

Table 1 Comparison of direct and relaxation algorithms with projection

Group	Dimension (m, p, q)	Method	MPCC		WDP		MDP		eMDP		TWDP		TMDP		eTMDP		ETMDP			
			Dom	Gap	Dom	Gap	Dom	Gap	Dom	Gap	Dom	Gap	Dom	Gap	Dom	Gap	Dom	Gap		
I	100, 110, 20	Direct	18	0.63	0	1.29	1	1.01	0	1.12	1	0.88	0	0.90	0	1.51	1	0.88	0	1.17
		Relaxation	32	0.58	50	0.00	49	0.00	50	0.00	49	0.01	50	0.00	50	0.00	49	0.00	50	0.00
	120, 130, 40	Direct	21	0.70	0	0.81	0	0.80	0	1.09	0	0.75	1	1.49	0	1.45	0	1.29	0	0.97
		Relaxation	29	0.77	50	0.00	50	0.00	50	0.00	50	0.00	49	0.00	49	0.00	50	0.00	50	0.00
	140, 150, 60 ¹	Direct	17	0.83	0	0.84	0	0.84	0	0.96	0	0.85	0	0.97	0	0.90	0	0.95	0	1.26
Relaxation		31	0.32	48	0.01	48	0.01	48	0.00	48	0.01	48	0.00	48	0.00	48	0.01	48	0.00	
II	30, 20, 10 ²	Direct	9	0.72	2	0.40	1	0.45	1	0.43	1	0.42	1	0.43	0	0.41	2	0.41	0	0.62
		Relaxation	41	0.13	48	0.01	50	0.00	50	0.00	50	0.00	49	0.01	49	0.00	50	0.00	49	0.03
	50, 40, 20	Direct	12	0.85	2	1.05	2	0.58	1	1.17	1	0.58	0	0.57	1	0.72	3	0.54	2	0.86
		Relaxation	38	0.23	48	0.01	48	0.02	49	0.01	49	0.00	49	0.00	50	0.00	49	0.00	47	0.00
	70, 60, 30	Direct	25	0.26	0	0.44	0	0.42	0	0.47	4	0.47	0	0.47	1	0.40	1	0.53	2	0.40
Relaxation		25	0.74	50	0.00	50	0.00	50	0.00	47	0.05	50	0.00	49	0.01	49	0.02	48	0.00	
III	30, 20, 10	Direct	23	0.21	5	0.32	3	0.33	19	0.14	6	0.30	3	0.27	24	0.13	21	0.23	40	0.01
		Relaxation	27	0.22	46	0.00	47	0.00	31	0.08	45	0.00	47	0.00	26	0.10	29	0.22	36	0.01
	50, 40, 20	Direct	19	0.50	7	0.60	5	0.67	27	0.35	9	0.62	8	0.70	28	0.30	17	0.45	29	0.03
		Relaxation	31	0.74	43	0.01	47	0.02	23	0.11	41	0.04	42	0.03	24	0.22	33	0.43	40	0.01
	70, 60, 30	Direct	29	0.29	12	0.45	9	0.91	28	0.41	12	0.36	13	0.33	37	0.19	33	0.26	29	0.11
Relaxation		21	0.48	39	0.03	41	0.03	22	0.22	39	0.04	38	0.05	13	0.41	17	0.69	38	0.03	
Totals		Direct	173	0.55	28	0.69	21	0.67	80	0.68	30	0.58	27	0.67	91	0.68	79	0.60	100	0.64
		Relaxation	275	0.47	422	0.01	430	0.01	370	0.05	420	0.01	422	0.01	359	0.08	370	0.15	412	0.01

¹ The total dominant cases less than the total number 50 means that some examples are infeasible.

² The total dominant cases larger than the total number 50 means that, for some examples, both direct and relaxation algorithms generated the best approximation solutions.