

**NON-COOPERATIVE GAME THEORY AS
A DECISION-MAKING TOOL IN CONFLICT SITUATIONS
AND ASYMMETRIC INFORMATION**

OSMAN ABDEL GHANI MOHAMED

**Master of Science
Universiti Putra Malaysia**

1998

**NON-COOPERATIVE GAME THEORY AS
A DECISION-MAKING TOOL IN CONFLICT SITUATIONS
AND ASYMMETRIC INFORMATION**

By

OSMAN ABDEL GHANI MOHAMED

Thesis Submitted in Fulfilment of the Requirements for the
Degree of Master of Science in the Faculty of
Science and Professional Arts
Universiti Putra Malaysia
Terengganu

December 1998

1000398350

DEDICATION

**This work is dedicated
to my parents**

ACKNOWLEDGEMENTS

In the Name of God, Most Gracious, Most Merciful.

Praise be to Allah, the Lord of the Worlds, and Peace be upon the Master of the Apostles, his Family and Companions.

I would like to express my sincere gratitude to the chairman of my supervisory committee Assoc. Prof. Dr. Hj. Ismail bin Mohd, whose excellent supervision, invaluable guidance, continuous encouragement, and numerous discussion were instrumental for the completion of this work. I also would like to extend my gratitude to the other members, Prof. Dr. Hj. Mohd. Sahar Sawiran and En. Abd. Fatah Wahab for their kind interest and constructive comments to this work are greatly appreciated.

Acknowledgement is due to Universiti Putra Malaysia for offering to me Graduate Assistantship, which is helpful to pursue my master. Special gratitude to Upper Nile University and Sudan Government for granting permission and encouraging are highly appreciated.

I thanks my colleagues and all Post Graduate Student in UPMT for cooperation socially and academically during my study, I also would like to extend my thanks to all my friends and any one who has helped me directly or indirectly.

ACKNOWLEDGEMENTS

In the Name of God, Most Gracious, Most Merciful.

Praise be to Allah, the Lord of the Worlds, and Peace be upon the Master of the Apostles, his Family and Companions.

I would like to express my sincere gratitude to the chairman of my supervisory committee Assoc. Prof. Dr. Hj. Ismail bin Mohd, whose excellent supervision, invaluable guidance, continuous encouragement, and numerous discussion were instrumental for the completion of this work. I also would like to extend my gratitude to the other members, Prof. Dr. Hj. Mohd. Sahar Sawiran and En. Abd. Fatah Wahab for their kind interest and constructive comments to this work are greatly appreciated.

Acknowledgement is due to Universiti Putra Malaysia for offering to me Graduate Assistantship, which is helpful to pursue my master. Special gratitude to Upper Nile University and Sudan Government for granting permission and encouraging are highly appreciated.

I thanks my colleagues and all Post Graduate Student in UPMT for cooperation socially and academically during my study, I also would like to extend my thanks to all my friends and any one who has helped me directly or indirectly.

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	<i>iii</i>
LIST OF TABLES	<i>vii</i>
LIST OF FIGURES	<i>ix</i>
SYMBOL AND ABBREVIATION	<i>xi</i>
ABSTRACT	<i>xii</i>
ABSTRAK	<i>xiv</i>
CHAPTER	
I INTRODUCTION	1
Back ground of the Study	1
Context of the Study	1
Classification of Games	2
Importance and Role of Game Theory	3
Research Problem	6
Development of the Study	7
Research objective	9
Organization of the Study	9
II GAME THEORY	10
Introduction	10
Basic Definitions	11
Static Games with Complete and Incomplete Information	13
Dominant Strategies	13
Nash Equilibrium	16
Bayesian Nash Equilibrium	23
Mixed Strategies	27

Dynamic Games with Symmetric and Asymmetric Information . . .	31
Subgame Perfect Equilibrium	31
Perfect Bayesian and Sequential Equilibria	36
III EXISTENCE OF EQUILIBRIUM	41
Introduction	41
Concave and Convex Functions	42
Optimization of Functional	45
Reaction curves and Existence of Equilibria	48
Reaction Curves and Nash equilibria	49
Stackelberg Solution and Reaction Curves	53
Coupled Constraint Games and Existence of Equilibria	55
IV NUMERICAL METHOD APPROACH	57
Introduction	57
The Relaxation Algorithm	58
A Simple Unconstrained Static Games	59
The Constrained Static Games	70
The Modified Violated Constraint Algorithm	74
V MORAL HAZARD	81
Introduction	81
Moral Hazard Games	82
Moral Hazard with Hidden Action	83
Standard Principal-Agent Model	84
Formulation of the Standard Principal-Agent Model	85
A Formal Diagrammatic Analysis	86
Risk Sharing in Standard Principal-Agent Model	88
Moral Hazard with Hidden Information	93
Formulation of the hidden Information Agency Model	94
Full Information, First Best Contracts	95
The Revelation Principle	96
Alleviating the Agency Problem	102
VI ADVERSE SELECTION	104
Adverse Selection Game	105
State-Space Diagram and the Existence of Equilibria	106
Wilson and Reactive Equilibrium	110
Signaling Games	111
Standard Signaling Game	112
General Structure of the Standard Signaling Game.	113

	Page
Sequential Equilibrium to the Standard Signaling Game . . .	114
Separation when T is A Compact Interval	118
Solution to Adverse Selection Games	120
VII SUMMARY AND CONCLUSIONS	121
Summary	121
Conclusion	125
Recommendation for Future Study	126
BIBLIOGRAPHY	127
APPENDICES	132
A: Additional Tables for Example 4.1 and 4.2	133
Vita	138

LIST OF TABLES

Table		Page
2.1	The Prisoner's Dilemma	14
2.2	Abstract Game	15
2.3	The Battle of the Sexes	18
2.4	Information Categories	21
2.5	The Welfare Game	28
2.6	Pure Coordination	32
2.7	Follow the Leader I	33
2.8	Dynamic Game of Asymmetric Information	38
4.1	The Convergence to Nash Equilibrium in Example 4.1	61
4.2	The Convergence to Nash Equilibrium in Example 4.2	64
4.3	The Convergence to Stackleberg Equilibrium in Example 4.1	66
4.4	The Convergence to Stackleberg Equilibrium in Example 4.1	68
4.5	Constant in Example 4.3	75
6.1	Insurance Game : Payoffs	106
7.1	Summary of the Numbers of Iterations together with the Time of Solutions for Examples 4.1, 4.2, and 4.3, at which the Algorithms Converge	123
A.1	The Convergence to Nash Equilibrium in Example 4.1	133
A.2	The Convergence to Nash Equilibrium in Example 4.1	134
A.3	The Convergence to Stackelberg Equilibrium in Example 4.1	134
A.4	The Convergence to Stackleberg Equilibrium in Example 4.1	135

A.5	The Convergence to Nash Equilibrium in Example 4.2	136
A.6	The Convergence to Nash Equilibrium in Example 4.2	136
A.7	The Convergence to Stackleberg Equilibrium in Example 4.2	137
A.8	The Convergence to Stackelberg Equilibrium in Example 4.2	137

LIST OF FIGURES

Figure	Page
2.1 Information Sets and Information Partitions	20
2.2 Follow the Leader I	32
2.3 Dynamic Game of Asymmetric Information	38
3.1 Constant Level Curves for φ_1 and φ_2 , and the Corresponding Reaction Curves (c_1 and c_2) of P_1 and P_2 , respectively.	50
3.2 Possible Configurations of the Reaction Curves	51
3.3 Graphical Construction of the Stackelberg Solution in a two-person Game-a "stalemate" Solution.	54
3.4 Coupled Constraint Game	56
4.1 The Convergence of Nash Equilibrium in Example 4.1 with starting estimate (10,2) using optimized α_s in graph I, $\alpha_s = 0.5$ in graph II and $\alpha_s = 1$ in graph III.	62
4.2 The Convergence of Nash Equilibrium in Example 4.2 with starting estimate (0,0) using $\alpha_s = 0.75$ in graph I, $\alpha_s = 0.5$ in graph II and $\alpha_s = 1$ in graph III.	65
4.3 The Convergence of Stackleberg Equilibrium in Example 4.1 with starting estimate (10,2) using optimized α_s in graph I, $\alpha_s = 0.5$ in graph II and $\alpha_s = 1$ in graph III.	67
4.4 The Convergence of Stackleberg Equilibrium in Example 4.2 with starting estimate (0,0) using $\alpha_s = 0.75$ in graph I, $\alpha_s = 0.5$ in graph II and $\alpha_s = 1$ in graph III.	69
5.1 Categories of Moral Hazard Games	83
5.2 Optimal Contract in Standard Principal-Agent game	88
5.3 Compatibility and Participation Constraints	90
5.4 Contract Selection Procedure	98
5.5 The Second Best Asymmetrical Information Contracts	101
6.1 Categories of Adverse Selection	104
6.2 Insurance Game: Nonexistence of Pooling Equilibrium	107

6.3	Insurance Game: A Separating Equilibrium	108
6.4	Insurance Game: No Equilibrium Exists	109
6.5	Indifference Curves Satisfying Single-Crossing and Incentive Compatibility	116

SYMBOLS AND ABBREVIATION

P_i	Player i
RHS	Right-hand side
LHS	Left-hand side
$E(x)$	Expected value of x
A, B	Matrices
◆	End of definitions, theorems, etc.
φ_i	Payoff function of P_i .
ϕ	Joint payoff function
N	Number of player
u_i	Action (Decision variable) of P_i , $u_i \in U_i$.
γ_i	Strategy (decision law) of P_i , $\gamma_i \in \Gamma_i$.
η_i	Information available to P_i .
t	Time
IR	Real line
∂	Subdifferential

Abstract of the thesis submitted to the senate of Universiti Putra Malaysia
in fulfillment of the requirements for the degree of Master of Sciences.

**NON-COOPERATIVE GAME THEORY AS
A DECISION-MAKING TOOL IN CONFLICT SITUATIONS
AND ASYMMETRIC INFORMATION**

By

Osman Abdel Ghani Mohamed

December, 1998

Chairman: Assoc. Prof. Ismail Bin Mohd, Ph.D.

Faculty: Faculty of Science and Professional Arts

The main purpose of this research is to study non-cooperative game theory as strategic decision making tool in conflict situations, with describing how to find solution to these models and to analyze asymmetric information.

The objective of dealing with the problem of decision making in conflict situations is to find optimal strategy among alternative strategies. Two approaches will be put into consideration; The mathematical modeling of the situation and computational solutions for these models.

Non-cooperative game theory renown for being encounter at once more common place, more interesting, and more difficult to analyze.

Therefore, a more detailed introduction to non-cooperative game theory and some of its theoretical ideas were introduced. The basic solution concepts and the

underlying theory were explained through some examples of basic kinds of some games.

Through the idea of reaction function together with relaxation algorithm and violated constraints method we proposed a method for computing non-cooperative equilibria in general synchronous games. To implement this idea a computer code was developed, and has been used successfully to solve some unconstrained and constrained game under open-loop information pattern. This code is referred to as Numerical Method Approach.

Relaxation methodology and violated constraints technique seem to be a useful method to increase the ability of game theory for solving more complex game theoretical problems.

The study continues with the way of modeling suggested by Rasmusen and a heavy use of principal-agent model to analyze asymmetric information. The structure and optimality of the contracts have been derived from the basic attributes such as taste, technologies, endowments and informational structure.