DEVELOPING SUPPLY-CHAIN PERFORMANCE OF AUTOMOTIVE INDUSTRIES THROUGH ANALYTIC HIERARCHY PROCESS (AHP)

S D Singh* and Dimple Bhandari**

*Corresponding Author: Dimple Bhandari  bhandari.dimple04@gmail.com

INTRODUCTION

The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making approach and was introduced by Saaty (1977 and 1994). The AHP has attracted the interest of many researchers mainly due to the nice mathematical properties of the method and the fact that the required input data are rather easy to obtain. The AHP is a decision support tool which can be used to solve complex decision problems. It uses a multi-level hierarchical structure of objectives, criteria, sub criteria, and alternatives. The pertinent data are derived by using a set of pair wise comparisons. These comparisons are used to obtain the weights of importance of the decision criteria, and the relative performance measures of the alternatives in terms of each individual decision criterion. If the comparisons are not perfectly consistent, then it provides a mechanism for improving consistency. Some of the industrial engineering applications of the AHP include its use in integrated manufacturing (Putrus, 1990), in the evaluation of technology investment decisions (Boucher and McStravic, 1991), in flexible manufacturing systems (Wabalickis, 1988), layout design (Cambron and Evans, 1991), and also in other engineering problems (Wang and Raz,1991).

As an AHP is a multiple criteria decision-making tool. This is an eigenvalue approach. It also provides a methodology to calibrate the numeric scale for the measurement of quantitative as well as qualitative performances. The scale ranges from 1/9 for least valued than to 1 for equal and to 9 for absolutely more important than covering the entire spectrum of the comparison. Some key and basic steps involved in this methodology are:

1 RIET, Faridabad.
1. State the problem.

2. Broaden the objectives of the problem or consider all actors, objectives and its outcome.

3. Identify the criteria that influence the behavior.

4. Structure the problem in a hierarchy of different levels constituting goal, criteria, sub-criteria and alternatives.

5. Compare each element in the corresponding level and calibrate them on the numerical scale. This requires n(n−1)/2 comparisons, where n is the number of elements with the considerations that diagonal elements are equal or 1 and the other elements will simply be the reciprocals of the earlier comparisons.

6. Perform calculations to find the maximum Eigenvalue, consistency index CI, consistency ratio CR, and normalized values for each criteria/alternative.

7. If the maximum Eigenvalue, CI, and CR are satisfactory then decision is taken based on the normalized values; else the procedure is repeated till these values lie in a desired range.

AHP helps to incorporate a group consensus. Generally this consists of a questionnaire for comparison of each element and geometric mean to arrive at a final solution.

The AHP has found widespread application in decision making problems, involving multiple criteria in systems of many levels (Liu and Hai, 2005). This method has the ability to structure complex, multi-person, multi attribute, and multi-period problem hierarchically (Yusuff et al., 2001). The AHP can be very useful in involving several decision-makers with different conflicting objectives to arrive at a consensus decision (Tam and Tummala, 2001).

LITERATURE REVIEW

Supply chain management is a concept that originated in the manufacturing industries in the early 1980s. It is developed from innovations such as Just In Time (JIT) (Vrijhoef and Koskela, 2000) and Total Quality Management (TQM) (Wong and Fung, 1999). Supply chain management can be seen as an example of evolutionary and cumulative innovation, which is often described as emanating from internal programs aimed at improving overall effectiveness (Saad et al., 2002). The focus is not only limited to increasing the internal efficiency of organizations, but also has now been broadened to include methods of reducing waste and adding value across the entire supply chain (Harland et al., 1999). Supply chain management has shifted the emphasis from internal structure to external linkages and processes, and is dependent on the interaction between the organization and its external environment, with strong feedback linkages and collective learning. It is seen as a set of practices aimed at managing and coordinating the whole supply chain from raw material suppliers to end customers (Slack et al., 2001), which develop greater synergy through collaboration along the whole supply chain (New and Ramsay, 1997).

The Council of Supply Chain Management Professionals also defines that supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers and customers. In essence, supply chain management integrates supply and demand management within and across companies.
Supply chain management is an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high-performing business model. It includes all of the logistics management activities noted above, as well as manufacturing operations, and it drives coordination of processes and activities with and across marketing, sales, product design, finance and information technology (The Council of Supply Chain Management Professionals, 2009).

Chopra and Meindl (2007) go further and state that a supply chain consists of all stages involved, directly or indirectly, in fulfilling a customer request. The supply chain not only includes the manufacturer and suppliers, but also transporters, warehouses, retailers, and customers themselves. Within each organization, the supply chain includes all functions involved in filling a customer request. These functions include, but are not limited to, new product development, marketing, operations, distribution, finance and customer service.

Supply chain management is associated with the effective management of the interfaces between all the organizations involved (Von Hipple, 1986), and the integration of both upstream and downstream processes (Christopher and Juttner, 2000). This significant emphasis on co-ordination and integration is strongly linked to the development of more effective and longer-term relationships between buyers and suppliers (Kosela, 1999).

These new types of relationships are increasingly perceived as a means to utilize resources better through the whole supply chain (Dubois and Gadde, 2000). In addition, they can also lead to greater transparency in transactions, increased trust and commitment (Ali et al., 1997). There are successful examples of where supply chain management is delivering significant performance improvements across the entire supply chain (Holti, 1997). It can also be an important element in innovation in products, processes and organization (Edum-Fotwe et al., 2001). Information can be more readily shared and knowledge identified, captured and disseminated throughout the organizations in the chain (Mowery, 1988). This has led to an increasing adoption of partnership approaches and inter-organizational alliances to achieve significant mutual benefits involving sharing resources, information, learning and other key assets (Akintoye et al., 2000).

However, supply chain management is a long, complex and dynamic process. Its successful implementation needs to be associated with a thorough understanding of the concept itself (Whipple and Frankel, 2000). Its implementation is also seen as being closely dependent upon the ability to create, manage and reshape relationships between individuals, organizations and networks within the supply chain (Spekman et al., 1998).

It requires new organizational arrangements and culture (Neely, 1998) which calls for considerable commitment, resources and time to develop.

It is important to recognize that supply chain management is complex and has proved to be difficult to implement. It is described as a multi-factor process, reliant upon close and long-term relationships within and between organizations (Saad et al., 2002). Its success is associated with the challenging and difficult development of a new
culture based on shared learning, greater transparency and trust. With a greater reliance on suppliers and the increasing emergence of outsourcing and fierce competition, the main challenge for supply chain management is to sustain and continuously improve the coordination and integration of all interactions and interfaces in order to enhance the overall performance of the supply chain. It is, therefore important to associate the concept of supply chain management based on continuous improvement with performance measurement.

Gunasekaran et al. (2004) develop a framework to promote a better understanding of the importance of supply chain management performance measurement and metrics. The proposed framework considers the measurement of supply chain processes (plan, source, make and deliver) with respect to strategic, tactical and operational levels and evaluates a score for prioritize for each metric by three level: highly, moderately, and less important level from an empirical study of selected British companies. It lacks identifying critical success factors for the whole supply chain system. Furthermore, for evaluating the score, the organization, suppliers and customers should come together to discuss how they will address the measurement and improvement of supply chain management performance. Industry consortiums, consultants and researchers could be helpful in promoting supply chain management performance measurement generally, and in developing measures and measurement techniques specifically.

Huang et al. (2005) summarize the Supply Chain Operations Reference (SCOR) model, its benefits along with illustrative case stories and describe a computer-assisted tool to configure supply chain threaded diagram per SCOR specification. Supply chain configuration is an integral part in SCOR project implementation. Currently, the configuration of ‘as-is’ or ‘to-be’ threaded-diagram describing a supply chain is done manually. To automate this process, a computer-assisted configuration tool has been developed and described in this paper. However, the configuration tool can so far only deal with a single manufacturing facility of a company. It does not take into account the interactions among multiple manufacturing facilities. Thus, this research limits to only single manufacturing facility of a company for studying.

Aramyan et al. (2007) propose conceptual framework that founds to be useful for measuring performance of the Dutch-German tomato supply chain. From the case study, it is concluded that four main categories of performance measures (efficiency, flexibility, responsiveness and food quality) are identified as key performance components of the tomato supply chain performance measurement system. This study also develops an integrated performance measurement system that contains financial as well as non-financial indicators combined with the specific characteristics of agri-food supply chains. Given the fact that the framework was evaluated in one particular case study (the Dutch-German tomato supply chain), caution is needed when generalizing the results. It also can be the limitation of this research to investigate only one food company.

Berrah and Cliville (2007) propose to build performance measurement systems by linking an overall performance expression to elementary performance. The overall performance is
associated to a global objective whose breakdown provides elementary objectives. Elementary performances are thus aggregated in a corollary way. This study deals with the supply chain performance formalization as it uses the performance indicators extend form Gunasekaran et al. (2004). These main strategic, tactical and operational indicators respect to SCOR model’s processes: plan, source, make and deliver. The case study concerns a bearing company with its suppliers and deliverers. The overall performance expression results from the aggregation, by the Weighted Arithmetic Mean (WAM), of the involved elementary performances. Besides, the Multiattractiveness Categorical Based Evaluation Technique (MACBETH) methodology has been applied to the performance expression of the four main processes of a supply chain. Indeed, this methodology gives a structured framework, which links the elementary performance expression to the overall performance. Factually, the SCOR model is originally founded on five distinct management processes, namely: plan, source, make, deliver and return. This study, however, the return process is not consider on the supply chain overall performance propose model.

Bhagwat and Sharma (2007a) develop a Balanced Scorecard (BSC) for measuring and evaluating day-to-day business operations of supply chain management from following four perspectives: finance, customer, internal business process and learning and growth. Three case studies develop and apply in Small and Medium sized Enterprises (SMEs) in India. The balanced scorecard developed in this paper provides a useful guidance for the practical managers in evaluation and measuring of supply chain management in a balanced way and proposes a balanced performance measurement system to map and analyze supply chains. However, addition research is recommended in order to determine whether the proposed perspectives and measures are a necessary and sufficient set.

Jammernegg and Reiner (2007) discuss the opportunities and challenges for improving the performance of supply chain processes by coordinated application of inventory management and capacity management. The propose technique by using process simulation to approach a supplier in the telecommunication and automotive industry, where a manufacturer (production facility) is located in a country with low labor costs and high worker deployment flexibility. Using process simulation, the authors demonstrate how the coordinated application of methods from inventory management and capacity management result in improved performance measures of both intraorganizational (costs) and interorganizational (service level) objectives. But it lacks to view the whole supply chain process as this research concentrates only costs and service level.

Yeh et al. (2007) propose a modified 2-tuple Fuzzy Linguistic Computing (FLC) model to evaluate the performance of supply chain management. In this model, the management implication of high precision setting involving in the Six Sigma: Define, Measure, Analyze, Improve and Control (DMAIC) processes is employed to construct the evaluation framework. The original 2-tuple fuzzy linguistic representation model is modified as the proposed model to provide the aggregation algorithm toward ensuring the consistent property. In this study, the Delphi method is used to precisely integrate the experts’
opinions on criterion selection, weighting identification and performance appraisal that are realistically expressed by fuzzy linguistic variables. The modified 2-tuple FLC technique is formed by utilizing a geometric operator and a couple of new symbol translation functions to aggregate precisely the 2-tuple terms involved. However, this framework lacks of combining the decision making levels.

Hwang et al. (2008) investigate the sourcing processes and their accompanied performance metrics in the SCOR model version 7.0 by using the stepwise regression model. The regression model was applied to examine the sourcing process of SCOR at level 2 and its performance metrics. The results obtained were further extended for discussion on the sourcing process of level 3. The researchers develop the questionnaire survey to collect empirical information from the Thin Film Transistor-Liquid Crystal Display (TFT-LCD) industry in Taiwan. In addition, this study also elaborates the institutionalization of the SCOR model and justifies the project planning system based on the SCOR model. However, this research concentrates on SCOR model version 7 only. When the newly developed version comes out, this study will have to consider for revision again.

Robb et al. (2008) propose and develop a model exploring the relationship between supply chain or operations practice and operational or financial performance by using a structural equation model with China furniture manufacturers of study. The industry is of particular interest in that, while labor productivity remains relatively low, exports have undergone substantial growth. The research highlights the relative importance of supply chain and operations practices and shows that the impact of practice on business performance is mediated by capabilities on operations dimensions. Another key finding is that practices are related to the importance placed on various dimensions the strongest link being between human resources and innovation, thus training can be seen to be a key to securing competitive advantage. The limitation of this research is it studied only operations dimension performance, not for the whole supply chains.

Theeranuphattana and Tang (2008) revisit the recent work of Chan and Qi (2003) which proposed an innovative performance measurement method for supply chain management. This research aims to propose a more user-friendly alternative performance measurement model by using fuzzy logic technique. The performance measurement model is a combination of two existing methods: Chan and Qi’s model and the Supply Chain Operations Reference (SCOR) model. To demonstrate the applicability of the combined approach, actual SCOR level 1 performance data and the measurement information from a case supply chain are collected and processed by Chan and Qi’s measurement algorithm. These two methods complement each other when measuring supply chain performance. However, only one Thai manufacturing company case study is presented to demonstrate the measurement and the application of the performance measurement method.

Zhu et al. (2008) aim to empirically investigate the construct of and the scale for evaluating Green Supply Chain Management (GSCM) practices implementation among manufacturers, the measurement scale instrument in the form of a
survey questionnaire developed from the various literature sources and interview academics and practitioners among Chinese manufacturers. Two measurement models of GSCM practices implementation were tested and compared by confirmatory factor analysis. The multi-item five-point Likert measurement scales using to evaluate the different facets of green supply chain management practices implemented and evaluate their strengths and weaknesses. However, this study concentrates only environmental performance with operational performance, not for the whole supply chain performance.

Cai et al. (2009) propose a framework using a systematic approach to improve the iterative Key Performance Indicators (KPIs) accomplishment in a supply chain context. The proposed framework quantitatively analyzes the interdependent relationships among a set of KPIs. This framework can provide an effective approach to managing supply chain performance in a dynamic environment. A KPI accomplishment cost transformation matrix (PCTM) analysis proposes in this paper, it is a new extension of the existing eigen structure analysis methods, Work Transformation Matrix (WTM) derived from the Design Structure Matrix (DSM) model from engineering to business performance management. However, the results from PCTM analysis method should not be adopted as direct decisions, but as supporting information for decision making.

Chae (2009) offers an industry-oriented, practical approach to performance measurement in supply chain management contexts and proposes key performance metrics which can be easily adapted for different businesses. A list of essential Key Performance Indicators (KPIs) is presented. Potential KPIs develop for each of the SCOR model’s four meta-process (plan, source, make and delivery) and have to be hierarchically grouped such as primary and secondary metrics. The review of industry standards and best practices in supply chain performance measurement suggest that ‘less is better’ as to developing performance metrics. Companies should focus on only a small list of KPIs which are critical for their operations management, customer service, and financial viability. The lack of this development model is the return process not consider in this work.

Chia et al. (2009) apply the Balanced Scorecard (BSC) approach on the logistics industry for measuring supply chain performance. This research empirically examines what senior supply chain executive’s measure and how they perceive performance measurement from a balanced scorecard. A survey designed from the four perspectives of the balanced scorecard framework is conducted on senior executives involved in the supply chain functions of client firms, and those executives from the logistics service provider industry. This study suggests that the measurement of performance of supply chain entities could be improved by using a more balanced perspective as provided for by the BSC framework. Further, the results show an apparent lack in the focus on drivers of strategic future performance, as implied in the results of the measurement of internal business processes and learning and growth indicators. These two perspectives contain measures that create future value, and address the development of core competencies but they were not as well measured. The limitation of this work is the sizes
of some respondent clusters are smaller than others. Hence, the results may not be representative of the individual clusters.

Rodriguez et al. (2009) propose the Quantitative Relationships Performance Measurement System (QRPMS) that clearly establishes traceability between a group of strategic objectives and associated Key Performance Indicators (KPIs). This study presents a unique proposal able to objectively identify and quantify relationships between KPIs defined within a performance measurement system base on the BSC, that offering additional information to managers to make cross-enterprise decisions. Then, the research projects KPIs upstream in the performance measurement system, establishing meaningful cause and effect relationships at the objectives levels. The proposed model is applied to a baby clothing manufacturer in Spain. As the research studied only one manufacturing company, it may be the disadvantage for this paper.

Thakkar et al. (2009) propose an integrated supply chain performance measurement framework for the case of Small and Medium scale Enterprises (SMEs) in India using set of qualitative and quantitative insights gained during the case study research. The proposed framework integrates the features of BSC and SCOR model to deliver a comprehensive performance measurement framework for SMEs. It also outlines the detailed guideline for the implementation and use of the framework. This research reports set of performance indicators for the supply chain processes like source, make and deliver in SMEs. It also relates the measures with various supply chain cycles like procurement, manufacturing, replenishment and customer order, but it does not consider in decision making levels.

Bigliardi and Bottani (2010) develop a BSC model that is designed and delimited for performance measurement in the food supply chain. The research provides a structured performance measurement system tailored for the food supply chain. The BSC model developed could serve as a reference for the food industry, to establish applicable performance appraisal indicators. The study starts from the literature concerning performance measurement and metrics, the food industry and the BSC model, the relevant financial and non-financial indicators, suitable to be used for companies belonging to the food industry. Then, indicators are submitted to a panel of experts, which operate following the Delphi technique, to gather possible suggestions or amendments. In its final form, the resulting BSC model is tested on two companies operating in the food industry, for a final validation. However, the fact that a specific industry field (the food industry) is examined could be seen as a limitation of the work as the results presented are not suitable to be generalized or extended to other contexts.

1. To identify performance measurement factors with respect to supplier relationship management, internal supply chain management and customer relationship management against strategic, tactical and operational levels for a supply chain performance measurement framework.

2. To develop a conceptual framework based on proposed performance measurement factors.

3. To validate the proposed framework by applying it to the case study companies in the
Thai manufacturing sector for the following purposes:

3.1 To evaluate supply chain performance in relation to performance measurement factors

3.2 To determine the importance of the performance measurement factors by using the AHP.

The proposed conceptual supply chain performance measurement framework comprises performance measurement factors with respect to supplier relationship management, internal supply chain management and customer relationship management. The performance measurement factors are further organized hierarchically across the decision making levels (strategic, tactical and operational).

**METHODOLOGY**

Analytic Hieratic Process evaluates performance through various hierarchical levels of the organization. The supply-chain performance factors are measured by the formation of metrics at the strategic, tactical and operational levels is to make the right decisions so that they can support each other in achieving the overall goals and objectives of an organization. The success of strategy formulation depends upon the degree of translation strategy into operations. Gunasekaran et al. (2001), based on literature survey, develop a framework of performance that distinguishes measures according to classic decision horizons: strategic, tactical and operational. The complexity of supply chain management prompts them to compile a list of the most indicative performance metrics for each hierarchical level. The authors underline the influence of hierarchical level measures to achieve the objectives of each hierarchical level. Financial indicators that include intangible elements are most appropriate for the strategic level (Gunasekaran and Kobu, 2007). In addition, Gunasekaran et al. (2004) developed a framework for supply chain management in case of performance measurement and metrics. The framework considers the measurement of supply chain processes (e.g., plan, source, make and deliver) with respect to strategic, tactical and operational levels, evaluates a score for prioritize for each metric by three levels: highly, moderately and less important levels from an empirical study of selected Indian companies.

Researcher visited two industries continuous type and job shop type and formed a conceptual frame work for performance factor of supply-chain by the help of experts in this field, top management and head of department like planning, production, quality, purchasing, etc., and decided performance factors. Questionnaires were prepared for interviews. On the behalf of interview qualitative data were collected and these data were converted into quantitatives data by the help of Linker scale.

**Collection of the Interview Data**

There are four main types of interviews: structured interviews, semi-structured interviews, unstructured interviews and group interviews. In this study, semi-structured interviews were considered to be more flexible than structured interviews and thus more appropriate for the objectives of this study, especially in the situation when the researcher was uncertain about what and how much information he would get from the interview (King, 1994). Structured interviews ensure that bias is reduced, however, flexibility is severely restricted Sarantakos (2001). The use
of semi-structure interviews meant that the researcher had a list of questions as an interview guide, so he was able to ask questions that were not listed and he also could change the order of the questions according to the flow of the discussion (Bryman, 2004). In this study, semi-structured interviews were used to collect both qualitative data (words) and quantitative data (numbers). Qualitative data were used for studying supply chain characteristics of each case study company, and identifying their supply chain performance. By contrast, quantitative data were used for measuring performance of case study companies.

Collection of the Observation Data

Observation constitutes a more ‘humanistic methodology’ (Jorgensen, 1989), and it entails the systematic noting and recording of events, behaviors, and artifacts in the social setting chosen for study (Marshall and Rossman, 2006). In this study, observation was chosen as one of data collection approaches during the interview period. The researcher’s observations were used to record the respondents’ body language and implied attitudes, as this might give clues about what they really thought about the issues. Marshall and Rossman (2006) argue that such clues mean it is vital to combine observation with in-depth interviews. According to Legard et al. (2003), people often convey their state of mind through their tone of voice, manner, or body language, so the researcher should be constantly receptive to these clues. Observation assisted in the building of holistic picture of the various stakeholders. The researcher noted these observations, included the respondent’s gesture, the external distractions such as phone calls or interruptions by colleagues, the perceived level of openness and the potential implied responses behind a specific comment. These observations were combined with the interview transcripts and other data sources for the analysis.

Collection of Secondary Data

The collection of secondary data relevant to the research was also undertaken. Together with the other data collection, this helped the researcher to gain a holistic overview, and in some instances helped him to clarify information collected in the interviews with the respondents. According to Yin (1994), it is necessary to pay considerable attention to the contextual conditions affecting the phenomenon being studied. Secondary data is useful because it can provide additional evidence or arguments, particularly about the wider context. In this study, the secondary data used included work process documents, handouts and reports from the case study companies, plus other public documents and notifications from the Federation of Thai Industries. These documents were widely used in the case study context chapter and also to an extent in the results chapters.

Conduct of the Interviews

“Maintaining and generating conversations with people on a specific topic, and the interpretations which social researchers make of the resulting data, constitute the fundamentals of interviews and interviewing. Rubin and Rubin (1995) explain that every step of an interview brings out new information and opens up windows into the experiences of the people interviewed. Qualitative interviewing is a way of finding out what others feel and think about their worlds. It addresses people’s knowledge of their human situation, including the meanings, ambiguities, contradictions and their inter-subjectivity (Kvale, 1996).
CONCLUSION

It provides a detailed analysis of performance measurement in order to understand supply chain performance of case study of automotive companies by using the AHP. These companies are the Continuous Type Industry (CTI) and Job Shop Type Industry (JSTI). The detailed analysis of supply chain performance measurement was based on performance measurement factors. The performance measurement factors were indentified on the three supply chain macro processes along with decision making levels. Therefore, this chapter analyzes performance measurement factors that contain in three themes: supplier relationship management, internal supply chain management and customer relationship management. However, a comparison of performance measurement for these three supply chain macro processes is presented at the beginning to provide an entire view of supply chain system.

REFERENCES


This article can be downloaded from http://www.ijmrbs.com/currentissue.php


