



UNIVERSITI PUTRA MALAYSIA

**FUZZINESS IN PERFORMANCE EVALUATION PROBLEMS USING
DATA ENVELOPMENT ANALYSIS**

EHSANOLLAH MANSOURIRAD

IPM 2010 8



**FUZZINESS IN PERFORMANCE EVALUATION
PROBLEMS USING DATA ENVELOPMENT
ANALYSIS**

EHSANOLLAH MANSOURIRAD

**DOCTOR OF PHYLOSOPHY
UNIVERSITI PUTRA MALAYSIA**

2010

i



To

My parents

For their encouragement and supports

&

My brother and sisters

And

My dear teachers



**EVALUATION OF FUZZINESS IN PERFORMANCE PROBLEMS USING
DATA ENVELOPMENT ANALYSIS**

By

EHSANOLLAH MANSOURIRAD

**Thesis Submitted to the School of Graduate Studies, Universiti Putra
Malaysia, in Fulfilment of Requirements for the Degree of Doctor of
Philosophy**

December 2010



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in
fulfilment of the requirement for the degree of Doctor of Philosophy

**EVALUATION OF FUZZINESS IN PERFORMANCE PROBLEMS USING
DATA ENVELOPMENT ANALYSIS**

By

EHSANOLLAH MANSOURIRAD

December 2010

Chair: Associate Prof. Mohd Rizam Abu Bakar, PhD

Faculty: Institute for Mathematical Research

Efficiency evaluation is an important part of decision making in many areas particularly in management and manufacturing sectors. Uncertainty and fuzziness of the real world problems have increased utilization of fuzzy sets theory in many research areas and data envelopment analysis is one of them. Utilizing data envelopment analysis to evaluate efficiency scores of decision making units in fuzzy environment requires fuzzy models and mathematical methods for solving fuzzy models with minimum calculation and maximum precision. Since current fuzzy data envelopment analysis models are not able to solve some problems in fuzzy environment, our attempt is to provide fuzzy data envelopment analysis models related to following various problems.



Some problems include uncontrollable data (for manager) that regularly have fuzzy essence. An uncontrollable fuzzy data envelopment analysis model is represented for these types of problems. The advantages of the proposed model are in capability of it in including uncontrollable factors particularly those with fuzzy nature in problems with fuzzy data and controlling factor weights by additional constraints which can avoid the model to become infeasibility. The disadvantage of the method is in using too many restrictions (one restriction for each fuzzy data) which makes the model complicated and expensive to solve.

For cases that interval efficiency scores are helpful, a method for solving fuzzy data envelopment analysis models is represented which interval efficiency scores can be achieved without adding restrictions to the model for each fuzzy data. In comparison with other methods, this method is simple, easy and with no additional constraint for each fuzzy data. In addition a fuzzy weights data envelopment analysis model is proposed to determine effect of data on the efficiency score. The model is informative in problems that the manager needs to know about uncertain effects of factors on efficiency score. The method of solving the model is simple and informative.

By suggesting categorical data envelopment analysis method for problems with uncertain membership in various categories, we can help the decision maker to recognize the efficient decision making units fairly. In comparison with available method for categorical problems, our method is more informative and the traditional



categorical method is a special case of our method. Finally, we provide a solution to comparison of production methods by utilizing fuzzy non-discretionary data envelopment analysis model. The proposed technique is more capable and informative while it includes factors with fuzzy essence that have effect on efficiency of production methods which is a real problem and may be its performance be effected by many fuzzy issues.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**EVALUASI KINERJA KEKABURAN PERMASALAHAN DALAM
MENGUNAKAN ANALISIS DATA EFISIENSI**

Oleh

EHSANOLLAH MANSOURIRAD

December 2010

Pengerusi : Prof. Madya Mohd Rizam Abu Bakar, PhD

Fakulti : Institut Penyelidikan Matematik

Penilaian keberkesanan merupakan bahagian penting dalam proses membuat keputusan dalam pelbagai bidang, terutama dalam sector pengurusan dan pembuatan. Ketidaktentuan dan kekaburan bagi masalah dunia sebenar telah meningkatkan penggunaan teori set kabur dalam beberapa bidang penyelidikan dan analisis pengumpulan data merupakan salah satu daripadanya. Penggunaan analisis pengumpulan data untuk menilai skor kecekapan terhadap unit pembuat keputusan dalam persekitaran kabur memerlukan model kabur dan kaedah matematik bagi menyelesaikan model kabur dengan perkiraan yang minimum tetapi ketepatan maksimum. Memandangkan model analisis pengumpulan data kabur terkini tidak dapat menyelesaikan banyak masalah yang berkaitan dengan



kecekapan penilaian dalam persekitaran kabur, kajian ini merupakan cubaan untuk menyediakan model analisis pengumpulan data kabur yang berkaitan dengan pelbagai masalah.

Sebahagian besar masalah merangkumi data tak terkawal (oleh pengurus) dan lazimnya mempunyai ciri kabur. Dalam kajian ini, model analisis pengumpulan data kabur yang bersifat tak terkawal dikemukakan bagi mengatasi masalah jenis ini. Keuntungan dari model yang dicadangkan dalam kemampuan dalam termasuk faktor tidak terkawal terutama mereka dengan alam kekaburan dalam masalah dengan data kekaburan dan berat faktor kawalan oleh kendala tambahan yang boleh mengelakkan model menjadi tidaklayakan. Kerugian dari kaedah ini dalam menggunakan sekatan terlalu banyak (satu sekatan untuk setiap data kekaburan) yang membuat model yang rumit dan mahal untuk menyelesaikan.

Bagi kes yang menggunakan skor kecekapan selang, suatu kaedah yang dapat menyelesaikan model analisis pengumpulan data yang mewakili skor kecekapan interval diperoleh tanpa menambah kekangan terhadap model bagi setiap data kabur. Model ini bermaklumat dalam masalah yang pengurus perlu mengetahui tentang kesan pasti faktor pada skor kecekapan. Kaedah penyelesaian model sederhana dan bermaklumat.



Tambahan pula, model analisis pengumpulan data kabur dicadangkan untuk mengenal pasti kesan data ke atas skor kecekapan.

Dengan mencadangkan kaedah analisis pengumpulan data berkategori bagi masalah yang mempunyai ketidaktentuan keahlian dalam pelbagai kategori dapat membantu pembuat keputusan menghargai keberkesanan unit pembuat keputusan secara adil. Dibandingkan dengan kaedah yang sedia untuk masalah kategoris, kaedah kami lebih bermaklumat dan kaedah kategoris tradisional adalah kes khusus dari kaedah kami. Akhirnya, suatu penyelesaian bagi membandingkan kaedah penghasilan dengan menggunakan model analisis pengumpulan data kabur telah dikemukakan. Teknik yang dicadangkan lebih mampu dan bermaklumat sementara itu termasuk faktor dengan esensi fuzzy yang berpengaruh terhadap kecekapan kaedah pengeluaran yang merupakan masalah nyata dan mungkin prestasinya akan dipengaruhi oleh isu fuzzy banyak.



ACKNOWLEDGEMENT

First and foremost, all praise to the almighty God for his blessing and merciful that enabled me to learn.

This thesis is the result of almost three years of work where I have been accompanied by some people. Now, I have the pleasant opportunity to express my gratitude to all of them.

I am sincerely grateful to my supervisor, Associate Professor Dr. Mohd Rizam Abu Bakar, for giving me the opportunity to work under his supervision, his indisputable interest in my research, his encouragement and genuine advises.

I want to thank my supervisory committee, Dr. Lai Soon Lee for his cooperation and pertinent advises and Dr. Azmi Jaafar for his encouragement during my study.

I am always thankful to Prof. Dr. Gholam Reza Jahanshahloo, Dr. Saber Saati , Dr. Behrouz Daneshian and Dr. Mohammad Tohidloo for encouraging me to pursue my studies. Also, I take this opportunity to thank Prof. Dr. Abdollah Shidfar and Dr. Hashem Saberi Najafi for their encouragements.

As well, I owe so much to my dear parents, Iran and Davood, my first teachers, who are always my source of inspiration and who encouraged me to pursue my studies and supported me throughout my life. It is to them that I dedicate this work, with love and gratitude.

Also, I would like to thank my brother and sisters and their family, Parand, Pooneh, Babak and Rasoul, my friend Shabnam Hamdi for always being there for me and for their unwavering support, patience and understanding during my study.



I certify that an Examination Committee has met on 21-12-2010 to conduct the final examination of Ehsanollah Mansourirad on his **Doctor of Philosophy** thesis entitled “**Evaluation of Fuzziness in Performance Problems Using Data Envelopment Analysis**” in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

Malik Hj Abu Hassan, PhD

Professor
Faculty of Science
Universiti Putra Malaysia
(Chairman)

Leong Wah Jun, PhD

Associate Professor
Faculty of Science
Universiti Putra Malaysia
(Internal Examiner)

Mansor Bin Monsi, PhD

Faculty of Science
Universiti Putra Malaysia
(Internal Examiner)

Josef Jablonsky, PhD

Professor
Faculty of Informatics and Statistics
University of Economics
Czech Republic
(External Examiner)

BUJANG KIM HUAT, PhD

Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:



This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for **Doctor of Philosophy**. The members of the Supervisory Committee were as follows:

Mohd Rizam Abu Bakar, PhD

Associate Professor
Faculty of Science
Universiti Putra Malaysia
(Chairman)

Azmi Jaafar, PhD

Associate Professor
Faculty of Computer Science and Information Technology
Universiti Putra Malaysia
(Member)

Lai Soon Lee, PhD

Lecturer
Faculty of Science
Universiti Putra Malaysia
(Member)

HASANAH MOHD GHAZALI, PhD

Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:



DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously and is not concurrently submitted for any other degree at Universiti Putra Malaysia or other institution.

EHSANOLLAH MANSOURIRAD

Date: 21 December 2010



TABLE OF CONTENTS

	Page
ABSTRACT	ii
ABSTRAK	v
ACKNOWLEDGMENTS	viii
APPROVAL	ix
DECLARATION	xi
LIST OF TABLES	xv
LIST OF ABBREVIATIONS	xviii
CHAPTER	
1 INTRODUCTION AND LITERATURE REVIEW	1
Basic Definitions and Knowledge	1
Data Envelopment Analysis	1
Some Fuzzy Concepts and Definitions	6
Description of Fuzzy Data Envelopment Analysis	7
Literature Review	9
Fuzzy Decision Making and Fuzzy Linear Programming	9
Fuzzy DEA	12
Categorical DMUs in DEA	18
2 A DEA MODEL WITH FUZZY DATA AND UNCONTROLLABLE INPUT FACTORS WITH UNCERTAINTY	24
Introduction	24
Proposed Model	25
Numerical Example and Discussion	36
Conclusion	46
3 INTERVAL EFFICIENCY SCORES USING A NEW METHOD IN FUZZY DATA ENVELOPMENT ANALYSIS	47
Introduction	47



	Illustration of the Proposed Model	48
	New Method Based on Fuzzy Division	50
	Numerical Example and Discussion	56
	Conclusion	69
4	FUZZY WEIGHTS IN DATA ENVELOPMENT ANALYSIS	71
	Introduction	71
	Fuzzy Weights DEA Model and Transformations	73
	Steps, Analysis and Discussion	79
	Numerical Example and Discussion	82
	Conclusion	96
5	TECHNIQUE FOR SOLVING CATEGORICAL DATA ENVELOPMENT ANALYSIS PROBLEMS WITH FUZZY ASPECT	97
	Introduction	97
	Illustration of Fuzzy CDEA Method	100
	Proposed Method and Steps	104
	Numerical Example and Discussion	107
	Conclusion	123
6	COMPARING PRODUCTION METHODS USING FUZZY DATA ENVELOPMENT ANALYSIS	124
	Introduction	124
	Comparing Production Methods and Some Backgrounds	126
	Methodology and Illustration of the Methods Comparison	129
	Production Heuristics	132
	The Non-Discretionary Fuzzy DEA model	133
	Numerical Example and Discussion	136
	Conclusion	140
7	SUMMARY, GENERAL CONCLUSION AND RECOMMENDATIONS FOR FUTURE RESEARCH	142
	Summary	142
	General Conclusion	144
	Recommendations for Future Studies	146



BIBLIOGRAPHY	149
BIODATA OF STUDENT	156
LIST OF PUBLICATIONS	157

