Deep Reinforcement Learning for Solving Two-Echelon Capacity Vehicle Routing Problems:An End to End Method

I. Appendices

TABLE I
RESULTS FOR THE 2E-CVRP INSTANCES OF RANDOM SET.

Instance	Gurobi (10m)			DRL-2ECVRP (Greedy)			DRL-2ECVRP (Sample-400)			DRL-2ECVRP (TL)		
	B.O	T(s)	Gap	B.O	T(s)	Gap	B.O	T(s)	Gap	B.O	T(s)	Gap
21c_2s_0.pkl	6.48	2.48	0.00	6.57	0.05	1.39	6.55	0.58	1.08	6.50	13.11	0.31
21c_2s_1.pkl	5.54	188.77	0.00	5.59	0.04	0.90	5.59	0.52	0.90	5.54	12.86	0.00
21c_2s_2.pkl	5.31	11.2	0.00	5.38	0.04	1.32	5.35	0.54	0.75	5.35	12.91	0.75
21c_2s_3.pkl	6.07	12.81	0.00	6.32	0.04	4.12	6.21	0.50	2.31	6.07	12.73	0.00
21c_2s_4.pkl	4.73	11.27	0.00	4.81	0.05	1.69	4.76	0.45	0.63	4.76	12.14	0.63
21c_2s_5.pkl	5.48	25.95	0.00	5.66	0.04	3.28	5.52	0.46	0.73	5.52	12.54	0.73
21c_2s_6.pkl	4.87	3.34	0.00	4.87	0.04	0.00	4.87	0.44	0.00	4.87	12.54	0.00
21c_2s_7.pkl	5.54	0.85	0.00	5.71	0.04	3.07	5.57	0.50	0.54	5.55	12.51	0.18
21c_2s_8.pkl	5.78	31.76	0.00	6.23	0.05	7.79	6.1	0.50	5.54	5.99	12.76	3.63
21c_2s_9.pkl	5.69	20.09	0.00	5.69	0.06	0.00	5.69	0.53	0.00	5.69	13.90	0.00
Mean	5.55	30.85	0.00	5.68	**0.05**	2.36	5.62	0.50	1.25	5.58	12.80	0.62
51c_5s_0.pkl	9.08	600.00	0.00	9.68	0.10	6.61	9.51	5.04	4.74	9.23	32.57	1.65
51c_5s_1.pkl	9.82	600.00	6.05	9.54	0.11	3.02	9.35	4.61	0.97	9.26	34.26	0.00
51c_5s_2.pkl	8.52	600.00	0.00	9.05	0.11	6.22	8.78	4.55	3.05	8.86	33.13	3.99
51c_5s_3.pkl	10.14	600.00	0.00	10.61	0.11	4.64	10.31	5.29	1.68	10.18	33.39	0.39
51c_5s_4.pkl	9.65	600.00	2.88	9.96	0.10	6.20	9.74	5.11	3.84	9.38	32.7	0.00
51c_5s_5.pkl	9.09	600.00	0.00	9.3	0.11	2.31	9.15	6.01	0.66	9.10	33.68	0.11
51c_5s_6.pkl	9.59	600.00	0.31	9.92	0.11	3.77	9.56	4.97	0.00	9.62	33.26	0.63
51c_5s_7.pkl	9.92	600.00	0.00	10.52	0.11	6.05	10.29	4.74	3.73	10.20	32.7	2.82
51c_5s_8.pkl	11.24	600.00	0.90	11.69	0.12	4.94	11.42	5.03	2.51	11.14	33.16	0.00
51c_5s_9.pkl	8.4	600.00	0.00	9.59	0.10	14.17	8.8	5.02	4.76	8.61	31.14	2.50
Mean	9.55	600.00	1.01	9.99	**0.11**	5.79	9.69	5.04	2.59	9.56	33.00	1.21
100c_5s_0.pkl	17.61	600.00	10.71	16.71	0.23	5.03	16.31	31.66	2.51	15.91	108.77	0.00
100c_5s__1.pkl	16.17	600.00	0.97	16.73	0.24	4.50	16.46	33.24	2.81	16.01	112.75	0.00
100c_5s__2.pkl	14.83	600.00	3.49	15.18	0.25	5.93	14.42	35.33	0.63	14.33	117.93	0.00
100c_5s__3.pkl	14.60	600.00	6.99	14.5	0.24	6.23	13.83	34.5	1.32	13.65	113.04	0.00
100c_5s__4.pkl	16.33	600.00	0.28	16.9	0.24	3.81	16.42	33.58	0.86	16.28	114.41	0.00
100c_5s__5.pkl	15.55	600.00	0.00	16.46	0.25	5.85	16.02	36.8	3.02	15.76	115.91	1.35
100c_5s__6.pkl	16.24	600.00	5.03	16.15	0.24	4.46	15.81	36.58	2.26	15.46	112.42	0.00
100c_5s__7.pkl	16.92	600.00	13.27	15.47	0.25	3.55	15.14	35.19	1.34	14.94	114.27	0.00
100c_5s__8.pkl	16.54	600.00	6.56	16.94	0.24	9.15	16.26	36.03	4.77	15.52	115.1	0.00
100c_5s__9.pkl	16.96	600.00	7.11	17.16	0.24	8.40	16.36	36.72	3.35	15.83	116.61	0.00
Mean	16.17	600.00	5.44	16.22	**0.24**	5.69	15.70	34.96	2.29	15.37	114.12	**0.14**

TABLE II
DRL-2ECVRP-TL AND GUROBI RESULTS FOR THE 2E-CVRP INSTANCES OF SET 2.

Instance	BKS	Gurobi(10m)			DRL-2ECVRP(TL)		
		B.O	T(s)	Gap	B.O	T(s)	Gap
Set2a_E-n22-k4-s10-14.dat	371.50	371.50	2.28	0.00	371.5	68.09	0.00
Set2a_E-n22-k4-s11-12.dat	427.22	427.22	33.66	0.00	427.22	66.12	0.00
Set2a_E-n22-k4-s12-16.dat	392.78	392.78	7.81	0.00	392.78	66.29	0.00
Set2a_E-n22-k4-s6-17.dat	417.07	417.07	2.00	0.00	417.06	65.19	0.00
Set2a_E-n22-k4-s8-14.dat	384.96	384.96	2.60	0.00	384.96	67.13	0.00
Set2a_E-n22-k4-s9-19.dat	470.60	470.60	26.75	0.00	470.6	66.91	0.00
Set2a_E-n33-k4-s1-9.dat	730.16	730.16	69.19	0.00	731.31	89.46	0.16
Set2a_E-n33-k4-s14-22.dat	779.05	779.05	600.00	0.00	784.42	89.46	0.69
Set2a_E-n33-k4-s2-13.dat	714.63	714.63	47.35	0.00	717.01	91.02	0.33
Set2a_E-n33-k4-s3-17.dat	707.48	707.48	166.51	0.00	712.33	90.41	0.69
Set2a_E-n33-k4-s4-5.dat	778.74	778.74	512.44	0.00	786.51	91.10	1.00
Set2a_E-n33-k4-s7-25.dat	756.85	756.85	154.78	0.00	765.65	92.84	1.16
Set2b_E-n51-k5-s11-19-27-47.dat	527.63	527.63	600.00	0.00	527.65	155.17	0.00
Set2b_E-n51-k5-s11-19.dat	581.64	581.64	600.00	0.00	585.6	142.32	0.68
Set2b_E-n51-k5-s2-17.dat	597.49	597.49	600.00	0.00	611.43	143.58	2.33
Set2b_E-n51-k5-s2-4-17-46.dat	530.76	544.96	600.00	2.68	557.26	146.63	4.99
Set2b_E-n51-k5-s27-47.dat	538.22	538.22	600.00	0.00	539.99	142.27	0.33
Set2b_E-n51-k5-s32-37.dat	552.28	552.28	600.00	0.00	555.87	145.01	0.65
Set2b_E-n51-k5-s4-46.dat	530.76	530.76	600.00	0.00	545.4	142.55	2.76
Set2b_E-n51-k5-s6-12-32-37.dat	531.92	554.16	600.00	4.18	549.04	154.18	3.22
Set2b_E-n51-k5-s6-12.dat	554.81	568.00	600.00	2.38	561.69	143.08	1.24

TABLE III
DRL-2ECVRP-TL AND GUROBI RESULTS FOR THE 2E-CVRP INSTANCES OF SET 3.

Instance	BKS	Gurobi(10m)			DRL-2ECVRP-(TL)		
		B.O	T(s)	Gap	B.O	T(s)	Gap
Set3_E-n22-k4-s13-14.dat	526.15	526.15	16.45	0.00	536.32	71.28	1.93
Set3_E-n22-k4-s13-16.dat	521.09	521.09	22.8	0.00	521.09	68.53	0.00
Set3_E-n22-k4-s13-17.dat	496.38	496.38	16.95	0.00	496.38	70.36	0.00
Set3_E-n22-k4-s14-19.dat	498.8	498.80	63.34	0.00	499.74	69.25	0.19
Set3_E-n22-k4-s17-19.dat	512.8	512.80	240.28	0.00	512.8	75.06	0.00
Set3_E-n22-k4-s19-21.dat	520.42	520.42	316.95	0.00	528.4	67.97	1.53
Set3_E-n33-k4-s16-22.dat	672.17	672.20	600.00	0.00	678.45	90.49	0.93
Set3_E-n33-k4-s16-24.dat	666.02	666.02	600.00	0.00	679.23	91.16	1.98
Set3_E-n33-k4-s19-26.dat	680.37	680.89	600.00	0.08	693.14	89.51	1.88
Set3_E-n33-k4-s22-26.dat	680.37	680.36	600.00	0.00	701.54	89.31	3.11
Set3_E-n33-k4-s24-28.dat	670.43	670.43	600.00	0.00	670.87	90.33	0.07
Set3_E-n33-k4-s25-28.dat	650.58	650.58	600.00	0.00	652.00	88.35	0.22
Set3_E-n51-k5-s13-19.dat	560.73	615.30	600.00	9.73	571.94	146.72	2.00
Set3_E-n51-k5-s13-42.dat	564.45	565.79	600.00	0.24	571.15	149.02	1.19
Set3_E-n51-k5-s13-44.dat	564.45	564.45	600.00	0.00	569.73	147.33	0.94
Set3_E-n51-k5-s40-42.dat	746.31	746.31	600.00	0.00	749.87	143.78	0.48
Set3_E-n51-k5-s41-42.dat	771.56	786.35	600.00	1.92	783.00	142.99	1.48
Set3_E-n51-k5-s41-44.dat	802.91	837.14	600.00	4.26	820.25	144.07	2.16

TABLE IV
DRL-2ECVRP-TL RESULTS FOR THE 2E-CVRP INSTANCES OF SET 4.

Instance	BKS	Gurobi(10m)			DRL-2ECVRP(TL)		
		B.O	T(s)	Gap	B.O	T(s)	Gap
Set4b_Instance50-1.dat	1569.42	1612.42	600.00	2.74	1581.59	150.66	0.78
Set4b_Instance50-2.dat	1438.33	1445.70	600.00	0.51	1470.39	147.96	2.23
Set4b_Instance50-3.dat	1570.43	1628.33	600.00	3.69	1579.15	150.79	0.56
Set4b_Instance50-4.dat	1424.04	1453.91	600.00	2.10	1464.18	143.37	2.82
Set4b_Instance50-5.dat	2193.52	1453.91	600.00	33.72	2230.55	153.07	1.69
Set4b_Instance50-6.dat	1279.87	1279.89	600.00	0.00	1328.84	142.12	3.83
Set4b_Instance50-7.dat	1458.63	1436.19	600.00	1.54	1430.82	147.79	1.91
Set4b_Instance50-8.dat	1363.74	1376.46	600.00	0.93	1365.18	142.67	0.11
Set4b_Instance50-9.dat	1450.27	1446.29	600.00	0.27	1407.34	149.87	2.96
Set4b_Instance50-10.dat	1407.65	1369.49	600.00	2.71	1363.89	142.8	3.11
Set4b_Instance50-11.dat	2047.46	2071.36	600.00	1.17	2079.90	155.31	1.58
Set4b_Instance50-12.dat	1209.42	1209.46	600.00	0.00	1219.68	142.91	0.85
Set4b_Instance50-13.dat	1481.83	1472.11	600.00	0.66	1456.28	149.99	1.72
Set4b_Instance50-14.dat	1393.61	1430.27	600.00	2.63	1409.19	143.92	1.12
Set4b_Instance50-15.dat	1489.94	1474.75	600.00	1.02	1474.80	150.73	1.02
Set4b_Instance50-16.dat	1389.17	1391.76	600.00	0.19	1389.44	145.15	0.02
Set4b_Instance50-17.dat	2088.49	2134.13	600.00	2.19	2115.50	154.36	1.29
Set4b_Instance50-18.dat	1227.61	1227.68	600.00	0.01	1273.44	144.35	3.73
Set4b_Instance50-19.dat	1546.83	1629.98	600.00	5.38	1560.99	147.12	0.92
Set4b_Instance50-20.dat	1272.97	1304.57	600.00	2.48	1283.95	145.77	0.86
Set4b_Instance50-21.dat	1577.82	1615.50	600.00	2.39	1600.25	146.32	1.42
Set4b_Instance50-22.dat	1281.83	1282.29	600.00	0.04	1339.56	139.59	4.50
Set4b_Instance50-23.dat	1652.98	1806.54	600.00	9.29	1658.66	147.61	0.34
Set4b_Instance50-24.dat	1282.68	1282.69	600.00	0.00	1317.89	141.29	2.74
Set4b_Instance50-25.dat	1408.57	1435.24	600.00	1.89	1422.71	145.24	1.00
Set4b_Instance50-26.dat	1167.46	1192.53	600.00	2.15	1188.41	143.34	1.79
Set4b_Instance50-27.dat	1444.5	1492.44	600.00	3.32	1487.74	143.07	2.99
Set4b_Instance50-28.dat	1210.44	1231.13	600.00	1.71	1222.79	138.49	1.02
Set4b_Instance50-29.dat	1552.66	1597.04	600.00	2.86	1603.21	146.19	3.26
Set4b_Instance50-30.dat	1211.49	1211.63	600.00	0.01	1232.81	141.39	1.76
Set4b_Instance50-31.dat	1440.86	1492.44	600.00	3.58	1458.54	147.66	1.23
Set4b_Instance50-32.dat	1199.00	1221.71	600.00	1.89	1222.01	146.63	1.92
Set4b_Instance50-33.dat	1478.86	1490.74	600.00	0.80	1504.05	148.17	1.70
Set4b_Instance50-34.dat	1233.92	1233.96	600.00	0.00	1289.91	140.29	4.54
Set4b_Instance50-35.dat	1570.72	1582.05	600.00	0.72	1586.65	148.22	1.01
Set4b_Instance50-36.dat	1228.89	1228.95	600.00	0.01	1255.46	140.73	2.16
Set4b_Instance50-37.dat	1528.73	1600.59	600.00	4.70	1584.25	151.46	3.63
Set4b_Instance50-38.dat	1169.2	1263.35	600.00	8.05	1210.82	151.26	3.56
Set4b_Instance50-39.dat	1520.92	1673.43	600.00	10.03	1561.93	152.33	2.70
Set4b_Instance50-40.dat	1199.42	1224.14	600.00	2.06	1193.63	147.51	0.48
Set4b_Instance50-41.dat	1667.96	1710.11	600.00	2.53	1749.47	149.81	4.89
Set4b_Instance50-42.dat	1194.54	1288.76	600.00	7.89	1235.20	148.59	3.40
Set4b_Instance50-43.dat	1439.67	1528.02	600.00	6.14	1444.55	150.32	0.34
Set4b_Instance50-44.dat	1045.13	1047.66	600.00	0.24	1055.99	151.63	1.04
Set4b_Instance50-45.dat	1450.96	1446.55	600.00	0.30	1438.17	152.92	0.88
Set4b_Instance50-46.dat	1088.77	1124.54	600.00	3.29	1081.54	149.5	0.66
Set4b_Instance50-47.dat	1587.29	1594.45	600.00	0.45	1597.33	149.1	0.63
Set4b_Instance50-48.dat	1082.2	1074.51	600.00	0.71	1162.79	146.56	7.45
Set4b_Instance50-49.dat	1434.88	1486.39	600.00	3.59	1484.73	150.13	3.47
Set4b_Instance50-50.dat	1083.12	1107.70	600.00	2.27	1125.82	148.15	3.94
Set4b_Instance50-51.dat	1398.05	1481.24	600.00	5.95	1447.54	151.94	3.54
Set4b_Instance50-52.dat	1125.67	1125.69	600.00	0.00	1138.73	146.73	1.16
Set4b_Instance50-53.dat	1567.77	1589.49	600.00	1.39	1625.62	150.62	3.69
Set4b_Instance50-54.dat	1127.61	1135.44	600.00	0.69	1136.14	150.28	0.76

TABLE V
DRL-2ECVRP-TL AND GUROBI RESULTS FOR THE 2E-CVRP INSTANCES OF SET 5.

Insatance	BKS	2E-CVRP(TL)	T(s)	Gap
Set5_100-5-1.dat	1564.46	1621.16	630.63	3.62
Set5_100-5-1b.dat	1099.35	1156.94	568.84	5.24
Set5_100-5-2.dat	1016.32	1044.41	649.12	2.76
Set5_100-5-2b.dat	782.25	829.10	579.64	5.99
Set5_100-5-3.dat	1045.29	1082.47	630.50	3.56
Set5_100-5-3b.dat	828.54	850.84	571.37	2.69
Set5_100-10-1.dat	1124.93	1174.19	711.04	4.38
Set5_100-10-1b.dat	911.80	936.94	609.40	2.76
Set5_100-10-2.dat	985.40	1025.25	700.47	4.04
Set5_100-10-2b.dat	766.28	795.06	621.08	3.76
Set5_100-10-3.dat	1042.63	1105.11	694.34	5.99
Set5_100-10-3b.dat	848.16	877.18	616.00	3.42