UNIVERSITI TEKNOLOGI MARA

FUZZY MIXED INTEGER GOAL PROGRAMMING MODELS FOR SHARIAH-COMPLIANT EQUITIES PORTFOLIO SELECTION

MAZURA BT MOKHTAR @ MOTHER

PhD

November 2021

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledge as referenced work. This thesis has not been submitted to any other academic institution and or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Candidate	: Mazura Bt Mokhtar @ Mother
Student I.D. No.	: 2012466774
Programme	: Doctor of Philosophy (Information Technology and Quantitative Sciences)-CS990
Faculty	: Computer and Mathematical Sciences
Thesis Title	: Fuzzy Mixed Integer Goal Programming Models For Shariah-compliant Equities Portfolio Selection
Signature of Student	: 
Date	: December 2021

ABSTRACT

Portfolio selection problem is a critical issue in financial decision making and being repeatedly emphasized by many researchers and practitioners. The success of a portfolio selection is highly dependent on a reliable prediction of asset future performance and portfolio optimization. Thus, this study focuses on the development of evaluation and portfolio optimization models to solve portfolio selection problem for Shariah-compliant equities. This study consists of four phases. Each phase is designed to achieve the objectives of this study which are; to identify the most important financial ratios, to develop Adaptive Neuro-Fuzzy Inference System (ANFIS) models for evaluating Shariah-compliant equities, to formulate a multi-objective mixed integer programming (MOMIP) model for multi-period portfolio optimization problem, and to formulate goal programming (GP) models for solving the MOMIP model. In the first phase, fuzzy Delphi method (FDM) was employed to identify the most important financial ratios in evaluating Shariah-compliant equities' performance. Then, in the second phase, ANFIS was used to develop an evaluation model for classifying Shariah-compliant equities into classes. Two input space partitioning methods, namely, Fuzzy C Means clustering (FCM) and Subtractive Clustering (SC) were used to generate initial fuzzy rules. In the third phase, a multi-period fuzzy portfolio optimization model was formulated to determine the amount of investment in the selected Shariah-compliant equities. Four conflicting objectives were considered, namely, maximizing terminal wealth, portfolio liquidity, cumulative dividend, and minimizing the cumulative risk of portfolios. Unlike the existing multi-period portfolio optimization models, this study considered *zakat* deduction in formulating the portfolio's net terminal wealth. Several real-world constraints were also incorporated into the proposed model. In the fourth phase, the resulting MOMIP model was solved using two GP approaches, namely pre-emptive GP and fuzzy GP (FGP). Computational experiments and sensitivity analysis using real data from Bursa Malaysia were performed to verify and validate the models. Result from FDM indicates that the most important financial ratios in evaluating Shariah-compliant equities' performance are return on equity, return on assets, earnings per share, operating profit margin, net profit margin, and debt to equity ratios. The experimental results from ANFIS show that the subtractive clustering-based ANFIS model provides better performance with 70.66% of overall accuracy, 71.43% of sensitivity, 68.38% of specificity, 87.11% of precision, and 78.49% of F-measure. The FCM based ANFIS model achieved 65.10% of overall accuracy, 64.86% of sensitivity, 65.81% of specificity, 85.02% of precision and 73.58% of F-measure. Extensive investigations successfully demonstrate the applicability of the proposed models. The results of sensitivity analysis also show that reasonable solutions can be achieved through the GP and FGP approaches. Thus, the models can be used by investors, fund managers, and investment companies to assist them in planning their investment strategy and building their portfolio.

ACKNOWLEDGEMENT

First and foremost, all praises are due to Allah who has given me the strength, patience, courage and knowledge to continue and finish my PhD journey.

This research would not have been possible without the support and guidance that I received from many people. I would like to express my deepest gratitude to my supervisor, Associate Professor Dr. Adibah Shuib, for her guidance, intellectual advice, invaluable comments and incredible patience during my study. Without her constant feedback this PhD would not have been achievable.

My humble acknowledgement and gratitude also go to my co-supervisor Professor Dr. Daud Mohammad, for his continuous advice and guidance not only for my research work but also for the much wider subjects that will benefit me in my future life.

Sincere thanks to my friend Rossidah who has always been a major source of support when things would get a bit discouraging. Thanks for always being there for me. I would also like to thank all my PhD colleagues from postgraduate lab of the Faculty of Computer and Mathematical Sciences for sharing the good as well as the bad times.

A special acknowledgement is devoted to my parents, Mokhtar Jasin and Azizah Amir, for their supports, love, guidance and sincere prayer which I will never be able to repay. Last but not least, I would like to give my heartfelt thanks to my husband, Saharani Abdul Rashid and my lovely daughter, Nur Alya Surfina. Their unconditional love, patience, understanding and steadfast support have enabled me to complete this thesis.

TABLE OF CONTENTS

	Page
CONFIRMATION BY PANEL OF EXAMINERS	**ii**
AUTHOR'S DECLARATION	**iii**
ABSTRACT	**iv**
ACKNOWLEDGMENT	**v**
TABLE OF CONTENTS	**vi**
LIST OF TABLES	**x**
LIST OF FIGURES	**xiv**
LIST OF ABBREVIATIONS	**xvi**
CHAPTER ONE: INTRODUCTION	**1**
1.1 Introduction	1
1.2 Shariah-compliant Investment	4
1.2.1 The Key Principles of Islamic Investment	5
1.2.2 Overview of Shariah Compliant Equities	8
1.3 Motivation of Research	10
1.4 Problem Statements	12
1.5 Research Questions	14
1.6 Research Objectives	14
1.7 Scope and Limitations	15
1.8 Significance of The Study	16
1.9 Novelty of The Study	18
1.10 Thesis Outline	18
CHAPTER TWO: LITERATURE REVIEW	**20**
2.1 Introduction	20
2.2 The History of Modern Portfolio Theory	20
2.3 Past Studies on Equity Performance Evaluation	23