

# Contents

<b>1 Hesitant Fuzzy Multiple Criteria Decision Analysis</b>	
<b>Based on TOPSIS</b> . . . . .	1
1.1 Hesitant Fuzzy Information. . . . .	2
1.2 Description of the Classical TOPSIS Method . . . . .	4
1.3 The Maximizing Deviation Model-Based Hesitant Fuzzy TOPSIS Approach. . . . .	5
1.3.1 The Maximizing Deviation Model to Determine Weights of Criteria . . . . .	6
1.3.2 The Hesitant Fuzzy TOPSIS Model to Rank the Alternatives. . . . .	10
1.4 Numerical Example and Comparison Analysis . . . . .	13
1.4.1 Problem Description and Decision Making Process . . . . .	13
1.4.2 Comparison Analysis. . . . .	15
1.5 Extension of the Proposed Method in the Interval-Valued Hesitant Fuzzy Situations . . . . .	18
1.5.1 Interval-Valued Hesitant Fuzzy Information . . . . .	19
1.5.2 The Maximizing Deviation Model-Based Interval-Valued Hesitant Fuzzy TOPSIS Approach . . . . .	21
1.5.3 Numerical Example with IVHFEs . . . . .	25
1.6 Conclusions . . . . .	28
References . . . . .	29
<b>2 Hesitant Fuzzy Multiple Criteria Decision Analysis Based</b>	
<b>on TODIM</b> . . . . .	31
2.1 Description of the Classical TODIM Method . . . . .	33
2.2 Ranking Functions Related to HFEs and IVHFEs . . . . .	34
2.2.1 The Existing Ranking Functions of HFEs. . . . .	35
2.2.2 The Proposed Ranking Functions . . . . .	37
2.3 The Ranking Functions-Based Hesitant Fuzzy TODIM Approach . . . . .	40

2.4	Illustration Example Based on the Evaluation Problem of Service Quality . . . . .	45
2.4.1	Description. . . . .	45
2.4.2	Decision Making Model. . . . .	46
2.4.3	Sensitivity Analysis of Parameters. . . . .	48
2.4.4	Comparative Analysis and Discussions . . . . .	49
2.5	Extension of the Developed Approach for Handling the MCGDM Problems with HTrFNs. . . . .	53
2.5.1	The Concept of HTrFN . . . . .	53
2.5.2	Hesitant Trapezoidal Fuzzy TODIM Decision Analysis Method. . . . .	59
2.5.3	Case Illustration . . . . .	63
2.6	Conclusions . . . . .	67
	References . . . . .	68
3	<b>Hesitant Fuzzy Multiple Criteria Decision Analysis Based on QUALIFLEX . . . . .</b>	<b>71</b>
3.1	The Concept of a Hesitancy Index for HFE . . . . .	72
3.1.1	The Hesitancy Index . . . . .	72
3.1.2	The Improved Distance Measures for HFES . . . . .	74
3.1.3	The Comparison Methods Based on Hesitancy Indices for HFES. . . . .	77
3.2	Hesitant Fuzzy QUALIFLEX Approach with a Signed Distance-Based Ranking Method. . . . .	79
3.3	A Case Study for Green Supplier Selection. . . . .	82
3.3.1	Decision Context. . . . .	82
3.3.2	Illustration of the Proposed Method. . . . .	84
3.3.3	Comparative Analysis and Discussions . . . . .	86
3.4	Extension of the Proposed Method for Heterogeneous Information. . . . .	91
3.5	Conclusions and Future Research Directions . . . . .	93
	References . . . . .	94
4	<b>Hesitant Fuzzy Multiple Criteria Decision Analysis Based on LINMAP . . . . .</b>	<b>97</b>
4.1	Some Basic Concepts. . . . .	98
4.1.1	Description of the Hesitant Fuzzy MCGDM Problems. . . . .	98
4.1.2	Interval-Valued Preference Relations . . . . .	99
4.1.3	Hesitant Fuzzy Preference Relation . . . . .	100
4.1.4	Optimization Problems with Interval-Objective Functions . . . . .	101
4.2	Hesitant Fuzzy LINMAP Group Decision Method with Interval Programming Models . . . . .	102
4.2.1	The Proposed Approach. . . . .	102

4.2.2	Other Generalizations of the Proposed Model . . . . .	108
4.2.3	An Energy Project Selection Problem and the Analysis Process . . . . .	113
4.3	Hesitant Fuzzy Programming Model-Based LINMAP Method. . . . .	121
4.3.1	Hesitant Fuzzy Consistency and Inconsistency Indices . . . . .	121
4.3.2	Optimization Model. . . . .	123
4.3.3	Issues that Involve Inconsistent Preference Structure of Criteria Weights . . . . .	126
4.3.4	Case Illustration and Discussions . . . . .	128
4.4	Conclusions and Future Research Directions . . . . .	135
	Appendix . . . . .	136
	References . . . . .	141
<b>5</b>	<b>Consensus Model-Based Hesitant Fuzzy Multiple Criteria Group Decision Analysis . . . . .</b>	<b>143</b>
5.1	Maximizing Consensus Model for Deriving the Weights of Experts. . . . .	144
5.1.1	Group Ordinal Consensus Index . . . . .	144
5.1.2	Group Cardinal Consensus Index . . . . .	146
5.1.3	The Model for Determining the Experts' Weights . . . . .	147
5.2	An Approach Based on TOPSIS for Solving the MCGDM Problem . . . . .	148
5.3	Illustrative Example. . . . .	150
5.4	Conclusions . . . . .	156
	References . . . . .	157
<b>6</b>	<b>Heterogeneous Multiple Criteria Group Decision Analysis . . . . .</b>	<b>159</b>
6.1	Heterogeneous Type of Decision Information . . . . .	160
6.1.1	Linguistic Variables and Fuzzy Numbers . . . . .	161
6.1.2	Hesitant Fuzzy Linguistic Term Sets . . . . .	162
6.2	Description of the Heterogeneous MCGDM Problems . . . . .	164
6.3	The Deviation Modeling Approach . . . . .	167
6.3.1	The Maximizing Deviation Model to Determine the Weights of Criteria. . . . .	167
6.3.2	The Minimizing Deviation Model to Solve the Heterogeneous MCGDM Problems . . . . .	170
6.3.3	The Proposed Algorithm . . . . .	176
6.4	Empirical Analysis for the Selection of Strategic Freight Forwarder. . . . .	177
6.4.1	Description of the Decision Making Problem . . . . .	177
6.4.2	Decision Making Process . . . . .	179
6.4.3	Comparative Analysis . . . . .	184
6.5	Conclusions . . . . .	189
	References . . . . .	190

Hesitant Fuzzy Methods for Multiple Criteria Decision  
Analysis

Zhang, X.; Xu, Z.

2017, XV, 191 p. 6 illus., 3 illus. in color., Hardcover

ISBN: 978-3-319-42000-4