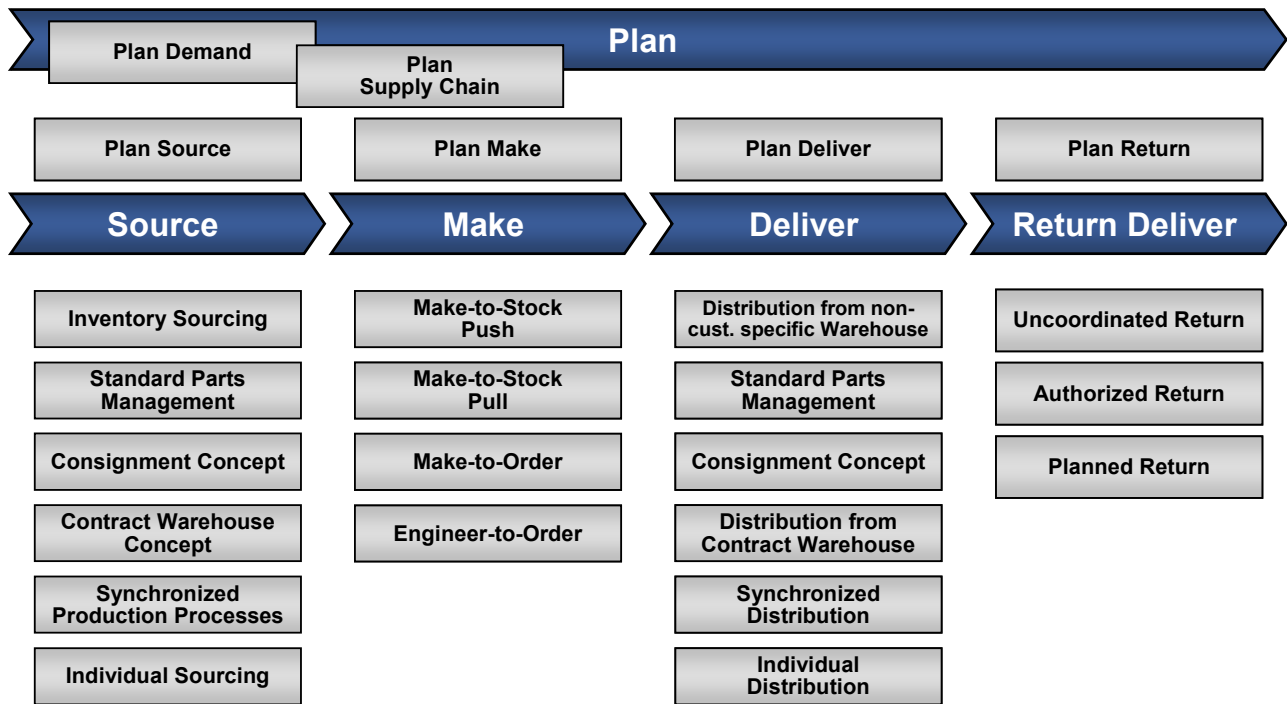


Figure 2. Standard process models – an enhancement of the SCOR model (according to [9])

In contrast to the SCOR model, distinct combinations of reference processes can be formed from a logistics and economic perspective based on the defined standard process models. Moreover, it is possible to rule out certain supply chain configurations right from the start in the designing stage. For instance Make-to-Order cannot be combined with a consignment concept reasonably. Depending on the given boundary conditions, ideal supply chains can be identified through the varying combinations of the process models. To this means, it is necessary to describe the processes-framework in different hierarchical levels of detail similar to the SCOR model, in order to e.g., be able to draw outcomes about the process and capital investment costs in the supply chain. In the following, we will illustrate this detailing process based on the example of Source and introduce the procedure for deriving the standard sourcing model.

6. Detailing Based on the Example of Source

In source, six different standard sourcing models can generally be distinguished, each of which pose different requirements for stock-keeping. One of the key differences is the shifting of the transferring of ownership between the seller and the customer [11]. The change-over of ownership decides which of the partners are responsible for the:

- storage and related costs,
- planning and control of stores
- capital lockup, and
- the risk of a loss in stock value.

Figure 3 explains how the sourcing models influence the functioning and location of the stock-keeping (according to [11]).

With traditional *Inventory Sourcing* the supplier delivers according to orders. The change-over of ownership occurs with the delivery of the goods. The customer thus carries the costs and risks involved with storing and provision. Furthermore, materials are consciously stored in advance, in order to ensure a high level of availability for subsequent manufacturing processes. As a result of this concept, process costs and capital lockup are high.

The concept of *Individual Sourcing* is similar, except that here only the parts which are required in individual cases are ordered. Thus costs for the interim storage are inapplicable, the material can be supplied directly, making it possible to cut inventory costs. Materials, however, have to be made available at the place of use, just as is ensured by the customer in Inventory Sourcing model.

In *Consignment Concept*, the change-over of ownership to the customer occurs at the point in time when the materials are removed directly at the place of use. This means that the storage and provision of goods are the responsibility of the supplier. Consequently, the supplier remains the owner of the goods until the customer uses them. The customer however has control of the stock at all times. The supplier has to ensure that a specific, pre-defined minimum stock level is maintained. The Consignment Concept is used primarily for high grade A and B items that are regularly required in large numbers.

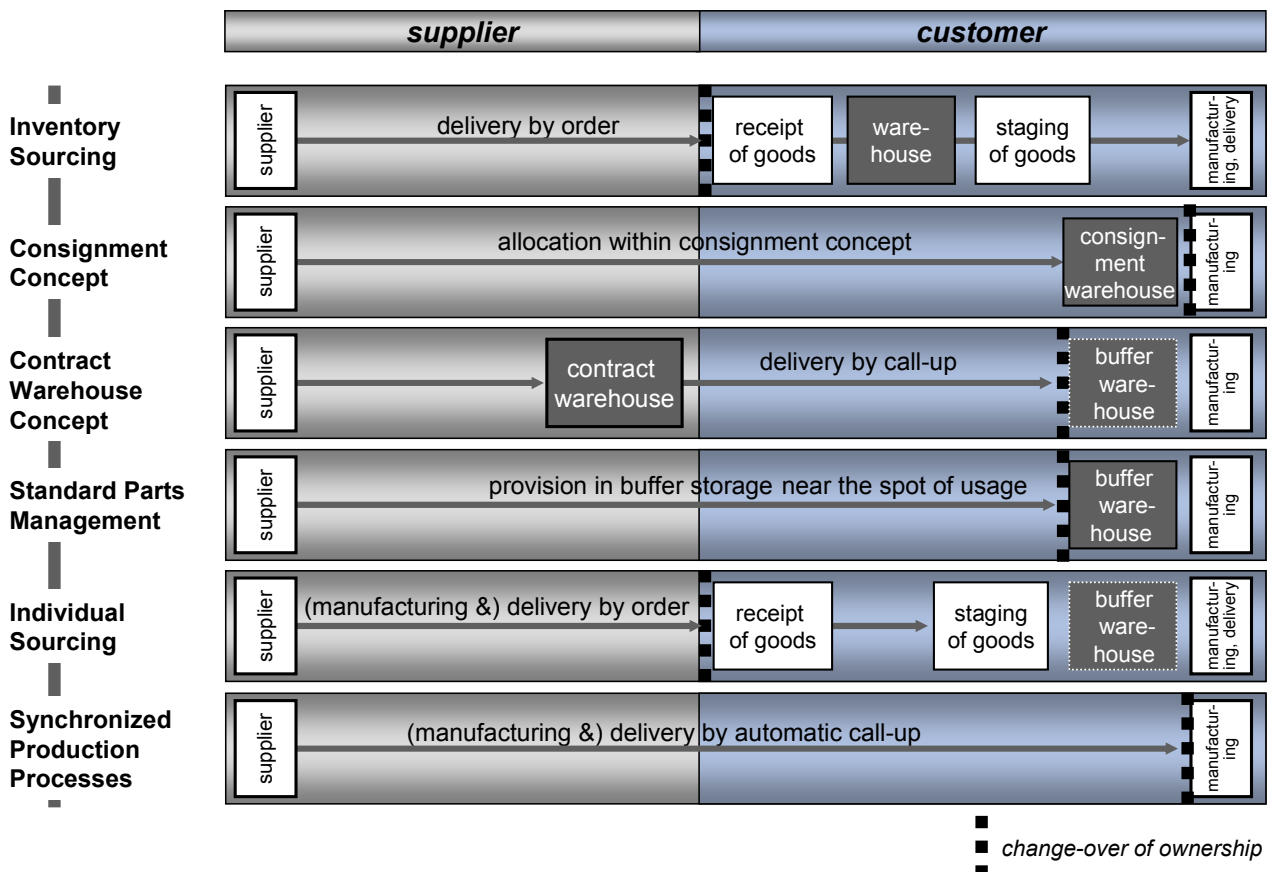


Figure 3. Impacts of sourcing models on function and location of stock-keeping

With *Standard Parts Management* materials are supplied, stored and provided in a buffer through an external service provider, which also handles all of the organizational processes. By providing materials in a buffer store near to where the materials are used, the stock level and costs are reduced, which, due to the change-over of ownership to the enterprise, nevertheless remain with the company. This procurement process is implemented with standard and C parts which are required relatively continuously.

With *Contract Warehouse Concept* a warehouse maintained by a supplier or service provider is operated in the proximity of the customer. Materials can thus be supplied synchronous to the demand directly at the place of use, on an on-call basis. The customer maintains only a buffer store near to the point of use and has low inventory costs. Contract Warehouse Concept is suitable in particular for procuring A and B parts with high to middle purchasing volumes and a rather irregular demand.

The most extreme form of linked processes between the supplier and customer is presented in *Synchronized Production Processes*. Here interim storage is no longer required because the suppliers production is produced for the customer according to demand (amount and time wise). Extremely high demands are placed both on the product quality as well as the delivery reliability, since a delivery problem results in an immediate standstill for the customer. As a consequence of the demand for high delivery reliability it is necessary to synchronize the production processes of the supplier and customer, controlled by automatic order release triggers. This model is applied especially with high quality and parts with high purchasing volumes which have a greater variance. Synchronized Production Processes represent the ideal coordination in a supply chain.

These standard sourcing models were derived with the assistance of morphological boxes. Characteristics relevant for distinguishing the procurement models, such as the delivery model, the responsibility for provision or the change-over of ownership, can be systematically described [10]. In Figure 4 a morphological box which shows the specific characteristics of the criteria developed for the Inventory Sourcing is depicted.

Every process model is described in detail by defining the relevant process elements, input and output as well as key figures. The process models and the provided detailed descriptions cover the requirements of all usual types of business.

A comparison of the six sourcing models shows that some of the process elements do not have to be conducted at all or only partially by the procurers, because the processes are shifted to the suppliers. In the context of modelling and evaluating a complete supply chain, it has to be kept in mind that these are considered in the supplier's delivery process. Thus, for example when consistently implementing the Consignment Concept, the process steps for material planning are shifted to the supplier.

The processes for the six standard sourcing models, based on Level 3 of the SCOR model, are depicted in Figure 5 as well as the corresponding (enterprise specific) Level 4 processes.

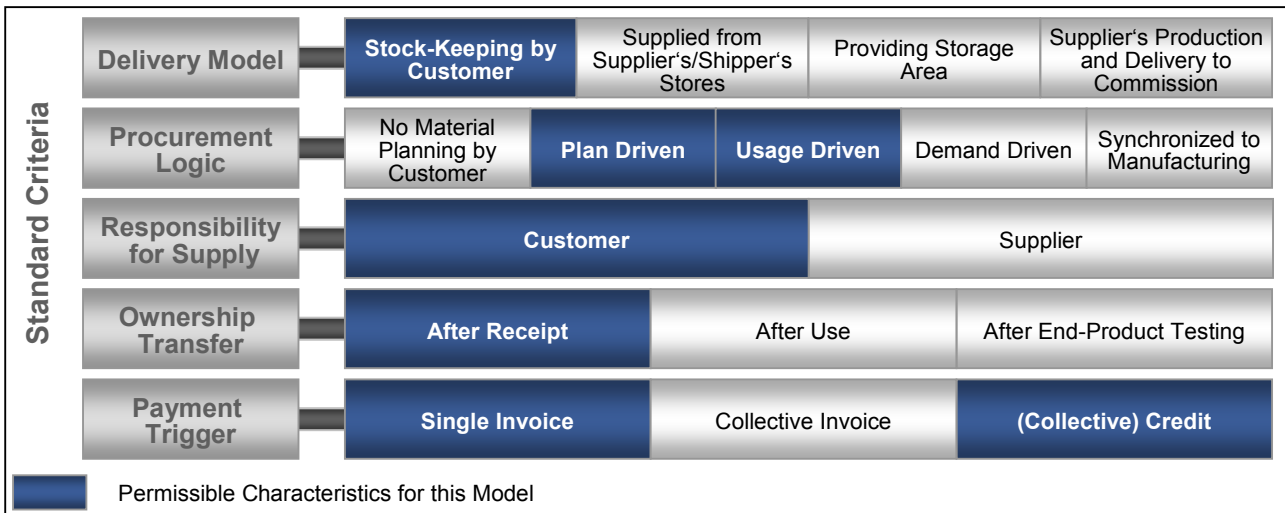


Figure 4. Morphological box with five standard criteria for Inventory Sourcing

An enormous potential for savings is evident in a direct comparison of the traditional sourcing models with the more modern procurement concepts [9-11]. Whereas with Inventory Sourcing and Individual Sourcing there are still numerous processes to be conducted, the more modern procurement concepts are characteristically more lean. Here, processes are not only necessarily shifted to the supplier, but both the supplier and the customer can also save in the stock keeping and testing processes. To some degree though, this leads to greater efforts in other Level 1 processes. Therefore, synchronized production processes can only be realized with additional control efforts (Plan). The decision maker is thus responsible for weighing, whether or not the savings justifies the efforts. This can lead to solutions which, although very different for individual enterprises, are still right for each of them.

7. Ongoing Research

The research conducted up to now for this project indicates that a functioning Logistic Performance Measurement System (LPMS), suitable to the reference processes, has to be a fundamental component of the framework which is to be developed. Currently, there are already a multitude of target systems for production companies (e.g. [5], [7], [12-14]). These have helped logistics managers develop an awareness of the aspects of logistic performance that their customers value most highly. Many companies have begun to systematically and continuously monitor and control these strategic Logistic Performance Indicators (LPIs). However, indications of the LPMSs' and LPIs' shortcomings are provided in literature reviews such as that undertaken for example by Shepherd and Günter [14]:

- Despite the wide-spread application of logistic reference models such as the SCOR model [5], universally-accepted definitions of LPIs do not seem to exist or, as in the case of SCOR, are still under development.
- The majority of the proposed LPMSs are primarily oriented towards a process perspective of logistic systems. Thus, the performance measurement systems consider important systemic perspectives of logistics systems as secondary. As a consequence, with the exception of processes, the performances of logistic system elements are being neglected.
- Often the relevant features of the LPIs (e.g., system design phase vs. system operation phase) are not well-defined and insufficient attempts are made to relate different features to each other. Furthermore, the formal purpose of LPIs remains unclear.

The Institute of Production Systems and Logistics is regularly engaged in quantitative analyses of the logistic performance of manufacturing companies. The experience gained from these projects highlights additional deficits of the application of LPMSs in logistics management practice. Prominent examples are:

- Manufacturing companies are not aware of the LPIs that are relevant in their particular competitive environment. As a consequence, there are gaps in the definitions of logistic LPIs that the companies use.
- Lower-level entities within the logistic systems – e.g., sub-processes or single work systems – struggle to contribute towards fulfilling the logistic objectives that have been defined for higher-level entities, e.g., the entire company or high-level logistic processes. A lack of LPI decomposition or decomposition incoherencies are among the reasons for this deficiency.
- Due to varying formal definitions of logistic performance indicators, logistic practitioners are often unsure about the exact aspects of logistic performance the indicators represent. For example, the majority of logistic managers are unlikely to be able to differentiate between alpha, beta and gamma service levels and may therefore be wary to make use of this particular LPI.

In conclusion, many manufacturing companies do not have precise and relevant information available about the current levels of their own logistic performance. Thus, deficits in logistic performance remain undetected hindering its use as a competitive factor. In order to counteract these shortcomings, the Institute of Production Systems and Logistics has formulated a comprehensive LPMS research program. The institute endeavours to eliminate the aforementioned shortcomings of the LPMSs currently available by providing more complete definitions of the logistic systems and the LPIs used by manufacturing companies.

Process Elements (Level 3)

Model	MRP/purchase order/release order	goods receipt	material inspection	material provision	release for payment
Inventory Sourcing	<ul style="list-style-type: none"> Inventory Management Ordering Material Planning/Quantity Planning Order Monitoring 	<ul style="list-style-type: none"> Verify Papers Verify Quantities/Visual Inspection Book Receipt Initiate Transport 	<ul style="list-style-type: none"> Product Testing Initiate Return 	<ul style="list-style-type: none"> Unpack, Repack Storage, Stock-Keeping, Picking Transport to Place of Use 	<ul style="list-style-type: none"> Verify Single Invoice Release Payment
Individual Sourcing	<ul style="list-style-type: none"> Ordering Clarification (Esp. E-T-O) Scheduling (No Material-Quantity Planning) Order Monitoring 	<ul style="list-style-type: none"> Verify Papers Verify Quantities/Visual Inspection Book Receipt Initiate Transport 	<ul style="list-style-type: none"> Product Testing Initiate Return 	<ul style="list-style-type: none"> Unpack, Repack Transport to Place of Use 	<ul style="list-style-type: none"> Verify Single Invoice Release Payment
Consignment Concept				<ul style="list-style-type: none"> Providing Storage Area Picking Transport to Place of Use 	<ul style="list-style-type: none"> Manage Supplier Accounts Issue Credits
Contractual Warehouse Management	<ul style="list-style-type: none"> Inventory Management Order Release Order Release Monitoring 				<ul style="list-style-type: none"> Collective Call-Up Verify Collective Invoice Payment Release
Standard Parts Management					<ul style="list-style-type: none"> Control Collective Invoice Payment Release
Synchronized Prod. Processes	<ul style="list-style-type: none"> Fully Automatic Call-Up 				<ul style="list-style-type: none"> Automatic Supplier Accounts Management Issue Credits Payment Release

Figure 5. Level 3 and (enterprise specific) Level 4 processes of the standard sourcing models

8. Conclusions

This paper showcases how SCOR may be extended in order to develop a framework for supply chain design. To this means six standard process models are suggested for Source Level 2. In comparison to those native to SCOR these six models are shown to be advantageous, distinguishing more clearly between different modes of procurement. Consecutively it is shown how these new models were detailed on SCOR Level 3 and 4. Utilizing these models the framework may be applied to gather process costs and costs of capital tie up easily and in a structured way. It also forms the basis for further steps in supply chain design. The additional consideration of logistic performance indicators, which are crucially dependent on the configuration of the supply chain, allows the evaluation of the overall supply chain performance as well as the impact of strategic logistic measures.

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