Application of fuzzy analytic network process for supplier selection in a manufacturing organisation

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ABSTRACT

The contemporary manufacturing organisations are forced to adopt advanced manufacturing paradigms for sustaining in the global markets. Supply chain management is an essential ingredient of advanced manufacturing systems since outsourcing gains vital importance. Supplier selection is a vital issue concerned in the process of managing global supply chains. A conceptual model for supplier selection encompassing various criteria and sub-criteria has been developed. In this article, fuzzy analytic network process (fuzzy ANP) approach has been used for the supplier selection process. The case study has been carried out in an Indian electronics switches manufacturing company. Based on supplier selection weighted index, the best supplier has been determined. This is followed by the conduct of sensitivity analysis as well as questionnaire-based validation. The results of the validation study indicated that the application of fuzzy ANP is practically feasible and adaptable in the contemporary industrial scenario.

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1. Introduction

Increasing competition has been forcing the manufacturing organisation to respond to dynamic demands of the customers (Cater, 2005). Contemporary manufacturing paradigms such as Agile Manufacturing demand the concept of outsourcing by adopting the principles of supply chain management (Gunasekaran, Lai, & Cheng, 2008). Supply chain encompasses all activities associated with the flow and transformation of goods from the raw material stage through to the end user as well as the associated information flows. Supply chain focuses on the improvement of customer service, profitability and business performance. Strategic partnership with better suppliers needs to be formed to improve quality, flexibility as well as to reduce lead time. Supplier selection is a cross-functional group decision making problem ensuring long-term commitment for the organisation. The problem of supplier selection is a multi-criteria decision making (MCDM) problem in the presence of many criteria and sub-criteria. A decision maker needs to make use one of the MCDM methods (Ayag & Ozdemir, 2009). Some of the widely used MCDM methods include analytic hierarchy process (AHP), analytic network process (ANP), strategy aligned fuzzy simple multi-attribute rating technique (SMART) (Chou & Chang, 2008), grey relational analysis (GRA). AHP is a hierarchically structured technique that concentrates, compares and evaluates the influence of various elements on the objectives. But practical decision making problems cannot be structured hierar-

chically because the interactions and dependencies are involved across the elements at various levels. This situation necessitated a holistic approach. ANP is a technique that overcomes the limitations of AHP. A holistic approach like ANP is required if all the attributes and alternatives are networked in a system to accept various dependencies. Two types of ANP include conventional and fuzzy type. In conventional ANP, pairwise comparisons at each level with respect to the objective of best supplier selection are conducted using a 9-point Saaty scale (Guneri, Cengiz, & Seker, 2009). The drawbacks associated with conventional ANP include crisp decision making, unbalanced judgement scale, imprecise and subjective judgement. Due to the vagueness and uncertain decision making with conventional ANP, the concept of fuzzy ANP is found to be advantageous. Fuzzy ANP replaces the hierarchies into a networked structure, in which all elements are interlinked (Chang, Wey, & Tseng, 2009). Due to this reason, fuzzy ANP has been used in this research project. The case study has been conducted in an Indian electronics switches manufacturing company. The experiences of the conduct of this case study with a focus on best supplier selection have been presented in the following sections of this article.

2. Literature review

The literature review has been carried out by referring to leading journal databases. The literature has been reviewed from three perspectives: (1) various methods used for supplier selection, (2) applications of ANP and (3) applications of fuzzy ANP.

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Table 1
Methods used for supplier selection process

Research articles	Contributions
Semih and Ik (2009)	A supplier evaluation approach based on ANP and the technique for order performance by similarity to ideal solution (TOPSIS) methods to help a telecommunication company in the GSM sector in Turkey under the fuzzy environment has been presented.
Wu (2009)	A hybrid model has been presented using data envelopment analysis (DEA), decision trees (DT) and neural networks (NNs) to assess supplier performance. The model consists of two modules: Module 1 applies DEA and classifies suppliers into efficient and inefficient clusters based on the resulting efficiency scores. Module 2 utilizes firm performance-related data to train DT, NNs model and apply the trained decision tree model to new suppliers. This results in favourable classification and prediction of accuracy rate.
Lin (2009)	A comprehensive decision method has been suggested for identifying top suppliers by considering the effects of interdependence among the selection criteria, as well as to achieve optimal allocation of orders among the selected suppliers. An integrated fuzzy analytic network process - multi objective linear programming (FANP-MOLP) approach has been used
Chou and Chang (2008)	A SMART approach has been used for solving the supplier/vendor selection problem from the perspective of strategic management of the supply chain.
Li, Yamaguchi, and Nagai (2007)	A new grey-based approach to deal with the supplier selection problem has been proposed.
Demirtas and Ustun (2008a)	An integration of ANP and multi-objective mixed integer linear programming (MOMILP) is proposed to consider both tangible and intangible factors in choosing the best suppliers and define the optimum quantities among selected suppliers to maximize the total value of purchasing and minimize the budget and defect rate.
Verma and Pullman (1998)	An examination of the difference between managers' rating of the perceived importance of different supplier attributes and their actual choice of suppliers in an experimental setting has been presented.
Ghodsypour and O'Brien (1998)	An integration of AHP and linear programming is proposed to consider both tangible and intangible factors in choosing the best suppliers and placing the optimum order quantities such that the total value of purchasing (TVP) becomes the maximum.
Choi and Hartley (1996)	Supplier selection practices across the supply chain have been explored. They have compared the supplier selection practices based on a survey of companies at different levels of auto industry. compare

2.1. Literature review on various methods used for supplier selection

The various methods used for supplier selection process are shown in Table 1.

2.2. Literature review on the applications of ANP

As inferred from Table 2, ANP has been applied for partner selection, organisation selection, purchasing decisions, multi-objective decision making as well as in optimum order quantity allocation.

2.3. Literature review on the applications of fuzzy ANP

The various applications of fuzzy ANP are shown in Table 3.

2.4. Research gap and problem domain

Selection of best supplier is a contemporary research issue in the field of SCM. Various approaches have been used by the researchers for supplier selection. Since the conceptual framework of supplier selection is a networked structure, techniques like fuzzy ANP have to be used. In this context, fuzzy ANP has been used for selecting the best supplier, which formed the problem domain of this article.

3. Research methodology

The methodology followed during this research project is shown in Fig. 1.

As shown, the project begins with the literature review on supplier selection models and applications of ANP and fuzzy ANP. A conceptual model for supplier selection has been designed. After developing the conceptual model, a suitable organisation for conducting the case study has been selected, and then, the necessary data have been gathered for conducting the case study. Then, fuzzy ANP has been selected as the technique for supplier selection process. This is followed by the execution of various steps in fuzzy ANP for selecting the best supplier. Based on supplier selection weighted index (SSWI) generated out of fuzzy ANP, the best supplier has been selected. This is followed by the conduct of sensitivity analysis for validating the sensitivity results of fuzzy ANP. Then, the results have been practically validated in the industrial scenario to explore its feasibility.

4. Case study

This section deals with the details about the case company, background of the case study and fuzzy ANP approach for supplier selection.

Table 2
Various applications of ANP.

Research articles	Contributions
Wu et al. (2009)	An integrated approach of ANP has been proposed to consider both tangible and intangible factors and to optimize the paid off earn by company from strategic alliance.
Wu et al. (2009)	An integrated multi-objective decision-making process by using ANP and mixed integer programming (MIP) to optimize supplier selection process has been presented.
Demirtas and Ustun (2008b)	ANP and multi-period goal programming integration has been used in purchasing decisions.
Lang, Chiang, and Lan (2009)	A novel hierarchical evaluation framework to assist the expert group to select the optimal supplier in supply chain management strategy (SCMS).
Ustun and Demirtas (2009)	An integrated approach of ANP and multi-objective mixed integer linear programming (MOMILP) is proposed to consider both tangible and intangible factors in choosing the best suppliers and define the optimum quantities among selected suppliers to maximize the total value of purchasing and minimize the budget and defect rate.
Ustun and Demirtas (2008)	An integration of ANP and achievement of scalarising functions is proposed to choose the best suppliers and define the optimum quantities among the selected suppliers by considering tangible–intangible criteria and time horizon.
Gencer and Gurpinar (2007)	An approach using ANP in supplier selection to evaluate the relations between supplier selection criterias in a feedback systematic.
Gencer and Gurpinar (2007)	ANP in supplier selection has been developed and implemented in an electronics company.