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# Revisiting the supplier selection problem: An integrated approach for group decision support

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ABSTRACT

Decision support for supplier selection is a highly researched theme in procurement management literature. However applications of group decision support theories are yet to be explored extensively in this domain. This study proposes an approach for group decision support for the supplier selection problem by integrating fuzzy Analytic Hierarchy Process (AHP) for group decision making and fuzzy goal programming for discriminant analysis. In the first step, the fuzzy AHP theory with the Geometric Mean Method has been used to prioritize and aggregate the preferences of a group of decision makers. Then consensus has been developed between these aggregated priorities using the Ordinal Consensus Improvement Approach. Subsequently, the consensual priorities of this group of decision makers have been integrated with fuzzy goal programming theory for discriminant analysis to provide predictive decision support. Finally it has been shown through a case study how the integrated approach using fuzzy AHP for group decision making and fuzzy goal programming with soft constraints has been more effective as compared to an existing approach for group decision making using only AHP.



## 1. Introduction

An extremely important activity in supply chain management is procurement management, being a primary point of contact with the supply chain partners. Therefore reviews of supply chain literature (e.g., Burgess, Singh, & Koroglu, 2006) indicate significant focus on procurement management in general and supplier selection in particular. Although it has been established that collective intelligence of a group of expert decision makers in consensus often is more effective than decision makers working in isolation for complex processes (Kerr & Tindale, 2004), there has been fewer attempts to extend theories for group decision making to the supplier selection problem, despite both domains having a plethora of literature in isolation.

In this study, theories for group decision making and discriminant analysis have been adopted to address this gap within existing literature. The study highlights the integrated application of fuzzy Analytic Hierarchy Process (AHP) and fuzzy goal programming (FGP) approaches for providing decision support for the supplier selection problem. In this study, the consensual preferences of a group of experts have been estimated using the fuzzy AHP theory for prioritization and aggregation. This output has been further integrated with fuzzy goal programming approaches for discriminant analysis whereby suppliers have been mapped to two soft overlapping sets consisting of highly capable class and less capable suppliers. For a firm, it would be more beneficial to source from the set of highly capable suppliers than from the set of less capable suppliers. Discriminant analysis based on fuzzy goal programming approaches further provides predictive decision support so that the selection process may be automated, without the continuous involvement of decision makers at every stage of the analysis. Finally, the outcome of this integrated approach has been compared with another approach for group decision support based on AHP and the improvement in outcome has been highlighted.

## 2. Review of literature

### 2.1. Overview of related decision support literature in supplier selection

Decision support literature is extremely extensive in supplier selection domain due to the conflicting nature of the goals and diversity of the evaluation criteria. Therefore many novel approaches like data envelopment analysis; interpretive structural modeling; cost minimization models, multi-attribute deterministic models; outranking models; neural networks; genetic algorithms and agent based models have been utilized in providing decision support for supplier selection. AHP and mathematical programming are two of the more popular approaches for the supplier selection problem (Ho, Xu, & Dey, 2010; Chai, Liu, & Ngai, 2012).

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AHP became a popular approach to provide decision support since it could analyze both qualitative and quantitative data. While some of the earlier studies adopted a crisp approach; the slightly recent studies integrated AHP with fuzzy set theory to accommodate the subjectivity in human decision making. Similarly many studies have demonstrated the application of methodologies based on mathematical programming for supplier selection. These studies have attempted to address the trade-offs of different criteria to achieve the most satisfying solution under context specific constraints. Table 1 provides a glimpse of some of the notable studies based on AHP and mathematical programming theories which provides decision support for supplier selection:

Despite a plethora of literature on supplier selection, none of these studies focused on providing group decision support to the supplier selection domain. Only a few studies have used group decision support theories for addressing this domain using approaches like AHP (Yahya & Kingsman, 1999; Muralidharan, Anantharaman, & Deshmukh, 2002; Lai, Wong, & Cheung, 2002; Cheng & Tang; 2009; Suergit, 2010; Büyüközkan, 2012; Kar & Pani, 2014), mathematical programming (Sanayei, Mousavi, Abdi, & Mohaghar, 2008), TOPSIS (Boran, Genc, Kurt, & Akay, 2009), VIKOR (Sanayei, Mousavi, & Yazdankhah, 2010) and ELECTRE (Devi & Yadav, 2012). For studies using AHP, Yahya and Kingsman (1999) and Muralidharan et al. (2002) focused on group decision making using the Eigen Vector Method for the prioritization of judgments of the group of experts. Similarly, although Lai et al. (2002), Cheng and Tang (2009) and Suergit (2010) used the geometric mean for prioritization but the achievement of consensus was not explored.

However, although consensus achievement is an important criteria of success in group decision making (Herrera-Viedma, Alonso, Chiclana, & Herrera, 2007; Chiclana, Mata, Martinez, Herrera-Viedma, & Alonso, 2008; Moreno-Jiménez, Aguarón, & Escobar, 2008), consensus development was not explored properly earlier due to the recent development of some of these theories. Again, Büyüközkan (2012) explored an axiomatic design based fuzzy group decision-making approach using AHP. To the best of our knowledge, only Kar and Pani (2014) explored the achievement of consensus using fuzzy AHP for prioritization, but the focus was limited to ranking few suppliers, although how the approach can be extended for predictive decision support was also suggested. The current study extends Kar and Pani (2014) by integrating fuzzy AHP with FGP and thus provides soft predictive decision support through discriminant analysis.

**Table 1**
Supplier selection studies using AHP and mathematical programming.

| Analytic Hierarchy Process | Mathematical programming |
|---|---|
| Arbel and Seidmann (1984) | Ghodsypour and O'Brien (2001) |
| Nydick and Hill (1992) | Karpak, Kumcu, and Kasuganti (2001) |
| Masella and Rangone (2000) | Talluri (2002) |
| Rapcsak, Sagi, Toth, and Ketszeri (2000) | Talluri and Narasimhan (2003) |
| Tam and Tummala (2001) | Talluri and Narasimhan (2005) |
| Handfield, Walton, Sroufec, and Melnyk (2002) | Hong, Park, Jang, and Rho (2005) |
| Zaim, Sevkli, and Tarim (2003) | Narasimhan, Talluri, and Mahapatra (2006) |
| Kahraman, Cebeci, and Ulukan (2003) | Wadhwa and Ravindran (2007) |
| Hsu and Chen (2007) | Ng (2008) |
| Lee (2009) | Wu, Zhang, Wu, and Olson (2010) |
| Hsu, Lee, and Kreng (2010) | Yücel and Güneri (2011) |
| Pani and Kar (2011) | Amin and Zhang (2012) |
| *Integrated approaches using AHP and mathematical programming* | |
| Ghodsypour and O'Brien (1998) | Cebi and Bayraktar (2003) |
| Xia and Wu (2007) | Kull and Talluri (2008) |
| Mendoza, Santiago, and Ravindran (2008) | Demirtas and Ustun (2008) |
| Demirtas and Ustun (2009) | Kokangul and Susuz (2009) |
| Kar, Pani, Mangaraj, and De (2011) | Shaw, Shankar, Yadav, and Thakur (2012) |
| Kannan, Khodaverdi, Olfat, Jafarian, and Diabat (2013) | Kar (2013) |

### 2.2. Decision support literature on group decision making

Decision support literature on group decision making has been extensively explored while focusing on objectives like structuring; ordering and ranking; and structuring and measuring within a focused problem domain (Peniwati, 2007). Different decision support approaches have been discussed in literature for addressing group decision making. Some of such popular approaches are the outranking models (Tavares, 2012), delphi method (Okoli & Pawlowski, 2004), multi-attribute theories (Wei, 2010; Pang & Liang, 2012), analytic network process (Levy & Taji, 2007), TOPSIS (Shih, Shyur, & Lee, 2007; Chen & Lee, 2010; Tan, 2011; Yue, 2012), preference distance based approaches (Yue, 2011; Tapia Garcia, Del Moral, Martínez, & Herrera-Viedma, 2012), multi-stage approaches (Silver, 1995) and different multi-valued logic based approaches (Zhang & Liu, 2011; Chen, Wang, & Lu, 2011; Chen & Niou, 2011; Chen, Lee, Yang, & Sheu, 2012; Wang & Li, 2012), to name a few. AHP is another well-developed approach for providing group decision support, and has been used in this study. However, only a few of these approaches have been explored for application in the supplier selection domain, as discussed earlier.

### 2.3. Group decision support using the Analytic Hierarchy Process

For estimating the collective preferences of a group of decision makers in consensus, a fuzzy AHP for group decision making has been used in this study. The AHP is a theory of measurement used for hierarchic problems where the solution to the main problem is obtained by solving the hierarchy of sub-problems iteratively. It is used to derive priorities from discrete and continuous paired comparisons taken from a scale reflecting the relative strength of judgments.

AHP is extremely suitable for group decision making due to specific reasons. Firstly, AHP has appropriate theories to estimate consistency of priorities of decision makers (Saaty, 1980; Aguaron, Escobar, & Moreno-Jiménez, 2003; Aguarón & Moreno-Jiménez, 2003; Escobar, Aguarón, & Moreno-Jiménez, 2004; Moreno-Jiménez et al., 2008). Secondly, there are systemic approaches to improve the consistency of priorities (Finan & Hurley, 1997; Xu & Wei, 1999; Cao, Leung, & Law, 2008). Thirdly, it provides different methods for the aggregation of group preferences (Dyer & Forman, 1992; Honert & Lootsma, 1997; Forman & Peniwati, 1998; Bolloju, 2001; Condon, Golden, & Wasil, 2003; Beynon, 2005; Escobar & Moreno-Jiménez, 2007). Also there are robust theories for consensus building within groups (Bryson, 1996; Honert, 1998; Escobar et al., 2004; Moreno-Jiménez et al., 2008; Dong, Zhang, Hong, & Xu, 2010; Wu & Xu, 2012). However the application of these theories for group decision making is yet to be explored extensively for supplier selection.

Two of the popular approaches for deriving the priorities within AHP theory are the Eigen Vector Method (EVM) and the Geometric Mean Method (GMM). EVM (Saaty, 1980) is the classic theory where prioritization is achieved by solving a linear system consisting of a matrix of judgments from a decision maker. In the GMM (Crawford & Williams, 1985), prioritization is achieved by the computation of the geometric mean of criteria specific judgments within a row in the judgment matrix. Aggregating judgments from expert decision makers using GMM improves both the sensitivity to extreme estimates and preservation of reciprocal properties. GMM also has lower computational time complexity as compared to EVM (i.e., $o(n)$ vis-à-vis $o(n^2)$. Thus GMM is the preferred