

Appendix A is the results of the numerical analysis in section 8, which contains two parts.

Firstly, the Table 1 in Appendix A, we discuss the impact of carbon emission reward-penalty and recovery rate reward-penalty on the system decisions and members benefits with the retailers' competition coefficient is fixed ($\varepsilon=0.5$). And the carbon emission reward-penalty intensity ranges from 0.2 to 2.6; the recovery rate reward-penalty intensity ranges from 0.05 to 0.3. Corresponding figure in the paper are Fig.4-Fig.7.

Secondly, based on the Table 2 in Appendix A, we mainly discuss the impact of competition among retailers on system decisions and members benefits under the fixed carbon emission reward-penalty intensity ($f=2$). And the recovery rate reward-penalty intensity ranges from 0.05 to 0.3, the competition coefficient ranges from 0 to 1. Corresponding figure in the paper are Fig.8-Fig.12.

Appendix A

Table 1 the optimal decisions vs. f, k in CLSC when competition coefficient is fixed($\varepsilon=0.5$)

The competition coefficient is fixed($\varepsilon=0.5$)										
f	k	w_H	w_L	τ_H	τ_L	p_1	p_2	π_M	π_{R1}	π_{R2}
0.2	0	3.90	1.40	0.53	0.38	9.26	9.28	21.59	21.71	17.43
	0.05	4.42	1.78	0.59	0.43	9.26	9.28	20.42	23.04	17.46
	0.10	4.92	2.15	0.66	0.48	9.26	9.28	18.97	24.56	17.48
	0.15	5.42	2.53	0.72	0.53	9.26	9.28	17.24	26.29	17.51
	0.20	5.92	2.90	0.79	0.58	9.26	9.28	15.24	28.19	17.54
	0.25	6.42	3.28	0.85	0.64	9.26	9.28	12.95	30.24	17.56
	0.30	6.92	3.65	0.92	0.70	9.26	9.28	10.37	32.48	17.59
0.6	0	3.80	1.20	0.51	0.32	9.26	9.28	21.42	21.38	17.42
	0.05	4.26	1.58	0.57	0.37	9.26	9.28	20.38	22.64	17.45
	0.10	4.76	1.95	0.64	0.42	9.26	9.28	19.08	24.09	17.48
	0.15	5.26	2.33	0.70	0.47	9.26	9.28	17.49	25.74	17.50
	0.20	5.76	2.70	0.77	0.52	9.26	9.28	15.62	27.57	17.53
	0.25	6.26	3.08	0.83	0.58	9.26	9.28	13.48	29.56	17.56
	0.30	6.76	3.45	0.90	0.64	9.26	9.28	11.05	31.73	17.58
1.0	0	3.60	1.00	0.48	0.27	9.26	9.28	21.17	21.07	17.42
	0.05	4.10	1.38	0.55	0.32	9.26	9.28	20.28	22.26	17.44
	0.10	4.60	1.75	0.61	0.37	9.26	9.28	19.11	23.63	17.47
	0.15	5.10	2.13	0.68	0.42	9.26	9.28	17.66	25.21	17.50
	0.20	5.60	2.50	0.74	0.47	9.26	9.28	15.93	26.97	17.52
	0.25	6.10	2.88	0.81	0.53	9.26	9.28	13.94	28.89	17.55
	0.30	6.60	3.25	0.87	0.59	9.26	9.28	11.64	30.99	17.58
1.4	0	3.4	0.8	0.46	0.22	9.27	9.29	20.85	20.77	17.41

	0.05	3.9	1.2	0.53	0.27	9.27	9.28	20.09	21.88	17.44
	0.10	4.4	1.6	0.59	0.32	9.27	9.28	19.06	23.19	17.46
	0.15	4.9	1.9	0.66	0.37	9.26	9.28	17.75	24.69	17.49
	0.20	5.4	2.3	0.72	0.42	9.26	9.28	16.16	26.38	17.52
	0.25	5.9	2.7	0.79	0.48	9.26	9.28	14.31	28.23	17.54
	0.30	6.4	3.1	0.85	0.54	9.26	9.28	12.16	30.27	17.57
1.8	0	3.3	0.6	0.44	0.16	9.27	9.29	20.45	20.48	17.40
	0.05	3.8	1.0	0.51	0.21	9.27	9.29	19.83	21.53	17.43
	0.10	4.3	1.4	0.57	0.26	9.27	9.29	18.94	22.76	17.46
	0.15	4.8	1.7	0.64	0.31	9.27	9.29	17.77	24.19	17.48
	0.20	5.3	2.1	0.70	0.36	9.27	9.29	16.32	25.80	17.51
	0.25	5.8	2.5	0.77	0.42	9.27	9.29	14.61	27.59	17.54
2.2	0	3.1	0.4	0.42	0.11	9.27	9.29	19.98	20.21	17.40
	0.05	3.6	0.8	0.48	0.16	9.27	9.29	19.50	21.18	17.42
	0.10	4.1	1.2	0.55	0.21	9.27	9.29	18.74	22.34	17.45
	0.15	4.6	1.5	0.62	0.26	9.27	9.29	17.71	23.70	17.48
	0.20	5.1	1.9	0.68	0.31	9.27	9.29	16.40	25.24	17.50
	0.25	5.6	2.3	0.75	0.37	9.27	9.29	14.83	26.96	17.53
2.6	0	3.0	0.2	0.40	0.05	9.27	9.29	19.43	19.95	17.39
	0.05	3.5	0.6	0.46	0.10	9.27	9.29	19.09	20.85	17.41
	0.10	4.0	1.0	0.53	0.15	9.27	9.29	18.47	21.94	17.44
	0.15	4.5	1.3	0.59	0.20	9.27	9.29	17.57	23.23	17.47
	0.20	5.0	1.7	0.66	0.25	9.27	9.29	16.40	24.69	17.49
	0.25	5.5	2.1	0.72	0.31	9.27	9.29	14.98	26.35	17.52
	0.30	6.0	2.5	0.79	0.38	9.27	9.29	13.27	28.18	17.55

Table 2 the optimal decisions vs. ε, k in CLSC when the carbon emission reward-penalty intensity is fixed ($f = 2$)

The carbon emission reward-penalty intensity is fixed ($f = 2$)										
ε	k	w_H	w_L	τ_H	τ_L	p_1	p_2	π_M	π_{R1}	π_{R2}
0.1	0	3	0.4	0.21	0.08	7.35	7.32	15.0	5.4	4.3
0.2		3	0.4	0.24	0.10	7.74	7.73	16.6	7.7	6.4
0.3		3	0.4	0.27	0.11	8.19	8.19	18.4	10.7	9.2
0.4		3	0.4	0.30	0.12	8.70	8.70	20.4	14.6	12.7
0.5		3	0.4	0.35	0.13	9.27	9.29	22.7	19.7	17.4
0.6		3	0.4	0.39	0.15	9.93	9.96	25.4	26.5	23.6
0.7		3	0.4	0.45	0.17	10.69	10.73	28.5	35.5	31.8
0.8		3	0.4	0.51	0.19	11.57	11.63	32.2	47.6	42.8

0.9		3	0.4	0.58	0.22	12.63	12.70	36.7	64.3	57.9
0.1	0.05	3.1	0.48	0.22	0.10	7.35	7.32	15.1	5.4	4.4
0.2		3.2	0.55	0.25	0.11	7.74	7.73	16.6	7.8	6.5
0.3		3.3	0.63	0.29	0.13	8.19	8.19	18.3	10.9	9.2
0.4		3.4	0.70	0.33	0.15	8.69	8.70	20.2	15.0	12.8
0.5		3.5	0.78	0.38	0.17	9.27	9.29	22.3	20.4	17.4
0.6		3.6	0.85	0.43	0.19	9.93	9.96	24.7	27.5	23.6
0.7		3.7	0.93	0.49	0.22	10.69	10.73	27.4	37.0	31.8
0.8		3.8	1.00	0.56	0.25	11.57	11.63	30.5	49.9	42.8
0.9		3.9	1.08	0.64	0.28	12.63	12.70	34.0	67.5	57.9
0.1		0.1	3.2	0.55	0.23	0.11	7.34	7.32	15.1	5.4
0.2	3.4		0.70	0.27	0.13	7.74	7.73	16.5	7.9	6.5
0.3	3.6		0.85	0.31	0.15	8.19	8.19	18.1	11.2	9.2
0.4	3.8		1.00	0.36	0.17	8.69	8.70	19.9	15.5	12.8
0.5	4.0		1.15	0.41	0.20	9.27	9.29	21.7	21.2	17.5
0.6	4.2		1.30	0.47	0.23	9.92	9.96	23.7	28.8	23.6
0.7	4.4		1.45	0.54	0.26	10.68	10.73	25.9	39.0	31.8
0.8	4.6		1.60	0.62	0.30	11.57	11.63	28.2	52.8	42.8
0.9	4.8		1.75	0.70	0.34	12.63	12.70	30.6	71.8	57.9
0.1	0.15		3.3	0.63	0.24	0.12	7.34	7.32	15.1	5.5
0.2		3.6	0.85	0.29	0.14	7.74	7.73	16.5	8.1	6.5
0.3		3.9	1.08	0.33	0.17	8.19	8.19	17.9	11.5	9.2
0.4		4.2	1.30	0.39	0.20	8.69	8.70	19.4	16.1	12.8
0.5		4.5	1.53	0.45	0.23	9.27	9.29	21.0	22.2	17.5
0.6		4.8	1.75	0.51	0.27	9.92	9.96	22.5	30.3	23.6
0.7		5.1	1.98	0.59	0.31	10.68	10.73	24.0	41.3	31.8
0.8		5.4	2.20	0.67	0.35	11.57	11.63	25.3	56.2	42.9
0.9		5.7	2.43	0.76	0.40	12.63	12.70	26.2	76.8	58.0
0.1		0.2	3.4	0.70	0.26	0.14	7.34	7.32	15.1	5.6
0.2	3.8		1.00	0.30	0.16	7.74	7.73	16.3	8.3	6.5
0.3	4.2		1.30	0.36	0.19	8.19	8.19	17.7	11.9	9.3
0.4	4.6		1.60	0.41	0.22	8.69	8.70	18.9	16.8	12.8
0.5	5.0		1.90	0.48	0.26	9.27	9.29	20.1	23.3	17.5
0.6	5.4		2.20	0.55	0.31	9.92	9.96	21.1	32.1	23.7
0.7	5.8		2.50	0.63	0.35	10.68	10.73	21.7	43.9	31.9
0.8	6.2		2.80	0.72	0.40	11.57	11.63	21.8	60.1	42.9
0.9	6.6		3.10	0.83	0.46	12.63	12.70	21.1	82.6	58.0
0.1	0.25		3.5	0.78	0.27	0.15	7.34	7.32	15.0	5.6
0.2		4.0	1.15	0.32	0.18	7.74	7.73	16.2	8.5	6.6
0.3		4.5	1.53	0.38	0.21	8.19	8.19	17.3	12.3	9.3

0.4		5.0	1.90	0.44	0.25	8.69	8.70	18.3	17.5	12.9
0.5		5.5	2.28	0.51	0.30	9.27	9.29	19.0	24.5	17.5
0.6		6.0	2.65	0.59	0.34	9.92	9.96	19.4	34.0	23.7
0.7		6.5	3.03	0.68	0.40	10.68	10.73	19.1	46.9	31.9
0.8		7.0	3.40	0.78	0.45	11.57	11.63	17.8	64.6	42.9
0.9		7.5	3.78	0.89	0.52	12.63	12.70	15.1	89.1	58.0
0.1	0.30	3.6	0.85	0.28	0.16	7.34	7.32	13.6	5.7	4.5
0.2		4.2	1.30	0.34	0.19	7.74	7.73	14.5	8.7	6.6
0.3		4.8	1.75	0.40	0.23	8.19	8.19	15.1	12.8	9.3
0.4		5.4	2.20	0.47	0.28	8.69	8.70	15.5	18.3	12.9
0.5		6.0	2.65	0.55	0.33	9.27	9.29	15.5	25.9	17.6
0.6		6.6	3.10	0.63	0.38	9.92	9.95	14.7	36.2	23.7
0.7		7.2	3.55	0.72	0.44	10.68	10.73	12.9	50.2	31.9
0.8		7.8	4.00	0.83	0.51	11.57	11.63	9.6	69.5	43.0
0.9		8.4	4.45	0.95	0.58	12.63	12.70	4.2	96.3	58.1