

Supplementary Material

Benchmark Instances for the Bilevel Optimization of the Toll Pricing Problem

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Abstract. The Toll Pricing Problem (TPP) seeks to optimize tolls in a network by maximizing profit while minimizing the travel cost of users. Bilevel optimization emerges as a suitable way for modeling this problem, as it allows the regulatory authority to anticipate users' responses to the toll policy. Due to the complexity of the problem, metaheuristics are frequently employed. The development of new metaheuristics requires a rigorous investigation process, involving the testing of different search strategies and parameter settings. Moreover, comparative evaluation between methods is essential to validate progress and guide improvements in bilevel optimization techniques. We propose a benchmark suite comprising 192 instances for a bilevel toll optimization problem. In this setting, the upper-level objective is to maximize the toll manager's profit, while the lower level minimizes the total travel cost for routing a set of commodities across a network. The benchmark includes instances ranging from 10 to 60 nodes and 5 to 40 commodities, with tolls applied to 20% to 40% of edges in smaller instances (up to 15 nodes) and 5% to 20% in larger instances (up to 60 nodes). A bilevel algorithm with multiple followers was used to generate reference results, which are provided for future benchmarking. The dataset includes the best obtained toll values and their corresponding routing costs.

Keywords: Toll Optimization, Bilevel Optimization, Benchmark Instances, Differential Evolution

1 Instances

Table 1. Complete Instance data

File	Nodes	Commodities	Edges	Toll Edges
instance_10_1_20.txt	10	5	15	3
instance_10_1_30.txt	10	5	15	5
instance_10_1_40.txt	10	5	15	6
instance_10_2_20.txt	10	8	15	3
instance_10_2_30.txt	10	8	15	5
instance_10_2_40.txt	10	8	15	6
instance_15_1_20.txt	15	5	27	6
instance_15_1_30.txt	15	5	27	9
instance_15_1_40.txt	15	5	27	11
instance_15_2_20.txt	15	10	27	6
instance_15_2_30.txt	15	10	27	9
instance_15_2_40.txt	15	10	27	11
instance_20_1_5.txt	20	5	22	2

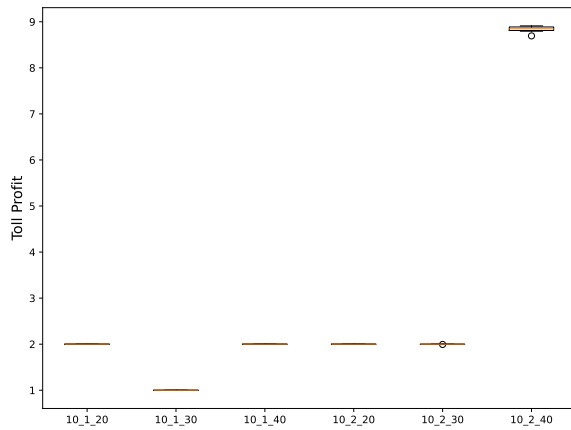
File	Nodes	Commodities	Edges	Toll Edges
instance_20_1_10.txt	20	5	22	3
instance_20_1_15.txt	20	5	22	4
instance_20_1_20.txt	20	5	22	5
instance_20_2_5.txt	20	10	22	2
instance_20_2_10.txt	20	10	22	3
instance_20_2_15.txt	20	10	22	4
instance_20_2_20.txt	20	10	22	5
instance_20_3_5.txt	20	7	22	2
instance_20_3_10.txt	20	7	22	3
instance_20_3_15.txt	20	7	22	4
instance_20_3_20.txt	20	7	22	5
instance_20_4_5.txt	20	10	22	2
instance_20_4_10.txt	20	10	22	3
instance_20_4_15.txt	20	10	22	4
instance_20_4_20.txt	20	10	22	5
instance_20_5_5.txt	20	13	22	2
instance_20_5_10.txt	20	13	22	3
instance_20_5_15.txt	20	13	22	4
instance_20_5_20.txt	20	13	22	5
instance_25_1_5.txt	25	5	35	2
instance_25_1_10.txt	25	5	35	4
instance_25_1_15.txt	25	5	35	6
instance_25_1_20.txt	25	5	35	7
instance_25_2_5.txt	25	10	35	2
instance_25_2_10.txt	25	10	35	4
instance_25_2_15.txt	25	10	35	6
instance_25_2_20.txt	25	10	35	7
instance_25_3_5.txt	25	8	35	2
instance_25_3_10.txt	25	8	35	4
instance_25_3_15.txt	25	8	35	6
instance_25_3_20.txt	25	8	35	7
instance_25_4_5.txt	25	12	35	2
instance_25_4_10.txt	25	12	35	4
instance_25_4_15.txt	25	12	35	6
instance_25_4_20.txt	25	12	35	7
instance_25_5_5.txt	25	17	35	2
instance_25_5_10.txt	25	17	35	4
instance_25_5_15.txt	25	17	35	6
instance_25_5_20.txt	25	17	35	7
instance_30_1_5.txt	30	5	51	3
instance_30_1_10.txt	30	5	51	6
instance_30_1_15.txt	30	5	51	8
instance_30_1_20.txt	30	5	51	11
instance_30_2_5.txt	30	10	51	3
instance_30_2_10.txt	30	10	51	6
instance_30_2_15.txt	30	10	51	8

File	Nodes	Commodities	Edges	Toll Edges
instance_30_2_20.txt	30	10	51	11
instance_30_3_5.txt	30	10	51	3
instance_30_3_10.txt	30	10	51	6
instance_30_3_15.txt	30	10	51	8
instance_30_3_20.txt	30	10	51	11
instance_30_4_5.txt	30	15	51	3
instance_30_4_10.txt	30	15	51	6
instance_30_4_15.txt	30	15	51	8
instance_30_4_20.txt	30	15	51	11
instance_30_5_5.txt	30	20	51	3
instance_30_5_10.txt	30	20	51	6
instance_30_5_15.txt	30	20	51	8
instance_30_5_20.txt	30	20	51	11
instance_35_1_5.txt	35	5	70	4
instance_35_1_10.txt	35	5	70	7
instance_35_1_15.txt	35	5	70	11
instance_35_1_20.txt	35	5	70	14
instance_35_2_5.txt	35	10	70	4
instance_35_2_10.txt	35	10	70	7
instance_35_2_15.txt	35	10	70	11
instance_35_2_20.txt	35	10	70	14
instance_35_3_5.txt	35	12	70	4
instance_35_3_10.txt	35	12	70	7
instance_35_3_15.txt	35	12	70	11
instance_35_3_20.txt	35	12	70	14
instance_35_4_5.txt	35	18	70	4
instance_35_4_10.txt	35	18	70	7
instance_35_4_15.txt	35	18	70	11
instance_35_4_20.txt	35	18	70	14
instance_35_5_5.txt	35	23	70	4
instance_35_5_10.txt	35	23	70	7
instance_35_5_15.txt	35	23	70	11
instance_35_5_20.txt	35	23	70	14
instance_40_1_5.txt	40	5	92	5
instance_40_1_10.txt	40	5	92	10
instance_40_1_15.txt	40	5	92	14
instance_40_1_20.txt	40	5	92	19
instance_40_2_5.txt	40	10	92	5
instance_40_2_10.txt	40	10	92	10
instance_40_2_15.txt	40	10	92	14
instance_40_2_20.txt	40	10	92	19
instance_40_3_5.txt	40	13	92	5
instance_40_3_10.txt	40	13	92	10
instance_40_3_15.txt	40	13	92	14
instance_40_3_20.txt	40	13	92	19
instance_40_4_5.txt	40	20	92	5

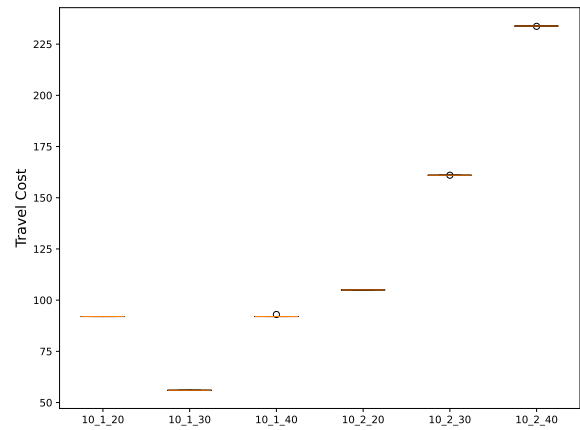
File	Nodes	Commodities	Edges	Toll Edges
instance_40_4_10.txt	40	20	92	10
instance_40_4_15.txt	40	20	92	14
instance_40_4_20.txt	40	20	92	19
instance_40_5_5.txt	40	27	92	5
instance_40_5_10.txt	40	27	92	10
instance_40_5_15.txt	40	27	92	14
instance_40_5_20.txt	40	27	92	19
instance_45_1_5.txt	45	5	116	6
instance_45_1_10.txt	45	5	116	12
instance_45_1_15.txt	45	5	116	18
instance_45_1_20.txt	45	5	116	24
instance_45_2_5.txt	45	10	116	6
instance_45_2_10.txt	45	10	116	12
instance_45_2_15.txt	45	10	116	18
instance_45_2_20.txt	45	10	116	24
instance_45_3_5.txt	45	15	116	6
instance_45_3_10.txt	45	15	116	12
instance_45_3_15.txt	45	15	116	18
instance_45_3_20.txt	45	15	116	24
instance_45_4_5.txt	45	22	116	6
instance_45_4_10.txt	45	22	116	12
instance_45_4_15.txt	45	22	116	18
instance_45_4_20.txt	45	22	116	24
instance_45_5_5.txt	45	30	116	6
instance_45_5_10.txt	45	30	116	12
instance_45_5_15.txt	45	30	116	18
instance_45_5_20.txt	45	30	116	24
instance_50_1_5.txt	50	5	144	8
instance_50_1_10.txt	50	5	144	15
instance_50_1_15.txt	50	5	144	22
instance_50_1_20.txt	50	5	144	29
instance_50_2_5.txt	50	10	144	8
instance_50_2_10.txt	50	10	144	15
instance_50_2_15.txt	50	10	144	22
instance_50_2_20.txt	50	10	144	29
instance_50_3_5.txt	50	17	144	8
instance_50_3_10.txt	50	17	144	15
instance_50_3_15.txt	50	17	144	22
instance_50_3_20.txt	50	17	144	29
instance_50_4_5.txt	50	25	144	8
instance_50_4_10.txt	50	25	144	15
instance_50_4_15.txt	50	25	144	22
instance_50_4_20.txt	50	25	144	29
instance_50_5_5.txt	50	33	144	8
instance_50_5_10.txt	50	33	144	15
instance_50_5_15.txt	50	33	144	22

File	Nodes	Commodities	Edges	Toll Edges
instance_50_5_20.txt	50	33	144	29
instance_55_1_5.txt	55	5	175	9
instance_55_1_10.txt	55	5	175	18
instance_55_1_15.txt	55	5	175	27
instance_55_1_20.txt	55	5	175	35
instance_55_2_5.txt	55	10	175	9
instance_55_2_10.txt	55	10	175	18
instance_55_2_15.txt	55	10	175	27
instance_55_2_20.txt	55	10	175	35
instance_55_3_5.txt	55	18	175	9
instance_55_3_10.txt	55	18	175	18
instance_55_3_15.txt	55	18	175	27
instance_55_3_20.txt	55	18	175	35
instance_55_4_5.txt	55	28	175	9
instance_55_4_10.txt	55	28	175	18
instance_55_4_15.txt	55	28	175	27
instance_55_4_20.txt	55	28	175	35
instance_55_5_5.txt	55	37	175	9
instance_55_5_10.txt	55	37	175	18
instance_55_5_15.txt	55	37	175	27
instance_55_5_20.txt	55	37	175	35
instance_60_1_5.txt	60	5	208	11
instance_60_1_10.txt	60	5	208	21
instance_60_1_15.txt	60	5	208	32
instance_60_1_20.txt	60	5	208	42
instance_60_2_5.txt	60	10	208	11
instance_60_2_10.txt	60	10	208	21
instance_60_2_15.txt	60	10	208	32
instance_60_2_20.txt	60	10	208	42
instance_60_3_5.txt	60	20	208	11
instance_60_3_10.txt	60	20	208	21
instance_60_3_15.txt	60	20	208	32
instance_60_3_20.txt	60	20	208	42
instance_60_4_5.txt	60	30	208	11
instance_60_4_10.txt	60	30	208	21
instance_60_4_15.txt	60	30	208	32
instance_60_4_20.txt	60	30	208	42
instance_60_5_5.txt	60	40	208	11
instance_60_5_10.txt	60	40	208	21
instance_60_5_15.txt	60	40	208	32
instance_60_5_20.txt	60	40	208	42

2 Graphics

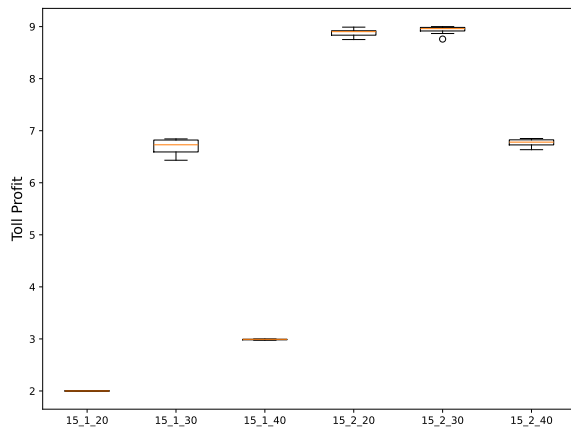


(a) Leader for instances with 10 customers

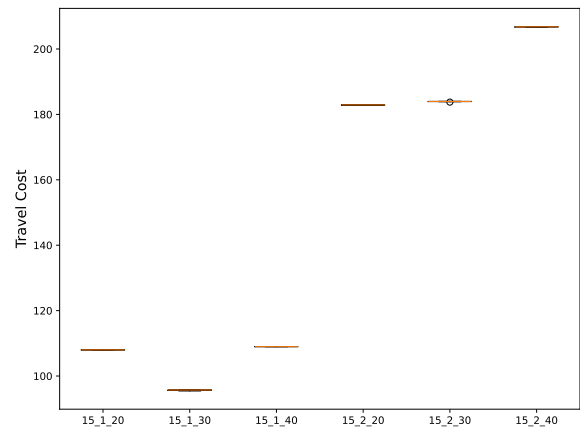


(b) Follower for instances with 10 customers

Figure 1. Resultados obtidos para o Leader e para o Follower nas instâncias com 10 nós.

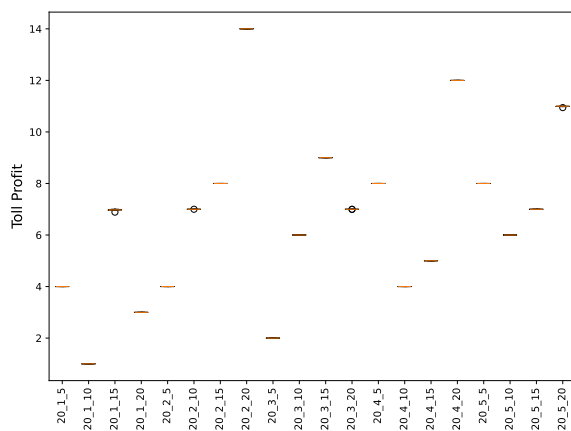


(a) Leader for instances with 15 customers

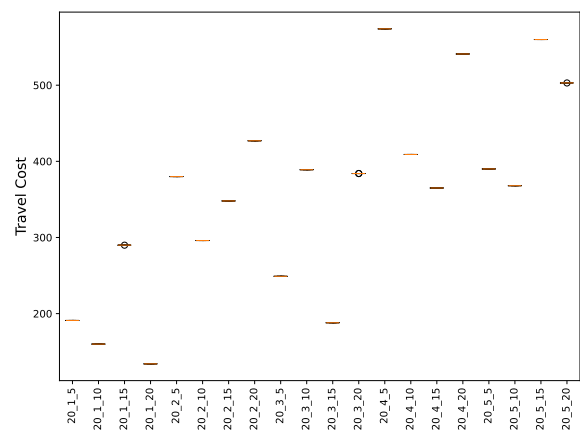


(b) Follower for instances with 15 customers

Figure 2. Resultados obtidos para o Leader e para o Follower nas instâncias com 15 nós.

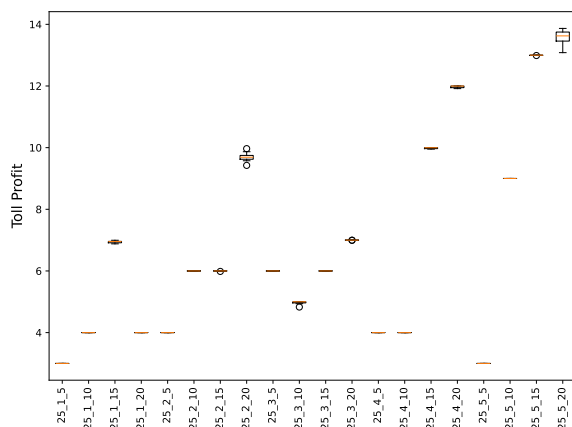


(a) Leader for instances with 20 customers

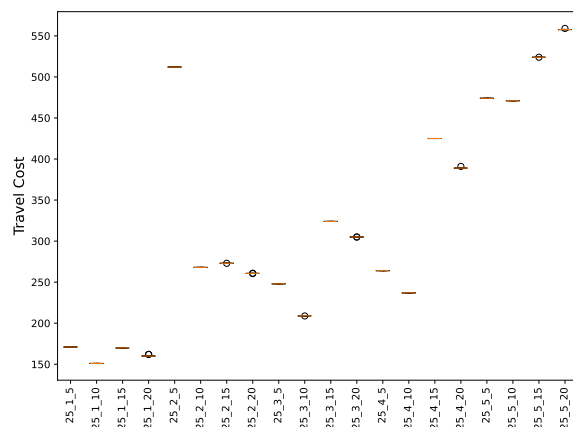


(b) Follower for instances with 20 customers

Figure 3. Resultados obtidos para o Leader e para o Follower nas instâncias com 15 nós.

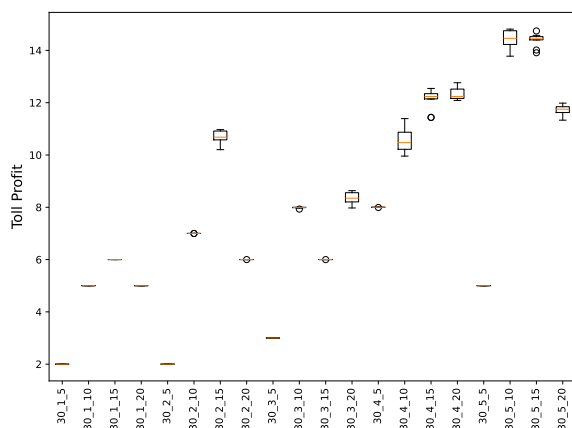


(a) Leader for instances with 25 customers

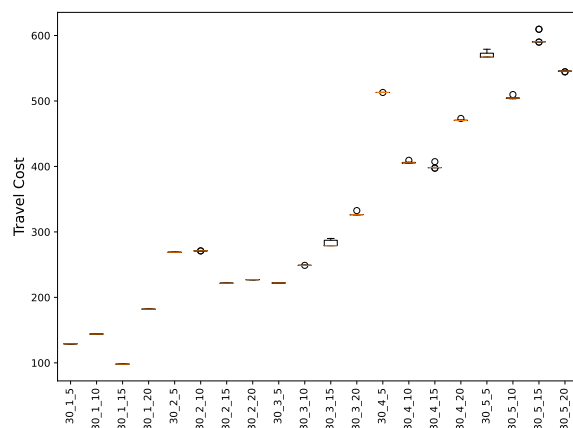


(b) Follower for instances with 25 customers

Figure 4. Resultados obtidos para o Leader e para o Follower nas instâncias com 25 nós.

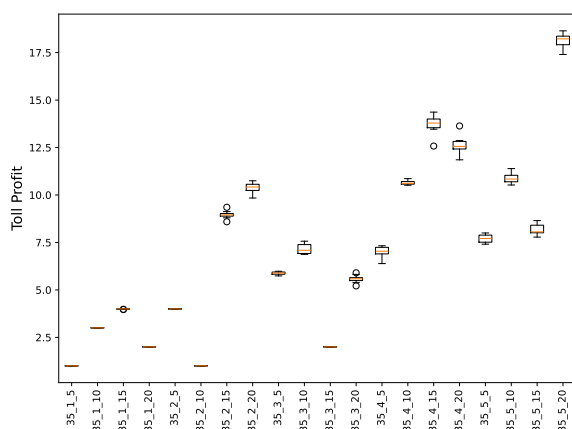


(a) Leader for instances with 30 customers

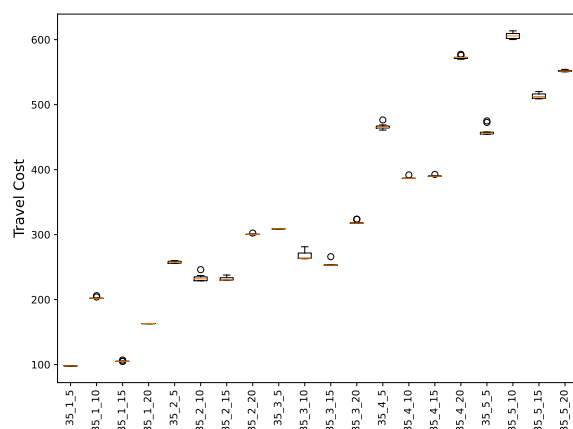


(b) Follower for instances with 30 customers

Figure 5. Resultados obtidos para o Leader e para o Follower nas instâncias com 30 nós.

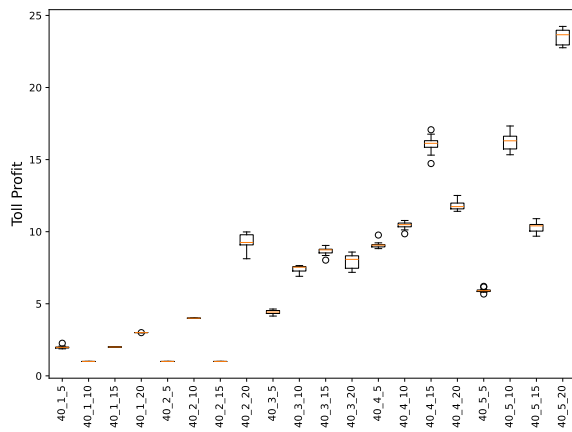


(a) Leader for instances with 35 customers

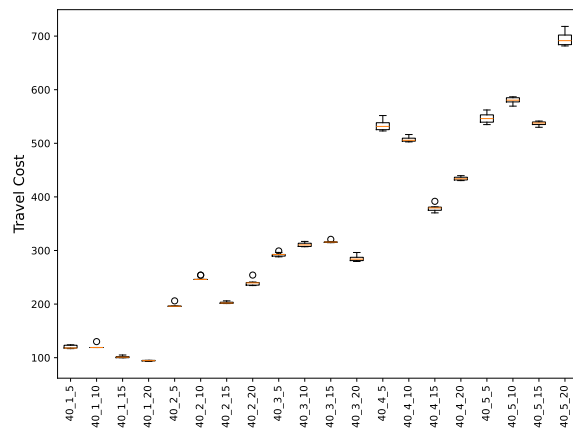


(b) Follower for instances with 35 customers

Figure 6. Resultados obtidos para o Leader e para o Follower nas instâncias com 35 nós.

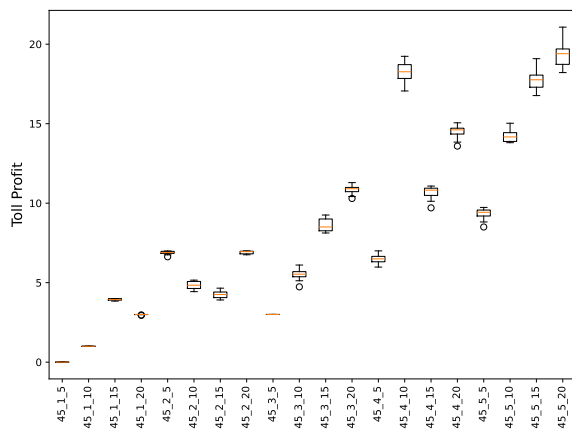


(a) Leader for instances with 40 customers

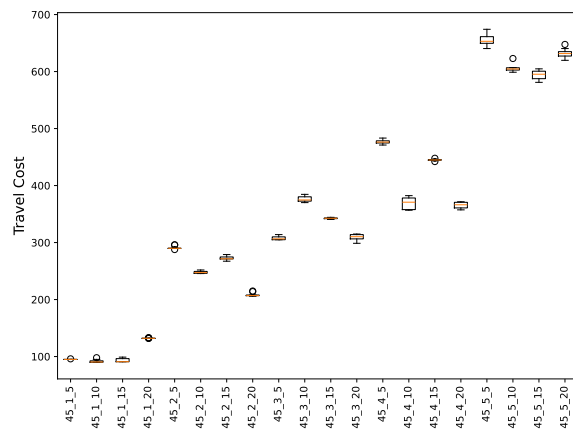


(b) Follower for instances with 40 customers

Figure 7. Resultados obtidos para o Leader e para o Follower nas instâncias com 40 nós.

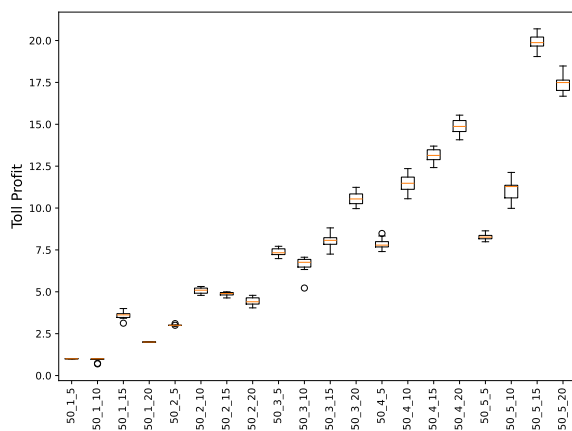


(a) Leader for instances with 45 customers

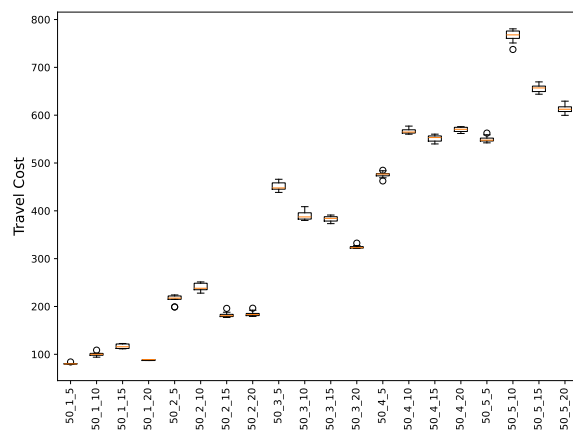


(b) Follower for instances with 45 customers

Figure 8. Resultados obtidos para o Leader e para o Follower nas instâncias com 45 nós.

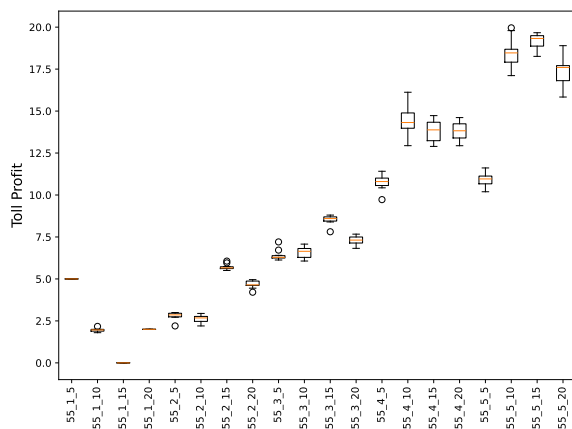


(a) Leader for instances with 50 customers

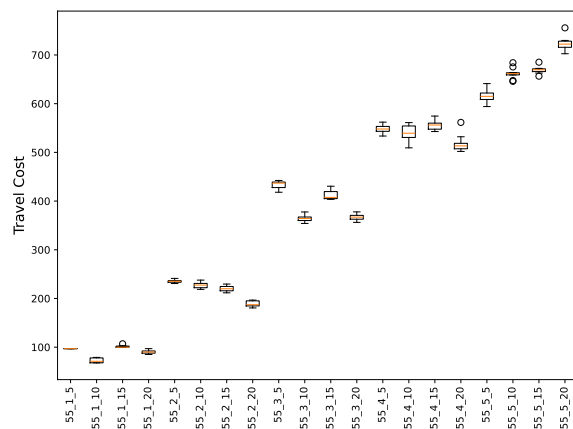


(b) Follower for instances with 50 customers

Figure 9. Resultados obtidos para o Leader e para o Follower nas instâncias com 50 nós.

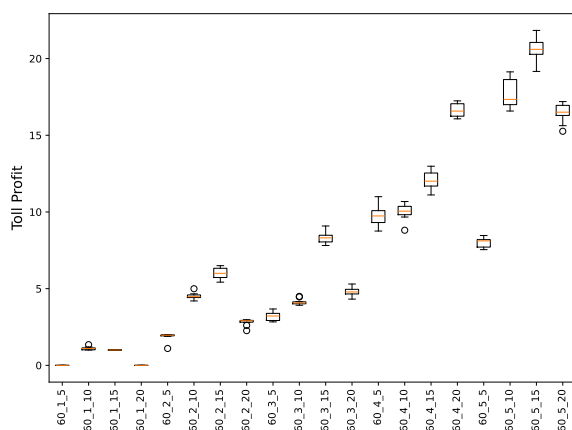


(a) Leader for instances with 55 customers

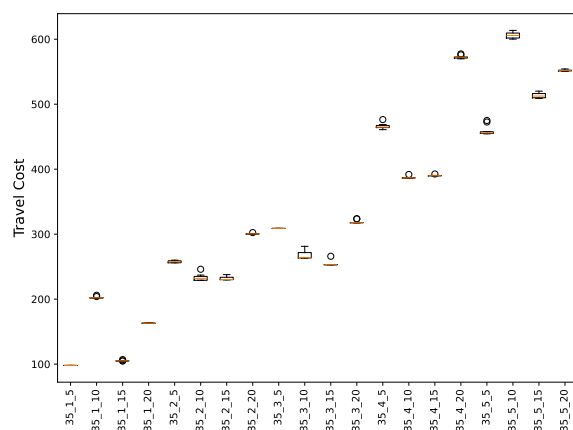


(b) Follower for instances with 55 customers

Figure 10. Resultados obtidos para o Leader e para o Follower nas instâncias com 55 nós.



(a) Leader for instances with 60 customers



(b) Follower for instances with 60 customers

Figure 11. Resultados obtidos para o Leader e para o Follower nas instâncias com 60 nós.