

A New Approach to Supplier Selection Problem: An Introduction of AHP-SCOR Integrated Model

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Abstract – Nowadays manufacturing industry is growing rapidly and large numbers of added value in business activities has been exercised. Supplier selection problem has improved in many areas by evaluation of supplier to increase supply chain performance. Supplier selection is one of the most important aspects in manufacturing industry. This paper suggest a combination techniques of Analytical Hierarchy Process (AHP) together with Supply Chain Operation Reference (SCOR) model to develop new decision support system (DSS) to the industry. There are four stages in supplier selection process which employed the norm stages of supplier selection process: data gathering, AHP calculation, SCOR evaluation, and implementation of decision making. Data analyzed was aligned with evaluation of data to synthesize of priorities and consistencies measurement. Organization's decision maker would gain benefits and acquire competitive advantage providing DSS practitioners to achieve a success of the holistic approach in future decision support system.

Index terms – Supply chain, AHP, SCOR, Decision Making, Supplier Selection, Decision Support System.

I. INTRODUCTION

Supplier selection is one of the most crucial activities performed by the organization especially in manufacturing industries. Supplier selection process should rather meet the requirement of the customer to fulfil their needs, and also making profit to organization. Habib (2014) ascertained that many researcher and practitioner typically pointed out on the issues of Supply Chain Management (SCM) in profit organizations during this last decade. The development of supply chain management as a part of a system capable in facing market competition, an adequate set of competencies is required (Esposito and Passaro, 2009). Organizations have to be consistent in various actions and strategies, particularly with the assessment processes that are assumed a crucial importance. SCM is required to improve operation, enhance customer satisfaction and also improve supplier selection problem.

Many literatures have reviewed on the supplier selection problem that discussed on multi criteria decision making method. In contrast, selecting supplier is imperative important practice in industry including manufacturers, distributors, retailers, and service providers.

This paper is organized as follow: provides a review of past academic literature on supplier selection. Literature analyzed supplier selection criterion and evaluation of criteria

performance in index of supply chain management. Quantitative analysis was conducted by distribution of a set of questionnaire to Giant hypermarket procurement manager. Data was analyzed and finals score obtained for final selection of supplier. Lastly, it provides conclusions.

II. SUPPLIER SELECTION

Sampson (2000) presumed that the customer supplier relation both in the service organizations concerning to SCM in the service industry. Increase importance of SCM has a big impact to organization to improve in purchasing activities. During the past decade, supplier selection process has undergone significant changes to beneficial both industries and suppliers. The current supplier selection process, the decision maker plays an important role in decision making stages.

The nature of selection process involves multi criteria decision skill that has become even more complex. Therefore, Supplier selection process is considered as a very complicated task. Tookey and Thiruchelvam (2011) and Florez-Lopez (2007) pointed out that organization one of the most crucial part of the purchasing function is supplier selection.

In Malaysia, supplier selection is an intense complex decision problem involving qualitative and quantitative factors that is indecisively in dealing with trade-off between tangible

and intangible suppliers' criteria (Farzad, Rasid, Aidy, Rosnah and Alireza, 2008). The supplier selection process involves a huge amount of a organization financial resources and anticipate a significant benefits from contracting suppliers (Beil, 2010). During an otherwise routine in supplier selection, mostly the supplier with the lowest price bid often wins the tender and there is a tendency that hypermarket is unaware with the availability of decision support system application for supplier selection. As a result, inefficient supply chain process will affect the entire organization's supply chain performance (Enyinda, Emeka and Fesseha, 2010).

Today, many organizations comprehend the most essential component of supply chain to improve business performance by obtaining products or services at the lowest possible cost, in the right quantity with the right quality at the right time (Kumar, Parashar, & Haleem, 2012). A well composition and systematic decision making method make ease to decision maker to identify and defining the right supplier due to growing number of potential supplier with numerous of different attributes of each suppliers.

A traditional supplier selection method was fundamentally based on financial measures. Due to many factors to be considered, decision maker often opted to choose the most common important criteria for supplier selection, which include price, quality and delivery. Recently, more and more emphasis has been devoted to other aspects, bringing multiple criteria into the evaluation process. Weber (1991) discussed Dickson's 23 criteria for suppliers' selection, based on a questionnaire sent to 273 procurement managers as shown in Table 1. Table 1 summarizes the findings of Dickson's study with regards to the importance of the 23 criteria described above. The factors: quality, delivery and performance history could be considered, in its respective order, as the three most important criteria. In summary, Weber (1991) study shows that in selecting suppliers, quality is the highest rank evaluated as extreme importance with 3.508 means rating followed by delivery and performance, 2.417 and 2.998 mean respectively. Meanwhile, price falls in 6th rank evaluated as considerable important supplier criteria.

Table 1: Dickson's vendor selection criteria a Rank Factor Mean Evaluation Rating

Rank	Factor	Mean Rating	Evaluation
1	Quality	3.508	Extreme importance
2	Delivery	3.417	
3	Performance history	2.998	
4	Warranties and claim policies	2.849	Considerable importance
5	Production facilities and capacity	2.775	
6	Price	2.758	
7	Technical capability	2.545	
8	Financial position	2.514	

9	Procedural compliance	2.488	Average importance
10	Communication system	2.426	
11	Reputation and positioning industry	2.412	
12	Desire for business	2.256	
13	Management and organization	2.216	
14	Operating controls	2.211	
15	Repair service	2.187	
16	Attitude	2.120	
17	Impression	2.054	
18	Packaging ability	2.009	
19	Labor relations record	2.003	Slight importance
20	Geographical location	1.872	
21	Amount of past business	0.597	
22	Training aids	1.537	
23	Reciprocal arrangements	0.610	

Ha and Krishnan (2008) updated Dickson's 23 set of attributes to 30 criteria as shown in Table 2. They provide a prerequisite of the difficulty of the problem as many conflicting factors should be taken into consideration. Also, while some of these attributes can be easily measured by qualitative or quantitative concepts, it will result to a delicate problem for the aggregation of these attributes in a last measurement such as out of 30 criteria the most common important criteria among supplier preference are price, quality and delivery. Larger number of attributes also contributes to the complications of being assigned with consistent and meaningful weights (Tookey and Thiruchelvam, 2011).

Table 2: Supplier Selection Attributes Framework

After sales service	Geographical location	Product appearance
Amount of past business	Impression	Production facilities and capacity
Attitude	JIT capability	Quality
Catalogue technology	Labor relations	Reciprocal arrangements
Communication system	Maintainability	Reputation and position in industry
Delivery	Management and Organization	Response to customer request
Ease-of-use	Operational controls	Technical capability
E-commerce capability	Packaging ability	Technical support
Environmentally friendly products	Performance history	Training aids
Financial position	Price	Warranties and claims

Dickson (1966) identified 23 important criteria for the supplier selection criteria and it was seen in publication of academic articles from 1966 to 1990 (Weber, 1991), whereas from 1992 to 2003, there were 49 related articles were published (Zhang, 2004; Weber et al., 1991; Dickson, 1966). Moreover, Cheraghi (2004) has discovered 36 criteria with additional of 13 criteria from the origin of Dickson's 23 criteria. Embarking from Dickson's academic study, Cheraghi (2004) has added 13 new criteria that are significant to be

include in supplier criteria list. Therefore, this paper considered 41 criteria (shown in **Appendix-1**) as independent variables in Malaysia study for hypermarket supplier selection.

III. DECISION SUPPORT SYSTEM

Decision support system (DSS) is generally known as computer-based system to gather data and information for further analysis and to facilitate the evaluation of assumptions underlying the use of particular model (Baizyldayeva et al., 2013). Today, DSS has been widely employed in business activities. A DSS allow decision makes the facility to analyze information to specific decision such as a decision for supplier selection.

Literature has proved that there are different views on the measurement of supplier criteria. The identification of supplier selection criteria has been essentially highlighted of many academicians and practitioners. Many studies had relatively presented criteria in supplier selection. Giuseppe et al. (2009) discussed that many conflicting in the analysis and measuring the supplier, based on the rank order of the supplier's criteria. The most utilized methodology is the Analytic Hierarchy Process (AHP) (Giuseppe et al., 2009; Weber et al., 1991; Dickson, 1966). Supplier selection is regarded as a multi criteria decision making (MCDM) because it incorporated to solve a decision problem involving many goals and objectives. MCDM refers to making decision in the occurrence of multiple choices for decision making process. Despite that, there are four types of MCDM methods to solve decision problem and AHP, developed by Saaty (1980) is one of the MCDM tool for decision making process, continuously be employ in extensively decision making theory.

AHP is a general theory to set priorities to a qualitative and quantitative decision making. AHP has been widely exercised in solving decision problems. This has been found in Khadijah and Lazim Abdullah (2012) study, environmental performance index was applied to the AHP principles to illustrate the world most countries' environment performance. Thus, AHP stands alone model needs to improve in its model and Bruno et al. (2009) has emphasize 51 out of 201 papers used AHP combined with other theories or approaches.

Supply chain reference operation (SCOR) model was established in 1996 founded by the Supply-Chain Council (SCC). According to Elgazzar et al. (2010), SCOR model is a business process reengineering, benchmarking, process measurement, and best practice analysis to be exercised in supply chain as an integrated modelling. Huan et al. (2004) claimed that SCOR model need to strive to improve concerning the use of network modelling tools to support management decision. The principle of SCOR allows

organizations to align supply chain management practice as well as filling the gaps in chain performance. SCOR model-based supply chain infrastructure exploited by Huan et al. (2004), Elgazzar (2010), and SCC (2010) is shown in a Figure 1.

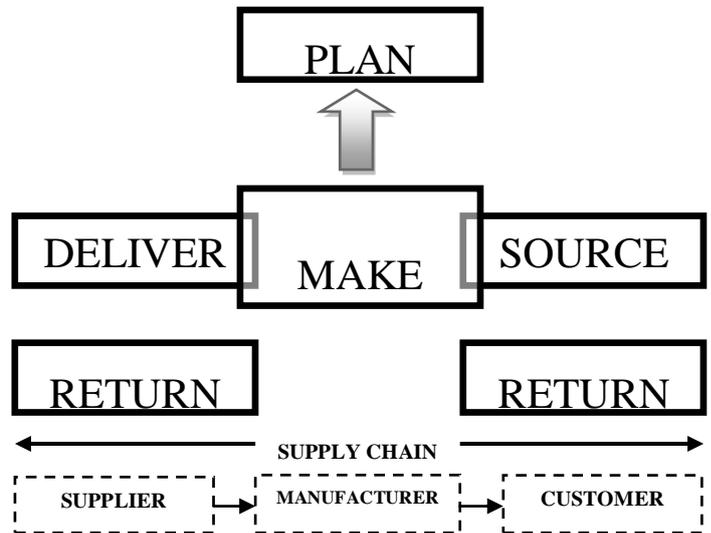


Figure 1: The SCOR model-based supply chain infrastructure

MCDM proposed the alternatives performance which each of the criteria are outranking and compared in pairs. Study by Boongasame and Boonjing (2010) clarifies that AHP stand alone methods are compensate optimization approaches for which bad score on some criteria can be compensated by excellent scores on other criteria. So, they used the Elimination and Choice Translating Reality III (ELECTRE III) and have been proposed to solve such problem. However, the score values outcome from the ranks of the alternatives may be inconsistent.

In response to the need for robustness of supplier selection system, this paper is justified to develop a theoretical model essential, the Analytic Hierarchy Process combined theory with SCOR model for the selection of supplier. This proposed research will be referred as AHP-SCOR Integrated Model. Therefore, to identify the right supplier, it is important to parallel the selection of right decision making criteria with the right decision making technique (Tookey and Thiruchelvam, 2011). This two elements are ensuring that organization objective is achieved and increase in organization's performance.

IV. AHP-SCOR INTEGRATED APPROACH

AHP-SCOR integrated approach is newly developed decision model to solve supply chain decision-making problem (Abdullah et al., 2013). In this study, one tool that is used to

support the decision-making is a modified AHP model by comparing the scores on the different criteria and employed SCOR model to quantitatively aggregate the criterion scores and comparing the aggregate scores. Subsequently, ranking reversals are applied, based on ELECTRE III methods. The construction of this outranking is to finalize the ranking of the SCOR model multiplying between criteria scores to determine which supplier is preferred. The combination of AHP, ELECTRE III and SCOR are illustrated in Figure 2.

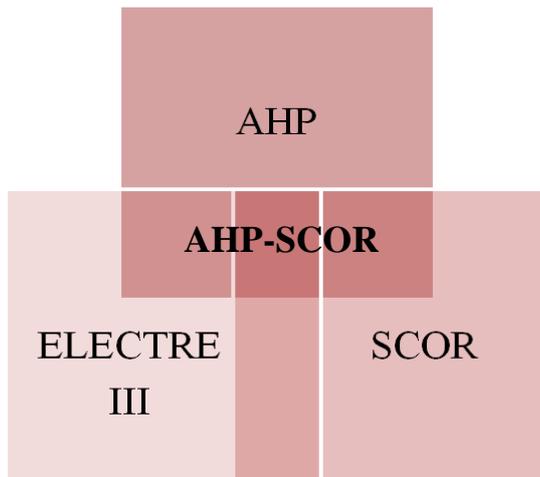


Figure 2: AHP, ELECTRE III and SCOR Combined Theory

Shown in proposed AHP-SCOR integrated model in **Appendix-2**, there are four stages in the model: stage 1, stage 2, stage 3 and stage 4. Stage 1 consists of the criteria identification, stage 2 indicates criteria weighted, criteria computation shown in stage 3, and the final stage is the final score measurement. Two major sections in this model are appraisal and selection. Appraisal consists of identifying the criteria and weighted the criteria, along with criteria computation and final score are in selection section.

This approach proposed to provide a guideline enhancing the support system in supply chain management decision-making as a whole. It demonstrates that different decision techniques that have been used may have different results when it is applied to the same problem.

Finally, the proposed integrated model will be applied to Giant Hypermarket as a sampling for verification purposes. 48 'stand alone' Giant hypermarket were chosen as sample for data collection method. Then the listed suppliers of this Giant hypermarket are ranked by the means of computation AHP-SCOR method.

The schematic methods for selection process are as follows:

- i. Gathering the data to structure the model. The best criteria will be selected. (details process in Section 4: Stages in Proposed Model)
- ii. Criteria will be calculated and weighted with AHP. Step 1 and step 2 are appraisal stages.
- iii. In selection stage, criteria AHP-SCOR will be computed.
- iv. Lastly, final score is analyzed and decision on the best supplier will be implemented.

V. STAGES IN PROPOSED MODEL

Stage 1: Data Gathering

The first stage denoted the identification of criteria. The criterion was based on the past literature (Cheraghi et al., 2004) from the 41 criteria presented in the theoretical framework. Applying the AHP in supplier selection can be considered as hypothetical problem. Thus, due to competitive advantage in the industry, organizations must able to choose the right supplier to meet supply chain goals. The criteria will then be developed in a hierarchy model. The study analysis is narrowed further as below:

Criteria	
Criteria 1	Cost
Criteria 2	Quality
Criteria 3	Organization
Criteria 4	Service
Criteria 5	Relationship

Supplier:
Supplier A
Supplier B
Supplier C

A schematic of the decision hierarchy for measuring supplier criteria is presented below and **Appendix-2** show a developed hierarchy model:

- Level 1: BEST SUPPLIER FOR HYPERMARKET
- Level 2: CRITERIA: 1, 2, 3, 4, 5
- Level 3: SUB-CRITERIA
- Level 4: ALTERNATIVES: Supplier A, B, C

Level 1

The top element of the hierarchy is the overall goal of the decision-making. Thus in this study, level 1 indicates the best supplier for hypermarket.

Level 2

The second level, which is known as the cluster that are grouped, represents the main criteria which classified into five

aspects; cost, quality, organization, service, and relationship. General criteria usually will impact the goal directly.

Level 3

Level 3 are sub-criteria for the 5 main criteria specify in level 2. There are 41 sub-criterion affecting business performance measurements.

Level 4

Alternative of the supplier A, B, and C are shown in level 4.

Stage 2: AHP Calculation

In the next step, a construction of a pair-wise comparison matrix is a major strength to derive accurate ratio scale priorities. Pair-wise comparisons in this study are based on standardization of nine likert scales (Table 3). Yang et al. (2011) denoted a ranging from 1 – 9 scale preference to pair-wise comparisons where, 1 denoted “equal more importance”, 3 represented “moderate more importance”, 5 was “strong more importance”, 7 denoted “very strong more importance”, and 9 “extreme more importance”

Table 3: Comparison Scale

Definition	Intensely of Importance
Equally important	1
Moderately important	3
Strongly more important	5
Very strongly more important	7
Extremely more important	9
Intermediate more important	2, 4, 6, 8

Saaty (1980) illustrated AHP steps as follows:

Step 1: Decomposition phase - defining the problem

Step 2: Hierarchy is established containing criteria and sub-criteria. Usually top element is the goals of the decision.

Step 3: Comparative judgement phase - criterion of one level of hierarchy are compared with construction of pair-wise comparison matrix using 9 likert scales (Table 3).

Step 4: Develop n(n-1) judgement. Example of resulting priorities of alternative A and B as follow:

$$[X1 \ X2 \ X3] \begin{pmatrix} aX1 & bX1 \\ aX2 & bX2 \\ aX3 & bX3 \end{pmatrix} = [pA \ pB]$$

Step 5: Hierarchical synthesis used by calculating the eigenvalue and eigenvector.

Step 6: Consistency is determined by $CI = (Imax-n) / (n-1)$, where CI is consistency index, CR is consistency ratio, RI is random index, Imax is the largest eigenvalue, and n is the

matrix size. CR is acceptable when $CR < 0.1$. Table 4 show a recommended RI values (Yang et al, 2011).

Table 4: Random Index

N	2	3	4	5	6	7	8	9	10
RI	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Step 7: Repeat step 4-6 for all level in hierarchy.

From the proceeding data of the pair-wise comparison, consistency will be derived. Consistency ratio (CR) is calculated by dividing Consistency index (CI) to random index (RI); $CR = CI/RI$. Nevertheless, the consistency ratio should be less than 0.1. Further, factor evaluation and factor weights will be multiply and the final score is illustrated in Table 6. Final AHP result shows that Supplier B scored high value with 0.416.

Table 5: Result Summary of Factor Evaluation and Factor Weight

Criteria	A	B	C
Cost	0.166	0.166	0.055
Quality	0.077	0.077	0.081
Organization	0.061	0.051	0.061
Service	0.057	0.057	0.012
Relationship	0.018	0.055	0.018
TOTAL	0.379	0.416*	0.227

Stage 3: SCOR Evaluation

The score of factor evaluation and factor weight will be applied with the proposed SCOR calculation to evaluate each of the criteria. The weights of SCOR variables are found and these weights are multiplied with the final AHP scores. After the AHP-SCOR methodology is applied, the best supplier is determined as illustrated in Figure 3.

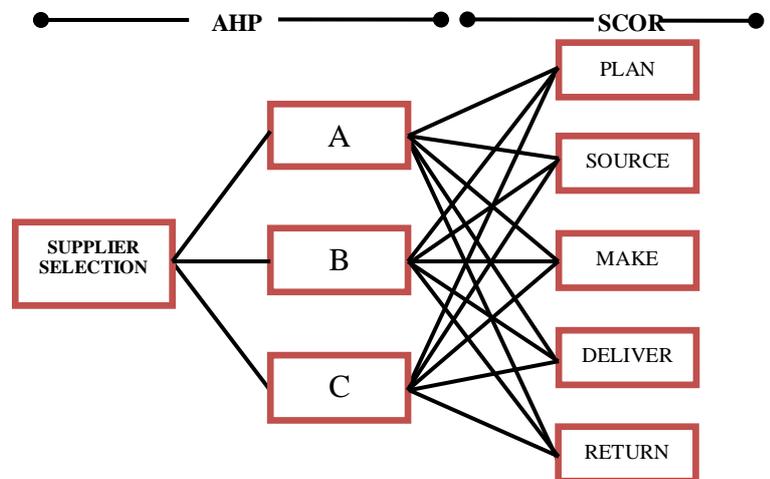


Figure 3: AHP and SCOR Metrics Evaluation

The final score, resulting from AHP and SCOR metrics evaluation are depicted in the following Table 3. In conclusion, the result will show that supplier A is the best choice of supplier.

Table 6: AHP-SCOR Final Score

	A	B	C
Final Score	0.183*	0.120	0.093

Stage 4: Decision Making Implementation

The final score will be obtained as an indicator of performance to supplier selection solution. Otherwise, ranking the fuzzy number can be exploited using the integral values ranking method developed by Liou and Wang’s model (Aydin and Kahraman, 2011).

VI. CONCLUSION

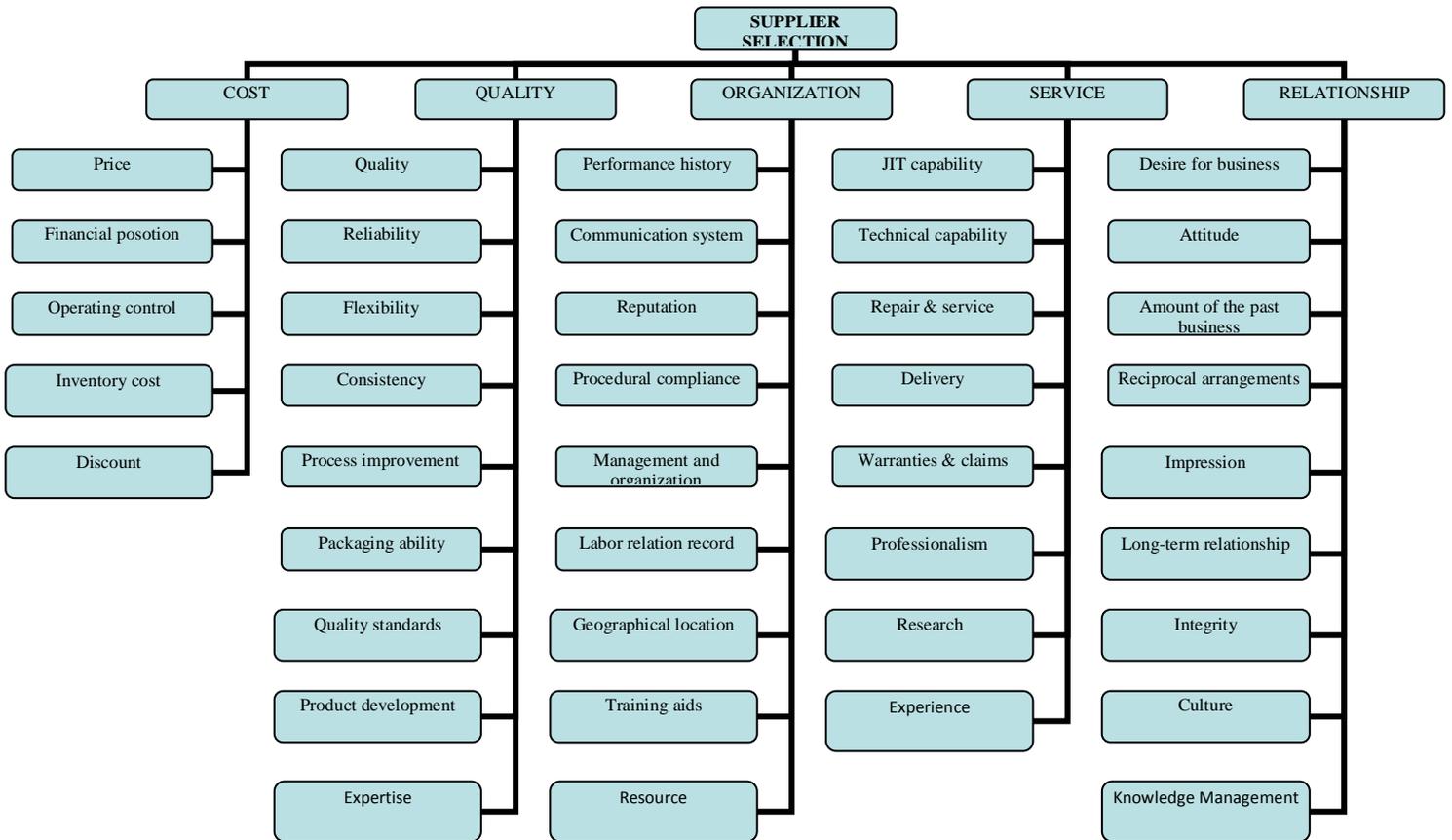
This paper presents a new methodology for decision support system in supplier selection process. Starting from the identification of criteria in AHP, and the integration with SCOR model which to obtain final score of which supplier is the best supplier among the other. Both qualitative and qualitative factors are involved in supplier selections’ criterion. As such, AHP is a widely used decision-making process, involving supplier evaluation process. Literature has supported the determination of supplier selection criterion to appraise suppliers. MCDM is deemed as significant in this study that involve complex decision-making, therefore, a theoretical model is developed to represent AHP methodology. The value acquired from supplier’s personal evaluation on the criteria evaluated in the hierarchy. Subsequently, the comparison matrix is calculated with pair-wise comparison matrix to obtained scores. The AHP-SCOR integrated approach is simplified in supplier selection using new decision support system. The final score of each supplier will be reckoned and the most score will be selected as the best supplier. This study discussed AHP model together with integrated SCOR approach to select hypermarket’s best suppliers applied in Malaysia scenario. Essentially, based on the research findings, suppliers in Malaysia would gain benefits and acquire competitive edge through the sustainability of new decision support system. Further research will be conducted to optimize the methodology and to define new system approach in DSS. In this paper, the new approach are based on theory and future research may develop a system where parameter can be keyed in by practitioner or decision maker to make ease by automated index calculation by each criteria.

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Appendix-1 A Developed Hierarchy Model



Appendix-2 AHP-SCOR Integrated Model

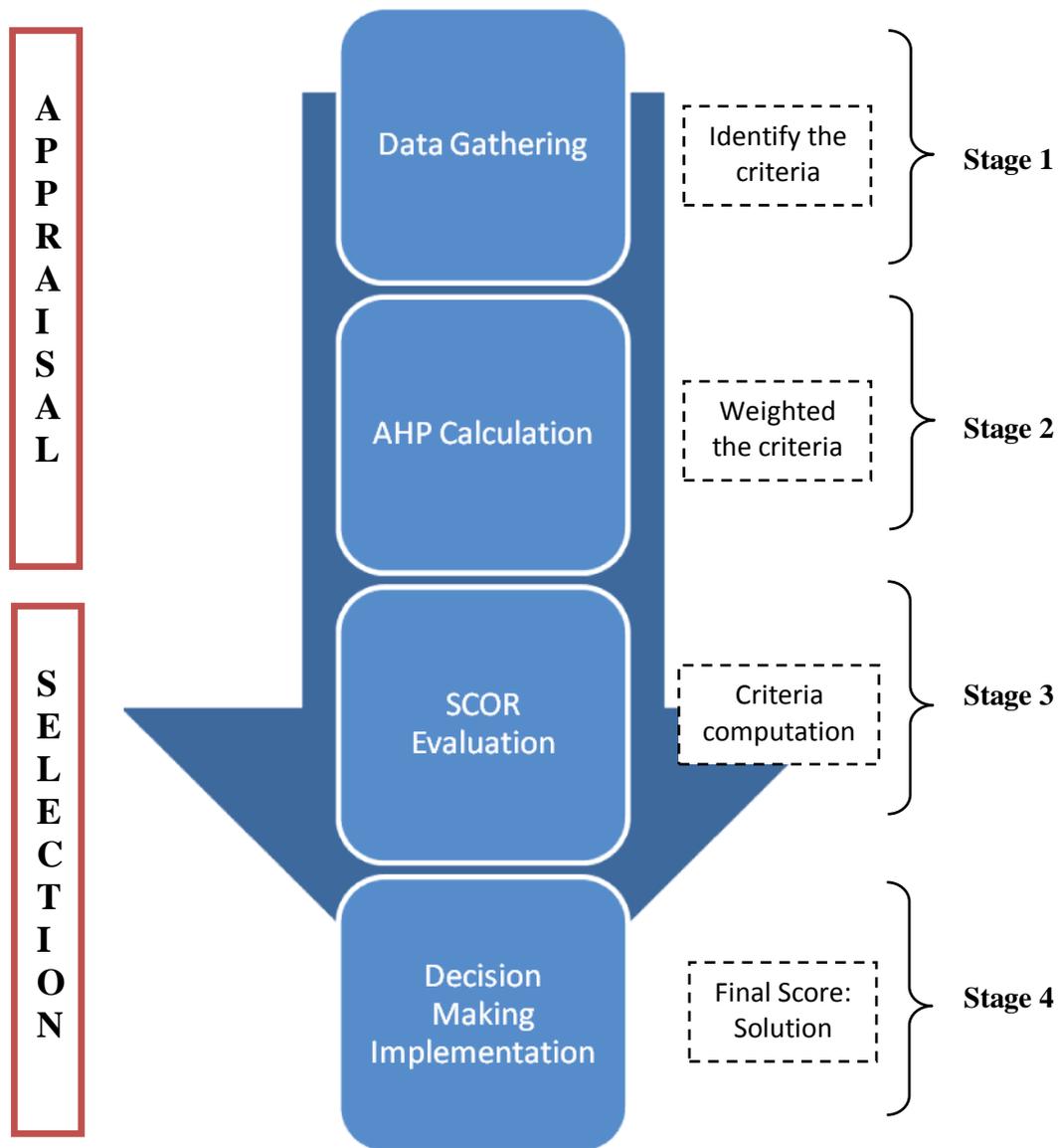


Figure 2: AHP-SCOR Integrated Model