Designing an integrated AHP based decision support system for supplier selection in automotive industry

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A B S T R A C T

Purpose: The purpose of this paper is to propose a decision support model for supplier selection based on analytic hierarchy process (AHP) using a case of automotive industry in a developing country of Pakistan and further performs sensitivity analysis to check the robustness of the supplier selection decision.
Methodology: The model starts by identifying the main criteria (price, quality, delivery and service) using literature review and ranking the main criteria based on experts' opinions using AHP. The second stage in the adopted methodology is the identification of sub criteria and ranking them on the basis of main criteria. Lastly perform sensitivity analysis to check the robustness of the decision using Expert Choice software.
Findings: The suppliers are selected and ranked based on sub criteria. Sensitivity analysis suggests the effects of changes in the main criteria on the suppliers ranking. The use of AHP in the supplier selection gives the decision maker the confidence of the consistency and the robustness throughout the process.
Practical implications: The AHP methodology adopted in this study provides managers in automotive industry in Pakistan with the insights of the various factors that need to be considered while selecting suppliers for their organizations. The selected approach also aids them in prioritizing the criterion. Managers can utilize the hierarchical structure of adopted supplier selection methodology suggested in this study to rank the suppliers on the basis of various factors/criteria.
Originality/value: This study makes three novel contributions in supplier selection area. First, AHP is applied to automotive industry and use of AHP in the supplier selection gives decision maker the confidence of the consistency. Second, sensitivity analysis enables in understanding the effects of changes in the main criteria on the suppliers ranking and help decision maker to check the robustness throughout the process. Last, we find it important to come with a simple methodology for managers of automotive industry so that they can select the best suppliers. Moreover, this approach will also help managers in dividing the complex decision making problem into simpler hierarchy.

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1. Introduction

Supplier selection is one of the strategic decision that companies have to take and are vital as they play significant role in overall supply chain management. It is a multi-criteria decision making (MCDM) problem. In addition, supplier selection in today's competitive market is the most critical function for the success of overall performance of supply chain cycle and organization. The present study focuses on building a decision support system for supplier selection strategy using Analytic hierarchy process (AHP) based on a case study of automotive sector in Pakistan.

1.1. Automobile industry in Pakistan

According to Beşkese and Şakra (2010), the automotive industry is the principle customer for many industrial branches such as iron and steel, light metals, petro-chemicals, glass, tires, etc. Moreover, it creates vast business volume and employment together with its suppliers as well as the auxiliary sectors of marketing, distribution, services, fuel, finance and insurance which supply automotive products/services to customers. That's why automotive industry is considered as a backbone of any industrialized nation and developing country like Pakistan.

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The Automotive industry has been an active and growing field in Pakistan for a long time, however not large enough to be in the prominent list of the top automotive industries, having a stable annual production 100–170 thousand automobiles only. Currently some of the major world automakers have set up assembly plants or are in joint ventures with local companies including Toyota, General Motors, Honda, Suzuki, and Nissan. The total contribution of Auto industry to GDP in 2012 was 2.8% which is likely to increase up to 5.6% in the next 5 years. Auto sector presently, contributes 16% to the manufacturing sector which is predicted to increase 25% in the next 7 years (Hanif, 2012).

After the first produced vehicle in 1953, the journey of auto industry has been rough, tough and sometime very smooth till 2012. Car industry saw boom in 2006–2007 when sales touched record peak of 180,834, the car industry has invested over Rs 20 billion in the last four to five years to meet growing demand. The direct employment in car industry hovers between 5500–6000 workers. Motorcycle production hit the country's record level of over 1.5 million units in 2010–2011. Auto sector now employs 192,000 people directly and around 1.2 million indirectly and has Rs 98 billion of investments and contributes Rs 63 billion as indirect tax in the national exchequer. Auto sector remains the second largest payer of indirect taxes after the petroleum sector in Pakistan (Hanif, 2012).

Pakistan Auto Industry Development Program (AIDP-2006), a study conducted by Ministry of Industries and Production, Government of Pakistan states that the Pakistan Auto Industry has become a leading industrial sector to steer the growth in large scale manufacturing sector. The report further elaborates that Pakistan is amongst a few countries of the world which manufacture all kinds of vehicles i.e. 2/3 wheelers, motorcars, LCVs, tractors, prime-movers &trucks and buses. The total country requirements are generally met from the local production except the import of certain categories of trucks and prime-movers.

As already alluded to, the automotive sector is the second largest sector in Pakistan and a lot of local parts manufacturers or suppliers are there and fulfilling the automotive manufacturer needs and demands. Moreover, local suppliers are key for the country's economic growth (since it is second largest tax payer sector) and a proper section of supplier is must for success. Since this country's economy depends on automotive sectors, so the job of buyer or procurement professionals are not only important but challenging as well. They should identify, define and measure what is best for the company and execute procurement decisions accordingly. In order to identify what is best for the company, supplier selection and its associated criteria selection will play an important role.

1.2. Supplier selection

Supplier selection criteria depends on various factors such as quality of product, price, delivery, financial measures, technical collaboration, company structures, quality systems and supplier experience and its reputation. These major criteria are composed of sub-criteria that may also affect the evaluation of the system. Some companies may have fewer criteria or sub-criteria than others based on experience or maturity level of the company's purchasing system and the availability of data. These criteria and their sub-criteria can be identified through literature review. The weight (effect) of each criteria and sub-criteria will be determined by soliciting experts' opinions through a survey of experts. The purpose of this survey is only to enumerate the critical success factors that will form the basis to identify the specific criteria and sub-criteria to formulate the AHP model.
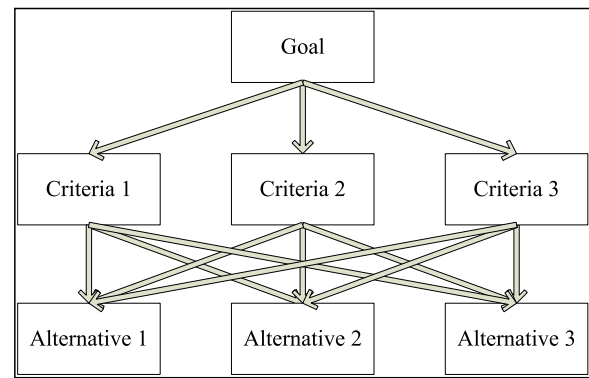

Fig. 1. AHP structure (adopted from Khan et al. 2016).

Table 1
Importance scale of factors in pair-wise comparison.

Importance scale	Importance description
1	Equal importance of "i" and "j"
3	Weak importance of "i" over "j"
5	Strong importance of "i" over "j"
7	Demonstrated importance of "i" over "j"
9	Absolute importance of "i" over "j"

Note: 2, 4, 6 and 8 are intermediate values.

1.3. Analytical hierarchy process

AHP is a common multi-criteria decision making method .It is developed by Saaty to assist in solving complex decision problems by capturing both subjective and objective evaluation measures. It breaks a complex problem into hierarchy or levels as shown in Fig. 1 below.

AHP uses a pair-wise comparison of the criteria importance with respect to the goal. This pair wise comparison allows finding the relative weight of the criteria with respect to the main goal. If quantitative data is available, the comparisons can be easily performed based on a defined scale or ratio and this cause the inconsistency of the judgment will be equal to zero which leads to perfect judgment.

If quantitative data is not available, a qualitative judgment can be used for a pair wise comparison. This qualitative pair wise comparison follows the importance scale suggested by Saaty (1980) as shown in Table 1.

The same process of pair-wise comparison is used to find the relative importance of the alternatives with respect to each of the criteria.

Each child has a local (immediate) and global priority (weight) with respect to the parent. The sum of priorities for all the children of the parents must equal 1. The global priority shows the alternatives relative importance with respect to the main goal of the model. The pair-wise comparison is performed in matrix format to check the consistency of the judgment.

The size of the comparison matrix (**A**) is $n \times n$ where n is the number of children (criteria or alternatives) being compared with relative to a specific parent (goal or the criteria). The elements of the matrix are a_{ij}. The matrix **A** is considered consistent if all of its elements are transitive and reciprocative such as

$$a_{ij} = a_{ik} \times a_{jk}$$
$$a_{ij} = 1/\ a_{jk}$$

where i, j and k are any elements of the matrix **A**.

$$\mathbf{A} = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix}$$

where $a_{ij} = 1$ when $i = j$.