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Development of a decision support system for supplier evaluation and order allocation

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ABSTRACT

This study aims to develop models and generate a decision support system (DSS) for the improvement of supplier evaluation and order allocation decisions in a supply chain. Supplier evaluation and order allocation are complex, multi criteria decisions. Initially, an analytic hierarchy process (AHP) model is developed for qualitative and quantitative evaluation of suppliers. Based on these evaluations, a goal programming (GP) model is developed for order allocation among suppliers. The models are integrated into a DSS that provides a dynamic, flexible and fast decision making environment. The DSS environment is tested at the purchasing department of a manufacturer and feedbacks are obtained.

1. Introduction

Successful supply chain management requires an effective and efficient sourcing strategy to eliminate the uncertainties in both supply and demand. Sourcing decisions are critical more than ever, since with the increase of the purchasing costs as compared to the overall costs, the purchasing function and the purchasing decisions have gained a considerable importance at each firm. On average, a typical manufacturing company spends 60% of its total turnover in purchasing materials, goods and services acquired from external suppliers (Bayrak, Çelebi, & Taşkın, 2007). Thus purchasing decisions have significant effects on lowering costs and increasing profits.

Sourcing decisions have some characteristics which are affected by globalization and the recent advances in information technologies. These decisions require the analysis of large amount of data obtained globally and this raises the issue of using advanced models in decision making. Secondly, sourcing decisions require the involvement of several decision makers in the global environments that further increases the complexity of decision making. Moreover sourcing decisions are made periodically and require tracking of the supplier performances on a regular basis. Computerized decision support systems (DSS) are often proposed as a remedy to overcome the difficulties and complexities involved in such decision processes.

Purchasing processes are analyzed in two stages: first stage is the selection of suppliers formally by filtering them through an evaluation process that includes both qualitative and quantitative measures. Second stage is the order allocation where the order amounts for each supplier are determined. Although there are numerous studies in the literature for supplier evaluation and order allocation, very few companies consider these approaches in their decision making processes. The reasoning is mostly due to the fact that manual application of these models is quite time consuming, complex and most often requires a model expert. Besides, these decisions are repetitive processes; companies not only seek for a single evaluation but also need to keep track of past performances of the suppliers. Moreover, the targets and the related constraints in the decision process are subject to change in time. Thus the models should be supported by integrated databases. In application, all these features should be embedded into a DSS that provides a dynamic, fast and flexible environment for decision making. This fact is heavily emphasized in the recent studies by Ordoobadi (2009a, 2009b), Pal and Kumar (2008), Ting and Cho (2008) as well as the earlier studies by Yang and Chen (2005) and Lee, Ha, and Kim (2001). In this study, such a DSS is developed and experimented in one of the leading white goods manufacturers in Turkey. The model base includes an analytic hierarchy process (AHP) model which is developed for supplier evaluation by using qualitative and quantitative criteria. Furthermore, a goal programming (GP) model is developed that uses the evaluations of the AHP model and allocates orders among suppliers.

The organization of the study is as follows: in Section 2, a literature survey of the recent studies on supplier selection problem and DSS applications are provided. In the third and fourth sections, the methodology of the study is introduced and the multi criteria decision models are developed. In Section 5, the DSS is presented with illustrations. Finally, conclusion and future work are proposed.

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2. Literature survey

Supplier evaluation and order allocation problem has attracted the attention of several researchers in the last decade. Boer, Labro, and Morlacchi (2001) present a review of decision methods reported in the literature for supporting the supplier selection process. Göçen (2008) groups the studies in the literature according to the methodologies used for supplier evaluation/selection and order allocation respectively. In a very recent study Ho, Xu, and Day (2010) review the literature related to multi-criteria decision making approaches for supplier evaluation and selection. Accordingly, the methods used for supplier selection can be categorized as linear weighting models like analytic hierarchy process (AHP), interpretive structural modeling (ISM), fuzzy set theory (FST); Total cost of ownership models; mathematical programming models such as linear programming (LP), mixed integer programming (MIP), goal programming (GP), data envelopment analysis (DEA); statistical/probabilistic models and artificial intelligence models like case based reasoning (CBR), genetic algorithm (GA), neural network (NN), expert systems (EX).

In an overall analysis of 181 articles referenced within these studies, AHP related methodologies seem to be the most popular techniques which are applied in over 36% of the studies. This is mostly due to the fact that AHP incorporates both qualitative and quantitative evaluation of the decision maker by the use of tangible and intangible factors designed in a hierarchical manner. It is suitable, flexible and easy-to-use for multi criteria decision making and can be applied in group decision making environments as well (Ho, 2008). Although the existence of large number of pair wise comparisons brings some limitations on the number of criteria used, this method has been proposed by many researchers to capture the individual judgments with all its facets (Forman & Gass, 2001).

The supplier evaluation process is followed by the order allocation decisions that are made mostly by developing mathematical programming approaches for multi criteria decision making. The great majority of the studies in the literature are dedicated to supplier selection problem only. The integrated models, which support both supplier evaluation and order allocation, constitute 23% of all the studies in this area. By its nature, order allocation problem includes several targets to be reached and thus, GP is widely used in order allocation for the selected suppliers.

In the extensive review on the approaches adopted in supplier evaluation and selection literature, Ho et al. (2010) propose that the integrated AHP–GP approach for supplier evaluation and order allocation is the most popular method. The main reason is that both AHP and GP have unique advantages respectively. The consistency verification operation of AHP ensures the unbiased evaluation on main criteria and sub criteria by the decision maker. AHP results provide consistent weightings of alternative suppliers; however, the decision maker needs to consider other constraints such as overall budget, quality of the supplies, time limitations, technology used in production, etc. while distributing the annual supply quota to its suppliers. GP provides a suitable model to evaluate these limitations so the integrated AHP–GP approach is assessed as the most beneficial technique for supplier evaluation and order allocation (Ho et al., 2010).

In the evolutionary context, Ghodsypour and O'Brien (1998) study is the earliest work that considers an integrated AHP-LP model to choose the best suppliers and place the optimum order quantities among them. Among the followers, Çebi and Bayraktar (2003) develop an integrated model by using AHP and lexicographic goal programming (LGP) to solve the supplier selection and order allocation problem. Wang, Huang, and Dismukes (2004) combine AHP and preemptive goal programming (PGP) to solve the supplier selection and order allocation problem. Wang, Huang, and Dismukes (2005) further improve the previous study and generate a procedure to calculate the overall supply chain effectiveness based on the effectiveness of supply item, product and supplier.

In addition to these inspiring studies, there exist more recent studies published in distinguished journals between 2005 and 2010. Liu and Wu (2005) combine AHP with DEA to make better decisions in supplier selection for order allocation. Yang and Chen (2005) incorporate gray relational analysis to the AHP methodology to select the best suppliers for cooperation. Bayazit and Karpak (2005) and Bayazit (2006) develop an AHP based model for vendor selection and sensitivity analysis is proposed for optimization. Bei, Wang, and Hu (2006) develop an AHP based model to find the most preferred supplier in manufacturing supply chain. Liao and Rittscher (2007) propose a non linear mixed integer programming model where the effect of lot sizing and carrier selection is included for dynamic demand allocation to suppliers. Perçin (2006) applies AHP-PGP integrated model for the order allocation problem of an automotive manufacturer. Aguezzoul and Ladet (2007) apply mixed non-linear programming for the order allocation model and the role of transportation is examined in order diversification. Özgen, Önüt, Tuzkaya, and Tuzkaya (2008) apply a two phase probabilistic linear programming methodology for multi-objective supplier evaluation and order allocation problems. Sevkli, Koh, Zaim, Demirbag, and Tatoglu (2007) propose AHP and weighted fuzzy linear programming (FLP) to solve the order allocation problem for an electronics manufacturer. Ha and Krishnan (2008) implement an integrated model of AHP, DEA and NN for supplier evaluation. Kokangul and Susuz (2009) develop an integrated model with AHP and multi objective non-linear integer programming where quantity discounts are incorporated at the mathematical model.

Although substantial modeling studies have been made for supplier evaluation and order allocation, the implementations by an advanced DSS is very few. Owing to the fact that supplier evaluation and order allocation decisions are multi criteria problems and require lengthy analysis on a periodical basis, it is recommended to implement the proposed methodologies into computer software and internet-based tools (Lee et al., 2001; Ordoobadi, 2009a, 2009b; Pal & Kumar, 2008; Ting & Cho, 2008; Yang & Chen, 2005).

There exist few numbers of studies which come up with a DSS development, but consider only the supplier evaluation problem. Humphreys, Huang, and Cadden (2005) develop a web based supplier evaluation tool by using expert systems. Humphreys, Wong, and Chan (2003) develop a knowledge-based DSS tool which helps companies to integrate environmental criteria into their supplier selection process. Choy et al. (2002a), Choy, Lee, and Lo (2002b) implement intelligent supplier management tools via case based reasoning and neural network. Akarte, Surendra, Ravi, and Rangaraj (2001) use AHP as a web based tool for the supplier evaluation process. Vokurka, Choobineh, and Vadi (1996) develop a prototype expert system to evaluate the potential suppliers.

Choi and Chang (2006) is the only study where a DSS is developed for the integrated problem of supplier evaluation and order allocation in a business to business e-procurement environment. Their approach is based on a two phased optimization that semantically builds a goal model through model identification and candidate supplier screening by a set of predefined rules. Our current study is similar to this study since a GP model based DSS is generated both for supplier evaluation and order allocation. However, it differs from this study with the inclusion of an AHP model that also handles the qualitative criteria in supplier evaluation. Furthermore the GP model is set with a different perspective of formulating the goals.