

Contents

1	Preliminary Concepts of Geometric Programming (GP) Model	1
1.1	Introduction	1
1.2	Geometric Program (GP)	5
1.3	Modified Geometric Programming (MGP) Problem	12
1.4	Constrained Geometric Programming (CGP) Problem	18
1.5	Constrained Modified Geometric Programming (CMGP) Problem	21
1.6	Conclusion	24
	References	25
2	Signomial Geometric Programming (GP) Problem	27
2.1	Introduction and History	27
2.2	Definition and Example	27
2.3	Convexity of Signomial Functions	28
2.4	Unconstrained NLP Problem	30
2.5	Unconstrained Modified Signomial Function	33
2.6	Constrained NLP Problem	37
2.7	Primal Modified Signomial GP Problem	40
2.8	Application	43
2.9	Conclusion	44
	References	45
3	Introduction to Fuzzy Set Theory	47
3.1	Overview	47
3.2	Uncertainty and Imprecision	48
3.3	Basic Fuzzy Set Theory	50
3.4	Operations on Fuzzy Sets	58
3.5	Geometrical Interpretation of Fuzzy Sets	63
3.6	Fuzzification	66
3.7	Extension Principle and Its Application	70

3.8	Definition (Extension Principle)	70
3.9	Cartesian Product	71
3.10	Definition (Extension Principle on n -Dimensional Universe)	71
3.11	Conclusions	73
	References	73
4	Fuzzy Numbers and Fuzzy Optimization	75
4.1	Introduction	75
4.2	Fuzzy Number	76
4.3	Generalized Fuzzy Number (GFN)	91
4.4	Generalized Trapezoidal Fuzzy Number (GTrFN)	91
4.5	Integral Value	92
4.6	Fuzzy Number and Its Nearest Interval Approximation	93
4.6.1	α -Level Set	93
4.6.2	Interval Number	93
4.6.3	Nearest Interval Approximation	94
4.6.4	Parametric Interval-Valued Function	95
4.7	Fuzzy Equation	95
4.8	Single-Objective Mathematical Programming	98
4.8.1	Calculus-Based Method: (Newton-Raphson Method)	99
4.9	Decision-Making in Fuzzy Environment of Mathematical Programming Problem	100
4.9.1	Max-Min Operator	100
4.9.2	Max Additive Operator	102
4.9.3	Max Product Operator	104
4.9.4	Fuzzy Optimization Approach	104
4.10	Fuzzy Optimization (Zimmerman Approach)	111
4.11	Some Basic Concepts of Uncertainty Theory	114
4.12	Intuitionistic Fuzzy Numbers	117
4.13	Neutrosophic Set	121
4.14	Hesitant Fuzzy Set	122
4.15	Pythagorean Fuzzy Set	126
4.16	Type-2 Fuzzy Set	128
4.17	Conclusion	130
	References	130
5	Fuzzy Unconstrained Geometric Programming Problem	133
5.1	Introduction	133
5.2	GP Problem with Fuzzy Parametric Interval-Valued Function	135
5.3	GP Problem with Simple Fuzzy Parametric Coefficients	141

5.4	GP Problem with Zimmermann Max-Min Operators	145
5.5	Conclusion	152
	References	153
6	Fuzzy Unconstrained Modified Geometric Programming Problem	155
6.1	Introduction	155
6.2	Unconstrained MGP Problem with Fuzzy Parametric Interval-Valued Function	156
6.3	Unconstrained MGP Problem with Simple Fuzzy Parametric Coefficients	163
6.4	Unconstrained MGP Problem with Zimmermann Max-Min Operator	168
6.5	Conclusion	173
	References	174
7	Fuzzy Constrained Geometric Programming Problem	175
7.1	Introduction	175
7.2	Geometric Programming Problem with Fuzzy Coefficient	177
7.3	Fuzzy Parametric Geometric Programming	180
7.4	Constrained GP Under Max-Min Operator	184
7.5	Conclusion	188
	References	189
8	Constrained Fuzzy Modified Geometric Programming Problem	191
8.1	Introduction	191
8.2	Modified Geometric Programming Problem with Fuzzy Coefficient	192
8.3	Fuzzy Parametric Modified Geometric Programming	197
8.4	Constrained MGP Under Max-Min Operator	200
8.5	Conclusion	206
	References	207
9	Fuzzy Signomial Geometric Programming Problem	209
9.1	Introduction and History	209
9.2	Unconstrained Problem	210
9.2.1	Unconstrained Fuzzy Signomial GP Problem	210
9.2.2	Unconstrained Modified Fuzzy Signomial GP Problem	216
9.3	Constrained GP Problem	224
9.3.1	Constrained Fuzzy Signomial GP Problem	224
9.3.2	Constrained Modified Fuzzy Signomial GP Problem	227
9.4	Conclusion	230
	References	231

10	Goal Geometric Programming	233
10.1	Introduction	233
10.2	Strength and Weakness of Goal Programming	234
10.3	Importance of Weighted Goal Programming (WGP)	236
10.4	Chebyshev Goal Programming Model	236
10.5	Multi-objective Problem	236
10.5.1	Multi-objective Goal Geometric Programming (MOGP) Problem	237
10.5.2	Multi-objective Weighted Goal Programming (MOWGP) Formula	239
10.5.3	Formulation of Goal GP Programming Using Weight	239
10.5.4	Dual Form of Goal GP Problem	239
10.6	Goal Programming with Logarithmic Deviation Variables	242
10.6.1	Weighted Goal Programming Problem with Logarithmic Deviation Variables	244
10.7	Fuzzy Goal Programming Problem	248
10.7.1	Fuzzy Multi-objective Goal Programming (FMOGP) in Parametric Form	250
10.7.2	Fuzzy Goal Programming Problem with Logarithmic Deviation Variables	251
10.7.3	Fuzzy Weighted Goal Programming Problem with Logarithmic Deviation Variables	252
10.8	Conclusion	255
	References	257
11	Fuzzy Multi-objective Geometric Programming (FMOGP) Problem	259
11.1	Introduction	259
11.2	Fuzzy Nonlinear Programming (FNLP)	259
11.3	Multi-objective Mathematical Programming (MOMP) Problem	262
11.4	Multi-objective Optimization	263
11.5	Fuzzy Multi-objective Mathematical Programming (FMOMP) Problem	276
11.6	Inventory Models Through Geometric Programming Approach	279
11.7	Conclusion	285
	References	285
12	Geometric Programming Problem Under Uncertainty	287
12.1	Introduction	287
12.2	Uncertain Chance-Constrained Geometric Programming (UCCGP) Model	287

12.2.1	UCCGP Model with Linear Uncertainty Distributions	289
12.2.2	UCCGP Model with Normal Uncertainty Distributions	290
12.2.3	UCCGP Model with Zigzag Uncertainty Distributions	291
12.2.4	Numerical Examples	292
12.3	Geometric Programming Approach Under Expected, Variance, 2-ND Moment, and Entropy-Based Zigzag Uncertainty Distribution	295
12.3.1	Solution Procedure Under Expected-Based UVs	298
12.3.2	Solution Procedure Under Variance-Based UVs	299
12.3.3	Solution Procedure Under 2-ND Moment-Based UVs	301
12.3.4	Solution Procedure Under Entropy-Based UVs	302
12.3.5	Applying the Proposed UCCGP to a Two-Bar Truss Structural Model	303
12.3.6	Numerical Example and Solution	310
12.4	Multi-objective Geometric Programming Problem Under Uncertainty	312
12.4.1	Uncertain Multi-objective Programming	312
12.4.2	UCCMOGP Model with Linear Uncertainty Distributions	315
12.4.3	UCCMOGP Model with Normal Uncertainty Distributions	317
12.4.4	UCCMOGP Model with Zigzag Uncertainty Distributions	319
12.4.5	Numerical Examples	321
12.5	Conclusion	329
	References	330

13 Intuitionistic and Neutrosophic Geometric Programming

	Problem	331
13.1	Introduction	331
13.2	Intuitionistic Fuzzy Posynomial Geometric Programming Problem	331
13.2.1	Posynomial Geometric Programming with Intuitionistic Fuzzy Coefficient	333
13.2.2	Numerical Example (Design of a Two-Bar Truss) (Kheiri and Cao 2016)	336
13.3	Intuitionistic Fuzzy Goal Programming Model	338
13.3.1	Goal Geometric Programming Model	340

13.3.2	Illustrative Numerical Example (Ghosh and Roy 2014).....	341
13.4	Neutrosophic Goal Geometric Programming Problem	344
13.4.1	Neutrosophic Multi-objective Goal Geometric Programming Problem	344
13.4.2	Mathematical Model	350
13.4.3	Neutrosophic Goal Geometric Programming Technique on Reliability Optimization Model	351
13.4.4	Numerical Example	353
13.5	Conclusion	355
	References	355
Index		357