

Contents

Introduction	1
1. Dealing with Uncertainties in a Robust Way	9
1.1. Robustness	10
1.1.1. Robust Linear Programming	10
1.1.2. Robust Combinatorial Optimization	12
1.2. Extending Robustness to Recoverable Robustness	15
2. k-Distance Recoverable Robustness	19
2.1. Introduction	19
2.2. Discrete Scenarios	23
2.2.1. Weighted Disjoint Hitting Set Problem	29
2.3. Interval Scenarios	32
2.3.1. Weighted Disjoint Hitting Set Problem	33
2.3.2. Minimum Weight Basis Problem for Matroids	35
2.4. Γ -scenarios	37
2.5. Shortest Path Problem	38
2.5.1. Simple (s, t) -Paths as First-Stage Solutions	39
2.5.2. (s, t) -Paths as First-Stage Solutions	41
2.6. Conclusion and Open Issues	48
3. Rent Recoverable Robustness	51
3.1. Introduction	51
3.2. Discrete Scenarios	53
3.3. Interval Scenarios	55
3.4. Γ -Scenarios	56
3.5. Approximation via Robust Solutions	58
3.6. Conclusion and Open Issues	60
4. Exact Subset Recoverable Robustness	61
4.1. Introduction	61
4.2. Discrete Scenarios	64
4.3. Interval Scenarios	67
4.3.1. Shortest Path Problem	71
4.3.2. Minimum (s, t) -Cut Problem	72
4.4. Γ -scenarios	73
4.4.1. Weighted Disjoint Hitting Set Problem	74
4.5. Matroids	75
4.5.1. Discrete Scenarios	76
4.5.2. Interval Scenarios	77
4.5.3. Γ -scenarios	79
4.6. Approximation Algorithms	81

4.7. Conclusion and Open Issues	83
5. A Recoverable Robust Knapsack Problem	85
5.1. Introduction	85
5.2. Discrete Scenarios	88
5.2.1. Complexity of the (k, ℓ) -rrKP	89
5.2.2. Extended Cover Inequalities	97
5.2.3. Computational Experiments	102
5.3. Interval Scenarios	107
5.4. Γ -Scenarios	107
5.4.1. An Optimal Γ -Strategy	108
5.4.2. A Polynomial Size ILP-Formulation	111
5.4.3. Extended Cover-Inequalities	113
5.5. Conclusion and Open Issues	117
6. Recoverable Robust Train Classification	119
6.1. Introduction	119
6.2. Encoding Classification Schedules	121
6.3. Recovery by Additional Sorting Steps	123
6.3.1. Generic Algorithm	125
6.3.2. Computational Complexity	127
6.3.3. Problem Variants	129
6.4. Limited Number of Delayed Trains	129
6.4.1. Experimental Evaluation	133
6.5. Types in Fixed Order	135
6.6. Conclusion and Open Issues	137
Bibliography	139
A. Max-Scenario Problems	145
A.1. Shortest Path Problem	145
A.2. Minimum (s, t) -Cut Problem	148
A.3. Weighted Disjoint Hitting Set Problem	150
B. Cardinality Constrained Minimum (s, t)-Cut Problem	153
Zusammenfassung (German)	155