INTEGRATION OF AN IMPROVED GREY-BASED METHOD AND FUZZY MULTI-OBJECTIVE MODEL FOR SUPPLIER SELECTION AND ORDER ALLOCATION

OMID JADIDI

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INTEGRATION OF AN IMPROVED GREY-BASED METHOD AND FUZZY MULTI-OBJECTIVE MODEL FOR SUPPLIER SELECTION AND ORDER ALLOCATION

By

OMID JADIDI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirement for the Degree of Master of Science

April 2009
DEDICATION

To

My Parents and Wife
INTEGRATION OF AN IMPROVED GREY-BASED METHOD AND FUZZY MULTI-OBJECTIVE MODEL FOR SUPPLIER SELECTION AND ORDER ALLOCATION

By

OMID JADIDI

April 2009

Chairman : Associate Professor Tang Sai Hong, PhD
Faculty : Engineering

For multi-attribute decision making (MADM) problems, a grey based approach (LI) had been developed to evaluate, rank and select the best suppliers. The method calculates a grey possibility degree between compared suppliers alternatives set and positive ideal referential alternative. The drawback of the method is that the negative ideal referential alternative is not considered in evaluating and ranking of the alternatives. Moreover, the method can only consider interval fuzzy number as input data and real number is neglected. Based on this model and other MADM methods, all demand was sold by the best supplier. In other cases, if the best supplier cannot satisfy all demand, multi-objective programming is used to formulate the problem and assign optimum order quantities to the best suppliers (multi-sourcing). Some techniques, such as goal programming (GP) approach, ε-Constraint method, Reservation level (RL) driven Tchebycheff procedure (RLTP) method had been proposed to solve the multi-objective models. It may be a problem that these
techniques traced back to more than 10 years ago. Therefore, there may be still the need to produce a new technique in order to solve the multi-objective models.

In this study, to overcome the first drawback, the LI method was improved based on the concepts of technique for order preference by similarity to ideal solution (TOPSIS) to consider both the positive and the negative ideal referential alternative for evaluation of the suppliers. The improved version of the LI method is called the I.LI method. Based on the concepts of TOPSIS, the chosen alternative should have the shortest distance from the positive ideal solution and the farthest from the negative ideal solution. Moreover, in order to solve the problems, a new grey based method (NG) based on the TOPSIS concepts was proposed that can easily consider both interval fuzzy number and real number simultaneously. Afterwards, an innovative comparative approach was proposed to compare the three MADM methods, the LI, the I.LI and the NG methods, and to show that which method is more optimal than the other methods.

Subsequently, in this thesis, an integration of the NG method and fuzzy multi-objective model was suggested for multi-sourcing and multi-product supplier selection problem. The score of suppliers calculated by the NG method was served as coefficients in one objective function of the multi-objective model. In this fuzzy multi-objective model, the products are divided into two independent and dependent products so that (1) the price breaks (discounts) depend on the size of the order quantities, (2) independent products’ sales volume affect the prices and discounts of the dependent products and (3) all products must be sold as a bundle. Finally, to overcome the third problem, a new weighted additive function, which is able to
consider relative importance of each objective as well as condition of fuzzy situation, is proposed to solve the fuzzy multi-objective model and assign optimum order quantities to the suppliers evaluated and ranked by the NG method.

The results of the innovative comparative approach showed that the result of the NG method is more optimal than the I.LI method and the latter is more optimal than the LI method. Therefore, the NG method was selected to be integrated with the fuzzy multi-objective model. Also, the fuzzy multi-objective model was solved by the new weighted additive function, and the results demonstrated that besides considering the relative importance of the objectives, the new technique is also able to consider the condition of fuzzy situation.
Abstrak tesis yang dikemukakan kepada Senat bagi Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

INTEGRASI PENAMBAHBAIKAN KAEDAH GREY-BASED DAN MODEL FUZZY MULTI-OBJECTIVE UNTUK PEMILIHAN PEMBEKALAN DAN PENENTUAN PEMESANAN

oleh

OMID JADIDI

April 2009

Pengerusi : Profesor Madya Dr. Tang Sai Hong, PhD
Fakulti : Kejuruteraan

teknik-teknik ini dikesan kembali lebih daripada 10 tahun lalu. Oleh itu, mungkin ada keperluan untuk menghasilkan teknik terbaru dengan tujuan menyelesaikan model-model multi objektif.

Dalam kajian ini, untuk mengatasi kelemanah yang pertama, kaedah LI telah diperbaiki berdasarkan konsep bagi teknik untuk susunan keutamaan oleh persamaan untuk penyelesaian yang ideal (TOPSIS) dengan mempertimbangkan kedua-dua positif dan negatif rujukan alternatif yang ideal bagi penilaian ke atas pembekal. Kaedah LI yang telah diperbaiki dipanggil kaedah I.LI. Berdasarkan konsep TOPSIS, pilihan alternatif sepatutnya mempunyai jarak terdekat bagi penyelesaian ideal yang positif dan jarak terjauh bagi penyelesaian ideal yang negatif. Dengan tujuan menyelesaikan masalah 1 dan 2, satu kaedah baru grey based (NG) berdasarkan konsep TOPSIS telah dicadangkan yang membolehkan pertimbangan dibuat ke atas kedua-dua nombor perantaraan fuzzy dengan nombor sebenar secara serentak. Satu pendekatan perbandingan yang berinovasi telah dicadangkan untuk membandingkan tiga kaedah MADM, iaitu LI, I.LI dan kaedah NG dan bagi menunjukkan kaedah yang mana merupakan lebih optimum daripada kaedah yang lain.

Dalam tesis ini, satu pengintegrasian kaedah NG dan model fuzzy multi-objective telah diusulkan bagi penyelesaian masalah pemilihan pembekal multi-sourcing dan multi-product. Mata bagi pembekal dihitung oleh kaedah NG dalam satu fungsi objektif model multi-objektif. Dalam model fuzzy multi-objektif, produk-produk akan dibahagikan kepada dua iaitu produk independen dan produk dependen supaya (1) pecahan harga (diskaun-diskaun) bergantung kepada saiz kuantiti yang ditempah, (2) jumlah jualan produk independen bergantung kepada harga dan diskaun produk-produk lain dan (3) kesemua produk mesti dijual secara pukal. Akhir sekali, untuk
mengatasi masalah ketiga, fungsi baru bahan tambah berat, yang dapat menimbangkan kepentingan relatif bagi setiap objektif serta keadaan bersifat fuzzy, adalah dicadangkan untuk tangani model fuzzy multi-objektif dan menentukan kuantiti pesanan yang optimum kepada para pembekal dinilai dengan dan mendapat tempat oleh kaedah NG.

Keputusan bagi pendekatan perbandingan menunjukkan bahawa hasil kaedah NG adalah lebih optimum daripada kaedah I.LI dan terkemudian itu merupakan lebih optimum daripada kaedah LI. Oleh itu, kaedah NG telah dipilih untuk diintegrasikan dengan model fuzzy multi-objektif. Model fuzzy multi-objektif telah diselesaikan oleh fungsi penambahan pemberat baru dan keputusan itu menunjukkan bahawa selain daripada mengambilkira kepentingan relatif matlamat tersebut, teknik terbaru itu juga dapat untuk menimbangkan keadaan bersifat fuzzy.
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Every praise is due to Allah alone, the Merciful and peace be upon His prophet who is forever a torch of guidance and knowledge for humanity as a whole.

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Special thanks are also due to all staff of Universiti Putra Malaysia for their help and support.
I certify that an Examination Committee has met on 23 April 2009 to conduct the final examination of Omid Jadidi on his Master of Science thesis entitled “INTEGRATION OF AN IMPROVED GREY BASED METHOD AND FUZZY MULTI-OBJECTIVE MODEL FOR SUPPLIER SELECTION AND ORDER ALLOCATION” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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Date: 17 July 2009
DECLARATION

I hereby declare that the thesis is based on my original work except for quotation and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

__________________________________________
OMID JADIDI

Date:
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LIST OF NOMENCLATURE

LI   The grey based method proposed by Li et al. (2007)
LLI  The improved version of the LI method
NG   The new grey based method proposed in this research
PI   Percentage of the improvement calculated by the comparative approach
SCM  Supply Chain Management
MvB  Make versus Buy
EOQ  Economic Ordering Quantity
MCDM Multi-Criteria Decision Making
DMs  Decision Makers
AHP  Analytic Hierarchy Process
TVP  Total Value of Purchasing
ANP  Applied Analytic Network Process
MOMILP Multi-Objective Mixed Integer Linear Programming
MADM Multi-Attribute Decision Making
MODM Multi-Objective Decision Making
TS   Total Sum
SAW  Simple Additive Weighting
WSM  Weighted Sum Model
WPM  Weighted Product Model
TOPSIS Technique for Order Preference by Similarity to Ideal Solution
$Z_k$ Negative Objective for Minimization
$Z_k^0$ Aspiration Level for Objective $Z_k$ that the DM Wants to Reach
$Z_k^+$ Maximum Value (worst solution) of Negative Objective $Z_k$
$Z_k^-$  Minimum Value of Negative Objective $Z_k$

g_x  Inequality Constraints

$h_x$  Equality Constraints

$x$  Vector of Optimization or Decision Variable

$\mu_{\alpha}(x)$  Membership Function

~  Indicates the Fuzzy Environment

$\leq~$  Fuzzified Version of $\leq$

JIT  Just-In-Time

CBR  Case-Based-Reasoning

AI  Artificial Intelligence

CA  Cluster Analysis

DEA  Data Envelopment Analysis

ABC  Activity Based Costing

VAHP  Voting Analytical Hierarchy process

FST  Fuzzy Sets Theory

MP  Mathematical programming

GA  Genetic Algorithm

TCO  Total Cost of Ownership

BOCR  Benefits, Opportunities, Costs and Risks

SIP  Stochastic Integer Programming

$P_j$  Set of Suppliers Offering Product $j$

$P'_j$  Set of Suppliers Offering Item $j$ as $j'$

$P^*_j$  Set of Suppliers Offering Item $j$ as $j^*$

$S_i$  Set of Items Offered by Supplier $i$
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\( Y'_{ilj} \)  
1 if an Order is Placed on Supplier \( i \) at Price Level \( j' \) for Product \( j' \), 0 Otherwise

\( Y^*_{ilj} \)  
1 if an Order is Placed on Supplier \( i \) at Price Level \( j^* \) for Product \( j^* \), 0 Otherwise

\( Y^*_{il} \)  
1 if All the Special Products Are Ordered on Supplier \( i \) at Price Level \( j^* \), 0 Otherwise

\( Y_i \)  
1 if at Least an Order is Placed on Supplier \( i \), 0 Otherwise

\( Q_\gamma \)  
Set of \( (\gamma = 1,2,\ldots,\theta) \) Attributes of Suppliers

\( W_\gamma \)  
Vector of Attribute Weights

\( G_{i\gamma} \)  
Vector of Attribute Rating

\( G^*_{i\gamma} \)  
Vector of Normalized Attribute Rating

\( V^*_{i\gamma} \)  
Vector of Weighted Normalized Attribute Rating

\( C_i \)  
Final Rating of Suppliers Calculated by Improved Li’s et al Method

\( \Gamma_i \)  
Final Rating of Suppliers Calculated by Simple Grey Based Method
CHAPTER 1

INTRODUCTION

1.1. Background of Study

With the globalization of the economic market, the development of information technology and high consumer expectations for quality products and short lead-times, companies have to take advantage of any opportunity to optimize their business processes. Many companies believe that a well-designed and implemented supply chain management (SCM) system is an important tool for increasing competitive advantage (Aissaouia et al., 2007; Li et al., 2007; Choi et al., 2007). To optimize these business processes, practitioners and academics have reached to the same judgment: for handling and maintaining a competitive position, companies have to work with their supply chain partners to improve the chain’s total performance. Therefore, being the main process in the upstream chain and affecting all areas of an organization, the purchasing function and its associated decisions are taking an increasing importance (Aissaouia et al., 2007). Fig.1.1 illustrates that the major purchasing decision processes can be classified into six parts: (1) make or buy, (2) supplier selection, (3) contract negotiation, (4) design collaboration, (5) procurement, and (6) sourcing analysis (Aissaouia et al., 2007).
In Fig. 1.1, the term ‘outsourcing’ is used for the case when a finished/semi-finished part or service is being purchased and the term ‘purchasing’ is also used for the case when a raw material is being purchased.

The make or buy decision process (Platts et al., 2002) (see stage 1, Fig. 1.1): in this process, an essential question in the development of a manufacturing strategy has always been the determination of what a company will make and what it will buy. However, with the advent of the information age, allowing businesses to communicate with each other with unprecedented speed and efficiency, there is growing interest in this question. If the operations of a company can be continuously matched with those of its suppliers, a supply chain that is consisting of several companies can act as a more coherent, functional unit than was previously possible.
In this dynamic and less centralized business environment, many manufacturing companies have commenced to place much more emphasis on their make versus buy (MvB) decisions; that is, when a manufacturer is faced with the design and production of a new process or component for one of its products, does it make it in-house, or does it buy it from another company?

The next process is supplier selection (Ustun and Demirtas, 2008b) (see stage 2, Fig. 1.1). One or a set of suppliers is chosen for procurement according to a predefined set of criteria or factors. Single sourcing and multiple sourcing are two kinds of supplier selection problem. For single sourcing, the management needs to select the best supplier, whereas for multiple sourcing he or she needs to divide order quantities among the selected suppliers. The contract negotiation process (see stage 3, Fig. 1.1) discusses the problem of designing a suitable contract. In the design collaboration (see stage 4, Fig. 1.1) stage, the purchaser and supplier work closely to design services and/or parts that meet quality standards and customer specifications.

In the procurement decision process (see stage 5, Fig. 1.1), the problem of guaranteeing that the suppliers would deliver the service and/or part in time and with minimum costs is discussed. Finally, in the sourcing analysis (see stage 6, Fig. 1.1) stage, the overall efficiency of a company procurement process is assessed. This stage would consider issues like assortments (ordering a group of service or and part from a single supplier), consolidation (shipping orders from more than one supplier together), and supplier performance measurements.