

A Trilevel r -Interdiction Selective Multi-Depot Vehicle Routing Problem

Mir Ehsan Hesam Sadati

*Department of Industrial Engineering,
Koç University,
İstanbul, Turkey*

Deniz Aksen*

*College of Administrative
Sciences and Economics,
Koç University,
İstanbul, Turkey*

Necati Aras

*Department of Industrial Engineering,
Boğaziçi University,
İstanbul, Turkey*

Supplementary Material

Results obtained on 3LRI-SMDVRP

The results of the two proposed reduction methods (REDUCTION 1 and 2) applied to 33 3LRI-SMDVRP instances with different value of $u = (1, \dots, 5)$ and $r = (1, \dots, 5)$ are given in following tables. For each instance, the solution value (Obj_Val) and the solution time are reported. The R_i column shows which reduction method is used (R_1 : REDUCTION 1, R_2 : REDUCTION 2). The ID columns indicate the IDs of the protected depots (u_ID) and interdicted depots (r_ID). The MNPP and VND+TSH Calls columns stand for the maximum number of possible patterns $\binom{m}{r}$ and the number of times VND+TSH is called by each reduction method, respectively. It must be note that no such instance exists for values of $u = 5$ and $r = 5$. These results can be found also in excel file which is available at

* Corresponding author. Tel.: +90 (1) 338 1684, Fax.: +90 (1) 338 1653, Email: daksen@ku.edu.tr (D. Aksen)

Table S1. Results of 3LRI-SMDVRP instances with $u = 1$, $r = 1$.

$u = 1, r = 1$									
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH$ Calls	$Time (s)$
p01	50	4	R1	2	4	578.82	4	4	285.28
p02	50	4	R1	2	1	461.69	4	4	308.65
p03	75	5	R1	3	2	667.18	5	4	365.07
p04	100	2	R2	1	2	1146.34	2	1	108.93
p05	100	2	R2	1	2	852.06	2	1	144.36
p06	100	3	R1	1	3	975.89	3	3	578.40
p07	100	4	R1	4	1	914.08	4	4	829.94
p08	249	2	R2	1	2	5521.92	2	2	725.61
p09	249	3	R1	1	2	4654.54	3	2	641.53
p10	249	4	R1	2	1	4078.68	4	2	558.33
p11	249	5	R1	2	4	3865.18	5	5	1627.87
p12	80	2	R2	2	1	1771.21	2	2	171.77
p13	80	2	R2	2	1	3813.42	2	2	135.37
p14	80	2	R2	2	1	4074.55	2	2	130.65
p15	160	4	R1	2	3	2959.85	4	4	438.18
p16	160	4	R1	3	2	4734.88	4	4	336.99
p17	160	4	R1	2	1	5174.04	4	2	168.58
p18	240	6	R1	5	6	3850.64	6	2	318.69
p19	240	6	R1	2	6	5924.58	6	4	846.72
p20	240	6	R1	6	2	6399.78	6	2	375.23
p21	360	9	R1	3	7	6144.41	9	5	5302.09
p22	360	9	R1	5	7	7847.96	9	4	2279.97
p23	360	9	R1	1	5	8357.61	9	4	2427.22
pr01	48	4	R1	3	4	701.02	4	4	145.43
pr02	96	4	R1	1	4	985.81	4	3	450.17
pr03	144	4	R1	2	3	1638.71	4	3	302.68
pr04	192	4	R1	4	3	1746.94	4	4	651.83
pr05	240	4	R1	1	4	2493.55	4	3	1921.06
pr06	288	4	R1	3	2	2720.58	4	3	2090.29
pr07	72	6	R1	4	2	1013.35	6	3	253.52
pr08	144	6	R1	5	1	1612.14	6	4	440.18
pr09	216	6	R1	3	4	1864.8	6	6	1055.36
pr10	288	6	R1	4	1	2867.17	6	5	3611.38
Average			R1				5.1	3.6	1059.65
			R2				2	1.7	236.11
			Overall				4.5	3.2	909.92

Table S2. Results of 3LRI-SMDVRP instances with $u = 1$, $r = 2$.

$u = 1, r = 2$									
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH$ Calls	$Time (s)$
p01	50	4	R1	2	3,4	621.18	6	5	232.55
p02	50	4	R1	2	3,4	484.77	6	6	325.95
p03	75	5	R1	3	1,2	700.09	10	9	807.22
p06	100	3	R2	1	2,3	1173.07	3	2	215.10
p07	100	4	R1	3	1,4	1034.45	6	3	357.50
p09	249	3	R2	2	1,3	5231.99	3	2	536.33
p10	249	4	R1	2	1,4	4549.57	6	5	1459.78
p11	249	5	R1	4	1,2	4395.47	10	3	766.49
p15	160	4	R1	4	2,3	3629.83	6	3	482.10
p16	160	4	R1	1	2,3	7276.99	6	4	446.34
p17	160	4	R1	3	1,2	7711.25	6	4	393.90
p18	240	6	R1	2	3,4	4405.02	15	5	996.25
p19	240	6	R1	2	5,6	8512.52	15	2	710.54
p20	240	6	R1	5	2,3	9051.25	15	2	558.96
p21	360	9	R1	8	2,3	6847.47	36	3	2195.12
p22	360	9	R1	2	3,4	10346.69	36	5	4341.56
p23	360	9	R1	4	2,3	10972.82	36	3	2142.80
pr01	48	4	R1	4	1,3	729.64	6	5	193.47
pr02	96	4	R1	1	2,3	1060.77	6	5	480.93
pr03	144	4	R1	3	1,4	1763.9	6	6	618.05
pr04	192	4	R1	4	2,3	1857.56	6	6	834.39
pr05	240	4	R1	1	2,4	2623.29	6	5	3232.47
pr06	288	4	R1	3	1,2	3100.89	6	4	2002.09
pr07	72	6	R1	2	3,4	1022.39	15	11	746.14
pr08	144	6	R1	5	1,6	1659.93	15	12	1200.93
pr09	216	6	R1	3	2,5	1940.46	15	11	1960.03
pr10	288	6	R1	5	3,4	3025.84	15	6	3891.62
Average			R1				12.4	5.3	1255.09
			R2				3	2	375.72
			Overall				11.7	5.1	1189.95

Table S3. Results of 3LRI-SMDVRP instances with $u = 1$, $r = 3$.

$u = 1, r = 3$										
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH$ Calls	Time (s)	
p01	50	4	R2	2	1,3,4	655.63	4	1	33.18	
p02	50	4	R2	2	1,3,4	502.07	4	1	54.93	
p03	75	5	R1	3	1,2,4	755.97	10	9	947.65	
p07	100	4	R2	3	1,2,4	1146.34	4	2	267.15	
p10	249	4	R2	2	1,3,4	5112.91	4	1	450.23	
p11	249	5	R1	2	3,4,5	4758.56	10	3	838.88	
p15	160	4	R2	2	1,3,4	4499.63	4	4	502.27	
p16	160	4	R2	3	1,2,4	9845.51	4	4	322.35	
p17	160	4	R2	4	1,2,3	10282.56	4	4	265.04	
p18	240	6	R1	5	1,2,3	5021.35	20	5	1082.90	
p19	240	6	R1	2	1,5,6	10969.28	20	6	2301.33	
p20	240	6	R1	4	1,2,6	11513.41	20	9	2980.80	
p21	360	9	R1	4	2,3,9	7513.16	84	4	3256.39	
p22	360	9	R1	2	5,6,7	12956.84	84	4	4543.43	
p23	360	9	R1	5	2,3,9	13574.76	84	4	3496.32	
pr01	48	4	R2	1	2,3,4	753.59	4	2	72.38	
pr02	96	4	R2	1	2,3,4	1088.19	4	1	130.98	
pr03	144	4	R2	4	1,2,3	1923.07	4	1	104.76	
pr04	192	4	R2	1	2,3,4	1987.31	4	1	215.87	
pr05	240	4	R2	2	1,3,4	2877.93	4	1	587.87	
pr06	288	4	R2	1	2,3,4	3508.28	4	1	618.27	
pr07	72	6	R1	4	2,3,5	1049.11	20	13	950.50	
pr08	144	6	R1	3	1,2,6	1752.33	20	12	1050.96	
pr09	216	6	R1	2	1,3,4	2220.1	20	2	310.63	
pr10	288	6	R1	3	1,2,6	3345.2	20	3	2039.27	
Average				R1				34.3	6.2	1983.25
				R2				4	1.8	278.87
				Overall				18.6	3.9	1096.97

Table S4. Results of 3LRI-SMDVRP instances with $u = 1$, $r = 4$.

$u = 1, r = 4$										
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH$ Calls	Time (s)	
p03	75	5	R2	1	2,3,4,5	798.93	5	1	128.97	
p11	249	5	R2	4	1,2,3,5	5138.5	5	2	415.13	
p18	240	6	R1	4	1,2,5,6	5759.7	15	4	698.20	
p19	240	6	R1	1	2,3,5,6	13491.13	15	6	2044.96	
p20	240	6	R1	1	2,3,5,6	14203.8	15	3	718.23	
p21	360	9	R1	1	3,4,5,6	8252.09	126	5	3734.87	
p22	360	9	R1	1	2,7,8,9	15311.09	126	8	10047.92	
p23	360	9	R1	1	3,4,5,9	16079.6	126	9	10451.41	
pr07	72	6	R1	5	2,3,4,6	1095.95	15	10	503.65	
pr08	144	6	R1	6	1,2,4,5	1847.88	15	7	519.45	
pr09	216	6	R1	6	1,3,4,5	2280.6	15	6	761.34	
pr10	288	6	R1	3	1,2,4,6	3591.6	15	5	3666.81	
Average				R1				48.3	6.3	3314.69
				R2				5	1.5	272.05
				Overall				41.1	5.5	2807.58

Table S5. Results of 3LRI-SMDVRP instances with $u = 1, r = 5$.

$u = 1, r = 5$										
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH$ Calls	$Time (s)$	
p18	240	6	R2	4	1,2,3,5,6	6236.61	6	2	486.59	
p19	240	6	R2	4	1,2,3,5,6	16219.87	6	6	1409.62	
p20	240	6	R2	4	1,2,3,5,6	16688.58	6	6	762.57	
p21	360	9	R1	1	2,3,4,8,9	8953.72	126	5	4062.04	
p22	360	9	R1	9	1,4,5,6,7	17921.62	126	8	12008.72	
p23	360	9	R1	9	3,4,5,6,7	18670.84	126	9	11854.92	
pr07	72	6	R2	5	1,2,3,4,6	1115.05	6	2	89.00	
pr08	144	6	R2	6	1,2,3,4,5	1908.85	6	1	62.29	
pr09	216	6	R2	2	1,3,4,5,6	2346.07	6	5	638.52	
pr10	288	6	R2	3	1,2,4,5,6	3846.27	6	1	555.16	
Average				R1				126	7.3	9308.56
				R2				6	3.3	571.96
				Overall				42	4.5	3192.94

Table S6. Results of 3LRI-SMDVRP instances with $u = 2, r = 1$.

$u = 2, r = 1$										
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH$ Calls	$Time (s)$	
p01	50	4	R1	2,4	1	578.43	4	4	284.81	
p02	50	4	R1	1,2	3	460.73	4	4	310.33	
p03	75	5	R1	2,3	5	646.06	5	5	422.62	
p06	100	3	R2	1,2	3	975.89	3	1	133.04	
p07	100	4	R1	1,4	3	901.65	4	4	816.19	
p09	249	3	R2	1,2	3	4361.07	3	1	464.34	
p10	249	4	R1	1,2	3	4052.86	4	3	853.73	
p11	249	5	R1	2,4	3	3846.73	5	5	1646.93	
p15	160	4	R1	2,3	1	2941.64	4	4	433.43	
p16	160	4	R1	2,3	1	4717.62	4	4	336.34	
p17	160	4	R1	1,4	2	5097.38	4	3	253.75	
p18	240	6	R1	5,6	3	3832.05	6	3	471.09	
p19	240	6	R1	2,6	5	5918.05	6	4	846.36	
p20	240	6	R1	1,6	2	6399.78	6	3	616.62	
p21	360	9	R1	3,7	9	6077.33	9	6	6590.10	
p22	360	9	R1	5,7	3	7773.17	9	4	2277.42	
p23	360	9	R1	5,7	9	8357.61	9	5	2973.60	
pr01	48	4	R1	1,3	4	701.02	4	4	144.01	
pr02	96	4	R1	1,4	3	972.92	4	4	655.17	
pr03	144	4	R1	2,3	1	1631.92	4	3	300.50	
pr04	192	4	R1	3,4	1	1743.18	4	4	650.30	
pr05	240	4	R1	1,4	3	2406.68	4	3	1902.92	
pr06	288	4	R1	2,3	1	2710.94	4	4	2392.40	
pr07	72	6	R1	2,4	3	1000.2	6	3	254.01	
pr08	144	6	R1	1,5	2	1592.49	6	5	579.02	
pr09	216	6	R1	3,4	6	1856.08	6	6	1059.03	
pr10	288	6	R1	1,4	3	2861.2	6	6	4735.28	
Average				R1				5.2	4.1	1272.24
				R2				3	1	298.69
				Overall				5.1	3.9	1200.12

Table S7. Results of 3LRI-SMDVRP instances with $u = 2$, $r = 2$.

$u = 2, r = 2$									
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH\ Calls$	$Time\ (s)$
p01	50	4	R2	1,3	2,4	611.76	6	3	152.43
p02	50	4	R2	2,4	1,3	480.24	6	1	43.54
p03	75	5	R1	2,3	4,5	682.23	10	10	881.39
p07	100	4	R2	1,2	3,4	967.69	6	1	106.24
p10	249	4	R2	2,4	1,3	4508.02	6	4	1293.30
p11	249	5	R1	1,4	2,3	4164.69	10	6	1548.61
p15	160	4	R2	1,3	2,4	3356.83	6	1	130.46
p16	160	4	R2	2,4	1,3	6871.84	6	2	203.55
p17	160	4	R2	2,4	1,3	7598.45	6	6	597.28
p18	240	6	R1	2,4	5,6	4365.6	15	9	1750.55
p19	240	6	R1	2,6	3,4	8289.7	15	6	1957.88
p20	240	6	R1	2,6	4,5	9003.52	15	5	1698.43
p21	360	9	R1	2,8	6,7	6818.49	36	7	5379.40
p22	360	9	R1	2,3	7,8	10286.51	36	8	7035.67
p23	360	9	R1	2,4	5,6	10927.52	36	6	4700.40
pr01	48	4	R2	1,3	2,4	701.02	6	1	39.50
pr02	96	4	R2	3,4	1,2	1019.8	6	1	99.67
pr03	144	4	R2	2,3	1,4	1763.9	6	1	79.09
pr04	192	4	R2	2,4	1,3	1804.44	6	1	214.12
pr05	240	4	R2	3,4	1,2	2551.41	6	2	913.76
pr06	288	4	R2	2,3	1,4	2874.94	6	1	583.28
pr07	72	6	R1	3,4	2,5	1002.25	15	12	797.68
pr08	144	6	R1	1,5	3,6	1623.7	15	15	1496.00
pr09	216	6	R1	2,6	1,4	1934.24	15	11	1962.55
pr10	288	6	R1	3,4	2,6	2956.41	15	8	4883.00
Average				R1			19.4	8.6	2840.96
				R2			6	1.9	342.79
				Overall			12.4	5.1	1541.91

Table S8. Results of 3LRI-SMDVRP instances with $u = 2$, $r = 3$.

$u = 2, r = 3$									
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH\ Calls$	$Time\ (s)$
p03	75	5	R2	2,4	1,3,5	731.41	10	1	87.10
p11	249	5	R2	1,4	2,3,5	4350.55	10	1	312.21
p18	240	6	R1	2,5	1,4,6	4873.09	20	14	2898.70
p19	240	6	R1	2,5	1,3,4	10836.91	20	10	3975.65
p20	240	6	R1	1,4	2,3,5	11462.95	20	13	4305.36
p21	360	9	R1	4,9	5,6,7	7464.44	84	8	5542.45
p22	360	9	R1	5,9	6,7,8	12644.15	84	6	6743.71
p23	360	9	R1	5,9	1,4,8	13530.81	84	7	6711.82
pr07	72	6	R1	2,3	1,5,6	1026.66	20	20	1446.07
pr08	144	6	R1	1,5	2,4,6	1702.87	20	17	1541.49
pr09	216	6	R1	2,4	3,5,6	1970.94	20	17	3147.14
pr10	288	6	R1	1,5	2,4,6	3114.95	20	12	7874.21
Average				R1			39.2	12.4	4418.66
				R2			10	1	199.66
				Overall			34.3	10.5	3715.49

Table S9. Results of 3LRI-SMDVRP instances with $u = 2$, $r = 4$.

$u = 2, r = 4$										
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH\ Calls$	$Time\ (s)$	
p18	240	6	R2	2,5	1,3,4,6	5406.59	15	7	1592.42	
p19	240	6	R2	4,6	1,2,3,5	12901.61	15	8	3316.17	
p20	240	6	R2	4,6	1,2,3,5	14004.47	15	15	5288.62	
p21	360	9	R1	2,6	5,7,8,9	7944.48	126	11	8768.63	
p22	360	9	R1	2,6	5,7,8,9	15125.52	126	19	24771.32	
p23	360	9	R1	7,9	1,4,5,8	16064.52	126	17	19990.65	
pr07	72	6	R2	3,5	1,2,4,6	1040.92	15	2	131.63	
pr08	144	6	R2	1,5	2,3,4,6	1702.82	15	3	324.21	
pr09	216	6	R2	2,4	1,3,5,6	2007.14	15	5	909.27	
pr10	288	6	R2	2,5	1,3,4,6	3203.29	15	3	1736.86	
Average				R1				126	15.7	17843.54
				R2				15	6.1	1899.88
				Overall				48.3	9	6682.98

Table S10. Results of 3LRI-SMDVRP instances with $u = 2$, $r = 5$.

$u = 2, r = 5$										
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH\ Calls$	$Time\ (s)$	
p21	360	9	R1	4,8	1,5,6,7,9	8490.73	126	30	27824.00	
p22	360	9	R1	2,6	4,5,7,8,9	17577	126	24	37813.13	
p23	360	9	R1	4,8	1,2,3,5,6	18556.13	126	25	34065.42	
Average				R1				126	26.3	33234.18
				R2				-	-	-
				Overall				126	26.3	33234.18

Table S11. Results of 3LRI-SMDVRP instances with $u = 3$, $r = 1$.

$u = 3, r = 1$									
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH$ Calls	$Time (s)$
p01	50	4	R2	1,2,4	3	573.37	4	1	68.12
p02	50	4	R2	1,2,4	3	460.73	4	2	154.41
p03	75	5	R1	2,3,5	4	645.73	5	5	422.24
p07	100	4	R2	1,2,4	3	901.15	4	2	492.01
p10	249	4	R2	1,2,3	4	4027.65	4	3	981.62
p11	249	5	R1	2,3,4	1	3843.38	5	5	1623.26
p15	160	4	R2	1,2,3	4	2929.46	4	1	97.63
p16	160	4	R2	1,2,3	4	4617.06	4	4	335.14
p17	160	4	R2	1,2,4	3	5095.39	4	4	342.67
p18	240	6	R1	3,5,6	2	3812.05	6	4	610.68
p19	240	6	R1	2,5,6	3	5894.56	6	4	846.32
p20	240	6	R1	1,3,6	2	6399.78	6	4	825.89
p21	360	9	R1	3,7,9	4	6022	9	9	8973.16
p22	360	9	R1	3,5,7	9	7752.31	9	5	2816.76
p23	360	9	R1	5,7,9	3	8357.14	9	6	3574.55
pr01	48	4	R2	1,3,4	2	698.89	4	1	35.30
pr02	96	4	R2	1,3,4	2	948.98	4	1	204.09
pr03	144	4	R2	1,2,3	4	1583.7	4	1	60.29
pr04	192	4	R2	1,3,4	2	1724.38	4	3	402.84
pr05	240	4	R2	1,3,4	2	2347.16	4	1	496.10
pr06	288	4	R2	1,2,3	4	2690.5	4	3	1529.17
pr07	72	6	R1	2,3,4	5	969.89	6	5	350.83
pr08	144	6	R1	1,2,5	6	1579.79	6	5	581.23
pr09	216	6	R1	3,4,6	5	1849.75	6	6	1057.16
pr10	288	6	R1	1,3,4	5	2822.88	6	6	4684.29
Average				R1			6.6	5.3	2197.20
				R2			4	2.1	399.95
				Overall			5.2	3.6	1262.63

Table S12. Results of 3LRI-SMDVRP instances with $u = 3$, $r = 2$.

$u = 3, r = 2$									
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH$ Calls	$Time (s)$
p03	75	5	R2	2,3,4	1,5	663.73	10	1	67.58
p11	249	5	R2	1,3,4	2,5	4060.68	10	5	1700.00
p18	240	6	R1	2,4,6	3,5	4336.78	15	9	1721.68
p19	240	6	R1	2,4,6	3,5	8134.62	15	9	2911.72
p20	240	6	R1	2,4,6	3,5	8900.85	15	10	3111.95
p21	360	9	R1	2,6,8	4,5	6808.1	36	7	5371.68
p22	360	9	R1	2,3,8	5,6	10262.69	36	8	7047.46
p23	360	9	R1	1,3,5	7,8	10921.29	36	10	7856.52
pr07	72	6	R1	2,3,4	1,5	979.33	15	13	845.52
pr08	144	6	R1	1,3,5	2,4	1611.75	15	15	1520.88
pr09	216	6	R1	2,3,4	1,6	1892.07	15	14	2408.22
pr10	288	6	R1	2,3,4	1,5	2923.81	15	14	8222.85
Average				R1			21.3	10.9	4101.85
				R2			10	3	883.79
				Overall			19.4	9.6	3565.51

Table S13. Results of 3LRI-SMDVRP instances with $u = 3$, $r = 3$.

$u = 3, r = 3$										
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH$ Calls	$Time (s)$	
p18	240	6	R2	2,4,6	1,3,5	4719.11	20	7	1466.57	
p19	240	6	R2	1,3,5	2,4,6	10038.72	20	2	880.70	
p20	240	6	R2	2,4,6	1,3,5	11199.34	20	20	6879.64	
p21	360	9	R1	3,6,9	5,7,8	7219.2	84	21	15080.03	
p22	360	9	R1	4,7,9	1,2,3	12452.19	84	28	28992.56	
p23	360	9	R1	3,5,8	1,2,4	13470.12	84	13	12320.53	
pr07	72	6	R2	2,4,5	1,3,6	1005.16	20	2	88.45	
pr08	144	6	R2	1,5,6	2,3,4	1613.69	20	2	344.92	
pr09	216	6	R2	2,3,4	1,5,6	1925.33	20	7	1263.07	
pr10	288	6	R2	3,4,6	1,2,5	2898.05	20	2	1133.13	
Average				R1				84	20.7	18797.71
				R2				20	6	1722.35
				Overall				39.2	10.4	6844.96

Table S14. Results of 3LRI-SMDVRP instances with $u = 3$, $r = 4$.

$u = 3, r = 4$										
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH$ Calls	$Time (s)$	
p21	360	9	R1	3,6,9	1,2,7,8	7730.68	126	42	32627.03	
p22	360	9	R1	3,6,8	2,4,5,9	14782.99	126	45	56296.28	
p23	360	9	R1	2,5,8	3,4,7,9	15991.34	126	38	46390.98	
Average				R1				126	41.7	45104.76
				R2				-	-	-
				Overall				126	41.7	45104.76

Table S15. Results of 3LRI-SMDVRP instances with $u = 3$, $r = 5$.

$u = 3, r = 5$										
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH$ Calls	$Time (s)$	
p21	360	9	R1	4,7,9	1,2,3,5,6	8297.25	126	70	65191.60	
p22	360	9	R1	4,6,8	1,2,3,7,9	17140.1	126	73	112809.86	
p23	360	9	R1	1,3,7	4,5,6,8,9	18451.88	126	64	84543.27	
Average				R1				126	69	87514.91
				R2				-	-	-
				Overall				126	69	87514.91

Table S16. Results of 3LRI-SMDVRP instances with $u = 4$, $r = 1$.

$u = 4, r = 1$									
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH\ Calls$	$Time\ (s)$
p03	75	5	R2	2,3,4,5	1	636.18	5	1	62.32
p11	249	5	R2	1,2,3,4	5	3706.4	5	1	258.80
p18	240	6	R1	2,3,5,6	1	3707.66	6	6	929.40
p19	240	6	R1	2,3,5,6	1	5795.24	6	6	1230.69
p20	240	6	R1	2,3,5,6	1	6399.11	6	5	1041.25
p21	360	9	R1	3,4,7,9	8	5972.87	9	9	9020.41
p22	360	9	R1	3,5,7,9	6	7728.91	9	5	2835.03
p23	360	9	R1	3,5,7,9	4	8342.6	9	7	4237.15
pr07	72	6	R1	2,3,4,5	6	959.61	6	5	343.65
pr08	144	6	R1	1,2,5,6	4	1566.05	6	6	671.22
pr09	216	6	R1	3,4,5,6	1	1837.68	6	6	1053.29
pr10	288	6	R1	1,3,4,5	2	2787.85	6	6	4696.79
Average				R1			6.9	6.1	2605.89
				R2			5	1	160.56
				Overall			6.6	5.3	2198.33

Table S17. Results of 3LRI-SMDVRP instances with $u = 4$, $r = 2$.

$u = 4, r = 2$									
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH\ Calls$	$Time\ (s)$
p18	240	6	R2	2,4,5,6	1,3	4137.6	15	4	791.00
p19	240	6	R2	1,2,3,5	4,6	7741.25	15	4	1245.60
p20	240	6	R2	2,4,5,6	1,3	8815.51	15	15	4691.26
p21	360	9	R1	3,5,7,9	1,4	6470.67	36	17	13805.22
p22	360	9	R1	3,5,7,9	1,8	9976.64	36	11	8949.73
p23	360	9	R1	2,4,5,8	7,9	10874.18	36	12	9451.14
pr07	72	6	R2	2,3,4,5	1,6	958.91	15	2	81.06
pr08	144	6	R2	1,4,5,6	2,3	1574.47	15	4	489.76
pr09	216	6	R2	3,4,5,6	1,2	1867	15	4	593.95
pr10	288	6	R2	1,2,3,4	5,6	2822.6	15	2	1380.24
Average				R1			36.0	13.3	10735.36
				R2			15	5	1324.70
				Overall			21.3	7.5	4147.90

Table S18. Results of 3LRI-SMDVRP instances with $u = 4$, $r = 3$.

$u = 4, r = 3$									
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH\ Calls$	$Time\ (s)$
p21	360	9	R1	3,5,7,9	1,2,4	6983.88	84	45	34133.74
p22	360	9	R1	2,4,6,8	3,7,9	12180.33	84	40	41243.95
p23	360	9	R1	1,5,7,9	2,3,4	13379.66	84	37	36641.83
Average				R1			84	40.7	37339.84
				R2			-	-	-
				Overall			84	40.7	37339.84

Table S19. Results of 3LRI-SMDVRP instances with $u = 4$, $r = 4$.

$u = 4, r = 4$									
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH\ Calls$	$Time\ (s)$
p21	360	9	R1	2,4,6,8	3,5,7,9	7324.14	126	89	70537.92
p22	360	9	R1	2,4,6,8	3,5,7,9	14149.21	126	83	104115.72
p23	360	9	R1	1,5,7,9	2,3,4,6	15803.41	126	73	88482.46
Average				R1			126.0	81.7	87712.03
				R2			-	-	-
				Overall			126.0	81.7	87712.03

Table S20. Results of 3LRI-SMDVRP instances with $u = 4$, $r = 5$.

$u = 4, r = 5$									
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH\ Calls$	$Time\ (s)$
p21	360	9	R2	3,5,7,9	1,2,4,6,8	7778.45	126	5	3323.48
p22	360	9	R2	2,4,6,8	1,3,5,7,9	16152.84	126	5	6970.73
p23	360	9	R2	2,4,6,8	1,3,5,7,9	18127.61	126	12	13460.37
Average				R1			-	-	-
				R2			126	7.3	7918.20
				Overall			126	7.3	7918.20

Table S21. Results of 3LRI-SMDVRP instances with $u = 5$, $r = 1$.

$u = 5, r = 1$									
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH\ Calls$	$Time\ (s)$
p18	240	6	R2	1,2,3,5,6	4	3707.66	6	5	770.83
p19	240	6	R2	1,2,3,5,6	4	5792.62	6	4	822.17
p20	240	6	R2	1,2,3,5,6	4	6359.6	6	6	1248.58
p21	360	9	R1	3,4,7,8,9	1	5967.49	9	9	9032.66
p22	360	9	R1	3,5,6,7,9	2	7694.68	9	7	3794.43
p23	360	9	R1	3,4,5,7,9	8	8280.29	9	9	5491.50
pr07	72	6	R2	2,3,4,5,6	1	955.2	6	2	76.56
pr08	144	6	R2	1,2,4,5,6	3	1544.22	6	2	233.18
pr09	216	6	R2	2,3,4,5,6	1	1837.68	6	5	814.87
pr10	288	6	R2	1,2,3,4,5	6	2740.41	6	1	1089.74
Average				R1			9.0	8.3	6106.20
				R2			6.0	3.6	722.28
				Overall			6.9	5.0	2337.45

Table S22. Results of 3LRI-SMDVRP instances with $u = 5$, $r = 2$.

$u = 5, r = 2$									
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH\ Calls$	$Time\ (s)$
p21	360	9	R1	3,4,5,7,9	1,2	6366.81	36	34	27340.13
p22	360	9	R1	1,3,5,7,9	4,6	9717.41	36	21	15723.39
p23	360	9	R1	1,3,5,7,9	2,6	10701.9	36	20	16169.73
Average				R1			36	25.0	19744.42
				R2			-	-	-
				Overall			36	25.0	19744.42

Table S23. Results of 3LRI-SMDVRP instances with $u = 5$, $r = 3$.

$u = 5, r = 3$									
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH$ Calls	$Time (s)$
p21	360	9	R1	1,3,5,7,9	2,4,8	6691.33	84	77	57311.34
p22	360	9	R1	1,3,5,7,9	2,4,6	11602.03	84	67	66800.07
p23	360	9	R1	1,3,5,7,9	2,4,6	13116.96	84	62	63643.16
Average			R1				84	68.7	62584.85
			R2				-	-	-
			Overall				84	68.7	62584.85

Table S24. Results of 3LRI-SMDVRP instances with $u = 5$, $r = 4$.

$u = 5, r = 4$									
Instance	n	m	R_i	u_ID	r_ID	Obj_Value	$MNPP$	$VND+TSH$ Calls	$Time (s)$
p21	360	9	R2	1,3,5,7,9	2,4,6,8	6990.07	126	1	877.24
p22	360	9	R2	1,3,5,7,9	2,4,6,8	13518.92	126	5	5445.66
p23	360	9	R2	1,3,5,7,9	2,4,6,8	15491.23	126	10	10456.78
Average			R1				-	-	-
			R2				126	5.3	5593.23
			Overall				126	5.3	5593.23