

ABSTRACT

The prediction of a realistic duration of a construction project is a key factor to be considered before starting a new project. Such prediction may affect the project's success and this is a problem of interest to both clients and contractors.

In Egypt, identifying a realistic project duration is often overlooked by both the client and the contractor during the tendering stage due to the limited data available and the sharp deadlines applied by the owner. The consequences, however, can be troublesome if productivity, quality and safety are sacrificed in addition to the low staff morale and conflicts arise among the project's parties during the implementation phase.

Models for predicting construction project duration have been developed. As such, the objectives of this research were to identify the significant factors affecting the commercial project duration in Egypt and to develop a fuzzy model to enable decision makers predicting commercial project duration under normal conditions in a reliable and practical way based on the data and time available at the tendering stage.

This study examined the thirty six factors affecting the commercial project duration concluded from the literature review and the construction experts interviews. Sensitivity rating of duration-influencing factors was carried out using a questionnaire survey amongst all key players of Egyptian construction industry, analyzed using statistical and weighting process where twelve criteria were selected and grouped under six groups to simplify the proposed fuzzy model as follow: project's cost, client's characteristics (including client's type, client's financial soundness and client's tendency for changes), tender documents completeness and clarity, project's characteristics (including complexity of the project, total built up area, number of stories and number of basements), environmental conditions (including economical conditions and political conditions) and construction site suitability (including construction site conditions), one output variable: expected project duration, and 729 firing rules.

To test the developed model, two case studies were analyzed using the proposed model, the run of the model for the first project gave 90% accuracy level with 10% error, while the run of the model for the second project gave 85% accuracy level with 15% error which are acceptable levels.

ACKNOWLEDGMENT

This journey would have been practically impossible without the encouragement and kind support of many people. I would like to thank my committee chair, ***Prof. Dr. Mohamed Emam Abdul-Razek***, Professor of Construction Engineering and Management, Faculty of Engineering and Technology – Arab Academy for Science, Technology and Maritime Transport, ***Prof. Dr. Emad Elbeltagi***, Professor of Construction Engineering and Management, Faculty of Engineering – Mansoura University and ***Dr. Abdel Monaem Sanad***, the head of Construction and Building Department, Faculty of Engineering and Technology – Arab Academy for Science, Technology and Maritime Transport for their continuous support, patience and the time they invested reading through and making constructive suggestions about my research.

Again, thanks to all Arab Academy staff for their professional support.

My special thanks goes to my mother, I appreciate all your kind support all through this journey. Above all, to my wife, who stood with me, supported me, and encouraged me to fight on to the end. Finally, to my children, Marawan, Ziad and Mariam, you are worth more than gold, and your future is bright and blessed.

TABLE OF CONTENTS

<i>Title</i>	<i>Page</i>
Abstract	I
Acknowledgment.....	II
Table of content	III
List of tables	VIII
List of figures	X
Chapter 1: INTRODUCTION	1
1-1 Problem statement.....	2
1-2 Objectives of the study	2
1-3 Scope of research.....	3
1-4 Research methodology.....	3
1-5 Disposition.....	3
Chapter 2: LITERATURE REVIEW	5
2-1 Introduction	5
2-2 Construction industry in Egypt	5
2-3 The project's life cycle.....	7
2-4 Project duration.....	8
2-4-1 Factors affecting construction project duration.....	10
2-4-1.1 Cost.....	15
2-4-1.2 Cash flow.....	15

2-4-1.3 Productivity on-site	16
2-4-1.4 Procurement.....	16
2-4-1.5 Project related factors.....	17
2-4-1.6 Technology and methodology of construction.....	18
2-4-1.7 Experience.....	18
2-4-1.8 Coordination.....	19
2-4-1.9 Weather.....	19
2-4-1.10 Construction site.....	19
2-4-1.11 Degree of completeness of project's design	20
2-5 Modeling of predicting construction project duration	21
2-5-1 Experience-base models.....	25
2-5-2 Parametric models.....	25
2-5-2.1 Time-Cost model.....	26
2-5-2.2 Other parametric models.....	27
2-5-3 Discrete state models.....	30
2-6 Fuzzy set	31
2-6-1 Fuzzy membership functions	31
2-6-2 Linguistic variables	33
2-6-3 Fuzzy if-then rules and approximate reasoning	34
2-6.4 Fuzzy set applications	35
2-7 Summary and conclusion	36

Chapter 3: FACTORS AFFECTING PROJECT DURATION OF COMMERCIAL BUILDINGS IN EGYPT	37
3-1 Introduction	37
3-2 Methodology.....	37
3-3 Questionnaire’s design.....	41
3-3-1 Population and sample size.....	41
3-3-2 Sample formation	43
3-3-3 Questionnaire contents	44
3-4 Analysis of the questionnaire results	45
3-4-1 General analysis	47
3-4-2 Analysis of the factors affecting the prediction of project duration for commercial buildings.....	48
3-4-2-1 Statistical method	49
3-4-2-2 Criteria weight method	72
3-5 Criteria final selection	77
3-6 Summary and conclusion	78
Chapter 4: PREDICTING PROJECT DURATION OF COMMERCIAL BUILDINGS USING FUZZY LOGIC	79
4-1 Introduction	79
4-2 The fuzzy logic system	79
4-2-1 Fuzzy output variable.....	80
4-2-2 Fuzzy input variables	81

4-2-3 Fuzzy decision rules	89
4-2-4 Firing strength of fuzzy decision rules	93
4-3 A fuzzy logic model for predicting project duration	93
4-4 Proposed form for predicting project duration of commercial buildings.....	94
4-5 Graphical User Interface (GUI).....	94
4-6 Model validation.....	96
4-7 Results validation.....	101
4-8 Summary and conclusion.....	102
Chapter 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS.....	103
5-1 Introduction	103
5-2 Contributions	103
5-3 Conclusions	103
5-4 Recommendations for future work.....	105
REFERENCES AND APPENDICES.....	106
REFERENCES.....	106
APPENDICES.....	111
Appendix A Factors affecting construction project duration	111
Appendix B Types of duration prediction models found in literature	119
Appendix C Statistical Analysis – Z-Scores.....	137
Appendix D Calculated Weight Score Method.....	143
Appendix E Proposed project duration prediction form for commercial buildings.....	149

LIST OF TABLES

<i>Table</i>	<i>Title</i>	<i>Page</i>
2-1	Percentage of private sector share in the construction industry contribution in GDP	5
2-2	Percentage of private sector share in construction industry investment	6
2-3	Percentage of construction workers to the whole workforce in Egypt and the percentage of private sector share in the construction workforce.....	6
2-4	Factors affecting construction project duration.....	14
2-5	Construction project duration prediction models' development.....	23
3-1	Factors Affecting Project Duration Prediction in Egypt	38
3-2	Questionnaire sample distribution	44
3-3	Collected questionnaires from different parties.....	45
3-4	Mean value of the questionnaire results of the main seven groups affecting prediction of commercial project duration	46
3-5	Ranking of the whole criteria according to owner-public group	51
3-6	Ranking of the whole criteria according to owner-private group	54
3-7	Ranking of the whole criteria according to consultant-public group.....	57
3-8	Ranking of the whole criteria according to consultant-private group.....	60
3-9	Ranking of the whole criteria according to contractor-public group	63
3-10	Ranking of the whole criteria according to contractor-private group	66
3-11	Ranking of the whole criteria in descending order according to the mean value for the six groups	69

3-12	Ranking of the most effective criteria according to the six groups in descending order	70
3-13	Criteria weight scores for owners-public group (group A).....	73
3-14	Ranking of the whole criteria according to the six groups (Criteria weight method)	74
3-15	Ranking of the most effective criteria according to the six groups in descending order (Criteria weight method).....	76
4-1	Input variables criteria measure and scores	85
4-2	Fuzzy Rules Formation	91
4-4	Results of model validation.....	101

LIST OF FIGURES

<i>Figure</i>	<i>Title</i>	<i>Page</i>
2-1	Factors affecting construction project duration, (Chan and Kumaraswamy, 2002).	11
2-2	Factors affecting construction project duration, (Chan and Kumaraswamy, 1995).	12
2-3	Examples of Linear Fuzzy sets	33
2-4	Membership functions for Linguistic Variable "Quality".....	34
3-1	Normal distribution bell shape (probability vs. z-score).....	43
4-1	Membership Functions of Output variable "Duration".....	80
4-2	Input variables values' and their associate scale	84
4-3	Input variable "Project's cost - CO".....	86
4-4	Input variable "Client's characteristics - CC".....	87
4-5	Input variable "Tender documents' completeness and clarity - TC".....	87
4-6	Input variable "Project's characteristics - PC".....	88
4-7	Input variable "Environmental conditions - EC".....	88
4-8	Input variable "Construction site suitability - CS".....	89
4-9	Graphical User Interface (GUI) – Input variables.....	95
4-10	Graphical User Interface (GUI) – Output variable	95
4-11	Graphical User Interface (GUI) for example 1 – Input variables	98
4-12	Graphical User Interface (GUI) for example 1 – Output variable.....	98
4-13	Graphical User Interface (GUI) for example 2 – Input variables	100
4-14	Graphical User Interface (GUI) for example 2 – Output variable.....	101