A Diagnostic Analysis Tool for Supply Chain Improvement

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Supply Chain continuous improvement has become a necessary strategy for businesses to attain the required performance level to compete worldwide. A fundamental phase to define the components and projects of the strategy is the diagnostic analysis phase. This project is concerned with a scheme for supply chain improvement developed for a Mexican company that fabricates and distributes aluminum profiles. The conceptual model is described and applied with particular emphasis in the diagnostic stage that includes a study of market structure, the analysis of the current chain physical structure and flows, and the analysis of the actual planning and control system infrastructure. Results of the project are also presented.

1. Introduction

In recent years the growth of world competition and increasingly demanding customers have created a fast moving environment for many companies. The late 1990s can therefore be characterized by change and uncertainty for manufacturing organizations and their respective supply chains. This is the case for the supply chain of a Mexican manufacturer of aluminum

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profiles with headquarters located in Monterrey, Mexico, named Alum-Insa hereafter.

In order to cope with this situation, Supply Chain performance improvement has become a necessary strategy for businesses to obtain the required level to compete worldwide, Lockamy, et al., 2000, Karabakal, et al., 2000, Blumenfeld, et al., 1987, Brown, et al., 2001, Kekre, et al., 1990 and Hax, et al., 1980. This could be achieved by providing schemes for performance improvement such as those of Beamon, et al, 1998 and DeToro, et al., 1997. Traditionally, each segment of the Supply Chain has been managed as a stand-alone entity focused on the achievement of local objectives. This approach originated inter-functional and inter-company conflicts, and limited the degree of improvement that could be achieved at the supply chain level.

This paper describes a scheme that has the purpose of guiding Alum-Insa to improve its logistics costs. The following section provides a review of the literature that deals with concepts and models related with supply chain improvement. The third section offers a brief review of the model structured for Alum-Insa. Section 4 provides the description and results of the ongoing application. Finally, several conclusions about the scheme are given in the last section.

2. Previous Research

Today`s changing industry dynamics have influenced the design, operation and objectives of supply chain systems by increasing emphasis on improved customer service levels, reduced cycle time, improved quality of products and services, reduced costs and flexibility of product offering to meet customer needs. The coordination of logistics functions required to achieve the previous objectives has increased the need for improved process performance.

A.T. Kearney, Inc., 1978, 1984 carried out some of the initial research literature concerning supply chain process performance. These works focused in the measurement of productivity of
logistics functions. As a result, a four-stage scheme for classifying organizations in performance measurement was defined. In 1991, A.T. Kearney, Inc. updated the previous productivity studies with an emphasis on quality dimensions as well. It was also geared towards identifying the best and most successful practices in quality and productivity improvement in the logistics process.

Beamon, et al., 1998 developed a Process Quality Model (PQM) for the assessment, improvement and control of quality in supply chain systems. The framework of the PQM contains the following seven interrelated modules in two stages:

- **Initial Stage:**
  - Identify process, technology and tasks performed.
  - Identify customers and their needs.
  - Define quality relevant to customers.

- **Improvement Stage:**
  - Identify current quality performance measures.
  - Evaluate current process and set standards.
  - Improve process.
  - Control and monitor process.

The initial stage is designed to be executed at the beginning of the improvement effort as a basis to carry out the continuous improvement. The last four modules included in the second stage facilitate the development of the effort and process control.

Ross, 2000 defines Supply Chain Quality Management (SCQM) as the participation of all members of a supply channel network in the continuous and synchronized improvement of all processes, products, services, and work cultures focused on generating sources of productivity and competitive differentiation through the active promotion of market-winning product and
service solutions that provide total customer value and satisfaction. It represents the latest stage in the total quality movement that focuses on how the entire supply channels can increase service value for the chain of customers it serves. SCQM methodology provides supply chains with the capabilities to sustain process improvement as a permanent management objective.

Ross’s SCQM, Beamon’s model and the efforts reported in A.T. Kearney, Inc., 1991 are based upon the principles of TQM established by Deming, Juran, Crosby and Feigenbaum. The improvement efforts derived from this foundation are based upon a change in culture. Changes are small and everybody participates. It is a kaizen approach to improvement. A systemic radical view of improvement is not looked for.

Reviewing various improvement programs implemented by leading international companies and reported in the literature, Lockamy, et al., 2000, Karabakal, et al., 2000, Blumenfeld, et al., 1987, Brown, et al., 2001, Kekre, et al., 1990 and Hax, et al., 1980, it seems that the use of quantitative models and simulation have taken an important role in assessing opportunity areas of potential improvement at the supply chain system level. The areas that are considered for further improvement are those of inventory management, demand forecasting, product production and distribution, and the redefinition of the structure of the supply chain. It is common to encounter the participation of ad-hoc teams with special knowledge and capabilities. The changes suggested in these efforts are radical and long term in nature.

Another approach for supply chain improvement emerged from the concept of waste removal from value streams. This movement was pioneered by Toyota’s Just in Time production system. A fundamental step of this approach is the identification of waste in supply chains. Hines, et al., 1997 proposes the use of seven value stream mapping tools to facilitate this task. They relate each tool to the different types of waste, suggesting the most appropriate for their
identification. The authors suggest the use of a kaizen or a radical re-engineering approach for waste removal, after the identification of waste is realized with the mapping tools. Scott, et al., 1991 recommend a three step process for supply chain integration; Supply chain mapping, positioning the organization in terms of supplier relations, and selecting improvement programs to enhance supply chain effectiveness. Their approach is radical and the use of the pipeline and variety funnel maps is fundamental. Other contributions to mapping tools and their contribution to strategic planning is provided by Jones, et al., 2003 and Gardner, et al., 2003.

Finally, there is the approach taken by the Cardiff Industrial Systems Dynamics Group for re-engineering supply chains, Towill, 1995 and Lewis, et al., 1997. It is based upon the discipline of systems dynamics that involves the application of feedback thinking and control engineering concepts to the study and design of supply chains. The methodology includes the inputs of industrial engineering, control engineering, simulation, and business process re-engineering into an integrated and comprehensive re-engineering modeling scheme that looks for the improvement of materials flow and control via the integration of the supply chain.

3. Description of Model for Supply Chain Improvement

The structure of the model for supply chain improvement includes several concepts from the approaches described in the previous section that consider a radical change. The model considers four phases and was developed by the team UDEM-Alum-Insa. The strategy alienation phase, the assessment of current situation, the generation and evaluation of areas for further improvement, and the phase of implementation and control.

3.1 Strategy alienation phase.

The initial phase has the purpose of linking the strategic direction of the enterprise with the project. Even though it is desirable to have the complete strategic context derived for the
enterprise, the fundamental and necessary information required for further consideration is that of the critical competitive factors. How the enterprise competes in terms of quality, price, response time and the like is of great relevance to determine the nature of the improvement effort. It is also relevant to determine the gaps in these factors required to compete successfully in the market.

3.2 Assessment of current situation.

The second phase corresponds to the assessment of the current situation. In this phase, the basic information required corresponds to the structure and characteristics of the market and the supply chain. It is important to determine the market size distribution and its location, and the required service level for each market segment. The physical structure of the supply chain namely; suppliers, manufacturing plants, and distribution facilities should be described in terms of quantity, capacity, location and function or role. In addition, the behavior of the inventory levels and flow of products or services throughout the chain must be mapped. Finally, It is suggested to also map the main information flows associated with the decisions regarding inventory and physical flows. This phase should serve as the basis to identify potential areas for improvement. This activity is facilitated by the use of TQM based tools and the mapping tools such as those suggested by Hines, et al., 1997 and Jones, et al., 2003.

3.3 Generation and evaluation of improvement options

The third phase has the purpose of generating and evaluating alternative options for improvement. The analysis of the information gathered in previous phase should provide us with ideas to structure strategies and projects to close the gaps of the critical competitive factors of interest. The mapping tools previously mentioned facilitate this activity. The use of mathematical and/or simulation models could also help us to develop and evaluate different alternatives for
improvement. Mathematical facility location, distribution and inventory models, discrete simulation models, and dynamic modeling of supply chain operations are the most used for the previous purposes.

3.4 Implementation and control.

In this phase, the projects generated from the previous stage are implemented. It is important that the required organizational and information system infrastructure be in place to insure a close monitoring of the results.

4. Application of Model and Results

The implementation of the model described previously is briefly presented in this section.

4.1 Strategy alienation phase.

The company targeted for implementing the improvement approach is part of a larger conglomerate with headquarters located in Monterrey, Mexico. This Firm fabricates and distributes aluminum profiles to the Mexican market, with two manufacturing plants and three distribution centers. Total sales were about 50 tons of product in year 2002. It is worth noticing that the plants are managed as independent firms with their own organizational structures. Thus, all the operational decisions are made with a high degree of independence and a lack of synergy and economies of scale.

Competitive factors and goals of the company.

The main competitive factors of the company are price and response time. However, it was recognized that due to intense pressure from competitors, price reductions were necessary. This situation derived in several cost cutting programs in all the operations of the company. Logistics costs, contributing 24% of total operating cost, was considered an important target for reduction.
A team formed with personnel from the logistics functions of the company, along with three more members of the Universidad de Monterrey, were appointed for the task of identifying potential areas for logistics cost reduction and suggesting measures to accomplish it. Reviewing the structure of total logistics cost, it was decided to search for potential areas for improvement initiating with the concept of transportation cost which contributed with about 43%. Warehousing and inventory carrying costs, with 25.8% and 22.6% respectively, were next in priority.

4.2 Assessment of current situation.

The structure of the market in terms of size and location is very important in the definition of the logistics costs. Current total annual sales volume total about 50 tons of product, worth 134 Million US Dlls. Export sales are 6.2% of total sales.

Sales in the Mexican market are distributed as follows. The plant at Monterrey contributes with 53.7% of total sales and the one at Mexico city with 40.1%. It is important to notice that 29.1% of total domestic sales are inter-company sales. That is, due to capacity unbalances and/or technology restrictions, both plants have to process part of each other’s sales volume, originating an important transportation cost between them to enable it.

Pareto graphs of the most important clients for Monterrey and Mexico, in terms of their volume purchases, were developed (e.g. see Figure No. 1). From these, it can be observed which of them have favorable conditions for FTL transportation by identifying their volume requirements. Similarly, one could expect that those that have low volume purchases would require the design of routing options to reduce the cost of transportation. It is observed that Monterrey has a better opportunity of using FTL transportation for about 12 of its clients that represent 65% of its sales. It was also found that 83.8% of the products sold were to order.
Figure No. 1. Volume profile of main clients for Mexico plant

Mexico’s client distribution is more disperse and favorable for transportation routing alternatives. At this plant 58.9% of the products sold were to stock.

Structure of current supply chain and flow distribution pattern

The structure of the Mexican supply chain is formed by two production facilities located in Monterrey and Mexico city, and three warehousing facilities; Monterrey, Mexico city, and Guadalajara facilities. Product flow distribution for year 2003 was mapped to determine potential areas for improvement. This is illustrated in Figure No. 2. Since both manufacturing plants are managed as independent companies, they are competing for the same market. Thus, the resulting distribution pattern does not reflect an optimal pattern if a centralized integrated strategy is
Two possibilities for decreasing transportation costs are envisioned: The re-assignment of market to distribution center or manufacturing plant, and the elimination of inter-plant flows.

![Figure No. 2. Current flow distribution pattern.](image)

Current transportation system.

The distribution of goods is carried out by trucks with capacities of 3.5, 11 and 20 tons. The monthly amount of trips averaged 500 during year 2003. These were carried out by about 32 transportation suppliers which participated very evenly. It is common to have up to 7 suppliers for each route.

The freight rates are per trip and set up by each supplier according to its particular cost structure and market conditions. Due to this situation, the variability shown by the rates in year 2003 is high. An additional analysis concerning the degree of utilization of truck capacity was carried out. The result indicated an 83% of utilization, yielding a low probability for
improvement. The following graph (Figure No. 3) illustrates the relation of transportation rates with respect to distance. This was approximated by a linear regression to use it for purposes of analysis and evaluation of different distribution scenarios.

Figure No. 3. Transportation rate behavior.

4.3 Generation and evaluation of improvement options.

The generation of alternate options for reducing transportation cost is based upon the analysis previously described. The first step carried out was to identify possible strategies or projects to specific characteristics of the market and supply chain structure. This is illustrated in the following Table No. 1.

Reduction of freight rate and number of suppliers.

The feasibility of reducing transportation cost by assigning service requirements to actual and new low cost suppliers depended upon their availability and service capacity. First, initial contacts were made with several new suppliers with sufficient capacity and experience. At the same time, it was required to determine if the current suppliers had enough capacity to undertake
higher participation. After this study, it was found that there was a potential cost saving of about 9.91% of total transportation cost if this project was implemented.

<table>
<thead>
<tr>
<th>Characteristic of Analysis</th>
<th>Strategy/project</th>
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<tbody>
<tr>
<td>High rate variability</td>
<td>Re-assign services to low-cost suppliers</td>
</tr>
<tr>
<td>Wide range of suppliers participating</td>
<td>Reduce suppliers and assign them more volume</td>
</tr>
<tr>
<td>Inefficient distribution patterns</td>
<td>Determine optimal patterns</td>
</tr>
<tr>
<td>Inter-company transactions</td>
<td>Re-assign processing capacity</td>
</tr>
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Table No. 1. Identification of improvement projects/strategies.

The previous option was complemented by an analysis of the reduction of the quantity of suppliers competing for our services. The idea behind this strategy was to ask for a rate reduction in exchange for a higher and certain volume under a longer term relationship.

Modification of distribution patterns.

The determination of better distribution patterns was done with the help of a mathematical model. In particular, the model described in Geoffrion, et al., 1974 was considered adequate for this situation. The objective was to optimally assign market share to current facilities, and to determine if the distribution centers were economically feasible to maintain. The solution of the model was analyzed and discussed resulting that:

- The elimination of Guadalajara distribution center was economically sound and did not have a negative impact on customer service.
- The elimination of inter-plant flows was technically feasible by exchanging processing capacity.
The re-assignments of customers to distribution centers had to be negotiated between the CEO’s of the companies involved.

Figure No. 4  Re-assignment of product flow distribution

Figure No. 4  shows the results of the re-assignments. The expected benefits total 8.7 % of total transportation cost.

4.4  Implementation and control.

The reduction of freight rates from reducing the supplier base and employing new less expensive suppliers was achieved immediately. The projects of eliminating interplant flows and re-assignment of customers to plants and distribution centers are currently underway.

In addition to the previous projects, it was also suggested to create a centralized organizational unit with the responsibility of improving performance at the supply chain level. Two new computational tools were developed to help in monitoring logistic costs and negotiate freight rates with suppliers via internet (see Figure No. 5 ).
5. Conclusions

This paper offers a brief description of the model developed at Alum-Insa to generate projects for improving supply chain performance. The structure of the model consists of four general stages, and each of these incorporate the utilization of various tools and schemes that are standard in quality improvement theory and practice. The projects generated are still being implemented. The results achieved have been significant, and these provide a solid basis to justify the continuation of this effort.

Figure No. 5. Computational tool to negotiate with suppliers.
6. Bibliography


