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Abstract

In the era of economic globalization, the competition of product in the market does not depend on a certain enterprise. The traditional competition among different enterprises has transitioned to the competition among different supply chains. In order to win in the global competition, enterprises tend to implement supply chain process reengineering to enhance the coordination among all supply chain members. This study focuses on how to systematically use the methodology and tools provided by SCOR to improve supply chain performance. The contribution of the paper is putting forward a systematic SCOR-based method for supply chain process reengineering, and applying it in Chinese automotive industry to analyze, optimize and redesign the logistic process of automobile supply chain.

1. Introduction

The economic globalization has brought significant transformations and challenges for enterprises’ internal and external activities. Firms that pursue sustained competitive advantages must establish core competences. In order to enhance the core competence, many firms apply “focus principle”, which emphasizes that a firm should adjust and outsource non-core operations to another firm (Leavitt 1972). Therefore, more and more firms locating in different cities around the world assemble together for their goals. They complete different working processes cooperatively, including quotation, design, manufacture, distribution and service (Kettinger 1997). The competition among firms has transformed into the one among supply chains. Thus, optimizing the supply chain processes has arisen as a challenge for managers.

Business process reengineering (BPR) was first advocated by Michael Hammer and Jame Champy (1994). This management theory emphasized the idea that firms should treat business process as the object to innovate, should care about the demand and satisfaction of customers, should rethink and redesign the recent business processes to achieve the maximal integration of technology and management functions, so as to break the function-organization structure and establish the process-oriented organization structure (Peter 1999). The ultimate purpose of BPR is to make great progresses on cost, quality,
Although BPR plays an important role in enterprises, the individual optimization cannot guarantee the optimal benefit of the whole supply chain. As a traditional process redesign method, BPR can only accomplish the internal firm process reengineering and cannot redesign the processes among firms on supply chain (Togar et al. 2004). Therefore, it is very critical for firms to transform BPR, which focuses on the optimization of internal firm processes, to supply chain process reengineering (SCPR) whose emphasis is on optimizing the processes of the whole external supply chain. Supply chain operations reference (SCOR) model is the first model to evaluate the performance of supply chain and to improve supply chain management. It integrates the management ideas such as business process reengineering, benchmarking and best practices analysis into a cross-functions frame and becomes the ideal model of supply chain process reengineering (Archie 2004).

Based on lots of theoretical studies, the paper abstracts a kind of supply chain reengineering method from application cases of numerous firms based on SCOR model. Then we choose Chinese automobile industry as the research object to analyze, optimize and reengineer the supply chain processes.

2. Supply Chain Operations Reference (SCOR) model

Supply Chain operations reference (SCOR) is a modeling approach that provides standard guidelines for companies, which was developed and continually evolved by the Supply Chain Council (SCC). These standard guidelines help to examine the configuration of supply chains, identify and measure metrics in supply chain. In addition SCOR helps to adopt best practices where deemed appropriate (Hermon 2003) and thus SCOR can be classified as a Normative modeling approach based on previously discussed classification. SCOR Methodology falls under the classification of normative models, where it provides standard definitions of measures and procedure for calculating the metrics. SCOR is a process reference model which combines the concepts of business process reengineering, benchmarking and best practices.

The SCOR model consists of five basic processes plan, source, make, deliver and return. 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. SCOR is a based on hierarchical modeling. The first level is top level which defines the scope and contents of SCOR, it provides wide definitions of plan, source, make, deliver, and return processes. Here basis of competition performance targets are set. The second level is configuration level. A company’s supply chain can be “configured-to-order” at Level 2 from 30 core “process categories.” Companies implement their operations strategy through the configuration they choose for their supply chain. The third level is process element level, which defines a company’s ability to compete successfully in its chosen markets. Companies define their operations strategy at Level 3. There are 3 levels under Level 3, where companies implement specific supply-chain management practices.

Earlier study on the SCOR model was done by Gordon Stewart (1997) who did his research from the corporate strategy perspective. He suggested that SCOR was the first cross-industrial framework model for integrating supply chain management, and it can be used to evaluate enterprise-wide supply chain performance and to improve supply chain management performance. Peter Bostorff of Pragmatek Consulting Company did most of the work for developing SCOR theory. He did not put the SCOR model in a real-life environment, rather to use a virtual company as the main implementation body of SCOR, which is rooted in his supply chain management experience from many industries in the past thirty years (Peter 2003).

SCOR model is a growing model. Joint planning team is very necessary for today’s application of SCOR, which can arrange various activities of the supply chain together to maximize the overall interests of the supply chain (George 2003). Some researchers thought the SCOR model was a strategic planning tool, and they also analyzed the strengths and
weaknesses of the SCOR model on the basis of previous studies (Samuel et al. 2004). Other researchers used SCOR to study benchmarking system of supply chain collaboration. They found that SCOR model could provide a new perspective for enterprises, make them better understand supply chain collaboration through benchmarking and enable them to improve supply chain performance (Togar et al. 2004). Samuel H. Huan. Sunil K. Sheoran and Harshal Keskar (2005) considered SCOR model as an effective strategy tool for managers to solve complex supply chain management problems. However, recent implementation of SCOR is deeply depended on project leader, many analysis process are also manual. Therefore, some scholars called for more support from computer technology.

Also, other scholars are committed to the evolution of SCOR. SCC sets up a special interest group (SIG) to study the integration of SCOR, Six Sigma and Lean methodology (Rod 2003). HP Company who studies from the perspective of the value chain, figured out that besides the areas of supply chain, an enterprise should also extend its sight to the field of design and customers. And the company firstly brought forward design chain operations reference model (DCOR) and customer chain operations reference model (CCOR). Meanwhile, another independent organization called Value-Chain Group (VCG) which was also dedicated to the research of value chain operation brought forward a complete value chain operations reference model (VCOR). In SCOR system application, there already exit some software tools based on the SCOR, such as SCOR Database (StreamlineSCM), ProcessWizard (Xelocit), EasySCOR (IDS Scheer), mySAP Tools (SAP) and so on (Scott 2006).

3. A SCOR-Based Method for SCPR

The implementation plan of the SCOR-based method for SCPR could be divided into 3 steps: first, describe the supply chain “as-is” situation using the standardize supply chain process definition and reference tools in SCOR model; Second, measure the performance of supply chain according to the metrics of SCOR model, benchmark the result with the best practices and do gap analysis; Last, design “To Be” supply chain process that can achieve objective performance by using the tools and methods of SCOR model.

3.1 Description and Analysis of “As Is” Supply Chain Process

The description and analysis of “As Is” supply chain process is the beginning of supply chain modeling process. The first step is defining the boundary of supply chain process. Enterprises can diagram an existing process and decide whether it is an atom process or can be subdivided into some sub-processes. SCOR assumes that all supply chain processes can be subdivided into one of five general process types: Plan, Source, Make, Deliver, and Return. These general processes make up the first level of SCOR model (Thomas 2006). After decomposing the supply chain process, enterprises usually prepare for drawing an “As Is” Geography Map. In another words, marking up the geographic position of sources, manufacturing sites and distribution centers in a map. Then with SCOR’s Level 2 symbols, we can draw the execution processes of each point, from manufacturing sites to sources, then distribution centers.

After the above jobs are completed, we turn to create a SCOR Thread Diagram which is made up of a series of Level 2 processes. Bold vertical lines separate enterprises, dashed vertical lines represent divisions within the same organization. Thread Diagram is the foundation of analyzing supply chain processes. Geography Map focuses on extra processes. But Thread Diagram includes more, such as intermediary organizations, planning and return processes (Scott 2006). The Level 3
processes are a group of standard activities which are decomposed from the processes of Level 2. Refining the Thread Diagram till satisfied, enterprises can acquire the nature and scope of their “As Is” supply chain process.

### 3.2 Performance of Supply Chain Process and Benchmarking

Once the existing supply chain process is described, we continue to measure its performance to know how the existing supply chain operates. SCOR Model defines five generic performance attributes and three levels of metrics. Based on metrics and formulas of SCOR Model and historical data, enterprises can determine which metrics they can use to define their specific supply chain (Vijay 2005). If an enterprise wants specific benchmark data, it needs to consult the SCC or some other professional benchmarking database suppliers such as Performance Measure Group LLC, to form the Supply Chain SCORcard (Paul 2005).

![Table 1. SCORcard of Supply Chain](https://example.com/table1)

<table>
<thead>
<tr>
<th>Overview</th>
<th>SCOR Level 1 Metrics</th>
<th>Actual</th>
<th>Parity</th>
<th>Advantage</th>
<th>Superior</th>
<th>Value from Improvements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Chain Reliability</td>
<td>Delivery Performance</td>
<td>50%</td>
<td>85%</td>
<td>90%</td>
<td>95%</td>
<td>$30M Revenue</td>
</tr>
<tr>
<td></td>
<td>Fill Rates</td>
<td>63%</td>
<td>94%</td>
<td>96%</td>
<td>98%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perfect Order Fulfillment</td>
<td>0%</td>
<td>80%</td>
<td>85%</td>
<td>90%</td>
<td>$30M Revenue</td>
</tr>
<tr>
<td>Responsiveness</td>
<td>Order Fulfillment Lead Times</td>
<td>35 days</td>
<td>7 days</td>
<td>5 days</td>
<td>3 days</td>
<td>$30M Revenue</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Supply Chain Response Time</td>
<td>97 days</td>
<td>82 days</td>
<td>55 days</td>
<td>13 days</td>
<td>Key enabler to cost and asset improvement</td>
</tr>
<tr>
<td></td>
<td>Production Flexibility</td>
<td>45 days</td>
<td>30 days</td>
<td>25 days</td>
<td>20 days</td>
<td></td>
</tr>
<tr>
<td>Cost</td>
<td>Total SCM Management Cost</td>
<td>19%</td>
<td>13%</td>
<td>8%</td>
<td>3%</td>
<td>$30M indirect Cost</td>
</tr>
<tr>
<td></td>
<td>Warranty Cost</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Value Added Employee Productivity</td>
<td>NA</td>
<td>$156K</td>
<td>$306K</td>
<td>$460K</td>
<td>NA</td>
</tr>
<tr>
<td>Asset</td>
<td>Inventory Days of Supply</td>
<td>119 days</td>
<td>55 days</td>
<td>38 days</td>
<td>22 days</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Cash-to-Cash Cycle Time</td>
<td>196 days</td>
<td>80 days</td>
<td>46 days</td>
<td>28 days</td>
<td>$7M Capital Charge</td>
</tr>
<tr>
<td></td>
<td>Net Asset Turns (Working Capital)</td>
<td>2.2 turns</td>
<td>8 turns</td>
<td>12 turns</td>
<td>19 turns</td>
<td>NA</td>
</tr>
</tbody>
</table>

With this SCORCard, enterprises can do gap analysis with others in the industry and decide if the redesign or improvement in “As Is” supply chain process is needed. Also from finance perspective, it helps enterprises to determine which aspect will
maximize ultimate profit. Usually enterprises tend to confirm the position of the supply chain performance in whole industry by Competition Model first, superior or lower than the average, and then determine the level of “To Be” supply chain process. Constrained by available resources, enterprises can’t expect to be superior in every category in the industry, but should expect to be very good in at least one or two. The lagging categories can be taken as pressure to remind enterprises to improve their supply chain performance continually.

Once the enterprises have a good understanding of the strengths and weaknesses of the “As Is” process, they can think about establishing supply chain strategy, setting goals and steps of implementation. The corporate strategy can be determined by the SWOT (Strength, Weakness, Opportunity, Threat) analysis. With SWOT analysis, enterprises can understand where their strengths and weaknesses are, and discover opportunities and threats which they confront at present. In the performance improvement implementation, enterprises may refer to the specific processes and sub-processes of SCOR reference handbook, and compare with corresponding best practices, then make their implementation plans.

3.3 “To Be” supply chain process reengineering and it’s application software

The tools and methods of “To Be” supply chain process reengineering are similar with those of “As Is” supply chain process reengineering. First, drawing a “To Be” Geography Map and SCOR Thread diagram; then, according to the supply chain measurement goal, enterprises should constantly adjust the Geography Map and Thread Diagram. After that, we start to describe the processes on the Level 3 by drawing Swimlane Diagram, which is a commonly used tool to describe the specific activities and related consequences on the Level 3.

In the complex supply chain system, it is hard for human brain to foresee the “To Be” supply chain’s operation. Along with the simulation technology development, enterprises take the advantage of specialized supply chain modeling software to assist the SCPR activities, observe “To Be” supply chain process’s performance and effectively avoid the possibly risk which may appear during the project’s implementation. Here is some available supply chain modeling software: Proforma Company’s ProVision, IDS Scheer’s EasySCOR, Xelocity’s ProcessWizard (Michael 2000).

4. Application Case in Chinese Automotive Industry

In order to examine this SCOR-based SCPR method, we apply it in Chinese automotive industry to redesign the logistic process of its supply chain. The logistic mode of recent Chinese automotive industry is a kind of self-support logistics. The logistic processes of purchase, manufacture and distribution in automotive industry are all implemented by assembly factory (Tamer 2001). Chinese native assembly factories start their steps late, and they are almost very small and without core technology, so they cooperate with foreign assembly factories to become joint venture companies one by another, in order to speed up their development (Jeffrey 2000). Chinese assembly factory purchase their direct materials from both foreign CKD (completely knock down) and native material suppliers, and the product market mainly lies in China. The recent development trend of Chinese automotive industry is that the assembly factories more and more focus on their core business activities, such as design, assemble, marketing, so the range of vertical integration is reduced, and vertical disintegration is present.

We simplify the research object as a SLMD automobile supply chain, which consists of Spare parts suppliers, Logistics suppliers, Manufacturers and Distributors. Assembly factory is the dominant of supply chain.
4.1 Describe and analyze the “As Is” logistic process of Supply Chain in Chinese automotive industry

The logistics of automobile supply chain should include at least 4 parts: a. logistic centre of assembly factory; b. foreign carrier chose by foreign CKD suppliers, which lie on upriver supply chain, such as Maersk. They deliver CKD parts to China from the CKD suppliers all over the world; c. the third party logistics (3PL) providers chose by native suppliers in China. They deliver the direct materials to logistic centre of assembly factory from native suppliers; d. logistic providers which deliver the final automobiles to all distributors (3S/4S).

In the SLMD Supply Chain, the logistic process can be generally defined as below:

1. Customers choose their cars in 3S/4S stores, and make contracts.
2. 3S/4S stores send the customer’s order to sell department of assembly factory.
3. According to the order, assembly factory makes production plan, and purchase department of assembly factory sends the future production plan to its spare parts suppliers.
4. According to the production plan, spare parts suppliers all over the world immediately order from their material suppliers and begin to produce, and calculate the lead time from leaving factory to entering into the store.
5. CKD suppliers choose the carrier and transport route to deliver the CKD parts from its factories to overseas packaging centre, then transport them to China. Meanwhile, native suppliers also should choose the carrier and transport route to deliver their products from its factories to assembly factory.
6. Before the parts are delivered to assembly factory, spare parts supplier should send the store-in list to the logistic centre of assembly factory. The store-in list include information about tab, quality and arrive time of the parts. When they arrive at assembly factory, the logistic centre must check them, according to the store-in list, and then input into the inventory information system.
7. The logistic centre of assembly factory sort the goods in the warehouse, and decide the time to deliver. Furthermore, goods might be repackaged if it’s necessary.
8. When the goods are sorted, the information will be sent to the assembly factory. At the same time, the inventory information system will record the store-out information.

When the goods are offloaded, they will be sent to the product line of assembly factory directly.

9. After the cars are assembled, assembly factory will choose native 3PL to deliver the cars to the 3S/4S store, according to the order.
10. When customers require return, the return of MRO materials only needs back to distributors (3S/4S store), the return of totally damaged products should be the same as normal logistics, but it is converse, which can be cast back to raw material suppliers.

The above process is very complex. We can describe the logistic process of automobile supply chain clearly, by using the second level of SCOR model. Please see figure 1.
Figure 1. Thread Diagram of SLMD Supply Chain

(1) Spare parts suppliers
The activities of spare parts suppliers are S1, S2, M1, M2, D1 and D2. After spare parts suppliers receive the production plan from assembly factory, they begin to produce the parts (S2). In order to avoid the situation that some materials of the upriver suppliers is out of stock or upriver suppliers can not ensure delivering the goods in time, spare parts suppliers should keep some safe inventory (S1). In the producing process, spare parts suppliers often produce more products in order to get scale economy effect. A part of products will meet the demand of instant order (M2), and others will store into inventory (M1). Suppliers send the parts to the warehouse of assembly factory (D1).

If production plan of assembly factory changes, assembly factory will add some temporary urgent orders. Spare parts suppliers need to transport the goods from inventory by air (D1), or produce the parts temporarily (M2) and transport them (D2). In reverse logistics, logistic centre receives the damaged goods (DR1) and delivers them to upriver suppliers (SR1).

Logistic centre of assembly factory

The operation of logistic centre of assembly factory includes S1, S2, M1 and D1. Before the goods arrive at logistic center of assembly factory, logistic center should receive a Store-in lists notice from spare parts suppliers. When the goods arrive, logistic center will check the goods with the store-in lists and store in the goods. Both the store-in goods (S1) and the urgent order goods (S2) will be sorted and reset in the distribution centre (M1).

Assembly factory

The activities of assembly factories are S1, M2 and D2. After the goods are offloaded, they may be sent to the factory directly (S2). Cars are assembled according to the customer’s order on the product line of assembly factory (M2). When the cars are put down the product line, they will be delivered to the distributors by the 3PL providers chose by assembly factory (D2).

Distributors

The activities of distributors are S2, D2, SR1, DR1 and DR2. After distributors receive the cars from assembly factory (S2), they will inform their customers to fetch the cars (D2). If it’s necessary to return, they should get the damaged products from customers (DR1) and transport them back to assembly factory (SR1). If 3S/4S store receive the MRO products, they can mend them in their repair workshops (DR2).

4.2 Evaluate Supply Chain performance in Chinese automotive industry

After “As Is” process of supply chain is clearly described, what we should carry out next is to know the operation performance of supply chain. According to the analysis of logistic process of automobile supply chain, the situation is that there are too much members in the supply chain and logistics is divided into many sectors. The more members there are in the supply chain, the more complex the communication becomes, and the more errors will happen, so the effectively and efficiency of the whole supply chain become difficult to enhance.

There are 13 performance indexes in the first level of the supply chain in SCOR model. However, these 13 performance indexes play different roles in specific firms. For the manufacturers (including spare parts suppliers and assembly factory), delivery performance indexes and perfect order fulfillment are the most important. Delivery performance, which focuses on the evaluation of delivery’s cost and time, is defined as the percentage of orders \( O_{2R} \) that the delivery is both in right time and right quantity.

\[
\text{Delivery performance} = \frac{O_{2R}}{O_{Total}}
\]

Furthermore, Perfect order fulfillment, which is similar but different with delivery performance, is the percentage of orders that the delivery is both in right time and right quantity minus the orders \( O_E \) with any error or delivery damage.
Perfect order fulfillment focuses on the assessment of the delivery quality. These indexes influence directly whether the whole working procedures of assembly factory will operate regularly or not and whether the production plan can be finished in time or not. The successful implementation of production plan is helpful to guarantee and enhance the levels of other performance indexes, such as decreasing the order cycle time and increasing the assets velocity. Figure 2 is the decomposition of perfect order fulfillment. According to the formula, we can compute the perfect order fulfillment rate and treat it as an industry benchmark and the prospective goal to do the gap analysis.
Perfect order Fulfillment

Cycle Time

Delivery in time

Completion of Production plan

Delivery performance

Perfect Order Fulfillment

Delivery in time

Time

Quantity

Quality

Perfect Order Fulfillment

Completion of Production plan

Delivery performance

Delivery in time

Supplier’s supplier

Spare parts Supplier

Logistic centre

Assembly factory

Distributor

Customer

Figure 2. Performance Decomposition of Perfect Order Fulfillment
After computing the performance indexes, it is necessary to do gap analysis between recent situation and objectives. According to SCORcard method, firms should establish the prospective performance of every index, which must be consistent with the strategic mission of the firm (Kee-hung 2002). The gap of total level between Chinese automobile industry and automobile industries in developed countries is very big. Moreover, the immaturity of Chinese automobile logistics expands this gap. In order to help Chinese automobile industry catches up with the international advanced level, the prospective performance of Chinese automobile logistics should achieve the international level firstly. Take the supply chain reliability index as an example; the following table indicates that the task of Chinese automobile logistic is very hard. Especially, the gap in the perfect order fulfillment index is very large.

Table 2. Gap Analysis of Chinese Automotive Industry by SCORcard

<table>
<thead>
<tr>
<th>Level</th>
<th>Performance Attributes</th>
<th>Metrics</th>
<th>Definitions</th>
<th>Actual</th>
<th>Parity</th>
<th>Value from Improvements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Supply Chain Reliability</td>
<td>Delivery performance</td>
<td>--</td>
<td>93%</td>
<td>98%</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fill Rate</td>
<td>--</td>
<td>95%</td>
<td>99%</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Perfect order fulfillment</td>
<td>--</td>
<td>90%</td>
<td>100%</td>
<td>10%</td>
</tr>
</tbody>
</table>


According to these gaps, firms could build the process reengineering plan and arrange work tasks purposively.

4.3 “To Be” supply chain process reengineering in Chinese automotive industry

In order to improve the performance of Chinese automotive industry, it is critical to break the status of self-support logistics of assembly factory. In the “To Be” logistic process of automobile supply chain, assembly factory should focus on core business process and dispose the self-support logistics which is non-core business process for an assembly factory. They should cooperate actively with the 3PL providers, integrate 3PL into the new supply chain system, decrease the number of carrier and develop the strategic partner relationship with strong and steady 3PL providers.

In the “To Be” logistic process of automobile supply chain, assembly factory will support the 3PL partners, who cooperate intimately with them, to become the dominant of supply chain. In the process of CKD parts purchasing, the goods is from various locations to the common destination. Thus, 3PL providers could get the information of assembly factory’s production plan through establishing the direct relationship with them, and replace assembly factory to coordinate the logistic activities of varied spare parts suppliers. For the same reason, 3PL providers could also replace the spare parts suppliers to coordinate the logistic activities through establishing the direct relationship with spare parts suppliers. In the process of production logistics, 3PL providers are able to arrange the goods to enter into or exit out from the 3PL’s warehouse, and can reach the JIT distribution demand of assembly factory, because they are holding both parts production plan and assembly factory’s production plan. Finally, in the process of sale logistics, 3PL providers become the center of the whole automobiles distribution, and take charge in distributing the cars to the varied distributors around the whole country. Figure 3 is the “To Be” logistic process of automobile supply chain.
Figure 3. “To Be” Logistic Process of Automobile Supply Chain
5. Conclusion and Further Research

The contents of SCOR model are very abundant, and its theory development and practice application have attracted more and more attention of scholars and managers from business field. According to the foundational theory of SCOR model, we bring forward a method for SCOR-based supply chain process reengineering. Furthermore, we choose Chinese automobile industry as our research object to carry out our basic analysis. But due to the lack of good data from practical firms, the description of the application is limited to level 2 of SCOR. Therefore, the emphasis of further research should focuses on a deeper exploration of practical studies.

Reference


