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Abstract Title:
Selection of Supply Chain Performance Measurement System Using AHP Approach

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Abstract

Analytic hierarchy process (AHP) based decision model presented in this paper structures the problem related to selection of supply chain performance measurement system in a hierarchical form with alternatives available to the decision maker. AHP is a suitable approach for undertaking quantitative as well as qualitative analysis. The approach differs from other multi-criteria as subjective judgments are readily included and the relevant inconsistencies are dealt with appropriately. The final outcome of the AHP is an optimum choice among decision alternatives. Thus, AHP based approach proposed in this paper provides a more realistic and accurate representation of the problem for selecting supply chain performance measurement system.

Keywords: Supply chain performance measurement system (SCPMS); Analytic hierarchy process (AHP); Multi-criteria decision making (MCDM), Automobile company.

1. Introduction

With the opening up of the Indian economy, the Indian automobile industry is flooded with automobile manufacturing giants like General Motors Corp., Honda, Toyota Motor Corp., Volkswagen AG, Daimler Chrysler etc. India has become one of the most sought after destination where these companies are interested in setting up their manufacturing base. This sudden and quick transformation in the mindset of the foreign companies is due to vast Indian market. On the other hand, liberalization have fueled the growth of Indian automobile industry along with its supply chain partners, which according to Automotive Mission Plan (AMP) 2006-16 envisages an investment of $40 billion. As projected in the document, the turnover of the automobile industry would increase to
$145 billion by 2016 from the current $35 billion, accounting for 10 percent of the GDP. Thus, the competition among the firms is very intense, prompting them to be innovative in order to reduce costs, enhance quality, and improve their performance and responsiveness to customers’ demand. To achieve these goals, existing firms as well as new entrants need to improve their supply chains' performance. Gunasekaran et al. (2004) have suggested that in order to evolve an efficient and effective supply chain, SCM needs to be assessed for its performance. Similar views were put forward by Ren et al. (2004) when they stated that design, implementation, and use of adequate performance management system (PMS) can play an important role if supply chains are to succeed in an increasingly complex, interdependent, and changing world because “You cannot manage what you cannot measure”. For that selecting supply chain performance measurement system which is appropriate for a particular supply chain is of paramount importance. Performance measurement selection is a critical step in the design and evaluation of any system. While there is an ever-increasing number of supply chain models presented in the literature, there is very little available in supply chain performance measure selection (Wu and Song, 2005).

In considering supply chain performance measurement system (PMS) for future, two major requirements emerge (Morgan, 2004).

1. Performance measures must be linked with the strategy of an organization, be part of an integrated control system, have internal validity and enable proactive management; and

2. The performance measurement system must be dynamic, intra-connectable, focused and usable.
The first requirement is an important requisite for internal stability, economy, efficiency and effectiveness. The second requirement raises the operational problem of making a performance measurement system (PMS) dynamic from both an internal and supply chain perspective (Morgan, 2004).

Beamon (1998) concludes that a single performance measure will be inadequate for an entire supply chain, and that a system of performance measures is required for accurate measurement of supply chain systems. An evaluation framework, which incorporates determinants of supply chain performance measurement system, would be useful in selecting appropriate SCPMS for the Indian automobile industry. One such approach, with an application of a systemic analysis technique is presented in this paper. This technique evaluates the various determinants of supply chain performance measurement system selection through an analytic hierarchy model.

The AHP model presented in this paper structures the problem related to selection of an supply chain performance measurement system in a hierarchical form. One of the important issues for any strategic planning would be how the organization should prioritize the determinants and what policy elements or initiatives impact them (Wheelwright, 1978). Section 2 provides a brief discussion of the determinants for selecting supply chain performance measurement system and alternatives to be evaluated in this model. These characteristics are then used to structure the model. Later, the proposed methodology for evaluating the decision model is presented and applied to a decision-making problem faced by an automobile industry. This is followed by a discussion and managerial implications of this research. Finally, we conclude the work with the limitations of this work and directions for further research.
2. Determinants of supply chain performance measurement system

There are three determinants of supply chain performance measurement system, namely, these are intra functional measurement system, inter functional measurement system and inter organizational measurement system. These are briefly described below:

2.1. Intra functional measurement system

A measurement system which develops excellence within each of its operating units such as the manufacturing, marketing, or logistics departments. Metrics for a company in this system will need to focus on individual functional departments. Most companies have focused their performance measurement on achieving functional excellence. Simatupang and Sridharan (2004) observed that as we move from functional excellence towards external integration, supply chain will be able to attain cost reductions while increasing efficiency and productivity. Hull et al. (1999) observed that problem with functional excellence is that as each department tries to optimize its own performance, but the overall performance is suboptimized.

2.2. Inter functional measurement system

A measurement system which develops excellence in its cross-functional processes rather than within its individual functional departments. Metrics for a company in this system will need to focus on cross-functional processes. This involves coordinated management of a company’s internal operational activities like production scheduling, labour allocation, inventory holding, job sequencing, shipping, etc. (Copacino, 1997). Basu (2001) observed that, extending intra-organisational PM systems into the domain of inter-organisational PM has meant paying lip service only to the concept of supply chain PM. Intra-organisational PM systems are not designed to measure beyond the boundaries of
the organisation (beyond simple measures such as delivery time, etc.), and using them to try to do this over-simplifies the inter-organisational perspective. Daugherty et al. (1996) observed that early discussions of integration were, for the most part, limited to integration within the firm. Staude (1987) posited the need for two types of organizational integration—interdepartmental and intradepartmental. In such situations, a systems approach suggest that the objectives of the firm as a whole should be considered more important than those of individual departments. Udomleartprasert and Junghirapanich (2003) highlighted the fact that although most of the organizations are managing the supply chains successfully, yet they have only achieved improvement in organizational performance. The organizations still have not achieved the desired results ascribed to supply chain management.

2.3. Inter organization measurement system

A measurement system which develops excellence in inter-enterprise processes. Metrics for a company in this system will focus on external and cross-enterprise metrics. This refers to integration of activities external to the company across the supply chain. Less than 5 percent of companies have achieved total integration with others (Copacino, 1997). Successful SCM requires a change from managing individual functions to integrating activities into key supply chain processes (Lambert and Cooper, 2000). Ballou et al. (2000) have shown that supply chain management has moved us from an intrafunctional vision of the channel toward an interfunctional and even inter-organizational one. This requires three things: A new type of metrics beyond normal accounting procedures for capturing inter-organizational data and expressing them in terms that facilitate benefits analysis; An information sharing mechanism for transferring information about
cooperative benefits among channel members; An allocation method for redistributing the rewards of cooperation in a way that all parties benefit fairly.

Collaboration is the key ingredient to attain external integration with other chain members (Simatupang and Sridharan, 2004), thereby, allowing to benchmark from a single company level to an interorganizational level (Simatupang and Sridharan, 2004a). Supply chain collaboration requires a reasonable amount of effort from all participating members to ensure the attainment of potential benefits (Barratt and Oliveira, 2001; Corbett et al., 1999).

3. Alternatives for the supply chain performance measurement system

After review of literature and discussion with fifteen experts in the field of supply chain, both from industry and the academia, some of the important supply chain performance measurement system are identified. For the purpose of illustration of our model, we analyze seven distinct alternatives. The seven alternatives are Supply chain balanced scorecard (SCBS), Hierarchical based measurement system (HBMS), Function based measurement system (FBMS), Perspective based measurement system (PBMS), Supply chain operations reference model (SCOR), Dimension based measurement system (DBMS) and Interface based measurement system (IBMS). These alternatives have been used in the proposed framework for the development of an AHP model. A brief description of these seven alternatives is given below.

3.1. Supply chain balanced scorecard (SCBS)

Brewer and Speh (2000) have developed a model where supply chain point of view is embedded within the balanced scorecard framework. This model describes the links of different perspectives to goals of SCM and then what are the measures to be adopted in
each. The internal perspective of the scorecard is extended to include both the inter-functional and inter-organizational partnership perspectives. SCBS emphasizes the interdependent as well as independent nature of supply chain and reorganizes the need to ascertain the extent to which effectively work together and function are coordinated and integrated. It also stimulates management to create other measures appropriate to their unique circumstances but it lacks in aligning overall supply chain objectives with objectives for the companies. This was the first significant framework to move beyond traditional logistics performance measures.

3.2. Hierarchical based measurement system (HBMS)

Gunasekaran et al. (2001) gave HBMS in which measures are classified into strategic, tactical and operational levels of management. This is done to assign them where they can be best dealt with by the appropriate management level, and quick decisions can be made. The metrics are further distinguished as financial and non-financial.

HBMS ties together the hierarchical view of supply chain performance measurement and maps the performance measures specific to organization goals. A clear guide cannot be made in such a system to put the measures into different levels that can lead to low level of conflicts among the supply chain partners.

3.3. Function based measurement system (FBMS)

Christopher (1992) developed a FBMS in which the measures are aggregated to cover the different processes in the supply chain. FBMS covers the detailed performance measures applicable at different linkages of supply chain. Approach is easy to implement and targets can be dedicated to individual departments. It does not provide the top level measures to cover the entire supply chain with the company strategy. It looks at the
supply chain in isolation, which gives the localized benefits that may harm the total supply chain benefits.

3.4. Perspective based measurement system (PBMS)

PBMS developed by Otto and Kotzab (2002) looks at supply chain in all the possible perspectives and provides measures to evaluate each perspective. The six perspectives are system dynamics, operations research, logistics, marketing, organization and strategy. It presents six unique sets of metrics to measure performance of SCM. This system provides a different vision to look supply chain. There can be trade off between measures of one perspective with the measures of other perspectives.

3.5. Supply chain operations reference model (SCOR)

The supply chain council created the SCOR model which is a framework for examining a supply chain in detail, defining and categorizing the processes that make up the supply chain, assigning metrics to the processes, and reviewing comparable benchmarks. The SCOR model is the only supply chain framework that links performance measures, best practices and software requirements to a detailed business process model. It integrates business process reengineering, benchmarking and process measurement into a cross-functional framework. In Supply Chain Operation Reference Model (SCOR), performance of most processes is measured from five perspectives: reliability, responsiveness, flexibility, cost, and asset (Supply chain council).

SCOR defines supply chain as the integrated process of plan, source, make, deliver and return spanning suppliers’ supplier to customers’ customer, aligned with operational strategy, material, work and information flows. The heart of SCOR is a pyramid of four levels that represent the path a company takes for supply-chain improvement. It requires
a well defined infrastructure, resources and project based completion approach. Implementation of such an exhaustive system requires fully dedicated managerial resources and continuous business process reengineering to align the business with the best practices.

3.6. Dimension based measurement system (DBMS)

DBMS suggests that any supply chain can be measured on three key dimensions: service, assets and speed (Hausman, 2000). Service relates to the ability to anticipate, capture and fulfill customer demands with personalized products and on-time delivery; Assets involve anything with commercial value, primarily inventory and cash; and Speed includes metrics which are time related, they track responsiveness and velocity of execution. Every supply chain should have at least one performance measure on each of these three critical dimensions.

3.7. Interface based measurement system (IBMS)

This framework aligns performance of each link within the supply chain. The framework begins with linkages at the focal company and moves outward a link at a time. The link by link approach provides a means for aligning performance from point-of-origin to point-of-consumption with the overall objective of maximizing shareholder value for the total supply chain as well as for each company (Pohlen and Lambert, 2001). IBMS looks at the supply chain as a series of different links and to optimize the total supply chain a win-win approach is required at all linkages. Conceptually it looks good but in actual business setting it requires openness and total sharing of information at every link of the chain, which seems to be difficult to implement.
4. The decision environment

A graphical representation of the ANP model and decision environment is shown in Fig. 1.

![AHP-based framework for Selecting Supply Chain Performance Measurement System](image)

**Fig. 1: AHP-based framework for Selecting Supply Chain Performance Measurement System**

It can be seen that the overall objective is to select SCPMS. The determinants for selecting SCPMS (Intra functional measurement system, Inter functional measurement system and Inter organization measurement system) are described in Section 2. The SCPMS alternatives in this model are the specific SCPMS that a decision maker wishes to evaluate, given the various attribute levels of the SCPMS. The various alternatives available to the decision maker in this example include Supply chain balanced scorecard (SCBS), Hierarchical based measurement system (HBMS), Function based measurement system (FBMS), Perspective based measurement system (PBMS), Supply chain operations reference model (SCOR), Dimension based measurement system (DBMS), Interface based measurement system (IBMS).
operations reference model (SCOR), Dimension based measurement system (DBMS) and Interface based measurement system (IBMS). In Section 5, we briefly describe the benefits of the AHP process and in section 6, apply it to an automobile company example to explain the AHP methodology.

5. Analytic Hierarchy Process

AHP (Saaty, 1980) is a multi-criteria decision-making technique. One of the main advantages of this method is the relative ease with which it handles multiple criteria. In addition to this, AHP is easier to understand and it can effectively handle both qualitative and quantitative data. The use of AHP does not involve cumbersome mathematics. AHP involves the principles of decomposition, pairwise comparisons, and priority vector generation and synthesis.

5.1. AHP as a qualitative tool

AHP is a multi-attribute, decision-making approach based on the reasoning, knowledge, and experience of the experts in the field. AHP can act as a valuable aid for decision making involving both tangible as well as intangible attributes that are associated with the model under study. AHP relies on the process of eliciting managerial inputs, thus allowing for a structured communication among decision makers. Thus, it can act as a qualitative tool for strategic decision-making problems. Mustafa Yurdakul & Yusuf Tansel (2004) used AHP model for credit evaluation of the manufacturing firms taking into account both financial as well as non financial measures.

5.2. Advantages of AHP

AHP is a suitable approach for undertaking quantitative as well as qualitative analysis (Saaty, 1980). The approach differs from other multi-criteria as subjective judgments are
readily included and the relevant inconsistencies are dealt with appropriately (Hafeez et al., 2002). The final outcome of the AHP is an optimum choice among decision alternatives.

Partovi et al. (1990) outlines the following benefits of using AHP:

(a) it formalizes and makes systematic what is largely a subjective decision process and thereby facilitates "accurate" judgments;

(b) as a by-product of the method, management receives information about the evaluation of the cost drivers' and activities' implicit weights; and

(c) the use of computers makes it possible to conduct sensitivity analysis on the results.

Another advantage of using AHP as stated by Harker and Vargas (1987) is that it results in better communication, leading to clearer understanding and consensus among decision makers groups, and hence a greater commitment to the chosen decision.

5.3. Limitations of AHP

Identifying the relevant attributes of the problem and determining their relative importance in decision-making process requires extensive discussion and brainstorming sessions. It requires calculations and formation pair-wise comparison matrices, thus, a careful track of matrices and pair-wise comparisons of attributes is necessary.

The pair-wise comparison of attributes under consideration can only be subjectively performed, and hence their accuracy of the results depends on the user’s expertise knowledge in the area concerned.

AHP models a decision-making framework that assumes uni-directional hierarchical relationship among decision levels. Therefore, AHP fails to capture interdependencies among different enablers, criteria, and sub-criteria (Agarwa & Shankar, 2003).
6. An Example of Automobile manufacturing company

The AHP model that is presented in this research has been evaluated in an actual automobile manufacturing company, which was interested in the selection of appropriate supply chain performance measurement system. The company wanted a systematic way to determine the best possible option for selecting the supply chain performance measurement system. The case experience helps us to understand in a better way the advantages and disadvantages of the methodology from a practical point of view. The analysis and the implementation of the AHP model are presented in the following steps.

Step 1. Model development and problem formulation

In this step, the decision problem is structured into its important components. The relevant criteria and alternatives are chosen on the basis of the review of literature and discussion with fifteen experts both from industry and academia. The relevant criteria and alternatives are structured in the form of a hierarchy where the criteria at the top level in the model have the highest strategic value. The top-level criteria in this model are Intra functional measurement system, Inter functional measurement system and Inter organization measurement system. These three criteria are termed as the determinants. The objective of this hierarchy is to select the best possible alternative that will best meet the goals of selecting best performance measurement system. The AHP model so developed is presented in Fig. 1. The alternatives that the decision maker wishes to evaluate are shown at the bottom of the model.

The opinion of the experts from the case company was sought in the comparisons of the relative importance of the criteria and the formation of pair-wise comparison matrices to be used in the AHP model. The results of all the three determinants would be used in the
calculation of supply chain performance measurement system composite score (SCPMSCS), which indicates the score assigned to a supply chain performance measurement system.

Step 2. Pair-wise comparison of three determinants

In this step, experts from the case company were asked to respond to a series of pair-wise comparisons where two components at a time are compared with respect to an upper level ‘control’ criterion. These comparisons are made so as to establish the relative importance of determinants in achieving the case company’s objectives. In such comparisons, a scale of 1–9 is used to compare two options (Saaty, 1980). In this a score of 1 indicates that the two options under comparison have equal importance, while a score of 9 indicates the overwhelming dominance of the component under consideration (row component) over the comparison component (column component) in a pair-wise comparison matrix. In case, a component has weaker impact than its comparison component, the range of the scores will be from 1 to 1/9, where 1 indicates indifference and 1/9 represents an overwhelming dominance by a column element over the row element. For the reverse comparison between the components already compared, a reciprocal value is automatically assigned within the matrix, so that in a matrix $a_{ij}a_{ji} = 1$. The matrix showing pair-wise comparison of determinants along with the e-vectors of these determinants is shown in Table I.
Table I: Pair-wise comparison of determinants

<table>
<thead>
<tr>
<th>Determinants</th>
<th>INTRA F</th>
<th>INTER F</th>
<th>INTER O</th>
<th>e-vector</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRA F</td>
<td>1</td>
<td>1/5</td>
<td>1/9</td>
<td>0.060</td>
</tr>
<tr>
<td>INTER F</td>
<td>5</td>
<td>1</td>
<td>1/4</td>
<td>0.231</td>
</tr>
<tr>
<td>INTER O</td>
<td>9</td>
<td>4</td>
<td>1</td>
<td>0.709</td>
</tr>
</tbody>
</table>

The e-vectors (also referred to as local priority vector) are the weighted priorities of the determinants and shown in the last column of the matrix. In this paper, a two-stage algorithm (Saaty, 1980) is used for computing e-vector. For the computation of the e-vector, we first add the values in each column of the matrix. Then, dividing each entry in each column by the total of that column, the normalized matrix is obtained which permits the meaningful comparison among elements. Finally, averaging over the rows is performed to obtain the e-vectors. These e-vectors would be used in Table V for the calculation of supply chain performance measurement system composite score (SCPMSCS) for alternatives.

Step 3. Evaluation of alternatives

The final set of pair-wise comparisons is made for the relative impact of each of the alternatives [Supply chain balanced scorecard (SCBS), Hierarchical based measurement system (HBMS), Function based measurement system (FBMS), Perspective based measurement system (PBMS), Supply chain operations reference model (SCOR), Dimension based measurement system (DBMS) and Interface based measurement system (IBMS)] on the determinants. The number of such pair-wise comparison matrices is dependent on the number of the determinants. In our present case, there are 3 determinants, which lead to 3 such pair-wise matrices.
Table II: Matrix for alternatives’ impact on determinant INTRA F

<table>
<thead>
<tr>
<th>INTRA F</th>
<th>SCBS</th>
<th>HBMS</th>
<th>FBMS</th>
<th>PBMS</th>
<th>SCOR</th>
<th>DBMS</th>
<th>IBMS</th>
<th>e-vector</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCBS</td>
<td>1</td>
<td>1</td>
<td>1/3</td>
<td>9</td>
<td>5</td>
<td>1/3</td>
<td>5</td>
<td>0.141</td>
</tr>
<tr>
<td>HBMS</td>
<td>1</td>
<td>1</td>
<td>1/7</td>
<td>7</td>
<td>7</td>
<td>1/5</td>
<td>5</td>
<td>0.118</td>
</tr>
<tr>
<td>FBMS</td>
<td>3</td>
<td>7</td>
<td>1</td>
<td>9</td>
<td>7</td>
<td>3</td>
<td>9</td>
<td>0.399</td>
</tr>
<tr>
<td>PBMS</td>
<td>1/9</td>
<td>1/7</td>
<td>1/9</td>
<td>1</td>
<td>1/3</td>
<td>1/7</td>
<td>1/3</td>
<td>0.020</td>
</tr>
<tr>
<td>SCOR</td>
<td>1/5</td>
<td>1/7</td>
<td>1/7</td>
<td>3</td>
<td>1</td>
<td>1/7</td>
<td>1/2</td>
<td>0.033</td>
</tr>
<tr>
<td>DBMS</td>
<td>3</td>
<td>5</td>
<td>1/3</td>
<td>7</td>
<td>7</td>
<td>1</td>
<td>5</td>
<td>0.247</td>
</tr>
<tr>
<td>IBMS</td>
<td>1/5</td>
<td>1/5</td>
<td>1/9</td>
<td>3</td>
<td>2</td>
<td>1/5</td>
<td>1</td>
<td>0.042</td>
</tr>
</tbody>
</table>

Table III: Matrix for alternatives’ impact on determinant INTER F

<table>
<thead>
<tr>
<th>INTER F</th>
<th>SCBS</th>
<th>HBMS</th>
<th>FBMS</th>
<th>PBMS</th>
<th>SCOR</th>
<th>DBMS</th>
<th>IBMS</th>
<th>e-vector</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCBS</td>
<td>1</td>
<td>5</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>7</td>
<td>0.389</td>
</tr>
<tr>
<td>HBMS</td>
<td>1/5</td>
<td>1</td>
<td>7</td>
<td>5</td>
<td>1/3</td>
<td>3</td>
<td>5</td>
<td>0.159</td>
</tr>
<tr>
<td>FBMS</td>
<td>1/7</td>
<td>1/7</td>
<td>1</td>
<td>1/2</td>
<td>1/7</td>
<td>1/5</td>
<td>1/2</td>
<td>0.027</td>
</tr>
<tr>
<td>PBMS</td>
<td>1/5</td>
<td>1/5</td>
<td>2</td>
<td>1</td>
<td>1/3</td>
<td>2</td>
<td>2</td>
<td>0.070</td>
</tr>
<tr>
<td>SCOR</td>
<td>1/3</td>
<td>3</td>
<td>7</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>7</td>
<td>0.246</td>
</tr>
<tr>
<td>DBMS</td>
<td>1/5</td>
<td>1/3</td>
<td>5</td>
<td>1/2</td>
<td>1/5</td>
<td>1</td>
<td>5</td>
<td>0.074</td>
</tr>
<tr>
<td>IBMS</td>
<td>1/7</td>
<td>1/5</td>
<td>2</td>
<td>1/2</td>
<td>1/7</td>
<td>1/5</td>
<td>1</td>
<td>0.035</td>
</tr>
</tbody>
</table>
Step 4. Calculation of supply chain performance measurement system composite score (SCPMSCS)

The SCPMSCS for an alternative i (SCPMSCSi) is the summation of the products of the relative importance weights of the alternative (Aia) and the relative importance weights of the determinants (Da) of the supply chain performance measurement system. It is represented as:

\[ \text{SCPMSCSi} = \sum A_{ia}D_a \]

For example, the SCPMSCS for SCOR is calculated as:

\[ \text{SCPMSCS}_{\text{SCOR}} = [(0.033 \times 0.060) + (0.246 \times 0.231) + (0.442 \times 0.709)] \]

\[ = 0.373 \]

The final results are shown in Table V.
Table V: Weightages of determinants for SCPMS alternatives

<table>
<thead>
<tr>
<th></th>
<th>SCBS</th>
<th>HBMS</th>
<th>FBMS</th>
<th>PBMS</th>
<th>SCOR</th>
<th>DBMS</th>
<th>IBMS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INTRA F</strong></td>
<td>0.141</td>
<td>0.118</td>
<td>0.399</td>
<td>0.020</td>
<td>0.033</td>
<td>0.247</td>
<td>0.042</td>
</tr>
<tr>
<td><em>(0.060)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>INTER F</strong></td>
<td>0.389</td>
<td>0.159</td>
<td>0.027</td>
<td>0.070</td>
<td>0.246</td>
<td>0.074</td>
<td>0.035</td>
</tr>
<tr>
<td><em>(0.231)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>INTER O</strong></td>
<td>0.225</td>
<td>0.153</td>
<td>0.018</td>
<td>0.051</td>
<td>0.442</td>
<td>0.063</td>
<td>0.048</td>
</tr>
<tr>
<td><em>(0.709)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Composite Score of Alternative</strong></td>
<td>0.258</td>
<td>0.152</td>
<td>0.043</td>
<td>0.054</td>
<td>0.373</td>
<td>0.077</td>
<td>0.043</td>
</tr>
</tbody>
</table>

It is observed from Table V that SCOR is the most-suited alternative for the supply chain performance measurement system for the case company. SCBS, HBMS, DBMS, PBMS IBMS and FBMS follow this alternative. It is observed from Table I that inter organization measurement system is the most effective type of measurement system to be employed by any supply chain. It is also observed from table II that FBMS (0.399) is found to be more appropriate for intra functional performance measurement system as compared to DBMS (0.247), SCBS (0.141), HBMS (0.118), IBMS (0.042), SCOR (0.033) and PBMS (0.020). Similarly, in the inter functional performance measurement system SCBS (0.389) is found to most effective. It is followed by SCOR (0.246), HBMS (0.159), DBMS (0.074), PBMS (0.070), IBMS (0.035) and FBMS (0.027). These results
should be seen in the light of the characteristics of the case company and the inputs provided by its experts in the pair-wise comparison.

7. Discussion and managerial implications

In this section, we first discuss the results of the model. Later, we present few suggestions to the prospective users of this model. Finally, we discuss the managerial implications of this model and some generalization of results.

The major contribution of this research lies in the development of a comprehensive model, which incorporates diversified issues for selecting supply chain performance measurement system. The proposed AHP model in this paper, not only guides the decision makers in the selection of the supply chain performance measurement system but also enable them to visualize the impact of various determinants in the arrival of the final solution.

For the case undertaken in this study, the results indicate that SCOR is the first choice of the case company, which is followed by SCBS, HBMS, DBMS, PBMS, IBMS and FBMS. The choice of the case company towards SCOR may be attributed to the fact that it links performance measures, best practices and software requirements to a detailed business process model. It integrates business process reengineering, benchmarking and process measurement into a cross-functional framework which can lead to enhanced competitiveness. It is relevant to discuss here the priority values of the determinants of performance measurement system, which influence this decision. From Table I, it is seen that inter organizational measurement system ($D_a = 0.709$) is the most important determinant for the selection of supply chain performance measurement system. Inter functional measurement system (0.231) and intra functional measurement system (0.060)
follow it. In fact inter organizational measurement system and inter functional measurement system put together had virtually determined the selection of supply chain performance measurement system. These implications are straightforward as the inter organizational measurement system has forced the companies to look beyond their own companies and towards supply chain in a holistic way.

Table V shows the SCPMSCS for the alternatives. It is observed from the table, that SCOR excels over the other six alternatives. Though, in the illustrated example, the model has been described for seven distinct alternatives, it can accommodate more than seven at the cost of complexity. In the light of the results obtained for the case company, it is to be noted that the results obtained are valid for the case company in its own decision environment. It is the decision environment of the user, which makes one alternative superior to other.

Though the proposed AHP model is based on a sound algorithm for systemic decision-making, care must be taken in its application, the reason being that the user has to compare the performance measurement system on a number of pair-wise comparison matrices.

The determinants identified in the proposed model are quite generic and with marginal adjustments can be used for different sector also.

8. Conclusion

The implementation of supply chain performance measurement system may cost in millions of dollars for company. The implementation of these may be a risky endeavor for the top management as it involves financial and operational aspects, which can determine the performance of the company in the long run. And no longer does the
companies compete against each other, it is the supply chains which compete. So the question now is not whether to go for it or not, but which framework to pick up. This research is relevant in this sense. The AHP model presented in this paper structured the problem of selection of supply chain performance measurement system in a hierarchical form and linked the determinants of the supply chain performance measurement system and the alternatives available to the decision maker.

Thus, a AHP approach proposed in this paper can provide to the decision maker a more realistic and accurate representation of the problem for selection of supply chain performance measurement system. This study aids the decision makers in the complex task of prioritizing their options. The utility of the AHP methodology in integrating both quantitative as well as the qualitative characteristics, which need the attention of the decision maker in arriving at the best possible solution, assumes tremendous value.

The model developed in this paper has a few limitations as well. The formation of the pair-wise comparison matrices and data acquisition is a tedious and time-consuming task. Also, more importantly, the results reported in this research are based on the opinion of the experts from the case company. Thus, the pair-wise comparison of the criteria always depends on the user’s knowledge and familiarity with the firm, its operations, and its industry. Therefore, the biasing of the experts to some criteria might have influenced the results. Although, we have tried to minimize this by checking the consistency of comparison using method of consistency-ratio check as suggested by Saaty (1980). Consistency ratio (CR) is calculated for all the pair-wise comparisons to check the inconsistency in decision-making. In the proposed model CR varies from 0.001 to 0.10, which is within tolerable limit (Saaty and Kearns, 1985). Hence, the identification of the
relevant attributes to the problem under consideration, the determination of their relative importance in comparison to others require extensive brainstorming sessions, and the accumulation of expertise and knowledge within the organization. Since many of the issues in the pair-wise comparisons are cross functional in nature, a team of managers from various functional departments should be assigned the responsibility of comparison. Delphi method may also be a promising technique that may be explored in this regard. Experts in the case automobile company considered that this approach lead to an objective analysis of the situation and is currently implementing SCOR for performance measurement of the supply chain.

A possible extension of this research study might be to study the preferences of the user companies corresponding to different sizes and sectors, where these criteria may be modeled as per the choice of companies. The model may also be subjected to sensitivity analysis. User-friendly software may also be developed on the basis of the model.

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