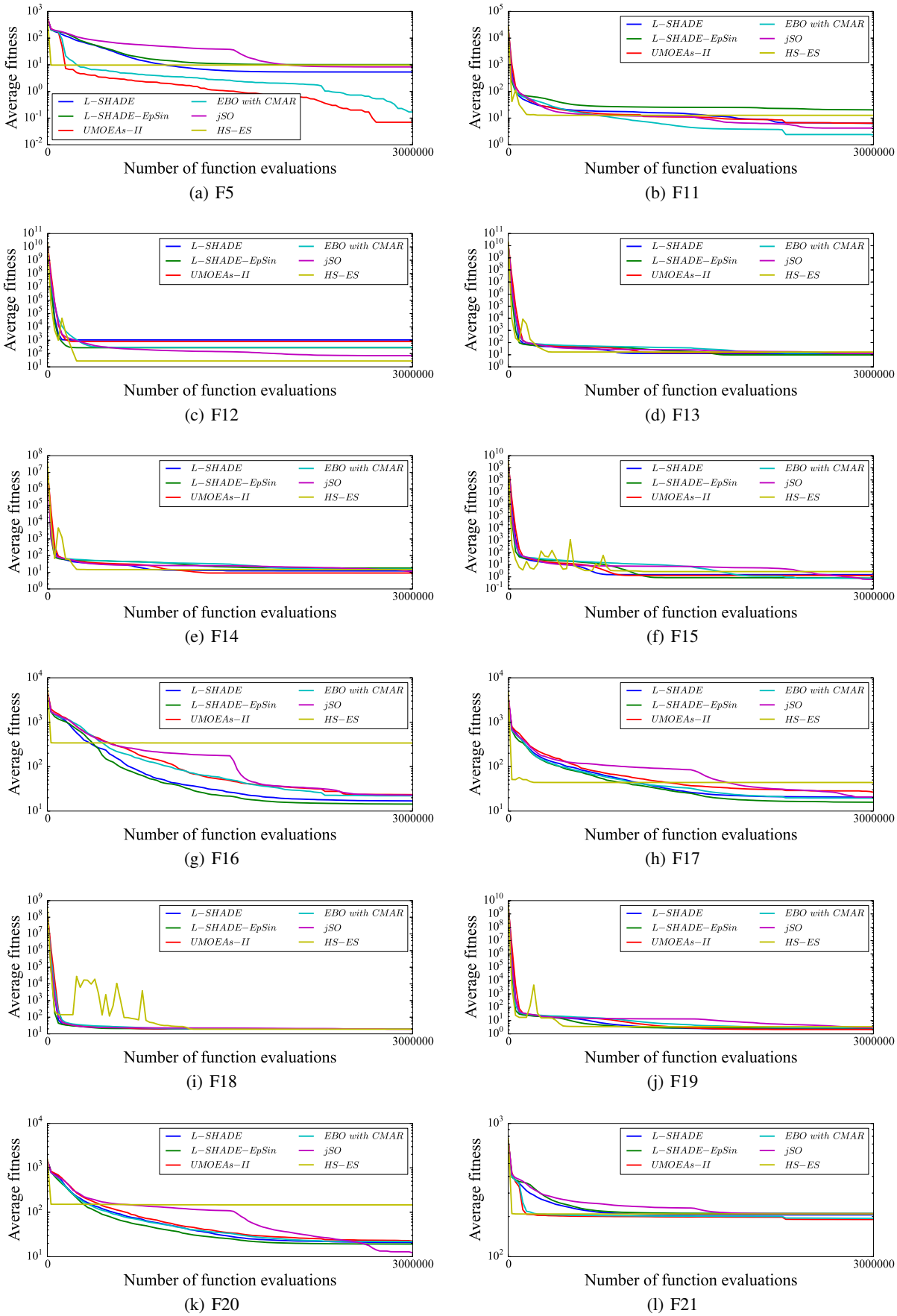
Supplementary materials of 3004 for IJCAI 2020 - Differential Evolution with Individuals Redistribution for Real Parameter Single Objective Optimization

L-SHADE-RSP	0.111601182
L-SHADE-EpSin	0.164073579
L-SHADE	0.16945768
MLCC-SI	0.246572549
SaDE/Mexp	0.341789903
CoBiDE	0.371153213
NDE	0.378045475
MPEDE	0.398172761
ETI-JADE	0.413083498
EDEV	0.419915175

Table 1: Friedman rank sum test at a 0.05 significance level of results of the ten DE algorithms for the CEC 2014 benchmark test suite



(a) F5 (b) F11

(c) F12 (d) F13

(e) F14 (f) F15

(g) F16 (h) F17

(i) F18 (j) F19

(k) F20 (l) F21

Figure 1: Convergence graphs of the six metaheuristics for 21 functions in the CEC 2017 benchmark test suite (the first part)

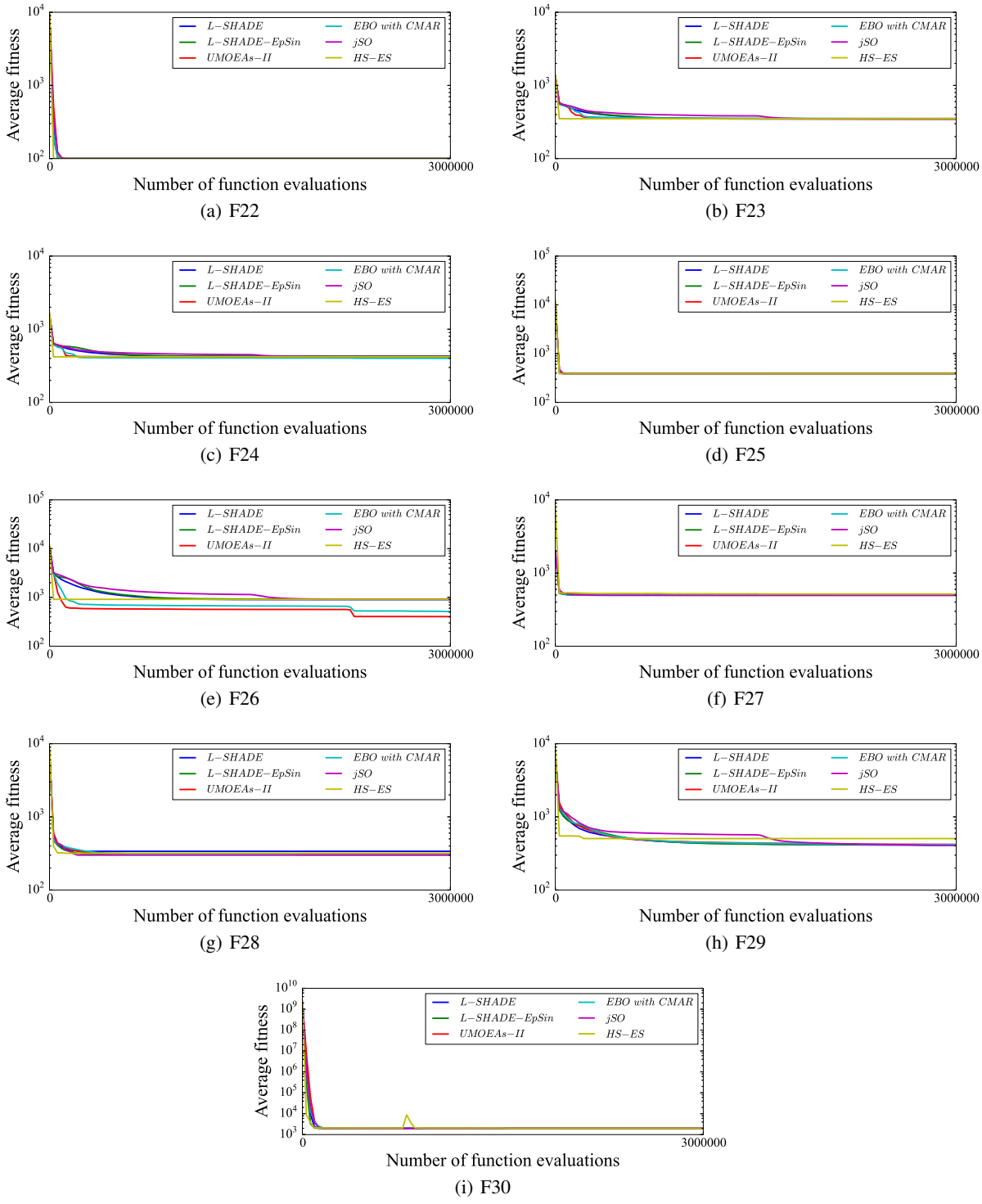


Figure 1: Convergence graphs of the six metaheuristics for 21 functions in the CEC 2017 benchmark test suite (the second part)

Function	Original	Complete restart	Individuals redistribution	
			1.00E-01	5.00E-02
F1	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F2	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F3	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F4	5.86E+01 (0.00E+00)	5.86E+01 (0.00E+00)≈	5.86E+01 (3.32E-14)≈≈	5.86E+01 (3.73E-14)≈≈
F5	5.37E+00 (1.16E+00)	4.46E+00 (8.54E-01)≈	4.77E+00 (1.06E+00)≈ −	6.14E+00 (1.59E+00)−−
F6	1.14E-13 (0.00E+00)	1.06E-13 (2.88E-14)≈	7.61E-12 (2.36E-11)≈≈	7.13E-12 (2.15E-11)≈≈
F7	3.66E+01 (1.48E+00)	3.56E+01 (7.77E-01)+	3.58E+01 (9.91E-01)+ ≈	3.59E+01 (7.27E-01)+ ≈
F8	6.20E+00 (1.27E+00)	4.60E+00 (1.03E+00)+	5.62E+00 (1.31E+00)≈ −	6.24E+00 (1.72E+00)≈ −
F9	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F10	1.09E+03 (1.57E+02)	1.01E+03 (1.83E+02)≈	1.03E+03 (2.63E+02)≈≈	9.87E+02 (3.34E+02)≈≈
F11	6.34E+00 (1.08E+01)	2.75E+00 (1.13E+00)+	1.05E+01 (2.07E+01)≈≈	1.37E+01 (2.39E+01)− ≈
F12	1.05E+03 (3.92E+02)	4.36E+02 (1.70E+02)+	5.47E+02 (1.68E+02)+ ≈	5.23E+02 (2.08E+02)+ ≈
F13	1.27E+01 (6.28E+00)	4.98E+00 (3.98E+00)+	3.73E+00 (2.95E+00)+ ≈	8.81E+00 (6.71E+00)≈≈
F14	1.21E+01 (9.96E+00)	1.32E+01 (6.63E+00)≈	1.49E+01 (8.82E+00)− ≈	1.72E+01 (7.80E+00)−−
F15	1.52E+00 (1.04E+00)	9.75E-01 (5.45E-01)≈	1.19E+00 (6.70E-01)≈≈	1.27E+00 (7.12E-01)≈≈
F16	1.69E+01 (1.03E+01)	1.67E+01 (4.61E+00)+	1.46E+01 (2.04E+00)≈ +	2.65E+01 (3.21E+01)≈≈
F17	2.05E+01 (6.64E+00)	1.94E+01 (4.64E+00)≈	3.21E+01 (6.67E+00)−−	1.05E+01 (7.68E+00)++
F18	1.97E+01 (5.32E+00)	1.94E+01 (4.00E+00)+	2.02E+01 (3.61E+00)≈ −	2.08E+01 (5.62E-01)≈ −
F19	2.34E+00 (1.03E+00)	3.16E+00 (3.50E-01)−	3.36E+00 (7.07E-01)− ≈	2.94E+00 (4.76E-01)−+
F20	2.09E+01 (7.30E+00)	1.64E+01 (6.04E+00)+	2.92E+01 (7.07E+00)−−	9.84E+00 (7.88E+00)++
F21	2.06E+02 (1.41E+00)	2.05E+02 (1.00E+00)≈	2.06E+02 (9.93E-01)≈≈	2.06E+02 (1.13E+00)≈ −
F22	1.00E+02 (0.00E+00)	1.00E+02 (0.00E+00)≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈
F23	3.48E+02 (2.34E+00)	3.46E+02 (2.08E+00)+	3.48E+02 (1.7E+00)≈ −	3.48E+02 (2.13E+00)≈ −
F24	4.25E+02 (1.48E+00)	4.24E+02 (7.32E-01)+	4.25E+02 (8.46E-01)≈ −	4.25E+02 (1.22E+00)≈ −
F25	3.87E+02 (2.19E-02)	3.87E+02 (1.06E-02)+	3.87E+02 (1.26E-02)+ ≈	3.87E+02 (4.90E-03)++
F26	9.02E+02 (3.06E+01)	8.83E+02 (2.12E+01)+	9.09E+02 (2.78E+01)≈ −	8.81E+02 (2.29E+01)+ ≈
F27	5.04E+02 (6.67E+00)	4.92E+02 (2.28E+00)+	4.85E+02 (7.12E+00)++	4.88E+02 (1.09E+01)+ ≈
F28	3.38E+02 (5.52E+01)	3.00E+02 (2.31E-13)+	3.00E+02 (2.60E-13)+ ≈	3.00E+02 (2.60E-13)+ ≈
F29	4.11E+02 (1.54E+01)	4.10E+02 (1.63E+01)≈	4.18E+02 (1.55E+01)−−	4.25E+02 (8.97E+00)−−
F30	1.99E+03 (6.39E+01)	1.94E+03 (2.90E+00)+	1.94E+03 (4.43E+00)+ ≈	1.94E+03 (3.58E+00)+ ≈

		Individuals redistribution		
1.00E-02	5.00E-03	1.00E-03	5.00E-04	1.00E-04
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	1.89E-15 (1.04E-14)≈≈	0.00E+00 (0.00E+00)≈≈
5.87E+01 (1.01E+00)≈≈	5.86E+01 (0.00E+00)≈≈	5.86E+01 (0.00E+00)≈≈	5.86E+01 (0.00E+00)≈≈	5.86E+01 (0.00E+00)≈≈
5.38E+00 (1.51E+00)≈ −	5.84E+00 (1.10E+00)≈ −	5.77E+00 (1.64E+00)≈ −	5.90E+00 (1.36E+00)≈ −	6.34E+00 (1.12E+00)−−
1.70E-12 (6.05E-12)≈≈	1.59E-12 (5.66E-12)≈≈	4.77E-13 (1.91E-12)≈≈	1.17E-13 (2.08E-14)≈≈	8.98E-13 (2.53E-12)≈≈
3.68E+01 (9.90E-01)≈ −	3.62E+01 (1.15E+00)≈≈	3.66E+01 (1.33E+00)≈ −	3.71E+01 (1.26E+00)≈ −	3.69E+01 (1.52E+00)≈ −
6.61E+00 (1.67E+00)≈ −	7.07E+00 (1.58E+00)≈ −	6.67E+00 (1.75E+00)≈ −	7.01E+00 (1.54E+00)≈ −	6.20E+00 (1.73E+00)≈ −
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
1.02E+03 (2.70E+02)≈≈	8.96E+02 (2.89E+02)++	1.04E+03 (2.52E+02)≈≈	1.04E+03 (2.18E+02)≈≈	9.71E+02 (3.37E+02)≈≈
1.64E+01 (2.17E+01)−−	1.58E+01 (2.08E+01)−−	1.81E+01 (2.44E+01)≈ −	2.12E+01 (2.54E+01)−−	1.82E+01 (2.47E+01)≈ −
6.93E+02 (3.07E+02)+−	8.74E+02 (3.87E+02)≈ −	9.95E+02 (3.62E+02)≈ −	1.07E+03 (3.96E+02)≈ −	1.07E+03 (3.37E+02)≈ −
1.30E+01 (6.34E+00)≈ −	1.38E+01 (6.41E+00)≈ −	1.42E+01 (5.64E+00)≈ −	1.56E+01 (5.01E+00)−−	1.51E+01 (5.38E+00)−−
1.97E+01 (6.19E+00)−−	2.07E+01 (4.92E+00)−−	1.91E+01 (7.23E+00)−−	2.13E+01 (3.82E+00)−−	1.87E+01 (7.69E+00)−−
1.81E+00 (9.77E-01)≈ −	2.43E+00 (1.29E+00)−−	2.34E+00 (1.01E+00)−−	2.54E+00 (1.12E+00)−−	3.28E+00 (1.27E+00)−−
1.39E+01 (4.09E+00)++	1.44E+01 (3.69E+00)++	1.49E+01 (3.48E+00)≈ +	1.40E+01 (3.84E+00)++	2.20E+01 (4.06E+01)−−
9.08E+00 (8.38E+00)++	1.61E+01 (1.18E+01)≈≈	1.05E+01 (7.30E+00)++	1.34E+01 (8.85E+00)++	1.21E+01 (9.67E+00)++
2.12E+01 (8.95E-01)≈ −	2.17E+01 (8.09E-01)−−	2.15E+01 (8.43E-01)−−	2.16E+01 (1.30E+00)−−	2.19E+01 (1.45E+00)−−
5.01E+00 (1.56E+00)−−	5.03E+00 (1.43E+00)−−	5.18E+00 (1.74E+00)−−	4.93E+00 (1.33E+00)−−	4.81E+00 (1.43E+00)−−
1.17E+01 (1.12E+01)++	1.25E+01 (1.02E+01)+ ≈	1.03E+01 (1.02E+01)++	1.05E+01 (1.10E+01)++	1.19E+01 (1.08E+01)++
1.64E+02 (5.30E+01)+ ≈	1.71E+02 (5.12E+01)≈≈	1.61E+02 (5.39E+01)≈≈	1.60E+02 (5.35E+01)+ ≈	1.86E+02 (4.35E+01)≈ +
1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈
3.13E+02 (8.28E+01)≈ +	3.43E+02 (4.08E+01)++	3.42E+02 (3.81E+01)≈ +	3.41E+02 (4.55E+01)≈ +	3.41E+02 (4.56E+01)≈ +
3.88E+02 (8.55E+01)≈ +	3.85E+02 (9.41E+01)≈ +	3.95E+02 (7.79E+01)≈≈	3.88E+02 (8.57E+01)≈ +	4.18E+02 (4.13E+01)++
3.87E+02 (1.64E-03)++	3.87E+02 (1.87E-03)++	3.87E+02 (1.50E-02)++	3.87E+02 (1.85E-02)≈ −	3.87E+02 (1.88E-02)≈ −
5.27E+02 (3.05E+02)++	5.97E+02 (3.03E+02)++	6.26E+02 (3.11E+02)+ ≈	6.97E+02 (3.09E+02)≈≈	6.11E+02 (3.18E+02)+ ≈
5.01E+02 (6.05E+00)≈ −	5.01E+02 (8.15E+00)≈ −	5.01E+02 (5.43E+00)≈ −	5.03E+02 (5.86E+00)≈ −	5.02E+02 (5.33E+00)≈ −
3.36E+02 (5.17E+01)≈ −	3.30E+02 (5.12E+01)≈≈	3.18E+02 (4.00E+01)≈≈	3.34E+02 (5.31E+01)≈ −	3.36E+02 (5.17E+01)≈ −
4.05E+02 (9.46E+00)++	4.04E+02 (1.64E+01)++	4.07E+02 (1.73E+01)++	4.11E+02 (7.25E+00)≈≈	4.07E+02 (1.84E+01)+ ≈
1.95E+03 (1.03E+01)+ ≈	1.95E+03 (3.05E+01)+ ≈	1.97E+03 (4.52E+01)≈ −	1.96E+03 (2.26E+01)+ ≈	1.98E+03 (4.88E+01)≈ −

Table 2: The results of the three versions of L-SHADE for the CEC 2017 benchmark test suite. The symbol behind the results based on complete restart shows the difference to the original results, while the two symbols behind the results with individuals redistribution show the difference to the original results and the results with complete restart, respectively. "+" and "−" denote significantly better and statistically worse than the peer in terms of Wilcoxon's rank sum test at a 0.05 significance level, respectively. Meanwhile, "≈" represents no significantly difference

Function	Original	Complete restart	Individuals redistribution	
			1.00E-01	5.00E-02
F1	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F2	3.79E-15 (1.23E-14)	9.47E-16 (5.19E-15)≈	9.47E-16 (5.19E-15)≈≈	3.79E-15 (1.23E-14)≈≈
F3	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F4	4.84E+01 (2.41E+01)	1.83E-07 (1.00E-06)+	2.62E+00 (1.12E+01)+ ≈	1.95E+00 (1.07E+01)+ ≈
F5	3.96E+01 (8.69E+00)	2.31E+01 (3.44E+00)+	2.36E+01 (3.39E+00)+ ≈	2.42E+01 (4.86E+00)+ ≈
F6	1.14E-13 (0.00E+00)	1.14E-13 (0.00E+00)≈	1.14E-13 (0.00E+00)≈≈	1.14E-13 (0.00E+00)≈≈
F7	6.77E+01 (8.73E+00)	5.41E+01 (3.87E+00)+	5.49E+01 (4.81E+00)+ ≈	5.53E+01 (5.08E+00)+ ≈
F8	3.87E+01 (7.07E+00)	2.40E+01 (3.50E+00)+	2.42E+01 (3.75E+00)+ ≈	2.47E+01 (4.17E+00)+ ≈
F9	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F10	2.08E+03 (5.98E+02)	1.10E+03 (2.00E+02)+	1.22E+03 (2.33E+02)+−	1.17E+03 (2.54E+02)+ ≈
F11	1.47E+01 (1.27E+01)	5.89E+00 (1.53E+00)+	6.06E+00 (1.87E+00)+ ≈	5.81E+00 (1.66E+00)+ ≈
F12	3.05E+02 (1.58E+02)	1.96E+02 (1.22E+02)+	1.72E+02 (1.45E+02)+ ≈	1.58E+02 (1.28E+02)+ ≈
F13	2.23E+01 (7.89E+00)	1.15E+01 (4.43E+00)+	1.10E+01 (4.55E+00)+ ≈	1.33E+01 (4.85E+00)+ ≈
F14	9.60E+00 (4.62E+00)	4.48E+00 (1.43E+00)+	4.71E+00 (1.25E+00)+ ≈	5.27E+00 (1.68E+00)+ ≈
F15	7.12E+00 (3.12E+00)	4.04E+00 (1.13E+00)+	3.76E+00 (1.07E+00)+ ≈	3.85E+00 (1.49E+00)+ ≈
F16	3.91E+02 (1.53E+02)	1.04E+02 (7.90E+01)+	7.59E+01 (8.27E+01)+ ≈	1.41E+02 (1.02E+02)+ ≈
F17	2.25E+01 (2.14E+01)	9.96E+00 (5.12E+00)+	7.89E+00 (3.02E+00)+ ≈	9.32E+00 (3.29E+00)+ ≈
F18	1.89E+01 (9.34E+00)	5.76E+00 (7.50E+00)+	3.93E+00 (3.84E+00)+ ≈	6.91E+00 (7.69E+00)+ ≈
F19	4.22E+00 (1.53E+00)	2.33E+00 (8.27E-01)+	2.25E+00 (9.66E-01)+ ≈	2.36E+00 (8.12E-01)+ ≈
F20	5.17E+01 (6.71E+01)	1.77E+00 (6.93E-01)+	2.26E+00 (9.90E-01)+ ≈	1.28E+01 (3.10E+01)+−
F21	2.40E+02 (1.07E+01)	2.25E+02 (3.39E+00)+	1.58E+02 (6.36E+01)++	1.38E+02 (5.87E+01)++
F22	1.00E+02 (0.00E+00)	1.00E+02 (2.71E-06)≈	1.00E+02 (3.96E-06)≈≈	1.00E+02 (4.18E-06)≈≈
F23	3.86E+02 (1.05E+01)	3.69E+02 (5.24E+00)+	3.68E+02 (5.47E+00)+ ≈	1.00E+02 (4.31E-06)++
F24	4.65E+02 (1.28E+01)	4.41E+02 (4.08E+00)+	4.41E+02 (4.72E+00)+ ≈	4.42E+02 (4.08E+00)+ ≈
F25	3.87E+02 (6.19E-01)	3.86E+02 (1.01E+00)+	3.87E+02 (6.03E-01)+ ≈	3.87E+02 (6.05E-01)+ ≈
F26	1.35E+03 (2.47E+02)	5.00E+02 (3.73E+02)+	8.62E+02 (4.16E+02)+−	3.00E+02 (8.66E-06)++
F27	4.95E+02 (1.00E+01)	4.75E+02 (5.71E+00)+	4.67E+02 (3.81E+00)++	4.63E+02 (3.74E+00)++
F28	3.25E+02 (4.58E+01)	3.00E+02 (1.10E-05)≈	3.00E+02 (1.32E-05)≈≈	3.00E+02 (1.00E-05)≈≈
F29	4.26E+02 (3.92E+01)	3.57E+02 (2.40E+01)+	3.50E+02 (2.70E+01)+ ≈	3.48E+02 (2.77E+01)++
F30	2.04E+03 (7.44E+01)	1.96E+03 (1.69E+01)+	1.96E+03 (2.09E+01)+ ≈	1.96E+03 (1.53E+01)+ ≈

		Individuals redistribution		
1.00E-02	5.00E-03	1.00E-03	5.00E-04	1.00E-04
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
0.00E+00 (0.00E+00)≈≈	1.89E-15 (7.21E-15)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
9.30E-01 (1.71E+00)+ ≈	4.70E+00 (1.47E+01)+ ≈	3.45E+01 (2.96E+01)≈ −	4.04E+01 (2.83E+01)≈ −	3.00E+01 (2.95E+01)+−
2.37E+01 (4.86E+00)+ ≈	2.41E+01 (4.38E+00)+ ≈	3.36E+01 (6.16E+00)+−	2.95E+01 (7.23E+00)+−	2.98E+01 (6.72E+00)+−
1.14E-13 (0.00E+00)≈≈	1.14E-13 (0.00E+00)≈≈	1.14E-13 (0.00E+00)≈≈	1.14E-13 (0.00E+00)≈≈	1.14E-13 (0.00E+00)≈≈
5.62E+01 (4.77E+00)+−	5.54E+01 (4.91E+00)+ ≈	5.67E+01 (4.68E+00)+−	5.99E+01 (7.89E+00)+−	6.36E+01 (9.64E+00)≈ −
2.51E+01 (5.09E+00)+ ≈	2.40E+01 (3.96E+00)+ ≈	3.33E+01 (9.14E+00)+−	3.44E+01 (8.42E+00)+−	3.46E+01 (6.94E+00)+−
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
1.16E+03 (2.56E+02)+ ≈	9.51E+02 (3.00E+02)++	1.47E+03 (4.80E+02)+−	1.32E+03 (4.87E+02)+−	1.19E+03 (3.56E+02)+ ≈
6.57E+00 (1.76E+00)+ ≈	8.33E+00 (2.08E+00)+−	1.25E+01 (5.81E+00)≈ −	1.04E+01 (4.38E+00)≈ −	8.82E+00 (3.70E+00)+−
2.31E+02 (1.45E+02)≈≈	1.92E+02 (1.27E+02)+ ≈	1.76E+02 (1.04E+02)+ ≈	2.76E+02 (1.92E+02)≈≈	2.30E+02 (2.29E+02)+ ≈
1.18E+01 (4.36E+00)+ ≈	9.54E+00 (4.89E+00)++	1.19E+01 (5.67E+00)+ ≈	1.15E+01 (4.71E+00)+ ≈	1.32E+01 (6.25E+00)+ ≈
4.78E+00 (1.34E+00)+ ≈	4.94E+00 (1.24E+00)+ ≈	4.54E+00 (1.54E+00)+ ≈	4.31E+00 (1.23E+00)+ ≈	4.64E+00 (1.12E+00)+ ≈
3.85E+00 (1.18E+00)+ ≈	3.87E+00 (1.23E+00)+ ≈	3.92E+00 (1.27E+00)+ ≈	3.94E+00 (1.29E+00)+ ≈	3.70E+00 (1.38E+00)+ ≈
1.09E+02 (9.51E+01)+ ≈	1.19E+02 (9.98E+01)+ ≈	1.16E+02 (8.76E+01)+ ≈	1.25E+02 (9.57E+01)+ ≈	1.11E+02 (7.87E+01)+ ≈
9.73E+00 (4.21E+00)+ ≈	9.05E+00 (4.09E+00)+ ≈	8.92E+00 (4.13E+00)+ ≈	1.01E+01 (4.57E+00)+ ≈	1.14E+01 (6.09E+00)+ ≈
4.94E+00 (5.09E+00)++	5.49E+00 (6.67E+00)+ ≈	4.62E+00 (6.00E+00)+ ≈	4.78E+00 (6.02E+00)+ ≈	5.99E+00 (7.05E+00)+ ≈
2.61E+00 (8.21E-01)+ ≈	2.58E+00 (8.29E-01)+ ≈	2.51E+00 (7.15E-01)+ ≈	2.66E+00 (7.97E-01)+ ≈	2.54E+00 (8.15E-01)+ ≈
3.80E+01 (6.38E+01)≈ −	4.18E+01 (5.75E+01)≈ −	2.91E+01 (5.13E+01)+−	3.20E+01 (5.08E+01)+−	3.38E+01 (5.09E+01)≈ −
1.09E+02 (3.25E+01)++	1.67E+02 (6.87E+01)+ ≈	1.45E+02 (6.53E+01)++	1.55E+02 (6.82E+01)+ ≈	1.36E+02 (6.06E+01)++
1.00E+02 (3.79E-06)≈≈	1.00E+02 (2.65E-06)≈≈	1.00E+02 (3.46E-06)≈≈	1.00E+02 (2.94E-06)≈≈	1.00E+02 (3.49E-06)≈≈
1.00E+02 (4.25E-06)++	1.00E+02 (6.25E-06)++	1.84E+02 (1.31E+02)++	2.33E+02 (1.45E+02)+ ≈	2.42E+02 (1.42E+02)+ ≈
4.01E+02 (9.18E+01)+ ≈	4.45E+02 (4.69E+01)+−	4.31E+02 (7.87E+01)++	4.50E+02 (4.85E+01)+−	4.02E+02 (1.03E+02)++
3.87E+02 (4.90E-03)−−	3.87E+02 (2.37E-03)−−	3.87E+02 (2.26E-03)−−	3.87E+02 (1.37E-02)− ≈	3.87E+02 (4.96E-02)≈ −
3.00E+02 (9.84E-06)++	3.95E+02 (2.90E+02)+ ≈	5.84E+02 (4.88E+02)+ ≈	4.73E+02 (3.95E+02)+ ≈	3.00E+02 (1.98E-01)+ ≈
4.73E+02 (1.13E+01)+ ≈	4.85E+02 (1.05E+01)+−	4.87E+02 (1.45E+01)+−	4.86E+02 (1.28E+01)+−	4.82E+02 (1.12E+01)+−
3.21E+02 (4.28E+01)≈≈	3.29E+02 (4.89E+01)≈ −	3.48E+02 (5.68E+01)−−	3.18E+02 (4.16E+01)≈≈	3.07E+02 (2.76E+01)≈≈
3.54E+02 (3.52E+01)+ ≈	3.64E+02 (3.11E+01)+ ≈	3.65E+02 (3.43E+01)+ ≈	3.91E+02 (3.77E+01)+−	3.94E+02 (3.47E+01)+−
1.97E+03 (2.19E+01)+ ≈	1.97E+03 (1.73E+01)+ ≈	1.96E+03 (1.77E+01)+ ≈	1.96E+03 (1.61E+01)+ ≈	1.97E+03 (1.98E+01)+ ≈

Table 3: The results of the three versions of CoBiDE for the CEC 2017 benchmark test suite. The symbol behind the results based on complete restart shows the difference to the original results, while the two symbols behind the results with individuals redistribution show the difference to the original results and the results with complete restart, respectively. "+" and "−" denote significantly better and statistically worse than the peer in terms of Wilcoxon's rank sum test at a 0.05 significance level, respectively. Meanwhile, "≈" represents no significantly difference

Function	Original	Complete restart	Individuals redistribution 1.00E-01	5.00E-02
F1	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)$hlineapprox$	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F2	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F3	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F4	5.86E+01 (0.00E+00)	6.14E+00 (1.73E+01)+	5.86E+01 (3.25E-14)≈ −	3.32E+01 (2.95E+01)+ ≈
F5	1.01E+01 (1.43E+00)	9.95E+00 (1.61E+00)≈	5.84E+00 (1.77E+00)++	1.06E+01 (1.59E+00)−−
F6	1.10E-13 (2.08E-14)	9.85E-14 (3.93E-14)≈	3.45E-11 (2.62E-11)−−	2.70E-11 (1.50E-11)−−
F7	4.10E+01 (1.69E+00)	4.11E+01 (1.28E+00)≈	3.64E+01 (1.07E+00)++	3.69E+01 (1.24E+00)++
F8	1.11E+01 (1.61E+00)	1.08E+01 (1.63E+00)≈	6.62E+00 (1.45E+00)++	1.34E+01 (1.82E+00)−−
F9	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F10	1.08E+03 (1.85E+02)	1.06E+03 (1.81E+02)≈	8.84E+02 (1.94E+02)++	8.33E+02 (1.87E+02)++
F11	2.04E+01 (2.68E+01)	7.87E+00 (1.52E+01)≈	7.16E+00 (1.48E+01)≈≈	5.59E+00 (1.49E+01)+ ≈
F12	2.73E+02 (1.52E+02)	2.35E+02 (1.36E+02)≈	3.08E+02 (1.60E+02)≈≈	2.93E+02 (1.49E+02)≈≈
F13	9.72E+00 (7.07E+00)	9.11E+00 (5.54E+00)≈	6.34E+00 (5.64E+00)≈ +	1.08E+01 (7.30E+00)− ≈
F14	1.80E+01 (6.50E+00)	1.77E+01 (6.72E+00)≈	1.89E+01 (5.84E+00)− ≈	1.71E+01 (8.38E+00)+ ≈
F15	7.73E-01 (7.15E-01)	8.52E-01 (8.84E-01)≈	1.15E+00 (8.06E-01)≈≈	1.30E+00 (7.58E-01)−−
F16	1.44E+01 (2.38E+00)	1.43E+01 (2.47E+00)≈	1.33E+01 (3.86E+00)≈≈	2.33E+01 (3.08E+01)−−
F17	1.58E+01 (5.56E+00)	1.55E+01 (5.53E+00)≈	1.06E+01 (2.90E+00)++	1.29E+01 (8.80E+00)++
F18	1.98E+01 (3.67E+00)	2.06E+01 (3.33E-01)−	2.07E+01 (3.91E-01)− ≈	2.01E+01 (3.40E+00)≈≈
F19	2.80E+00 (8.53E-01)	2.71E+00 (8.59E-01)≈	3.53E+00 (6.92E-01)−−	3.13E+00 (7.03E-01)−−
F20	1.92E+01 (8.07E+00)	2.05E+01 (7.19E+00)≈	2.46E+01 (1.03E+01)− ≈	9.07E+00 (8.80E+00)++
F21	2.11E+02 (1.38E+00)	2.11E+02 (1.72E+00)≈	2.06E+02 (1.68E+00)++	1.82E+02 (5.01E+01)≈≈
F22	1.00E+02 (0.00E+00)	1.00E+02 (0.00E+00)≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈
F23	3.53E+02 (2.04E+00)	3.53E+02 (2.53E+00)≈	3.50E+02 (2.01E+00)++	3.51E+02 (2.81E+00)+ ≈
F24	4.28E+02 (2.10E+00)	4.28E+02 (1.56E+00)≈	4.26E+02 (1.59E+00)++	4.27E+02 (2.14E+00)++
F25	3.87E+02 (7.25E-03)	3.84E+02 (1.08E+00)+	3.87E+02 (1.85E-03)+−	3.87E+02 (1.79E-03)+−
F26	9.25E+02 (3.56E+01)	8.69E+02 (1.85E+02)≈	9.06E+02 (3.70E+01)+ ≈	8.73E+02 (1.14E+02)+ ≈
F27	5.06E+02 (4.65E+00)	4.92E+02 (3.44E+00)+	4.89E+02 (5.95E+00)++	4.90E+02 (6.08E+00)+ ≈
F28	3.11E+02 (3.26E+01)	3.00E+02 (2.83E-13)≈	3.00E+02 (2.83E-13)≈≈	3.08E+02 (2.89E+01)≈≈
F29	4.13E+02 (7.73E+00)	4.14E+02 (8.29E+00)≈	4.21E+02 (5.81E+00)−−	4.11E+02 (2.15E+01)≈≈
F30	1.98E+03 (5.01E+01)	1.95E+03 (1.45E+01)+	1.94E+03 (2.25E-01)+ ≈	1.94E+03 (7.29E+00)+ ≈

Individuals redistribution 1.00E-02	5.00E-03	1.00E-03	5.00E-04	1.00E-04
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
5.86E+01 (0.00E+00)≈ −	5.86E+01 (0.00E+00)≈ −	5.86E+01 (0.00E+00)≈ −	5.86E+01 (0.00E+00)≈ −	5.86E+01 (0.00E+00)≈ −
8.54E+00 (2.09E+00)++	1.08E+01 (1.75E+00)≈≈	1.07E+01 (1.72E+00)≈≈	1.06E+01 (1.87E+00)≈≈	1.06E+01 (1.93E+00)≈≈
2.26E-11 (1.06E-11)−−	1.84E-11 (6.28E-12)−−	1.76E-11 (8.65E-12)−−	1.46E-11 (5.83E-12)−−	9.63E-12 (4.16E-12)−−
3.99E+01 (2.71E+00)++	3.95E+01 (2.03E+00)++	4.11E+01 (2.23E+00)≈≈	4.13E+01 (1.66E+00)≈≈	4.12E+01 (2.19E+00)≈≈
9.36E+00 (2.03E+00)++	1.13E+01 (2.12E+00)≈≈	1.18E+01 (1.83E+00)≈≈	1.15E+01 (1.88E+00)≈≈	1.20E+01 (1.49E+00)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
9.05E+02 (2.02E+02)++	7.92E+02 (2.45E+02)++	8.98E+02 (1.87E+02)++	8.14E+02 (2.52E+02)++	9.04E+02 (1.45E+02)++
8.03E+00 (1.35E+01)≈ −	7.51E+00 (1.47E+01)≈≈	1.09E+01 (1.99E+01)≈≈	1.21E+01 (2.26E+01)≈≈	1.02E+01 (2.06E+01)+ ≈
3.41E+02 (2.17E+02)≈ −	3.16E+02 (2.27E+02)≈≈	3.81E+02 (1.98E+02)−−	3.98E+02 (2.62E+02)−−	3.92E+02 (1.85E+02)−−
1.32E+01 (5.71E+00)−−	1.29E+01 (7.96E+00)−−	1.33E+01 (6.28E+00)−−	1.59E+01 (8.82E+00)−−	1.34E+01 (5.81E+00)−−
2.06E+01 (5.15E+00)−−	1.95E+01 (6.27E+00)− ≈	2.04E+01 (5.43E+00)−−	1.94E+01 (7.32E+00)−−	2.08E+01 (4.81E+00)−−
4.44E+00 (3.54E+00)−−	4.33E+00 (2.76E+00)−−	4.24E+00 (2.92E+00)−−	4.01E+00 (2.55E+00)−−	4.02E+00 (2.50E+00)−−
1.56E+01 (4.48E+00)≈≈	1.31E+01 (3.35E+00)≈≈	1.26E+01 (3.75E+00)++	1.50E+01 (5.90E+00)≈≈	1.36E+01 (5.04E+00)++
7.36E+00 (5.86E+00)++	8.19E+00 (6.25E+00)++	7.67E+00 (6.29E+00)++	9.46E+00 (6.02E+00)++	8.37E+00 (5.64E+00)++
2.12E+01 (7.20E-01)−−	2.09E+01 (7.54E-01)−−	2.10E+01 (7.93E-01)≈≈	2.10E+01 (6.72E-01)≈≈	2.12E+01 (7.19E-01)−−
4.91E+00 (1.41E+00)−−	4.81E+00 (1.18E+00)−−	4.64E+00 (1.12E+00)−−	4.73E+00 (1.60E+00)−−	4.45E+00 (1.29E+00)−−
8.06E+00 (8.21E+00)++	8.92E+00 (1.09E+01)++	8.30E+00 (9.27E+00)++	6.09E+00 (5.73E+00)++	6.46E+00 (6.24E+00)++
2.08E+02 (2.05E+01)++	1.97E+02 (3.86E+01)≈≈	2.05E+02 (2.85E+01)≈ +	2.12E+02 (1.79E+00)−−	2.08E+02 (2.05E+01)++
1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈
3.52E+02 (4.56E+00)≈≈	3.53E+02 (3.60E+00)≈≈	3.52E+02 (3.94E+00)≈≈	3.53E+02 (3.26E+00)≈≈	3.52E+02 (4.40E+00)≈≈
4.02E+02 (8.14E+01)≈≈	4.14E+02 (5.82E+01)≈≈	4.28E+02 (2.31E+00)≈≈	4.22E+02 (4.19E+01)≈≈	4.30E+02 (2.26E+00)−−
3.87E+02 (1.92E-03)+−	3.87E+02 (1.91E-03)+−	3.87E+02 (1.80E-03)+−	3.87E+02 (5.77E-03)≈ −	3.87E+02 (5.78E-03)≈ −
6.00E+02 (2.92E+02)++	6.36E+02 (3.01E+02)++	8.13E+02 (1.80E+02)++	7.52E+02 (2.66E+02)+ ≈	7.97E+02 (2.19E+02)+ ≈
5.03E+02 (5.48E+00)+−	5.05E+02 (4.70E+00)≈ −	5.06E+02 (4.79E+00)≈ −	5.04E+02 (4.76E+00)≈ −	5.06E+02 (4.59E+00)≈ −
3.14E+02 (3.76E+01)≈≈	3.25E+02 (4.65E+01)≈≈	3.07E+02 (2.76E+01)≈≈	3.27E+02 (4.90E+01)≈≈	3.22E+02 (4.50E+01)≈≈
4.02E+02 (1.84E+01)++	4.10E+02 (1.01E+01)++	4.10E+02 (8.65E+00)++	4.09E+02 (8.70E+00)++	4.08E+02 (5.39E+00)++
1.95E+03 (2.60E+01)≈≈	1.95E+03 (2.29E+01)≈≈	1.98E+03 (4.73E+01)≈ −	1.98E+03 (4.75E+01)≈ −	1.97E+03 (3.96E+01)≈ −

Table 4: The results of the three versions of L-SHADE-EpSin for the CEC 2017 benchmark test suite. The symbol behind the results based on complete restart shows the difference to the original results, while the two symbols behind the results with individuals redistribution show the difference to the original results and the results with complete restart, respectively. "+" and "−" denote significantly better and statistically worse than the peer in terms of Wilcoxon's rank sum test at a 0.05 significance level, respectively. Meanwhile, "≈" represents no significantly difference

Function	Original	Complete restart	Individuals redistribution	
			1.00E-01	5.00E-02
F1	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F2	2.69E-11 (9.54E-11)	6.49E-13 (2.11E-12)+	0.00E+00 (0.00E+00)++	9.47E-16 (5.19E-15)++
F3	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F4	2.79E+00 (1.86E+00)	5.93E-13 (2.84E-12)+	5.05E+00 (1.20E+01)≈ −	2.92E+00 (1.79E+00)≈ −
F5	2.64E+01 (5.63E+00)	2.13E+01 (3.19E+00)+	1.93E+01 (4.34E+00)++	1.96E+01 (3.26E+00)+ ≈
F6	0.00E+00 (0.00E+00)	4.17E-14 (5.57E-14)−	6.44E-14 (5.73E-14)− ≈	7.96E-14 (5.30E-14)−−
F7	5.64E+01 (6.30E+00)	5.14E+01 (3.38E+00)+	4.92E+01 (3.81E+00)++	5.00E+01 (2.97E+00)+ ≈
F8	2.93E+01 (6.21E+00)	2.16E+01 (4.08E+00)+	2.14E+01 (4.12E+00)+ ≈	2.04E+01 (4.46E+00)+ ≈
F9	1.06E-01 (1.86E-01)	0.00E+00 (0.00E+00)+	0.00E+00 (0.00E+00)+ ≈	0.00E+00 (0.00E+00)+ ≈
F10	1.51E+03 (4.01E+02)	1.55E+03 (4.49E+02)≈	1.57E+03 (4.84E+02)≈≈	1.66E+03 (5.53E+02)≈≈
F11	3.56E+01 (2.54E+01)	1.26E+01 (4.09E+00)+	9.24E+00 (8.41E+00)++	8.25E+00 (3.10E+00)++
F12	9.08E+02 (4.93E+02)	6.15E+02 (3.27E+02)+	1.01E+03 (5.32E+02)≈ −	8.71E+02 (3.33E+02)≈ −
F13	4.43E+01 (2.89E+01)	2.09E+01 (7.21E+00)+	1.80E+01 (8.55E+00)+ ≈	1.82E+01 (8.01E+00)+ ≈
F14	3.89E+01 (1.86E+01)	1.10E+01 (3.55E+00)+	7.71E+00 (2.81E+00)++	1.10E+01 (5.05E+00)+ ≈
F15	4.01E+01 (2.87E+01)	1.40E+01 (5.08E+00)+	9.88E+00 (4.55E+00)++	1.05E+01 (7.02E+00)++
F16	2.72E+02 (1.06E+02)	1.96E+02 (8.64E+01)+	1.61E+02 (1.20E+02)+ ≈	2.18E+02 (1.11E+02)+ ≈
F17	9.68E+00 (5.63E+00)	8.23E+00 (4.45E+00)≈	8.61E+00 (4.31E+00)≈≈	8.04E+00 (4.33E+00)≈≈
F18	4.14E+01 (3.39E+01)	1.76E+01 (1.09E+01)+	2.91E+01 (1.68E+01)≈ −	3.15E+01 (1.54E+01)≈ −
F19	2.91E+01 (2.00E+01)	8.20E+00 (3.18E+00)+	5.51E+00 (2.20E+00)++	8.49E+00 (3.84E+00)+ ≈
F20	2.05E+01 (4.23E+01)	6.38E+00 (2.19E+01)≈	1.76E+00 (1.88E+00)+ ≈	3.07E+00 (3.08E+00)≈≈
F21	2.27E+02 (5.22E+00)	2.22E+02 (3.22E+00)+	2.01E+02 (4.62E+01)++	1.94E+02 (5.24E+01)+ ≈
F22	1.00E+02 (4.48E-01)	1.00E+02 (0.00E+00)≈	1.00E+02 (1.39E-13)≈≈	1.00E+02 (8.30E-14)≈≈
F23	3.74E+02 (7.98E+00)	3.63E+02 (5.02E+00)+	3.62E+02 (6.25E+00)+ ≈	3.59E+02 (5.52E+00)++
F24	4.39E+02 (8.43E+00)	4.29E+02 (7.58E+00)+	4.28E+02 (7.57E+00)+ ≈	4.28E+02 (6.19E+00)+ ≈
F25	3.87E+02 (1.90E+00)	3.84E+02 (1.55E+00)+	3.87E+02 (1.71E+00)+−	3.87E+02 (8.55E-01)+−
F26	9.39E+02 (4.67E+02)	2.00E+02 (1.54E-13)+	7.16E+02 (4.18E+02)+−	7.64E+02 (3.86E+02)+−
F27	5.03E+02 (7.40E+00)	4.87E+02 (7.72E+00)+	4.88E+02 (1.03E+01)+ ≈	4.89E+02 (1.03E+01)+ ≈
F28	3.14E+02 (3.57E+01)	3.00E+02 (2.27E-13)≈	3.21E+02 (4.28E+01)≈≈	3.14E+02 (3.67E+01)≈≈
F29	4.16E+02 (2.24E+01)	4.09E+02 (2.37E+01)≈	4.04E+02 (2.55E+01)+ ≈	3.93E+02 (3.54E+01)+ ≈
F30	2.16E+03 (1.42E+02)	2.08E+03 (7.30E+01)+	2.15E+03 (9.37E+01)≈ −	2.14E+03 (1.11E+02)≈ −

1.00E-02	5.00E-03	Individuals redistribution 1.00E-03	5.00E-04	1.00E-04
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
4.06E-11 (2.22E-10)−−	0.00E+00 (0.00E+00)++	5.48E-12 (3.00E-11)+−	1.89E-15 (1.04E-14)++	7.78E-11 (4.24E-10)−−
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
3.32E+00 (1.51E+00)≈ −	7.85E+00 (1.69E+01)≈ −	5.45E+00 (1.19E+01)≈ −	3.32E+00 (1.51E+00)≈ −	3.32E+00 (1.51E+00)≈ −
2.01E+01 (3.79E+00)+ ≈	2.23E+01 (4.96E+00)+ ≈	2.65E+01 (6.42E+00)≈ −	2.48E+01 (5.87E+00)≈ −	2.34E+01 (4.32E+00)+ ≈
6.06E-14 (5.77E-14)− ≈	6.82E-14 (5.66E-14)− ≈	7.58E-14 (5.45E-14)−−	6.82E-14 (5.66E-14)− ≈	6.44E-14 (5.73E-14)− ≈
5.03E+01 (5.47E+00)+ ≈	5.01E+01 (4.77E+00)+ ≈	5.04E+01 (3.93E+00)+ ≈	5.33E+01 (6.54E+00)≈≈	5.46E+01 (4.92E+00)≈ −
2.05E+01 (3.72E+00)+ ≈	2.13E+01 (4.98E+00)+ ≈	2.55E+01 (4.74E+00)+−	2.52E+01 (5.38E+00)+−	2.53E+01 (5.00E+00)+−
0.00E+00 (0.00E+00)+ ≈	0.00E+00 (0.00E+00)+ ≈	0.00E+00 (0.00E+00)+ ≈	3.03E-02 (1.15E-01)≈≈	1.51E-02 (8.29E-02)+ ≈
1.61E+03 (6.32E+02)≈≈	1.44E+03 (5.46E+02)≈≈	1.59E+03 (6.53E+02)≈≈	1.76E+03 (8.62E+02)≈≈	1.41E+03 (3.74E+02)≈≈
2.44E+01 (1.36E+01)≈ −	2.74E+01 (1.34E+01)≈ −	2.99E+01 (1.30E+01)≈ −	2.94E+01 (1.07E+01)≈ −	3.08E+01 (1.64E+01)≈ −
9.23E+02 (4.28E+02)≈ −	8.12E+02 (4.06E+02)≈≈	7.80E+02 (4.01E+02)≈≈	8.09E+02 (4.52E+02)≈≈	8.31E+02 (4.03E+02)≈≈
2.08E+01 (1.59E+01)+ ≈	1.96E+01 (1.03E+01)+ ≈	2.02E+01 (8.91E+00)+ ≈	1.97E+01 (8.80E+00)+ ≈	2.92E+01 (1.30E+01)+−
1.23E+01 (6.86E+00)+ ≈	1.44E+01 (7.48E+00)+ ≈	1.31E+01 (5.44E+00)+ ≈	1.14E+01 (6.45E+00)+ ≈	1.37E+01 (8.59E+00)+ ≈
1.72E+01 (1.26E+01)+ ≈	2.67E+01 (1.90E+01)+−	1.98E+01 (1.18E+01)+ ≈	2.95E+01 (1.67E+01)≈ −	2.38E+01 (1.44E+01)+−
2.22E+02 (1.11E+02)≈≈	1.87E+02 (1.26E+02)+ ≈	2.11E+02 (1.19E+02)+ ≈	2.00E+02 (1.05E+02)+ ≈	1.77E+02 (1.26E+02)+ ≈
1.03E+01 (6.29E+00)≈≈	9.78E+00 (5.38E+00)≈≈	1.05E+01 (4.94E+00)≈ −	9.11E+00 (4.45E+00)≈≈	1.01E+01 (4.12E+00)≈ −
2.90E+01 (2.08E+01)≈ −	2.67E+01 (1.68E+01)≈ −	2.95E+01 (1.66E+01)≈ −	3.07E+01 (1.91E+01)≈ −	3.66E+01 (2.03E+01)≈ −
1.44E+01 (1.05E+01)+−	1.11E+01 (8.86E+00)+ ≈	1.71E+01 (1.32E+01)+−	1.24E+01 (1.03E+01)+ ≈	1.77E+01 (1.13E+01)+−
1.10E+01 (3.08E+01)≈≈	6.36E+00 (2.16E+01)≈≈	6.30E+00 (2.21E+01)≈≈	4.05E+00 (9.51E+00)+ ≈	8.00E+00 (2.22E+01)≈≈
2.10E+02 (3.78E+01)+ ≈	2.27E+02 (7.39E+00)≈ −	2.26E+02 (5.63E+00)≈ −	2.07E+02 (4.29E+01)+ ≈	2.13E+02 (3.87E+01)≈ +
1.00E+02 (8.3E-14)≈≈	1.00E+02 (8.30E-14)≈≈	1.00E+02 (1.39E-13)≈≈	1.00E+02 (1.96E-13)≈≈	1.00E+02 (1.15E-13)≈≈
3.56E+02 (7.46E+00)++	3.64E+02 (7.95E+00)+ ≈	3.71E+02 (6.33E+00)+−	3.70E+02 (8.55E+00)+−	3.67E+02 (7.56E+00)+−
4.28E+02 (7.37E+00)+ ≈	4.43E+02 (7.60E+00)−−	4.39E+02 (6.17E+00)≈ −	4.38E+02 (6.56E+00)≈ −	4.38E+02 (7.10E+00)≈ −
3.87E+02 (1.68E+00)+−	3.87E+02 (8.64E-01)+−	3.87E+02 (6.19E-01)+−	3.87E+02 (6.17E-01)+−	3.87E+02 (6.32E-01)+−
8.54E+02 (2.84E+02)+−	8.42E+02 (4.69E+02)≈ −	8.59E+02 (4.73E+02)≈ −	9.19E+02 (4.18E+02)≈ −	8.15E+02 (4.77E+02)≈ −
5.01E+02 (7.52E+00)≈ −	5.00E+02 (6.51E+00)+−	4.95E+02 (7.63E+00)+−	4.95E+02 (8.15E+00)+−	4.96E+02 (8.47E+00)+−
3.24E+02 (4.51E+01)≈≈	3.21E+02 (4.35E+01)≈≈	3.12E+02 (3.75E+01)≈≈	3.14E+02 (3.67E+01)≈≈	3.14E+02 (3.57E+01)≈≈
4.08E+02 (2.12E+01)+ ≈	4.08E+02 (1.95E+01)+ ≈	4.10E+02 (2.45E+01)≈≈	4.07E+02 (2.56E+01)+ ≈	4.16E+02 (1.61E+01)≈≈
2.17E+03 (1.30E+02)≈ −	2.14E+03 (1.06E+02)≈ −	2.12E+03 (8.35E+01)≈ −	2.15E+03 (1.35E+02)≈ −	2.14E+03 (1.11E+02)≈ −

Table 5: The results of the three versions of SaDE/Mexp for the CEC 2017 benchmark test suite. The symbol behind the results based on complete restart shows the difference to the original results, while the two symbols behind the results with individuals redistribution show the difference to the original results and the results with complete restart, respectively. "+" and "−" denote significantly better and statistically worse than the peer in terms of Wilcoxon's rank sum test at a 0.05 significance level, respectively. Meanwhile, "≈" represents no significantly difference

Function	Original	Complete restart	Individuals redistribution 1.00E-01	5.00E-02
F1	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F2	1.14E-14 (1.42E-14)	0.0E+00 (0.0E+00)+	0.00E+00 (0.00E+00)+ ≈	0.00E+00 (0.00E+00)+ ≈
F3	2.84E-14 (2.89E-14)	1.33E-14 (2.45E-14)≈	1.71E-14 (2.65E-14)≈≈	1.33E-14 (2.45E-14)≈≈
F4	1.14E-14 (2.31E-14)	5.75E+00 (6.43E+00)−	2.14E+01 (2.81E+01)− ≈	3.99E-01 (1.22E+00)≈ +
F5	2.64E+01 (7.45E+00)	2.36E+01 (4.96E+00)≈	2.22E+01 (4.78E+00)+ ≈	2.26E+01 (4.94E+00)+ ≈
F6	4.56E-09 (2.5E-08)	1.14E-13 (0.00E+00)≈	1.14E-13 (0.00E+00)≈≈	1.14E-13 (0.00E+00)≈≈
F7	5.41E+01 (6.61E+00)	5.50E+01 (4.25E+00)≈	5.23E+01 (5.56E+00)≈ +	5.12E+01 (4.41E+00)≈ +
F8	2.84E+01 (7.85E+00)	2.58E+01 (5.46E+00)≈	2.10E+01 (5.04E+00)++	2.43E+01 (4.74E+00)≈≈
F9	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F10	1.60E+03 (3.06E+02)	1.32E+03 (2.76E+02)+	1.42E+03 (2.33E+02)+ ≈	1.34E+03 (3.63E+02)+ ≈
F11	1.51E+01 (6.77E+00)	1.09E+01 (3.46E+00)+	8.06E+00 (3.31E+00)++	8.16E+00 (3.03E+00)++
F12	9.85E+02 (3.77E+02)	5.04E+02 (1.85E+02)+	5.19E+02 (2.66E+02)+ ≈	4.67E+02 (2.18E+02)+ ≈
F13	2.26E+01 (4.51E+00)	1.00E+01 (3.86E+00)+	8.77E+00 (4.53E+00)+ ≈	1.27E+01 (7.77E+00)+ ≈
F14	2.67E+01 (2.91E+00)	4.70E+00 (1.66E+00)+	4.31E+00 (4.25E+00)++	1.08E+01 (7.69E+00)+−
F15	7.85E+00 (3.81E+00)	4.20E+00 (1.38E+00)+	3.74E+00 (1.18E+00)+ ≈	3.67E+00 (1.45E+00)+ ≈
F16	4.06E+02 (1.78E+02)	2.40E+02 (1.62E+02)+	1.96E+02 (1.34E+02)+ ≈	2.55E+02 (1.76E+02)+ ≈
F17	4.49E+01 (1.58E+01)	1.72E+01 (8.86E+00)+	1.50E+01 (9.17E+00)+ ≈	1.70E+01 (9.98E+00)+ ≈
F18	2.37E+01 (2.51E+00)	1.63E+01 (9.08E+00)+	1.63E+01 (9.38E+00)+ ≈	1.61E+01 (9.55E+00)+ ≈
F19	3.19E+00 (1.64E+00)	3.34E+00 (1.23E+00)≈	3.13E+00 (9.92E-01)≈≈	2.60E+00 (6.96E-01)≈ +
F20	5.37E+01 (4.79E+01)	6.17E+00 (6.17E+00)+	5.27E+00 (5.71E+00)+ ≈	2.25E+01 (3.95E+01)+ ≈
F21	2.26E+02 (7.73E+00)	2.23E+02 (5.14E+00)≈	1.99E+02 (5.08E+01)≈≈	2.12E+02 (3.81E+01)≈≈
F22	1.00E+02 (0.00E+00)	1.00E+02 (0.00E+00)≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈
F23	3.77E+02 (8.16E+00)	3.70E+02 (6.82E+00)+	3.72E+02 (6.32E+00)+ ≈	3.74E+02 (6.09E+00)≈ −
F24	4.50E+02 (8.62E+00)	4.39E+02 (4.08E+00)+	4.37E+02 (4.82E+00)+ ≈	4.40E+02 (5.16E+00)+ ≈
F25	3.78E+02 (4.46E-02)	3.77E+02 (1.56E+00)+	3.78E+02 (9.12E-03)+−	3.78E+02 (1.04E-02)+−
F26	1.33E+03 (2.06E+02)	2.80E+02 (4.07E+01)+	1.15E+03 (5.90E+01)+−	1.09E+03 (1.66E+02)+−
F27	5.00E+02 (2.58E-04)	4.65E+02 (3.15E+01)≈	4.86E+02 (9.65E+00)+ ≈	4.86E+02 (1.02E+01)+ ≈
F28	4.95E+02 (9.54E+00)	3.00E+02 (2.80E-13)+	3.00E+02 (2.31E-13)+ ≈	3.24E+02 (4.44E+01)+ ≈
F29	2.70E+02 (4.08E+01)	2.92E+02 (5.13E+01)≈	3.95E+02 (3.74E+01)−−	3.97E+02 (3.28E+01)−−
F30	2.06E+02 (1.36E+00)	3.04E+02 (1.04E+02)−	1.95E+03 (1.05E+01)−−	1.96E+03 (1.41E+01)−−

1.00E-02	5.00E-03	Individuals redistribution 1.00E-03	5.00E-04	1.00E-04
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
9.47E-16 (5.19E-15)+ ≈	0.00E+00 (0.00E+00)+ ≈	0.00E+00 (0.00E+00)+ ≈	0.00E+00 (0.00E+00)+ ≈	0.00E+00 (0.00E+00)+ ≈
1.14E-14 (2.31E-14)+ ≈	7.58E-15 (1.97E-14)+ ≈	1.14E-14 (2.31E-14)+ ≈	1.33E-14 (2.45E-14)≈≈	7.58E-15 (1.97E-14)+ ≈
4.89E+01 (2.22E+01)−−	5.36E+01 (1.78E+01)−−	4.76E+01 (2.43E+01)−−	5.20E+01 (2.05E+01)−−	5.04E+01 (2.27E+01)−−
2.24E+01 (6.39E+00)+ ≈	2.77E+01 (6.74E+00)≈ −	2.89E+01 (9.06E+00)≈ −	2.53E+01 (6.62E+00)≈≈	2.65E+01 (7.23E+00)≈≈
1.14E-13 (0.00E+00)≈≈	1.14E-13 (0.00E+00)≈≈	1.14E-13 (0.00E+00)≈≈	1.14E-13 (0.00E+00)≈≈	1.14E-13 (0.00E+00)≈≈
5.10E+01 (4.72E+00)≈ +	5.11E+01 (4.67E+00)≈ +	5.38E+01 (6.78E+00)≈≈	5.39E+01 (6.71E+00)≈≈	5.47E+01 (5.64E+00)≈≈
2.42E+01 (6.64E+00)+ ≈	2.52E+01 (7.22E+00)≈≈	3.00E+01 (7.78E+00)≈ −	2.85E+01 (7.71E+00)≈≈	2.82E+01 (6.76E+00)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
1.06E+03 (3.45E+02)++	1.28E+03 (3.40E+02)+ ≈	1.47E+03 (3.36E+02)≈ −	1.37E+03 (3.17E+02)+ ≈	1.35E+03 (3.07E+02)+ ≈
2.34E+01 (1.24E+01)−−	2.40E+01 (1.10E+01)−−	3.38E+01 (1.95E+01)−−	2.69E+01 (1.84E+01)−−	2.47E+01 (1.75E+01)−−
7.42E+02 (2.89E+02)+−	9.11E+02 (3.24E+02)≈ −	8.94E+02 (3.42E+02)≈ −	9.93E+02 (3.66E+02)≈ −	9.30E+02 (3.24E+02)≈ −
1.46E+01 (6.94E+00)+−	1.33E+01 (7.91E+00)+ ≈	1.66E+01 (6.52E+00)+−	1.52E+01 (8.03E+00)+−	1.99E+01 (8.48E+00)≈ −
7.95E+00 (7.26E+00)+−	5.49E+00 (2.20E+00)+ ≈	5.08E+00 (1.72E+00)+ ≈	5.11E+00 (2.12E+00)+ ≈	4.80E+00 (1.50E+00)+ ≈
3.52E+00 (1.52E+00)++	3.35E+00 (1.39E+00)++	4.53E+00 (2.20E+00)+ ≈	4.13E+00 (1.75E+00)+ ≈	6.66E+00 (3.14E+00)≈ −
2.29E+02 (1.41E+02)+ ≈	1.64E+02 (1.39E+02)+ ≈	1.72E+02 (1.31E+02)+ ≈	1.60E+02 (1.40E+02)++	2.02E+02 (1.43E+02)+ ≈
2.27E+01 (1.28E+01)+ ≈	2.43E+01 (1.35E+01)+−	2.55E+01 (1.38E+01)+−	2.89E+01 (1.29E+01)+−	2.18E+01 (1.20E+01)+ ≈
1.57E+01 (9.53E+00)+ ≈	1.64E+01 (8.96E+00)+ ≈	1.87E+01 (6.98E+00)+ ≈	1.90E+01 (7.07E+00)+ ≈	2.14E+01 (6.87E+00)+ ≈
2.78E+00 (9.19E-01)≈ +	2.45E+00 (1.56E+00)≈ +	2.31E+00 (1.02E+00)++	2.53E+00 (1.01E+00)≈ +	4.14E+00 (2.01E+00)≈≈
3.05E+01 (4.94E+01)+ ≈	3.88E+01 (5.57E+01)+−	1.56E+01 (2.31E+01)+−	3.42E+01 (4.25E+01)+−	2.96E+01 (4.11E+01)+−
2.27E+02 (8.69E+00)≈ −	2.28E+02 (8.72E+00)≈ −	2.24E+02 (2.47E+01)≈ −	2.28E+02 (9.04E+00)≈ −	1.68E+02 (6.49E+01)++
1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈
3.71E+02 (9.56E+00)+ ≈	3.77E+02 (1.17E+01)≈ −	3.77E+02 (9.49E+00)≈ −	3.78E+02 (7.46E+00)≈ −	3.80E+02 (8.88E+00)≈ −
4.41E+02 (8.29E+00)+ ≈	4.43E+02 (9.57E+00)+ ≈	4.44E+02 (8.25E+00)+−	4.45E+02 (1.23E+01)+ ≈	4.34E+02 (4.50E+01)+ ≈
3.78E+02 (8.25E-03)+ ≈	3.78E+02 (5.82E-01)+ ≈	3.78E+02 (1.18E-02)+−	3.78E+02 (3.35E-02)≈ −	3.78E+02 (3.51E-02)≈ −
1.15E+03 (1.05E+02)+−	1.2E+03 (2.01E+02)+−	1.22E+03 (9.96E+01)+−	1.20E+03 (1.30E+02)+−	1.19E+03 (1.00E+02)+−
4.98E+02 (9.18E+00)≈ −	5.01E+02 (7.33E+00)≈ −	5.01E+02 (5.94E+00)≈ −	5.03E+02 (7.62E+00)−−	5.00E+02 (8.44E+00)≈ −
3.51E+02 (5.52E+01)+−	3.36E+02 (5.22E+01)+−	3.26E+02 (4.78E+01)+ ≈	3.28E+02 (5.14E+01)+ ≈	3.25E+02 (4.65E+01)+ ≈
4.08E+02 (3.09E+01)−−	4.20E+02 (3.26E+01)−−	4.32E+02 (1.54E+01)−−	4.32E+02 (1.72E+01)−−	4.33E+02 (2.55E+01)−−
1.96E+03 (1.75E+01)−−	1.96E+03 (1.29E+01)−−	1.98E+03 (5.03E+01)−−	1.98E+03 (4.29E+01)−−	2.00E+03 (8.52E+01)−−

Table 6: The results of the three versions of MPEDE for the CEC 2017 benchmark test suite. The symbol behind the results based on complete restart shows the difference to the original results, while the two symbols behind the results with individuals redistribution show the difference to the original results and the results with complete restart, respectively. "+" and "−" denote significantly better and statistically worse than the peer in terms of Wilcoxon's rank sum test at a 0.05 significance level, respectively. Meanwhile, "≈" represents no significantly difference

Function	Original	Complete restart	Individuals redistribution	
			1.00E-01	5.00E-02
F1	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	1.89E-15 (4.91E-15)≈≈	1.89E-15 (4.91E-15)≈≈
F2	1.82E-13 (3.01E-13)	4.17E-14 (3.71E-14)+	2.84E-14 (1.83E-14)+ ≈	2.94E-14 (1.90E-14)+ ≈
F3	1.31E-13 (3.70E-13)	7.44E-12 (3.84E-11)≈	9.42E-13 (4.93E-12)≈≈	4.55E-14 (1.10E-13)≈ +
F4	4.79E+01 (2.41E+01)	1.33E-01 (7.28E-01)+	5.99E+00 (1.78E+01)+ ≈	9.47E-15 (2.15E-14)++
F5	2.17E+01 (5.46E+00)	1.46E+01 (3.29E+00)+	1.90E+01 (3.90E+00)≈ −	1.84E+01 (4.00E+00)+−
F6	1.10E-13 (2.08E-14)	1.14E-13 (0.00E+00)≈	1.14E-13 (0.00E+00)≈≈	1.14E-13 (0.00E+00)≈≈
F7	5.19E+01 (4.82E+00)	4.46E+01 (2.48E+00)+	4.87E+01 (4.51E+00)+−	4.89E+01 (4.02E+00)+−
F8	2.18E+01 (4.45E+00)	1.49E+01 (2.71E+00)+	1.89E+01 (3.66E+00)+−	1.97E+01 (4.05E+00)≈ −
F9	5.97E-03 (2.27E-02)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F10	1.22E+03 (3.65E+02)	7.87E+02 (2.17E+02)+	9.12E+02 (2.30E+02)+−	8.72E+02 (1.68E+02)+ ≈
F11	1.94E+01 (2.08E+01)	9.25E+00 (3.22E+00)+	9.28E+00 (3.50E+00)+ ≈	9.85E+00 (3.90E+00)≈≈
F12	1.12E+03 (3.91E+02)	6.08E+02 (1.97E+02)+	6.67E+02 (2.21E+02)+ ≈	6.35E+02 (2.37E+02)+ ≈
F13	4.13E+01 (1.63E+01)	1.62E+01 (5.47E+00)+	1.69E+01 (6.26E+00)+ ≈	1.89E+01 (7.12E+00)+ ≈
F14	2.51E+02 (7.30E+02)	1.64E+02 (4.25E+02)≈	1.25E+02 (2.64E+02)+ ≈	1.58E+02 (5.39E+02)≈≈
F15	9.89E+01 (2.43E+02)	1.15E+02 (3.37E+02)−	1.70E+02 (6.65E+02)−−	2.08E+02 (5.98E+02)− ≈
F16	2.32E+02 (1.58E+02)	1.43E+02 (9.88E+01)+	1.83E+02 (1.04E+02)≈≈	1.21E+02 (1.01E+02)+ ≈
F17	3.61E+01 (3.72E+01)	1.21E+01 (7.01E+00)+	1.50E+01 (7.36E+00)+ ≈	1.40E+01 (9.09E+00)+ ≈
F18	7.03E+03 (1.51E+04)	3.81E+03 (1.17E+04)+	2.47E+03 (6.61E+03)+ ≈	3.28E+03 (6.45E+03)+ ≈
F19	1.07E+03 (5.20E+03)	1.60E+02 (3.93E+02)+	9.86E+01 (2.97E+02)+ ≈	1.63E+02 (4.13E+02)+ ≈
F20	5.32E+01 (6.36E+01)	3.07E+00 (2.17E+00)+	9.12E+00 (2.32E+01)+ ≈	5.75E+01 (5.94E+01)≈ −
F21	2.23E+02 (3.96E+00)	2.17E+02 (2.98E+00)+	1.00E+02 (6.50E-07)++	1.00E+02 (6.25E-07)++
F22	1.00E+02 (8.30E-14)	1.00E+02 (0.00E+00)≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈
F23	3.71E+02 (7.64E+00)	3.61E+02 (3.71E+00)+	3.38E+02 (8.09E+01)++	1.00E+02 (5.57E-07)++
F24	4.40E+02 (6.05E+00)	4.31E+02 (3.29E+00)+	2.24E+02 (7.41E+01)++	2.00E+02 (8.30E-07)++
F25	3.87E+02 (1.61E-01)	3.86E+02 (1.01E+00)+	3.86E+02 (1.41E+00)+ ≈	3.87E+02 (6.06E-01)+ ≈
F26	1.13E+03 (8.81E+01)	9.77E+02 (1.90E+02)+	5.00E+02 (3.55E+02)++	3.00E+02 (1.56E-06)++
F27	5.04E+02 (7.86E+00)	4.87E+02 (4.59E+00)+	4.77E+02 (1.20E+01)++	4.72E+02 (1.31E+01)++
F28	3.52E+02 (6.17E+01)	3.00E+02 (2.83E-13)+	3.00E+02 (2.31E-13)+ ≈	3.03E+02 (1.89E+01)+ ≈
F29	4.17E+02 (3.23E+01)	3.87E+02 (3.52E+01)+	3.42E+02 (1.66E+01)++	3.48E+02 (2.27E+01)++
F30	2.16E+03 (1.61E+02)	1.96E+03 (3.47E+01)+	1.99E+03 (1.87E+02)+ ≈	2.06E+03 (5.63E+02)+ ≈

		Individuals redistribution		
1.00E-02	5.00E-03	1.00E-03	5.00E-04	1.00E-04
2.37E-15 (5.39E-15)≈≈	2.37E-15 (5.39E-15)≈≈	1.42E-15 (4.34E-15)≈≈	1.42E-15 (4.34E-15)≈≈	1.89E-15 (4.91E-15)≈≈
2.94E-14 (1.75E-14)+ ≈	3.85E-08 (2.11E-07)− ≈	1.14E-14 (1.60E-14)++	1.14E-14 (1.60E-14)++	2.84E-15 (8.67E-15)++
1.55E-13 (5.91E-13)≈ +	1.38E-13 (5.41E-13)≈≈	9.47E-14 (2.93E-13)≈≈	5.31E-14 (1.45E-13)≈ +	3.83E-13 (1.21E-12)≈≈
3.40E+01 (2.92E+01)≈ −	4.87E+01 (2.39E+01)≈ −	4.38E+01 (2.63E+01)≈ −	3.63E+01 (2.94E+01)≈ −	4.04E+01 (2.86E+01)≈ −
1.97E+01 (3.24E+00)≈ −	1.76E+01 (3.69E+00)+−	1.75E+01 (3.53E+00)+−	1.72E+01 (3.05E+00)+−	1.73E+01 (4.03E+00)+−
1.14E-13 (0.00E+00)≈≈	1.14E-13 (0.00E+00)≈≈	1.14E-13 (0.00E+00)≈≈	1.14E-13 (0.00E+00)≈≈	1.14E-13 (0.00E+00)≈≈
4.91E+01 (3.24E+00)+−	4.97E+01 (3.06E+00)≈ −	4.74E+01 (5.28E+00)+−	4.81E+01 (4.32E+00)+−	4.75E+01 (3.77E+00)+−
1.91E+01 (2.98E+00)+−	1.56E+01 (3.66E+00)+ ≈	1.76E+01 (4.95E+00)+−	1.73E+01 (3.96E+00)+−	1.64E+01 (3.70E+00)+ ≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	5.97E-03 (2.27E-02)≈≈
6.45E+02 (3.00E+02)++	6.06E+02 (2.33E+02)++	6.63E+02 (1.99E+02)++	6.38E+02 (2.23E+02)++	6.30E+02 (2.41E+02)++
1.22E+01 (1.28E+01)+ ≈	1.49E+01 (1.40E+01)≈≈	1.22E+01 (1.40E+01)≈≈	1.48E+01 (1.84E+01)≈≈	1.27E+01 (9.44E+00)≈≈
6.94E+02 (2.10E+02)+ ≈	7.49E+02 (3.00E+02)+−	1.02E+03 (3.74E+02)≈ −	1.16E+03 (4.47E+02)≈ −	1.12E+03 (3.36E+02)≈ −
1.05E+02 (4.01E+02)≈ −	2.59E+01 (1.14E+01)+−	3.16E+02 (1.60E+03)−−	5.74E+01 (1.55E+02)−−	5.39E+01 (9.69E+01)≈ −
2.15E+02 (9.13E+02)+ ≈	8.46E+01 (1.66E+02)+ ≈	8.47E+01 (1.74E+02)+ ≈	1.35E+02 (3.26E+02)+ ≈	4.66E+01 (7.97E+01)+ ≈
7.38E+01 (3.38E+02)+ ≈	8.87E+01 (2.67E+02)+ ≈	2.94E+02 (8.28E+02)− ≈	1.09E+02 (2.16E+02)− ≈	1.98E+02 (3.95E+02)≈ −
1.64E+02 (1.29E+02)≈≈	1.72E+02 (1.26E+02)≈≈	1.95E+02 (1.47E+02)≈≈	2.19E+02 (1.17E+02)≈ −	2.10E+02 (1.58E+02)≈≈
1.59E+01 (1.03E+01)+ ≈	1.51E+01 (9.25E+00)+ ≈	1.29E+01 (1.01E+01)+ ≈	2.16E+01 (3.32E+01)+ ≈	1.73E+01 (9.97E+00)+−
7.12E+02 (3.05E+03)++	4.86E+03 (1.25E+04)+ ≈	6.63E+02 (2.24E+03)+ ≈	2.35E+03 (8.32E+03)+ ≈	9.61E+02 (3.32E+03)+ ≈
2.06E+01 (7.21E+01)+ ≈	2.25E+02 (8.78E+02)+ ≈	8.78E+01 (3.89E+02)+ ≈	1.32E+02 (4.96E+02)+ ≈	5.72E+01 (1.58E+02)≈ +
4.85E+01 (6.00E+01)≈ −	6.91E+01 (6.27E+01)≈ −	4.62E+01 (5.73E+01)≈ −	5.97E+01 (7.57E+01)≈ −	6.85E+01 (7.04E+01)≈ −
1.00E+02 (5.50E-07)++	1.00E+02 (6.10E-07)++	1.00E+02 (5.92E-07)++	1.00E+02 (5.51E-07)++	1.00E+02 (4.91E-07)++
1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (8.30E-14)≈≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈
1.00E+02 (8.41E-07)++	1.00E+02 (7.67E-07)++	1.00E+02 (1.23E-06)++	1.34E+02 (8.94E+01)++	1.89E+02 (1.24E+02)++
2.00E+02 (9.44E-07)++	1.93E+02 (2.54E+01)++	1.97E+02 (1.83E+01)++	1.97E+02 (1.83E+01)++	2.08E+02 (4.40E+01)++
3.87E+02 (1.34E-02)+ ≈	3.87E+02 (9.98E-03)+−	3.87E+02 (6.07E-01)+−	3.87E+02 (8.51E-02)+−	3.87E+02 (1.44E-01)≈ −
3.00E+02 (1.25E-06)++	3.00E+02 (1.41E-06)++	3.00E+02 (1.60E-06)++	3.00E+02 (1.35E-06)++	3.00E+02 (1.11E-06)++
4.91E+02 (1.41E+01)+−	4.94E+02 (1.20E+01)+ ≈	4.92E+02 (1.69E+01)+−	4.97E+02 (1.39E+01)+−	4.91E+02 (1.89E+01)+−
3.45E+02 (5.65E+01)≈ −	3.51E+02 (5.58E+01)≈ −	3.30E+02 (5.12E+01)≈≈	3.27E+02 (4.96E+01)≈≈	3.42E+02 (5.64E+01)≈ −
3.47E+02 (2.51E+01)++	3.47E+02 (2.36E+01)++	3.57E+02 (2.73E+01)++	3.53E+02 (2.45E+01)++	3.55E+02 (2.89E+01)++
1.95E+03 (2.11E+01)+ ≈	1.99E+03 (1.62E+02)+ ≈	1.96E+03 (2.19E+01)+ ≈	2.16E+03 (6.52E+02)+−	2.07E+03 (2.77E+02)+−

Table 7: The results of the three versions of ETI-JADE for the CEC 2017 benchmark test suite. The symbol behind the results based on complete restart shows the difference to the original results, while the two symbols behind the results with individuals redistribution show the difference to the original results and the results with complete restart, respectively. "+" and "−" denote significantly better and statistically worse than the peer in terms of Wilcoxon's rank sum test at a 0.05 significance level, respectively. Meanwhile, "≈" represents no significantly difference

Function	Original	Complete restart	Individuals redistribution 1.00E-01	Individuals redistribution 5.00E-02
F1	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F2	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F3	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F4	5.86E+01 (0.00E+00)	1.30E+01 (2.31E+01)+	5.86E+01 (3.61E-14)≈ −	5.86E+01 (0.00E+00)≈ −
F5	7.86E+00 (1.06E+00)	7.26E+00 (1.82E+00)≈	2.68E+00 (1.33E+00)++	6.05E+00 (1.60E+00)++
F6	1.14E-13 (0.00E+00)	1.4E-13 (7.72E-14)≈	3.15E-11 (7.45E-12)−−	2.25E-11 (4.75E-12)−−
F7	3.87E+01 (1.40E+00)	3.87E+01 (2.18E+00)≈	3.53E+01 (7.89E-01)++	3.51E+01 (7.52E-01)++
F8	7.56E+00 (1.21E+00)	7.66E+00 (1.92E+00)≈	3.03E+00 (1.49E+00)++	7.87E+00 (2.23E+00)≈≈
F9	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F10	1.03E+03 (1.78E+02)	1.02E+03 (1.78E+02)≈	1.85E+03 (2.78E+02)−−	1.61E+03 (4.84E+02)−−
F11	2.30E+01 (2.70E+01)	8.38E+00 (1.04E+01)≈	5.38E+00 (1.49E+01)++	3.29E+00 (1.08E+01)++
F12	1.17E+02 (8.27E+01)	8.69E+01 (9.33E+01)≈	5.86E+01 (5.66E+01)+ ≈	4.70E+01 (7.27E+01)++
F13	1.97E+01 (1.28E+00)	1.93E+01 (3.02E+00)≈	6.18E+00 (5.8E+00)++	1.14E+01 (5.76E+00)++
F14	1.51E+01 (7.78E+00)	1.64E+01 (6.03E+00)≈	1.57E+01 (8.52E+00)− ≈	2.07E+01 (6.98E+00)−−
F15	3.97E+00 (3.44E-01)	4.66E+00 (1.93E+00)−	5.34E-01 (3.8E-01)++	4.61E-01 (2.97E-01)++
F16	1.43E+01 (2.44E+00)	1.69E+01 (4.86E+00)−	1.42E+01 (4.85E+00)≈ +	3.75E+01 (2.63E+01)−−
F17	2.10E+01 (6.90E+00)	2.22E+01 (6.13E+00)≈	2.10E+01 (9.83E+00)≈≈	4.78E+01 (1.26E+01)−−
F18	1.98E+01 (3.65E+00)	1.97E+01 (3.36E+00)+	1.81E+01 (6.58E+00)++	1.93E+01 (5.02E+00)+ ≈
F19	4.07E+00 (5.74E-01)	3.89E+00 (1.18E+00)≈	2.30E+00 (5.93E-01)++	4.30E+00 (1.59E+00)≈≈
F20	1.71E+01 (7.44E+00)	2.03E+01 (6.02E+00)≈	4.25E+00 (6.79E+00)++	4.82E+01 (2.35E+01)−−
F21	2.09E+02 (1.40E+00)	2.10E+02 (1.77E+00)≈	2.04E+02 (1.38E+00)++	2.08E+02 (1.62E+00)++
F22	1.00E+02 (0.00E+00)	1.00E+02 (0.00E+00)≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈
F23	3.51E+02 (1.77E+00)	3.52E+02 (2.71E+00)≈	3.49E+02 (3.44E+00)++	3.50E+02 (2.25E+00)≈ +
F24	4.26E+02 (1.58E+00)	4.27E+02 (1.58E+00)−	4.25E+02 (1.00E+00)≈ +	4.25E+02 (1.18E+00)≈ +
F25	3.87E+02 (3.33E-03)	3.84E+02 (1.32E+00)+	3.87E+02 (1.67E-03)+−	3.87E+02 (1.75E-03)+−
F26	9.33E+02 (3.85E+01)	8.16E+02 (2.55E+02)≈	9.21E+02 (2.61E+01)≈≈	8.80E+02 (2.94E+01)+−
F27	5.00E+02 (8.19E+00)	4.92E+02 (3.57E+00)+	4.91E+02 (6.27E+00)+ ≈	4.96E+02 (7.50E+00)≈≈
F28	3.08E+02 (2.89E+01)	3.00E+02 (2.31E-13)≈	3.00E+02 (4.08E-10)≈≈	3.00E+02 (4.53E-10)≈≈
F29	4.14E+02 (1.74E+01)	4.17E+02 (1.36E+01)≈	4.14E+02 (4.59E+00)−+	4.93E+02 (2.95E+01)−−
F30	1.97E+03 (3.61E+01)	1.95E+03 (1.04E+01)≈	1.94E+03 (3.78E-01)++	1.94E+03 (6.07E+00)++

Individuals redistribution 1.00E-02	Individuals redistribution 5.00E-03	Individuals redistribution 1.00E-03	Individuals redistribution 5.00E-04	Individuals redistribution 1.00E-04
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
5.86E+01 (0.00E+00)≈ −	5.86E+01 (0.00E+00)≈ −	5.86E+01 (0.00E+00)≈ −	5.86E+01 (0.00E+00)≈ −	5.86E+01 (0.00E+00)≈ −
1.26E+01 (2.98E+00)−−	1.14E+01 (2.61E+00)−−	1.19E+01 (3.34E+00)−−	1.14E+01 (3.03E+00)−−	1.20E+01 (2.87E+00)−−
1.49E-11 (2.90E-12)−−	1.44E-11 (3.63E-12)−−	9.35E-12 (2.28E-12)−−	9.85E-12 (2.45E-12)−−	6.48E-12 (2.65E-12)−−
4.54E+01 (3.77E+00)−−	4.40E+01 (3.30E+00)−−	4.41E+01 (3.68E+00)−−	4.35E+01 (3.36E+00)−−	4.28E+01 (3.22E+00)−−
1.33E+01 (3.92E+00)−−	1.11E+01 (2.79E+00)−−	1.19E+01 (3.77E+00)−−	1.09E+01 (3.26E+00)−−	1.15E+01 (2.87E+00)−−
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
1.16E+03 (5.44E+02)≈≈	1.42E+03 (5.05E+02)−−	1.71E+03 (3.31E+02)−−	1.68E+03 (5.02E+02)−−	1.61E+03 (4.89E+02)−−
2.09E+01 (2.41E+01)≈≈	1.80E+01 (2.30E+01)≈≈	2.14E+01 (2.65E+01)≈≈	3.10E+01 (2.94E+01)≈≈	2.20E+01 (2.67E+01)≈≈
1.17E+02 (7.90E+01)≈≈	1.27E+02 (8.12E+01)≈ −	1.12E+02 (7.75E+01)≈≈	1.73E+02 (9.82E+01)−−	1.32E+02 (9.92E+01)≈≈
1.54E+01 (1.08E+00)++	2.30E+01 (2.84E+00)−−	1.82E+01 (3.82E+00)≈≈	1.69E+01 (2.94E+00)++	1.53E+01 (1.31E+00)++
2.15E+01 (1.16E+00)−−	1.64E+01 (8.86E+00)≈≈	1.91E+01 (5.96E+00)≈≈	2.07E+01 (4.07E+00)−−	2.13E+01 (1.00E+00)−−
5.27E+00 (2.21E+00)− ≈	4.79E+00 (2.53E+00)− ≈	2.65E+00 (2.60E+00)≈ +	1.72E+00 (2.21E+00)++	1.94E+00 (2.38E+00)++
2.54E+01 (2.44E+01)− ≈	2.05E+01 (9.29E+00)− ≈	2.05E+01 (8.31E+00)−−	2.02E+01 (6.85E+00)− ≈	2.05E+01 (7.00E+00)−−
2.41E+01 (1.80E+01)≈≈	3.13E+01 (1.42E+01)−−	3.17E+01 (1.37E+01)−−	3.56E+01 (1.37E+01)−−	3.53E+01 (8.11E+00)−−
2.09E+01 (1.98E-01)−−	2.08E+01 (1.83E-01)−−	2.05E+01 (3.36E-02)−−	2.05E+01 (3.79E-02)−−	2.05E+01 (3.86E-02)−−
5.87E+00 (3.25E+00)≈≈	5.23E+00 (2.42E+00)≈≈	4.84E+00 (2.22E+00)≈≈	4.59E+00 (2.12E+00)≈≈	5.07E+00 (2.28E+00)−−
2.57E+01 (1.46E+01)− ≈	2.70E+01 (1.28E+01)− ≈	2.74E+01 (1.32E+01)−−	3.26E+01 (1.45E+01)−−	3.54E+01 (1.05E+01)−−
1.07E+02 (2.74E+01)++	1.37E+02 (5.32E+01)++	2.02E+02 (3.45E+01)++	2.04E+02 (2.85E+01)++	2.01E+02 (3.44E+01)++
1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈
3.42E+02 (6.12E+01)++	3.36E+02 (7.05E+01)++	3.60E+02 (5.30E+00)−−	3.60E+02 (5.74E+00)−−	3.59E+02 (5.66E+00)−−
1.95E+02 (2.41E+01)++	2.98E+02 (1.22E+02)≈≈	3.54E+02 (1.11E+02)≈≈	3.85E+02 (9.32E+01)++	3.77E+02 (9.89E+01)++
3.87E+02 (1.32E-03)+−	3.87E+02 (1.76E-03)+−	3.87E+02 (1.42E-03)+−	3.87E+02 (3.84E-03)+−	3.87E+02 (6.14E-03)≈ −
2.97E+02 (1.49E+01)++	2.99E+02 (4.64E+00)++	4.93E+02 (3.26E+02)+ ≈	5.46E+02 (3.55E+02)+ ≈	4.96E+02 (3.32E+02)+ ≈
4.98E+02 (7.50E+00)≈ −	4.99E+02 (6.68E+00)≈ −	5.00E+02 (6.74E+00)≈ −	5.03E+02 (5.38E+00)≈ −	5.02E+02 (5.93E+00)≈ −
3.11E+02 (3.37E+01)≈≈	3.07E+02 (2.76E+01)≈≈	3.11E+02 (3.26E+01)≈≈	3.07E+02 (2.76E+01)≈≈	3.08E+02 (2.89E+01)≈≈
4.35E+02 (3.84E+01)≈≈	4.23E+02 (2.40E+01)≈≈	4.37E+02 (1.96E+01)−−	4.41E+02 (1.56E+01)−−	4.39E+02 (1.95E+01)−−
1.95E+03 (1.09E+01)≈ +	1.95E+03 (2.77E+01)≈ −	1.96E+03 (2.74E+01)≈≈	1.96E+03 (2.73E+01)≈≈	1.96E+03 (2.70E+01)≈≈

Table 8: The results of the three versions of L-SHADE-RSP for the CEC 2017 benchmark test suite. The symbol behind the results based on complete restart shows the difference to the original results, while the two symbols behind the results with individuals redistribution show the difference to the original results and the results with complete restart, respectively. ”+” and ”−” denote significantly better and statistically worse than the peer in terms of Wilcoxon’s rank sum test at a 0.05 significance level, respectively. Meanwhile, ”≈” represents no significantly difference

Function	Original	Complete restart	Individuals redistribution	
			1.00E-01	5.00E-02
F1	9.47E-16 (3.61E-15)	0.00E+00 (0.00E+00)≈	9.47E-16 (3.61E-15)≈≈	4.74E-16 (2.59E-15)≈≈
F2	1.02E-10 (2.84E-10)	8.53E-15 (1.52E-14)+	1.65E-13 (7.09E-13)+ ≈	1.20E-13 (5.63E-13)+ ≈
F3	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F4	1.86E+00 (2.02E+00)	7.97E-01 (1.62E+00)+	1.20E+00 (1.86E+00)≈ −	1.06E+00 (1.79E+00)≈ −
F5	2.61E+01 (6.06E+00)	1.61E+01 (2.63E+00)+	1.63E+01 (3.38E+00)+ ≈	1.58E+01 (3.53E+00)+ ≈
F6	3.03E-14 (5.11E-14)	9.85E-14 (3.93E-14)−	7.96E-14 (5.3E-14)− ≈	8.34E-14 (5.11E-14)− ≈
F7	6.01E+01 (8.83E+00)	4.75E+01 (2.83E+00)+	4.56E+01 (2.91E+00)++	4.63E+01 (2.21E+00)+ ≈
F8	2.89E+01 (6.83E+00)	1.72E+01 (2.68E+00)+	1.60E+01 (3.04E+00)+ ≈	1.59E+01 (2.83E+00)+ ≈
F9	1.54E-01 (2.59E-01)	2.98E-03 (1.63E-02)+	3.63E-02 (1.16E-01)+ ≈	7.23E-02 (2.04E-01)≈≈
F10	1.79E+03 (3.39E+02)	1.31E+03 (2.25E+02)+	1.16E+03 (2.16E+02)++	1.02E+03 (2.78E+02)++
F11	1.51E+01 (8.76E+00)	8.04E+00 (3.88E+00)+	1.32E+01 (5.30E+00)≈ −	1.53E+01 (8.35E+00)≈ −
F12	1.09E+03 (3.73E+02)	5.21E+02 (2.32E+02)+	1.22E+03 (3.76E+02)≈ −	9.99E+02 (4.8E+02)≈ −
F13	2.61E+01 (9.48E+00)	1.34E+01 (6.87E+00)+	2.45E+01 (9.98E+00)≈ −	2.69E+01 (9.85E+00)≈ −
F14	1.07E+01 (7.59E+00)	5.87E+00 (2.36E+00)+	5.91E+00 (3.61E+00)+ ≈	8.41E+00 (4.97E+00)≈ −
F15	8.46E+00 (6.43E+00)	3.89E+00 (1.22E+00)+	4.02E+00 (1.93E+00)+ ≈	3.76E+00 (1.55E+00)+ ≈
F16	3.47E+02 (1.59E+02)	1.86E+02 (1.35E+02)+	2.33E+02 (1.54E+02)+ ≈	2.11E+02 (1.51E+02)+ ≈
F17	2.58E+01 (2.36E+01)	1.08E+01 (5.34E+00)+	8.22E+00 (5.84E+00)++	7.16E+00 (3.35E+00)++
F18	1.72E+01 (9.17E+00)	1.63E+01 (9.79E+00)≈	1.04E+01 (9.80E+00)++	1.2E+01 (1.03E+01)++
F19	5.71E+00 (4.05E+00)	3.77E+00 (1.44E+00)+	4.03E+00 (1.74E+00)≈≈	3.56E+00 (1.57E+00)+ ≈
F20	4.87E+01 (5.69E+01)	2.17E+00 (1.15E+00)+	9.34E-01 (6.32E-01)++	1.31E+01 (3.10E+01)+ ≈
F21	2.3E+02 (6.11E+00)	2.17E+02 (3.15E+00)+	2.19E+02 (3.23E+00)+−	2.18E+02 (2.92E+00)+ ≈
F22	1.00E+02 (0.00E+00)	1.00E+02 (1.15E-13)≈	1.00E+02 (2.27E-13)≈≈	1.00E+02 (2.29E-13)≈≈
F23	3.76E+02 (7.11E+00)	3.6E+02 (4.12E+00)+	3.63E+02 (4.53E+00)+−	3.59E+02 (4.82E+00)+ ≈
F24	4.49E+02 (7.85E+00)	4.33E+02 (3.17E+00)+	4.38E+02 (3.34E+00)+−	4.37E+02 (4.32E+00)+−
F25	3.78E+02 (6.57E-01)	3.78E+02 (1.11E+00)+	3.78E+02 (8.17E-01)+−	3.78E+02 (9.70E-01)+−
F26	1.25E+03 (1.05E+02)	9.25E+02 (6.04E+01)+	9.65E+02 (1.48E+02)+−	9.75E+02 (7.50E+01)+−
F27	4.97E+02 (1.21E+01)	5.00E+02 (1.25E-04)−	4.97E+02 (1.27E+01)++	4.91E+02 (2.31E+01)+ ≈
F28	3.58E+02 (7.13E+01)	4.30E+02 (6.94E+01)−	3.50E+02 (6.60E+01)≈ +	3.49E+02 (6.96E+01)≈ +
F29	3.45E+02 (5.60E+01)	2.89E+02 (3.49E+01)+	2.95E+02 (4.51E+01)+ ≈	2.87E+02 (5.21E+01)+ ≈
F30	3.21E+02 (3.45E+02)	2.07E+02 (1.39E+00)+	2.10E+02 (3.72E+00)+−	2.09E+02 (2.93E+00)+−

		Individuals redistribution		
1.00E-02	5.00E-03	1.00E-03	5.00E-04	1.00E-04
1.89E-15 (1.04E-14)≈≈	1.89E-15 (6.17E-15)≈≈	2.84E-15 (6.88E-15)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
6.16E-14 (1.23E-13)+−	2.99E-13 (1.55E-12)+ ≈	1.80E-14 (2.17E-14)+ ≈	6.02E-12 (3.29E-11)+ ≈	1.14E-14 (2.65E-14)+ ≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
1.20E+00 (1.86E+00)≈ −	1.86E+00 (2.02E+00)≈ −	9.30E-01 (1.71E+00)≈ −	1.59E+00 (1.99E+00)≈ −	1.06E+00 (1.79E+00)≈ −
1.36E+01 (4.04E+00)++	2.31E+01 (6.58E+00)≈ −	2.86E+01 (7.44E+00)≈ −	2.86E+01 (6.94E+00)≈ −	2.72E+01 (7.14E+00)≈ −
8.34E-14 (5.11E-14)− ≈	8.34E-14 (5.11E-14)− ≈	8.34E-14 (5.11E-14)− ≈	8.34E-14 (5.11E-14)− ≈	6.82E-14 (5.66E-14)− ≈
4.52E+01 (2.49E+00)++	4.46E+01 (3.13E+00)++	5.34E+01 (6.29E+00)+−	5.62E+01 (6.47E+00)+−	5.51E+01 (6.27E+00)+−
1.23E+01 (3.11E+00)++	2.30E+01 (5.42E+00)+−	2.70E+01 (6.65E+00)≈ −	2.66E+01 (7.13E+00)≈ −	2.66E+01 (5.76E+00)≈ −
2.09E-02 (3.85E-02)≈≈	8.95E-03 (2.73E-02)+ ≈	1.12E-01 (3.56E-01)≈≈	7.55E-02 (2.02E-01)≈≈	1.42E-01 (2.17E-01)≈ −
7.33E+02 (3.00E+02)++	9.21E+02 (2.94E+02)++	1.33E+03 (4.30E+02)+ ≈	1.36E+03 (4.18E+02)+ ≈	1.23E+03 (3.26E+02)+ ≈
1.39E+01 (6.48E+00)≈ −	1.44E+01 (1.34E+01)≈ −	1.55E+01 (9.85E+00)≈ −	1.71E+01 (9.82E+00)≈ −	1.30E+01 (4.77E+00)≈ −
1.15E+03 (2.98E+02)≈ −	9.69E+02 (3.43E+02)≈ −	1.11E+03 (4.38E+02)≈ −	1.07E+03 (3.4E+02)≈ −	1.01E+03 (4.57E+02)≈ −
2.51E+01 (9.51E+00)≈ −	2.60E+01 (9.06E+00)≈ −	2.50E+01 (1.10E+01)≈ −	2.30E+01 (1.02E+01)≈ −	2.49E+01 (1.50E+01)≈ −
7.23E+00 (4.70E+00)+ ≈	7.46E+00 (4.16E+00)≈≈	6.88E+00 (4.21E+00)+ ≈	6.71E+00 (2.68E+00)+ ≈	7.14E+00 (4.54E+00)+ ≈
8.78E+00 (2.66E+01)− ≈	3.19E+00 (1.17E+00)++	3.90E+00 (2.09E+00)+ ≈	4.95E+00 (2.80E+00)+ ≈	5.60E+00 (4.29E+00)+ ≈
1.62E+02 (1.08E+02)+ ≈	1.92E+02 (1.44E+02)+ ≈	1.84E+02 (1.18E+02)+ ≈	1.86E+02 (1.12E+02)+ ≈	1.64E+02 (1.16E+02)+ ≈
1.24E+01 (7.55E+00)+ ≈	2.01E+01 (2.26E+01)≈ −	1.41E+01 (8.33E+00)+ ≈	1.94E+01 (8.67E+00)≈ −	1.64E+01 (1.03E+01)+ ≈
1.09E+01 (1.04E+01)++	1.32E+01 (1.01E+01)+ ≈	1.29E+01 (9.85E+00)+ ≈	2.08E+01 (1.28E+01)≈≈	1.57E+01 (1.34E+01)≈≈
4.67E+00 (2.96E+00)≈≈	4.22E+00 (1.89E+00)≈≈	5.48E+00 (3.88E+00)≈ −	5.54E+00 (5.24E+00)≈≈	5.97E+00 (5.52E+00)≈≈
1.77E+01 (4.12E+01)+ ≈	9.71E+00 (2.99E+01)+ ≈	1.43E+01 (3.65E+01)+ ≈	2.58E+01 (4.80E+01)+ ≈	1.09E+01 (2.97E+01)+ ≈
2.27E+02 (5.35E+00)+−	2.31E+02 (7.75E+00)≈ −	2.30E+02 (6.77E+00)≈ −	2.31E+02 (7.00E+00)≈ −	2.28E+02 (6.78E+00)≈ −
1.00E+02 (2.31E-13)≈≈	1.00E+02 (2.29E-13)≈≈	1.00E+02 (2.31E-13)≈≈	1.00E+02 (2.12E-13)≈≈	1.00E+02 (2.31E-13)≈≈
3.63E+02 (5.96E+00)+ ≈	3.72E+02 (8.72E+00)≈ −	3.78E+02 (7.99E+00)≈ −	3.76E+02 (6.75E+00)≈ −	3.73E+02 (8.72E+00)≈ −
4.42E+02 (7.10E+00)+−	4.49E+02 (7.69E+00)≈ −	4.48E+02 (8.22E+00)≈ −	4.48E+02 (7.55E+00)≈ −	4.49E+02 (5.82E+00)≈ −
3.78E+02 (4.64E-02)+−	3.78E+02 (8.05E-01)+−	3.79E+02 (4.67E+00)−−	3.78E+02 (8.53E-01)+−	3.78E+02 (1.17E+00)+−
1.07E+03 (8.45E+01)+−	1.26E+03 (1.14E+02)≈ −	1.27E+03 (1.19E+02)≈ −	1.26E+03 (7.86E+01)≈ −	1.22E+03 (2.04E+02)≈ −
4.99E+02 (5.96E+00)−+	4.98E+02 (1.15E+01)− ≈	5.00E+02 (9.40E-05)− ≈	4.96E+02 (1.71E+01)++	4.90E+02 (2.23E+01)++
3.67E+02 (7.19E+01)≈ +	3.50E+02 (7.57E+01)≈ +	3.67E+02 (7.81E+01)≈ +	3.27E+02 (5.78E+01)≈ +	3.68E+02 (7.70E+01)≈ +
2.86E+02 (4.11E+01)+ ≈	3.08E+02 (5.44E+01)+ ≈	2.92E+02 (4.83E+01)+ ≈	3.02E+02 (5.11E+01)+ ≈	2.79E+02 (4.65E+01)++
2.11E+02 (6.72E+00)+−	2.09E+02 (2.63E+00)+−	2.09E+02 (1.92E+00)+−	2.09E+02 (3.20E+00)+−	2.10E+02 (7.05E+00)+−

Table 9: The results of the three versions of EDEV for the CEC 2017 benchmark test suite. The symbol behind the results based on complete restart shows the difference to the original results, while the two symbols behind the results with individuals redistribution show the difference to the original results and the results with complete restart, respectively. "+" and "−" denote significantly better and statistically worse than the peer in terms of Wilcoxon's rank sum test at a 0.05 significance level, respectively. Meanwhile, "≈" represents no significantly difference

Function	Original	Complete restart	Individuals redistribution	
			1.00E-01	5.00E-02
F1	9.47E-16 (3.6E-15)	3.79E-15 (6.39E-15)≈	1.42E-14 (5.28E-15)−−	1.28E-14 (5.72E-15)−−
F2	7.77E-14 (7.72E-14)	6.88E-12 (6.07E-12)−	3.17E-11 (5.32E-11)−−	2.23E-11 (2.95E-11)−−
F3	3.79E-14 (2.73E-14)	1.34E-13 (6.59E-14)−	6.25E-14 (1.39E-13)≈ +	2.84E-14 (2.89E-14)≈ +
F4	3.65E+01 (2.98E+01)	1.33E-01 (7.28E-01)+	3.50E+01 (3.04E+01)≈ −	3.32E+01 (3.01E+01)≈ −
F5	2.14E+01 (4.01E+00)	1.86E+01 (4.00E+00)+	2.85E+01 (8.11E+00)−−	2.38E+01 (6.24E+00)≈ −
F6	1.14E-13 (0.00E+00)	7.62E-06 (1.84E-06)−	9.64E-10 (3.27E-09)−+	3.20E-10 (4.98E-10)−+
F7	5.22E+01 (4.13E+00)	4.97E+01 (3.46E+00)+	6.06E+01 (8.75E+00)−−	5.9E+01 (9.08E+00)−−
F8	2.28E+01 (4.68E+00)	2.09E+01 (3.41E+00)≈	2.82E+01 (8.18E+00)−−	2.53E+01 (5.15E+00)≈ −
F9	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F10	1.81E+03 (3.70E+02)	1.50E+03 (2.09E+02)+	1.89E+03 (3.60E+02)≈ −	1.84E+03 (4.18E+02)≈ −
F11	1.25E+01 (1.79E+01)	4.03E+00 (1.17E+00)+	1.42E+01 (1.86E+01)≈ −	6.40E+00 (2.76E+00)≈ −
F12	4.01E+02 (1.85E+02)	3.23E+02 (1.79E+02)≈	4.15E+02 (2.30E+02)≈≈	3.57E+02 (2.20E+02)≈≈
F13	2.20E+01 (8.03E+00)	9.39E+00 (3.98E+00)+	1.84E+01 (7.13E+00)≈ −	1.72E+01 (6.71E+00)+−
F14	1.83E+01 (1.10E+01)	5.56E+00 (1.86E+00)+	1.09E+01 (8.59E+00)+−	7.40E+00 (2.60E+00)+−
F15	4.72E+00 (2.24E+00)	2.98E+00 (9.96E-01)+	5.73E+00 (2.66E+00)≈ −	5.25E+00 (2.53E+00)≈ −
F16	2.09E+02 (1.11E+02)	1.37E+02 (1.03E+02)+	1.90E+02 (1.41E+02)≈≈	1.57E+02 (1.42E+02)≈≈
F17	2.85E+01 (1.15E+01)	1.00E+01 (2.23E+00)+	2.76E+01 (1.22E+01)≈ −	2.69E+01 (1.11E+01)≈ −
F18	2.24E+01 (6.25E+00)	1.70E+01 (8.10E+00)+	1.99E+01 (8.68E+00)≈ −	2.15E+01 (7.39E+00)≈ −
F19	5.66E+00 (2.02E+00)	3.41E+00 (8.00E-01)+	5.94E+00 (1.78E+00)≈ −	5.74E+00 (2.20E+00)≈ −
F20	2.79E+01 (2.30E+01)	3.54E+00 (1.73E+00)+	1.95E+01 (3.07E+01)+−	2.40E+01 (3.27E+01)+−
F21	2.23E+02 (4.23E+00)	2.21E+02 (3.77E+00)≈	1.76E+02 (6.31E+01)≈≈	1.37E+02 (5.72E+01)++
F22	1.00E+02 (8.30E-14)	1.00E+02 (3.68E-11)≈	1.00E+02 (1.14E-12)≈≈	1.00E+02 (1.94E-12)≈≈
F23	3.67E+02 (6.39E+00)	3.62E+02 (5.22E+00)+	3.31E+02 (1.05E+02)++	2.18E+02 (1.37E+02)+ ≈
F24	4.38E+02 (3.70E+00)	4.35E+02 (4.00E+00)+	4.27E+02 (7.76E+01)++	3.21E+02 (1.23E+02)≈≈
F25	3.87E+02 (1.10E-01)	3.87E+02 (1.97E-02)+	3.87E+02 (8.75E-02)≈ −	3.87E+02 (8.51E-02)≈ −
F26	1.10E+03 (4.96E+01)	1.1E+03 (4.27E+01)≈	1.17E+03 (3.18E+02)−−	3.58E+02 (2.20E+02)++
F27	4.98E+02 (7.10E+00)	4.88E+02 (5.17E+00)+	4.96E+02 (6.86E+00)≈ −	4.94E+02 (6.44E+00)+−
F28	3.07E+02 (2.76E+01)	3.00E+02 (1.99E-12)≈	3.25E+02 (4.51E+01)≈≈	3.10E+02 (3.15E+01)≈≈
F29	4.38E+02 (2.86E+01)	4.18E+02 (1.49E+01)+	4.35E+02 (2.87E+01)≈ −	4.26E+02 (3.11E+01)+−
F30	2.01E+03 (5.63E+01)	1.95E+03 (1.09E+01)+	2.04E+03 (5.63E+01)≈ −	3.02E+03 (1.51E+03)−−

		Individuals redistribution		
1.00E-02	5.00E-03	1.00E-03	5.00E-04	1.00E-04
1.14E-14 (5.78E-15)−−	1.33E-14 (5.19E-15)−−	1.33E-14 (3.60E-15)−−	1.28E-14 (4.34E-15)−−	1.28E-14 (4.34E-15)−−
2.76E-11 (6.74E-11)−−	3.86E-11 (7.58E-11)−−	3.43E-11 (4.28E-11)−−	1.98E-11 (2.51E-11)−−	1.01E-11 (1.01E-11)− ≈
1.42E-13 (4.13E-13)≈ −	3.83E-13 (1.24E-12)≈ −	3.98E-14 (3.70E-14)≈ +	7.20E-14 (1.26E-13)≈ +	2.25E-13 (4.23E-13)−−
3.87E+01 (2.92E+01)≈ −	1.65E+01 (2.70E+01)≈≈	3.72E+01 (2.96E+01)≈ −	3.66E+01 (2.90E+01)≈ −	2.50E+01 (2.90E+01)≈ −
2.39E+01 (6.86E+00)≈ −	2.35E+01 (5.33E+00)≈ −	2.31E+01 (5.07E+00)≈ −	2.21E+01 (4.62E+00)≈ −	2.26E+01 (4.82E+00)≈ −
3.48E-10 (6.34E-10)−+	5.21E-10 (9.75E-10)−+	2.82E-09 (1.23E-08)−+	3.68E-10 (5.87E-10)−+	9.54E-10 (2.27E-09)−+
5.43E+01 (5.08E+00)≈ −	5.43E+01 (4.79E+00)≈ −	5.54E+01 (5.91E+00)−−	5.42E+01 (5.52E+00)≈ −	5.38E+01 (3.36E+00)≈ −
2.45E+01 (4.17E+00)≈ −	2.55E+01 (5.79E+00)≈ −	2.52E+01 (5.82E+00)≈ −	2.45E+01 (4.82E+00)≈ −	2.42E+01 (3.95E+00)≈ −
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
1.79E+03 (4.27E+02)≈ −	1.92E+03 (3.43E+02)≈ −	1.72E+03 (2.90E+02)≈ −	1.56E+03 (3.32E+02)+ ≈	1.69E+03 (2.27E+02)≈ −
7.04E+00 (4.03E+00)≈ −	6.20E+00 (4.08E+00)≈ −	6.47E+00 (3.21E+00)≈ −	6.19E+00 (4.14E+00)≈ −	5.57E+00 (2.29E+00)+−
4.75E+02 (3.05E+02)≈ −	4.17E+02 (2.22E+02)≈≈	3.55E+02 (2.70E+02)≈≈	3.55E+02 (2.02E+02)≈≈	2.48E+02 (2.20E+02)++
1.81E+01 (6.13E+00)+−	1.43E+01 (6.27E+00)+−	1.35E+01 (6.48E+00)+−	1.38E+01 (7.21E+00)+−	1.12E+01 (4.55E+00)+ ≈
5.73E+00 (1.91E+00)+ ≈	5.35E+00 (2.74E+00)+ ≈	5.58E+00 (1.74E+00)+ ≈	5.61E+00 (1.82E+00)+ ≈	5.95E+00 (1.73E+00)+ ≈
4.05E+00 (1.91E+00)≈ −	3.80E+00 (1.62E+00)≈ −	3.87E+00 (1.47E+00)≈ −	3.36E+00 (1.11E+00)≈≈	3.25E+00 (1.18E+00)+ ≈
1.35E+02 (1.07E+02)+ ≈	1.63E+02 (1.31E+02)≈≈	1.45E+02 (9.07E+01)+ ≈	1.51E+02 (9.81E+01)+ ≈	1.14E+02 (9.63E+01)+ ≈
2.24E+01 (9.16E+00)+−	2.11E+01 (1.09E+01)+−	1.91E+01 (9.14E+00)+−	1.77E+01 (8.24E+00)+−	1.40E+01 (6.19E+00)+−
1.96E+01 (7.08E+00)≈≈	1.99E+01 (6.72E+00)≈≈	1.89E+01 (7.33E+00)≈≈	1.68E+01 (8.66E+00)+ ≈	1.99E+01 (6.70E+00)≈≈
4.04E+00 (1.16E+00)+ ≈	3.96E+00 (1.15E+00)+ ≈	3.60E+00 (9.77E-01)+ ≈	3.88E+00 (8.37E-01)+−	3.53E+00 (9.72E-01)+ ≈
1.46E+01 (1.24E+01)+−	2.54E+01 (3.42E+01)≈ −	2.10E+01 (3.38E+01)+−	2.17E+01 (3.36E+01)+−	1.99E+01 (2.48E+01)+−
1.33E+02 (5.59E+01)++	1.32E+02 (5.49E+01)++	1.05E+02 (2.30E+01)++	1.00E+02 (4.10E-07)++	1.04E+02 (2.30E+01)++
9.91E+01 (4.91E+00)≈≈	1.00E+02 (2.41E-12)≈≈	9.66E+01 (1.23E+01)≈≈	9.51E+01 (1.54E+01)≈≈	9.22E+01 (1.58E+01)≈≈
2.51E+02 (1.34E+02)+ ≈	2.44E+02 (1.37E+02)+ ≈	1.98E+02 (1.30E+02)++	1.18E+02 (6.90E+01)++	1.18E+02 (6.91E+01)++
3.75E+02 (1.07E+02)≈≈	3.26E+02 (1.2E+02)++	2.08E+02 (4.28E+01)++	2.00E+02 (2.55E-10)++	1.97E+02 (1.83E+01)++
3.87E+02 (8.02E-02)≈ −	3.87E+02 (9.18E-02)≈ −	3.87E+02 (6.07E-02)≈ −	3.87E+02 (7.62E-02)≈ −	3.87E+02 (8.83E-02)≈ −
3.81E+02 (2.49E+02)++	3.00E+02 (9.57E-02)++	3.00E+02 (9.57E-02)++	2.97E+02 (1.82E+01)++	3.00E+02 (1.42E-02)++
4.94E+02 (5.81E+00)+−	4.95E+02 (6.07E+00)+−	4.95E+02 (5.12E+00)+−	4.93E+02 (5.81E+00)+−	4.91E+02 (7.10E+00)+ ≈
3.15E+02 (3.85E+01)≈≈	3.20E+02 (4.10E+01)≈≈	3.10E+02 (3.03E+01)≈≈	3.14E+02 (3.41E+01)≈≈	3.07E+02 (2.62E+01)≈≈
4.26E+02 (2.28E+01)+−	4.27E+02 (2.50E+01)+−	4.13E+02 (3.54E+01)+ ≈	4.18E+02 (2.27E+01)+ ≈	4.26E+02 (2.35E+01)+−
2.01E+03 (4.62E+01)≈ −	2.01E+03 (5.32E+01)≈ −	1.98E+03 (3.55E+01)≈ −	1.99E+03 (4.25E+01)≈ −	1.98E+03 (2.64E+01)+−

Table 10: The results of the three versions of MLCC-SI for the CEC 2017 benchmark test suite. The symbol behind the results based on complete restart shows the difference to the original results, while the two symbols behind the results with individuals redistribution show the difference to the original results and the results with complete restart, respectively. "+" and "−" denote significantly better and statistically worse than the peer in terms of Wilcoxon's rank sum test at a 0.05 significance level, respectively. Meanwhile, "≈" represents no significantly difference

Function	Original	Complete restart	Individuals redistribution 1.00E-01	5.00E-02
F1	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F2	0.00E+00 (0.00E+00)	9.89E-13 (2.97E-12)−	1.44E-13 (4.66E-13)−+	5.78E-14 (1.77E-13)−+
F3	0.00E+00 (0.00E+00)	8.28E-11 (4.36E-10)−	0.00E+00 (0.00E+00)≈ +	0.00E+00 (0.00E+00)≈ +
F4	5.91E+01 (1.70E+00)	5.66E+01 (1.07E+01)≈	5.48E+01 (1.44E+01)≈≈	4.89E+01 (2.19E+01)≈≈
F5	4.58E+01 (1.49E+01)	2.60E+01 (5.62E+00)+	2.54E+01 (5.80E+00)+ ≈	2.45E+01 (5.22E+00)+ ≈
F6	1.06E-13 (2.88E-14)	2.01E-13 (9.29E-14)−	1.14E-13 (0.00E+00)≈ +	1.10E-13 (2.08E-14)≈ +
F7	7.15E+01 (9.99E+00)	5.24E+01 (4.96E+00)+	5.38E+01 (4.61E+00)+ ≈	5.22E+01 (5.55E+00)+ ≈
F8	4.80E+01 (1.72E+01)	2.44E+01 (4.67E+00)+	2.58E+01 (5.93E+00)+ ≈	2.39E+01 (4.34E+00)+ ≈
F9	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F10	2.15E+03 (5.73E+02)	1.57E+03 (2.30E+02)+	1.56E+03 (2.58E+02)+ ≈	1.37E+03 (2.59E+02)++
F11	1.04E+01 (3.89E+00)	5.51E+00 (1.86E+00)+	6.20E+00 (1.84E+00)+ ≈	6.17E+00 (2.82E+00)+ ≈
F12	2.58E+02 (1.67E+02)	2.20E+02 (8.96E+01)≈	3.00E+02 (1.27E+02)≈ −	3.09E+02 (1.73E+02)≈ −
F13	1.74E+01 (8.28E+00)	1.08E+01 (3.54E+00)+	1.24E+01 (4.37E+00)+ ≈	1.22E+01 (5.34E+00)+ ≈
F14	1.52E+01 (1.06E+01)	7.70E+00 (2.95E+00)+	1.03E+01 (6.11E+00)≈≈	1.64E+01 (1.05E+01)≈ −
F15	7.91E+00 (4.20E+00)	4.83E+00 (1.79E+00)+	4.20E+00 (1.38E+00)++	4.25E+00 (1.37E+00)+ ≈
F16	6.09E+02 (2.54E+02)	2.55E+02 (1.30E+02)+	1.80E+02 (1.38E+02)+ ≈	3.45E+02 (2.00E+02)+ ≈
F17	7.50E+01 (8.79E+01)	2.84E+01 (9.03E+00)+	2.61E+01 (8.44E+00)+ ≈	2.40E+01 (1.01E+01)+ ≈
F18	1.11E+01 (1.03E+01)	1.86E+01 (7.79E+00)−	1.90E+01 (7.54E+00)− ≈	1.60E+01 (8.91E+00)− ≈
F19	3.77E+00 (1.54E+00)	4.48E+00 (1.16E+00)≈	3.84E+00 (8.18E-01)≈ +	4.24E+00 (8.19E-01)≈≈
F20	8.33E+01 (7.57E+01)	6.91E+00 (6.74E+00)+	5.01E+00 (6.55E+00)++	1.04E+02 (6.92E+01)≈ −
F21	2.46E+02 (1.27E+01)	2.27E+02 (6.56E+00)+	2.21E+02 (2.34E+01)+ ≈	2.05E+02 (4.79E+01)+ ≈
F22	1.00E+02 (8.30E-14)	1.00E+02 (0.00E+00)≈	1.00E+02 (0.0E+00)≈≈	1.00E+02 (0.00E+00)≈≈
F23	3.92E+02 (1.60E+01)	3.18E+02 (1.11E+02)+	3.61E+02 (4.97E+01)+ ≈	3.63E+02 (5.01E+01)+ ≈
F24	4.70E+02 (1.79E+01)	4.49E+02 (7.18E+00)+	4.50E+02 (7.49E+00)+ ≈	4.43E+02 (6.67E+00)++
F25	3.87E+02 (2.58E-02)	3.87E+02 (1.58E-02)+	3.87E+02 (1.71E-02)+ ≈	3.87E+02 (1.88E-02)+ ≈
F26	1.36E+03 (3.34E+02)	2.93E+02 (2.54E+01)+	7.91E+02 (4.40E+02)+−	9.02E+02 (4.04E+02)+−
F27	4.87E+02 (7.85E+00)	4.79E+02 (5.13E+00)+	4.69E+02 (3.77E+00)++	4.63E+02 (4.09E+00)++
F28	3.26E+02 (4.78E+01)	3.00E+02 (2.86E-13)≈	3.00E+02 (2.76E-13)≈≈	3.00E+02 (2.83E-13)≈≈
F29	4.34E+02 (5.84E+01)	3.83E+02 (3.40E+01)+	4.00E+02 (2.87E+01)+ ≈	3.93E+02 (3.51E+01)+ ≈
F30	1.97E+03 (1.20E+01)	1.96E+03 (8.04E+00)≈	1.96E+03 (1.27E+01)≈≈	1.96E+03 (1.48E+01)≈≈

1.00E-02	5.00E-03	Individuals redistribution 1.00E-03	5.00E-04	1.00E-04
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
1.89E-15 (7.21E-15)≈ +	9.47E-16 (5.19E-15)≈ +	0.00E+00 (0.00E+00)≈ +	0.00E+00 (0.00E+00)≈ +	0.00E+00 (0.00E+00)≈ +
0.00E+00 (0.00E+00)≈ +	0.00E+00 (0.00E+00)≈ +	0.00E+00 (0.00E+00)≈ +	0.00E+00 (0.00E+00)≈ +	1.90E+01 (1.04E+02)≈ −
1.45E+01 (2.52E+01)++	5.10E+01 (1.95E+01)≈≈	5.47E+01 (1.49E+01)≈≈	5.34E+01 (1.77E+01)≈≈	5.66E+01 (1.07E+01)≈≈
2.73E+01 (7.30E+00)+ ≈	4.10E+01 (1.01E+01)≈ −	4.33E+01 (1.40E+01)≈ −	4.36E+01 (1.79E+01)≈ −	4.53E+01 (1.12E+01)≈ −
9.47E-14 (4.31E-14)≈ +	1.06E-13 (2.88E-14)≈ +	9.85E-14 (3.93E-14)≈ +	1.06E-13 (2.88E-14)≈ +	1.06E-13 (2.88E-14)≈ +
5.26E+01 (4.13E+00)+ ≈	5.49E+01 (4.06E+00)+−	6.68E+01 (1.22E+01)≈ −	6.69E+01 (1.10E+01)≈ −	6.90E+01 (1.32E+01)≈ −
2.91E+01 (9.64E+00)+−	4.56E+01 (1.43E+01)≈ −	4.25E+01 (1.23E+01)≈ −	4.79E+01 (1.70E+01)≈ −	4.28E+01 (1.57E+01)≈ −
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
1.26E+03 (3.38E+02)++	1.53E+03 (4.99E+02)+ ≈	2.11E+03 (5.12E+02)≈ −	2.16E+03 (4.18E+02)≈ −	2.16E+03 (4.21E+02)≈ −
5.97E+00 (2.60E+00)+ ≈	1.65E+01 (1.22E+01)−−	1.09E+01 (4.05E+00)≈ −	1.79E+01 (1.74E+01)−−	1.45E+01 (1.39E+01)≈ −
2.90E+02 (1.44E+02)≈ −	3.06E+02 (1.30E+02)≈ −	4.41E+02 (2.00E+02)−−	5.42E+02 (2.76E+02)−−	6.30E+02 (3.18E+02)−−
1.17E+01 (5.03E+00)+ ≈	1.13E+01 (5.39E+00)+ ≈	1.46E+01 (6.83E+00)≈≈	1.27E+01 (6.64E+00)+ ≈	1.96E+01 (8.27E+00)≈ −
2.19E+01 (1.11E+01)−−	2.29E+01 (1.15E+01)−−	2.63E+01 (1.05E+01)−−	2.77E+01 (1.23E+01)−−	2.33E+01 (1.11E+01)−−
3.33E+00 (1.58E+00)++	4.06E+00 (1.58E+00)++	4.79E+00 (2.04E+00)+ ≈	5.76E+00 (1.99E+00)+ ≈	8.22E+00 (3.81E+00)≈ −
4.91E+02 (2.51E+02)≈ −	4.99E+02 (2.08E+02)≈ −	4.68E+02 (2.24E+02)+−	5.17E+02 (2.29E+02)≈ −	4.92E+02 (2.25E+02)+−
3.79E+01 (3.30E+01)+ ≈	3.59E+01 (2.41E+01)+ ≈	5.13E+01 (5.46E+01)+ ≈	7.38E+01 (7.09E+01)≈ −	5.75E+01 (4.32E+01)≈ −
2.06E+01 (5.70E+00)− ≈	2.13E+01 (4.82E+00)− ≈	2.04E+01 (6.05E+00)− ≈	2.12E+01 (5.25E+00)− ≈	2.25E+01 (4.21E+00)−−
4.91E+00 (1.45E+00)− ≈	4.77E+00 (1.06E+00)− ≈	5.42E+00 (1.25E+00)−−	5.35E+00 (1.36E+00)−−	6.08E+00 (1.69E+00)−−
8.31E+01 (8.51E+01)≈ −	1.09E+02 (6.81E+01)−−	6.78E+01 (7.79E+01)≈ −	1.04E+02 (8.60E+01)≈ −	8.57E+01 (8.21E+01)≈ −
2.47E+02 (1.29E+01)≈ −	2.47E+02 (1.38E+01)≈ −	2.50E+02 (1.76E+01)≈ −	2.50E+02 (1.89E+01)≈ −	2.49E+02 (1.56E+01)≈ −
9.74E+01 (1.41E+01)≈≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈	1.00E+02 (0.00E+00)≈≈
3.71E+02 (9.16E+00)+ ≈	3.81E+02 (5.50E+01)≈ −	3.94E+02 (1.46E+01)≈ −	3.90E+02 (5.72E+01)≈ −	3.92E+02 (1.44E+01)≈ −
4.59E+02 (1.24E+01)+−	4.73E+02 (2.00E+01)≈ −	4.70E+02 (1.83E+01)≈ −	4.67E+02 (1.46E+01)≈ −	4.68E+02 (1.90E+01)≈ −
3.87E+02 (6.46E-03)++	3.87E+02 (3.89E-03)++	3.87E+02 (1.05E-02)++	3.87E+02 (2.14E-02)≈ −	3.87E+02 (4.64E-02)−−
9.44E+02 (5.06E+02)+−	1.05E+03 (4.86E+02)+−	9.45E+02 (5.47E+02)+−	9.33E+02 (5.45E+02)+−	1.27E+03 (4.66E+02)≈ −
4.76E+02 (1.28E+01)+ ≈	4.89E+02 (1.00E+01)≈ −	4.88E+02 (8.70E+00)≈ −	4.88E+02 (9.53E+00)≈ −	4.89E+02 (7.44E+00)≈ −
3.28E+02 (4.71E+01)≈≈	3.07E+02 (2.76E+01)≈≈	3.23E+02 (4.74E+01)≈≈	3.14E+02 (3.76E+01)≈≈	3.07E+02 (2.76E+01)≈≈
4.23E+02 (4.23E+01)≈ −	4.31E+02 (4.60E+01)≈ −	4.38E+02 (4.45E+01)≈ −	4.47E+02 (4.84E+01)−−	4.90E+02 (8.58E+01)−−
1.96E+03 (1.17E+01)+ ≈	1.96E+03 (9.58E+00)≈≈	1.96E+03 (1.23E+01)≈≈	1.97E+03 (3.10E+01)≈ −	1.99E+03 (4.39E+01)−−

Table 11: The results of the three versions of NDE for the CEC 2017 benchmark test suite. The symbol behind the results based on complete restart shows the difference to the original results, while the two symbols behind the results with individuals redistribution show the difference to the original results and the results with complete restart, respectively. "+" and "−" denote significantly better and statistically worse than the peer in terms of Wilcoxon's rank sum test at a 0.05 significance level, respectively. Meanwhile, "≈" represents no significantly difference

Function	Original	Complete restart	Individuals redistribution 1.00E-01	5.00E-02
F1	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F2	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F3	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F4	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F5	2.00E+01 (7.77E-04)	2.00E+01 (1.55E-03)−	2.00E+01 (3.49E-05)≈ +	2.00E+01 (3.70E-03)≈ +
F6	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	1.53E-02 (8.39E-02)≈≈	0.00E+00 (0.00E+00)≈≈
F7	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F8	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F9	1.09E+01 (1.21E+00)	1.09E+01 (1.41E+00)≈	5.82E+00 (2.13E+00)++	1.10E+01 (1.42E+00)≈≈
F10	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	1.76E-12 (3.32E-13)−−	1.58E-12 (6.29E-13)−−
F11	8.81E+02 (1.30E+02)	8.52E+02 (1.75E+02)≈	6.67E+02 (1.33E+02)++	6.37E+02 (1.62E+02)++
F12	4.73E-02 (6.91E-03)	4.98E-02 (9.68E-03)≈	2.88E-02 (1.96E-02)++	2.45E-02 (1.76E-02)++
F13	8.36E-02 (1.06E-02)	1.14E-01 (1.35E-02)−	1.03E-01 (1.23E-02)−+	1.02E-01 (1.38E-02)−+
F14	1.73E-01 (3.06E-02)	1.70E-01 (1.81E-02)≈	1.79E-01 (1.78E-02)≈≈	1.77E-01 (1.90E-02)≈≈
F15	1.43E+00 (8.94E-02)	1.41E+00 (1.13E-01)≈	1.72E+00 (2.16E-01)−−	1.73E+00 (1.71E-01)−−
F16	6.50E+00 (3.93E-01)	6.52E+00 (5.66E-01)≈	7.25E+00 (6.74E-01)−−	5.43E+00 (4.82E-01)++
F17	1.26E+02 (9.08E+01)	8.12E+01 (4.86E+01)≈	4.41E+01 (2.35E+01)++	4.75E+01 (3.68E+01)++
F18	3.50E+00 (1.48E+00)	2.78E+00 (1.72E+00)≈	2.20E+00 (7.50E-01)+ ≈	1.77E+00 (6.01E-01)++
F19	2.04E+00 (8.16E-01)	1.89E+00 (7.24E-01)≈	1.46E+00 (4.84E-01)++	1.23E+00 (6.41E-01)++
F20	1.16E+00 (3.05E-01)	1.13E+00 (2.73E-01)≈	1.05E+00 (2.67E-01)≈≈	1.10E+00 (2.78E-01)≈≈
F21	5.39E+01 (5.69E+01)	3.30E+01 (4.26E+01)≈	2.99E+00 (5.10E+00)++	2.34E+01 (4.39E+01)++
F22	3.62E+01 (3.96E+01)	2.24E+01 (2.17E+01)≈	9.84E+00 (7.38E+00)++	6.41E+00 (6.79E+00)++
F23	2.00E+02 (0.00E+00)	2.00E+02 (0.00E+00)≈	3.15E+02 (2.19E-13)−−	3.15E+02 (2.38E-13)−−
F24	2.00E+02 (0.00E+00)	2.00E+02 (0.00E+00)≈	2.01E+02 (5.33E+00)≈≈	2.00E+02 (1.47E-09)≈≈
F25	2.00E+02 (0.00E+00)	2.00E+02 (0.00E+00)≈	2.03E+02 (9.81E-03)−−	2.03E+02 (2.68E-02)−−
F26	1.00E+02 (1.04E-02)	1.00E+02 (1.46E-02)−	1.00E+02 (1.49E-02)− ≈	1.00E+02 (1.24E-02)−+
F27	2.03E+02 (1.83E+01)	2.13E+02 (3.46E+01)≈	3.00E+02 (0.00E+00)−−	3.00E+02 (0.00E+00)−−
F28	2.00E+02 (0.00E+00)	2.00E+02 (0.00E+00)≈	8.08E+02 (1.31E+01)−−	8.03E+02 (1.35E+01)−−
F29	2.00E+02 (0.00E+00)	2.00E+02 (0.00E+00)≈	7.14E+02 (3.46E-01)−−	7.14E+02 (2.44E-01)−−
F30	2.00E+02 (0.00E+00)	2.00E+02 (0.00E+00)≈	6.59E+02 (2.34E+02)−−	8.77E+02 (2.19E+02)−−

1.00E-02	5.00E-03	Individuals redistribution 1.00E-03	5.00E-04	1.00E-04
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
2.00E+01 (5.75E-05)≈ +	2.00E+01 (5.21E-03)≈ +	2.00E+01 (8.11E-05)≈ +	2.00E+01 (1.40E-04)≈ +	2.00E+01 (4.29E-05)≈ +
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
8.53E+00 (2.46E+00)++	1.02E+01 (1.71E+00)++	1.03E+01 (1.78E+00)≈ +	1.02E+01 (1.45E+00)++	9.82E+00 (1.58E+00)++
1.39E-12 (7.82E-13)−−	4.61E-12 (1.59E-11)−−	1.49E-03 (5.45E-03)−−	1.39E-03 (5.28E-03)≈≈	1.39E-03 (5.28E-03)≈≈
5.95E+02 (1.83E+02)++	5.96E+02 (1.56E+02)++	6.03E+02 (1.66E+02)++	5.50E+02 (2.00E+02)++	6.09E+02 (1.81E+02)++
2.17E-02 (1.82E-02)++	1.77E-02 (1.32E-02)++	3.31E-03 (5.65E-03)++	5.20E-03 (4.92E-03)++	1.48E-02 (1.30E-02)++
3.59E-02 (5.09E-03)++	3.76E-02 (5.00E-03)++	3.69E-02 (6.58E-03)++	3.69E-02 (6.27E-03)++	3.77E-02 (4.54E-03)++
2.50E-02 (4.61E-03)++	2.62E-02 (3.76E-03)++	2.57E-02 (4.86E-03)++	2.64E-02 (3.96E-03)++	2.64E-02 (4.21E-03)++
1.81E+00 (3.17E-01)−−	1.62E+00 (2.17E-01)−−	1.64E+00 (1.29E-01)−−	1.56E+00 (2.10E-01)−−	1.63E+00 (1.71E-01)−−
5.48E+00 (5.06E-01)++	5.50E+00 (5.77E-01)++	5.36E+00 (4.88E-01)++	5.54E+00 (5.06E-01)++	5.37E+00 (5.77E-01)++
1.01E+02 (7.59E+01)≈≈	8.45E+01 (6.75E+01)+ ≈	1.63E+02 (9.73E+01)≈ −	1.56E+02 (1.02E+02)≈ −	1.28E+02 (9.47E+01)≈ −
4.12E+00 (1.80E+00)≈ −	4.11E+00 (1.78E+00)≈ −	3.54E+00 (1.50E+00)≈≈	4.38E+00 (1.73E+00)≈ −	4.28E+00 (1.86E+00)≈ −
1.61E+00 (8.70E-01)≈≈	1.50E+00 (5.39E-01)++	1.41E+00 (6.46E-01)++	1.41E+00 (5.97E-01)++	1.37E+00 (6.85E-01)++
2.19E+00 (7.44E-01)−−	2.12E+00 (9.55E-01)−−	1.74E+00 (5.54E-01)−−	1.64E+00 (8.39E-01)≈≈	1.54E+00 (7.31E-01)≈≈
6.66E+01 (6.70E+01)≈≈	8.95E+01 (9.23E+01)≈≈	6.12E+01 (6.80E+01)≈≈	7.98E+01 (8.16E+01)≈≈	7.00E+01 (6.81E+01)≈≈
4.01E+00 (6.73E+00)++	1.04E+01 (9.84E+00)++	7.41E+00 (8.56E+00)++	9.41E+00 (9.41E+00)++	8.03E+00 (9.21E+00)++
3.15E+02 (1.96E-13)−−	3.15E+02 (1.88E-13)−−	3.08E+02 (2.92E+01)−−	3.08E+02 (2.92E+01)−−	3.11E+02 (2.10E+01)−−
2.00E+02 (1.56E-10)≈≈	2.00E+02 (1.48E-10)≈≈	2.00E+02 (3.79E-10)≈≈	2.00E+02 (4.26E-07)≈≈	2.00E+02 (7.70E-10)≈≈
2.03E+02 (3.59E-02)−−	2.03E+02 (3.40E-02)−−	2.01E+02 (1.23E+00)−−	2.01E+02 (1.29E+00)−−	2.01E+02 (1.26E+00)−−
1.00E+02 (4.30E-03)++	1.00E+02 (4.48E-03)++	1.00E+02 (4.83E-03)++	1.00E+02 (3.40E-03)++	1.00E+02 (4.66E-03)++
3.00E+02 (0.00E+00)−−	3.00E+02 (0.00E+00)−−	2.00E+02 (1.45E-13)≈≈	2.00E+02 (1.45E-13)≈≈	2.00E+02 (1.45E-13)≈≈
8.24E+02 (1.65E+01)−−	8.33E+02 (1.63E+01)−−	7.93E+02 (1.63E+02)−−	7.73E+02 (1.95E+02)−−	7.89E+02 (1.61E+02)−−
7.14E+02 (8.60E-01)−−	7.15E+02 (1.51E+00)−−	7.17E+02 (4.02E+00)−−	7.15E+02 (3.63E+00)−−	7.16E+02 (3.02E+00)−−
1.10E+03 (3.62E+02)−−	1.20E+03 (4.92E+02)−−	1.30E+03 (5.12E+02)−−	1.22E+03 (3.91E+02)−−	1.30E+03 (5.85E+02)−−

Table 12: The results of the three versions of L-SHADE-EpSin for the CEC 2014 benchmark test suite. The symbol behind the results based on complete restart shows the difference to the original results, while the two symbols behind the results with individuals redistribution show the difference to the original results and the results with complete restart, respectively. ”+” and ”−” denote significantly better and statistically worse than the peer in terms of Wilcoxon’s rank sum test at a 0.05 significance level, respectively. Meanwhile, ”≈” represents no significantly difference

Function	Original	Complete restart	Individuals redistribution	
			1.00E-01	5.00E-02
F1	1.33E-14 (6.39E-15)	9.95E-15 (7.60E-15)≈	6.16E-15 (7.16E-15)+ ≈	6.16E-15 (7.16E-15)+ ≈
F2	9.47E-16 (5.19E-15)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F3	3.22E-14 (2.86E-14)	1.52E-14 (2.56E-14)+	1.33E-14 (2.45E-14)+ ≈	9.47E-15 (2.15E-14)+ ≈
F4	5.32E-01 (1.38E+00)	8.58E+00 (7.18E+00)−	2.34E+01 (2.92E+01)≈≈	2.48E+00 (1.07E+01)≈ +
F5	2.01E+01 (3.27E-02)	2.01E+01 (8.39E-02)+	2.01E+01 (8.89E-02)++	2.00E+01 (6.39E-02)++
F6	4.69E+00 (3.03E+00)	7.62E-01 (7.13E-01)+	2.66E-01 (4.72E-01)++	2.65E-01 (4.81E-01)++
F7	5.75E-04 (2.21E-03)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F8	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F9	2.57E+01 (6.00E+00)	2.37E+01 (4.75E+00)≈	2.28E+01 (4.61E+00)≈≈	2.35E+01 (4.94E+00)≈≈
F10	1.11E-02 (1.31E-02)	0.00E+00 (0.00E+00)+	0.00E+00 (0.00E+00)+ ≈	0.00E+00 (0.00E+00)+ ≈
F11	2.14E+03 (4.24E+02)	1.74E+03 (3.90E+02)+	1.86E+03 (3.14E+02)+ ≈	1.79E+03 (3.16E+02)+ ≈
F12	1.54E-01 (1.11E-01)	1.59E-01 (1.56E-01)≈	5.14E-02 (3.46E-02)++	6.78E-02 (4.01E-02)++
F13	1.60E-01 (2.82E-02)	1.93E-01 (2.31E-02)−	1.68E-01 (2.54E-02)≈ +	1.76E-01 (2.58E-02)−+
F14	2.27E-01 (3.17E-02)	1.55E-01 (1.46E-02)+	1.62E-01 (1.12E-02)+−	1.57E-01 (1.79E-02)+ ≈
F15	2.59E+00 (7.15E-01)	2.14E+00 (5.23E-01)+	1.98E+00 (4.05E-01)+ ≈	2.09E+00 (3.82E-01)+ ≈
F16	9.80E+00 (5.49E-01)	9.31E+00 (6.07E-01)+	9.26E+00 (5.56E-01)+ ≈	9.03E+00 (5.75E-01)++
F17	2.65E+02 (1.69E+02)	9.39E+01 (6.59E+01)+	1.05E+02 (6.17E+01)+ ≈	1.16E+02 (9.72E+01)+ ≈
F18	1.60E+01 (1.18E+01)	8.52E+00 (2.47E+00)+	8.06E+00 (2.58E+00)+ ≈	7.60E+00 (2.48E+00)+ ≈
F19	2.48E+00 (1.14E+00)	1.70E+00 (7.00E-01)+	1.68E+00 (7.40E-01)+ ≈	2.07E+00 (7.70E-01)≈≈
F20	1.14E+01 (4.54E+00)	6.08E+00 (1.78E+00)+	4.89E+00 (2.03E+00)++	4.53E+00 (1.73E+00)++
F21	1.24E+02 (8.60E+01)	6.01E+01 (5.99E+01)+	3.84E+01 (5.19E+01)+ ≈	4.53E+01 (5.87E+01)+ ≈
F22	2.48E+01 (3.57E+00)	2.24E+01 (1.70E+00)+	2.33E+01 (3.00E+00)+ ≈	2.32E+01 (3.36E+00)+ ≈
F23	3.30E+02 (1.73E-13)	3.30E+02 (3.34E-04)−	3.36E+02 (1.92E-10)−−	3.36E+02 (9.60E-11)−−
F24	2.01E+02 (5.88E-02)	2.01E+02 (5.76E-02)−	2.01E+02 (6.91E-02)− ≈	2.01E+02 (5.85E-02)− ≈
F25	2.00E+02 (3.07E-03)	2.00E+02 (5.06E-07)≈	2.00E+02 (2.94E-03)≈≈	2.00E+02 (3.07E-03)≈≈
F26	1.00E+02 (3.06E-02)	1.00E+02 (2.78E-02)≈	1.00E+02 (2.21E-02)− ≈	1.00E+02 (2.73E-02)− ≈
F27	3.81E+02 (6.88E+01)	3.03E+02 (3.44E+00)+	3.09E+02 (1.74E+01)+ ≈	3.18E+02 (3.33E+01)+ ≈
F28	3.73E+02 (7.88E-01)	3.77E+02 (7.46E+00)≈	4.16E+02 (1.60E+00)−−	4.17E+02 (3.19E+00)−−
F29	2.03E+02 (1.08E+00)	2.06E+02 (9.86E-01)−	4.26E+02 (1.24E+00)−−	4.26E+02 (1.15E+00)−−
F30	2.56E+02 (5.28E+01)	3.14E+02 (5.02E+01)−	3.94E+02 (9.01E+00)−−	3.97E+02 (1.12E+01)−−

1.00E-02	5.00E-03	Individuals redistribution 1.00E-03	5.00E-04	1.00E-04
4.74E-15 (6.81E-15)++	8.05E-15 (7.16E-15)+ ≈	6.63E-15 (7.21E-15)+ ≈	7.58E-15 (7.21E-15)+ ≈	6.16E-15 (7.16E-15)+ ≈
9.47E-16 (5.19E-15)≈≈	0.00E+00 (0.00E+00)≈≈	9.47E-16 (5.19E-15)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
5.68E-15 (1.73E-14)+ ≈	1.33E-14 (2.45E-14)+ ≈	7.58E-15 (1.97E-14)+ ≈	9.47E-15 (2.15E-14)+ ≈	9.47E-15 (2.15E-14)+ ≈
4.38E+01 (2.66E+01)−−	5.36E+01 (1.83E+01)−−	5.34E+01 (1.82E+01)−−	4.81E+01 (2.42E+01)−−	5.00E+01 (2.29E+01)−−
2.01E+01 (8.26E-02)++	2.00E+01 (7.66E-02)++	2.01E+01 (8.87E-02)++	2.01E+01 (9.60E-02)++	2.00E+01 (4.25E-02)++
7.78E-01 (7.88E-01)+ ≈	7.08E-01 (8.19E-01)+ ≈	1.11E+00 (1.23E+00)+ ≈	9.78E-01 (7.46E-01)+ ≈	7.19E-01 (9.59E-01)+ ≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	3.29E-04 (1.80E-03)≈≈	1.23E-03 (3.22E-03)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
2.34E+01 (6.74E+00)≈≈	2.52E+01 (5.24E+00)≈≈	2.68E+01 (9.59E+00)≈≈	2.85E+01 (7.42E+00)≈ −	3.00E+01 (8.04E+00)−−
0.00E+00 (0.00E+00)+ ≈	0.00E+00 (0.00E+00)+ ≈	0.00E+00 (0.00E+00)+ ≈	0.00E+00 (0.00E+00)+ ≈	0.00E+00 (0.00E+00)+ ≈
1.63E+03 (4.23E+02)+ ≈	2.04E+03 (3.47E+02)≈ −	2.03E+03 (4.99E+02)≈ −	2.14E+03 (5.25E+02)≈ −	1.98E+03 (3.31E+02)≈ −
6.20E-02 (4.61E-02)++	6.92E-02 (4.88E-02)++	6.02E-02 (4.87E-02)++	4.67E-02 (4.19E-02)++	5.68E-02 (3.94E-02)++
1.71E-01 (2.97E-02)≈ +	1.88E-01 (2.48E-02)− ≈	1.84E-01 (2.01E-02)− ≈	1.87E-01 (3.15E-02)− ≈	1.78E-01 (3.16E-02)− ≈
1.56E-01 (1.72E-02)+ ≈	1.60E-01 (1.42E-02)+ ≈	1.60E-01 (1.97E-02)+ ≈	1.58E-01 (1.69E-02)+ ≈	1.62E-01 (1.71E-02)+−
1.96E+00 (4.07E-01)+ ≈	2.00E+00 (3.42E-01)+ ≈	2.64E+00 (5.75E-01)≈ −	2.81E+00 (6.18E-01)≈ −	2.68E+00 (6.84E-01)≈ −
9.24E+00 (5.43E-01)+ ≈	8.92E+00 (4.80E-01)++	8.79E+00 (5.67E-01)++	8.88E+00 (5.11E-01)++	9.21E+00 (6.25E-01)+ ≈
2.36E+02 (1.21E+02)≈ −	2.45E+02 (1.01E+02)≈ −	2.29E+02 (9.81E+01)≈ −	2.48E+02 (9.39E+01)≈ −	2.32E+02 (1.14E+02)≈ −
6.23E+00 (1.93E+00)++	5.80E+00 (2.28E+00)++	8.09E+00 (5.35E+00)+ ≈	1.02E+01 (1.08E+01)+ ≈	9.38E+00 (4.84E+00)+ ≈
2.56E+00 (7.32E-01)≈ −	2.23E+00 (8.45E-01)≈ −	2.23E+00 (1.25E+00)≈≈	2.18E+00 (9.05E-01)≈≈	2.73E+00 (1.02E+00)≈ −
4.32E+00 (1.81E+00)++	5.99E+00 (2.95E+00)+ ≈	6.29E+00 (3.94E+00)+ ≈	8.44E+00 (3.87E+00)+−	8.74E+00 (3.42E+00)+−
1.39E+02 (8.59E+01)≈ −	1.48E+02 (7.85E+01)≈ −	1.33E+02 (6.69E+01)≈ −	1.02E+02 (9.31E+01)≈ −	9.32E+01 (7.13E+01)≈ −
2.31E+01 (2.76E+00)+ ≈	2.33E+01 (3.06E+00)+ ≈	2.30E+01 (2.28E+00)+ ≈	2.21E+01 (1.40E+00)+ ≈	2.33E+01 (2.86E+00)≈≈
3.36E+02 (1.05E-10)−−	3.36E+02 (1.19E-13)−−	3.36E+02 (3.75E-10)−−	3.36E+02 (3.88E-10)−−	3.36E+02 (1.19E-13)−−
1.53E+02 (1.60E+01)++	1.57E+02 (1.11E+01)++	1.63E+02 (1.47E+01)++	1.62E+02 (1.11E+01)++	1.57E+02 (1.33E+01)++
2.00E+02 (3.28E-03)≈ −	2.00E+02 (3.18E-03)≈ −	2.00E+02 (3.35E-03)≈ −	2.00E+02 (2.94E-03)≈≈	2.00E+02 (2.59E-03)≈≈
1.00E+02 (2.79E-02)− ≈	1.00E+02 (3.47E-02)≈≈	1.00E+02 (3.08E-02)− ≈	1.00E+02 (2.48E-02)−−	1.00E+02 (2.94E-02)≈≈
3.22E+02 (3.35E+01)+−	3.10E+02 (2.01E+01)+ ≈	3.17E+02 (2.71E+01)+ ≈	3.16E+02 (2.68E+01)+ ≈	3.20E+02 (3.01E+01)+−
4.18E+02 (3.20E+00)−−	4.20E+02 (4.11E+00)−−	4.23E+02 (4.37E+00)−−	4.22E+02 (4.34E+00)−−	4.22E+02 (3.74E+00)−−
4.30E+02 (9.71E+00)−−	4.27E+02 (4.29E+00)−−	4.29E+02 (4.98E+00)−−	4.30E+02 (4.52E+00)−−	4.31E+02 (1.02E+01)−−
3.92E+02 (9.02E+00)−−	3.95E+02 (1.79E+01)−−	4.15E+02 (3.22E+01)−−	4.01E+02 (1.49E+01)−−	4.14E+02 (2.71E+01)−−

Table 13: The results of the three versions of MPEDE for the CEC 2014 benchmark test suite. The symbol behind the results based on complete restart shows the difference to the original results, while the two symbols behind the results with individuals redistribution show the difference to the original results and the results with complete restart, respectively. "+" and "−" denote significantly better and statistically worse than the peer in terms of Wilcoxon's rank sum test at a 0.05 significance level, respectively. Meanwhile, "≈" represents no significantly difference

Function	Original	Complete restart	Individuals redistribution	
			1.00E-01	5.00E-02
F1	1.47E-13 (1.37E-13)	2.46E-13 (2.49E-13)−	1.77E-13 (1.11E-13)≈≈	1.93E-13 (1.18E-13)− ≈
F2	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F3	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	1.89E-15 (1.04E-14)≈≈	1.89E-15 (1.04E-14)≈≈
F4	2.08E-14 (3.80E-14)	3.79E-15 (1.44E-14)≈	5.68E-15 (1.73E-14)≈≈	1.33E-14 (2.45E-14)≈≈
F5	2.00E+01 (6.71E-04)	2.00E+01 (4.84E-05)≈	2.00E+01 (5.19E-05)≈≈	2.00E+01 (1.25E-04)≈≈
F6	3.17E-01 (5.80E-01)	0.00E+00 (0.00E+00)≈	4.99E-02 (1.53E-01)≈≈	1.53E-02 (8.39E-02)≈≈
F7	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F8	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F9	2.28E+01 (5.30E+00)	1.53E+01 (2.60E+00)+	1.79E+01 (3.21E+00)+−	1.87E+01 (3.96E+00)+−
F10	3.75E-02 (2.47E-02)	5.55E-03 (9.36E-03)+	8.33E-03 (1.29E-02)+ ≈	6.94E-03 (1.26E-02)+ ≈
F11	1.11E+03 (3.66E+02)	6.59E+02 (2.38E+02)+	7.27E+02 (2.28E+02)+ ≈	8.13E+02 (1.45E+02)+−
F12	4.51E-02 (1.99E-02)	2.12E-02 (8.61E-03)+	2.16E-02 (8.57E-03)+ ≈	2.77E-02 (1.38E-02)+ ≈
F13	1.30E-01 (3.03E-02)	9.22E-02 (1.71E-02)+	1.13E-01 (2.05E-02)+−	1.14E-01 (2.29E-02)+−
F14	1.34E-01 (3.86E-02)	1.16E-01 (2.14E-02)≈	1.14E-01 (1.78E-02)≈≈	1.15E-01 (1.88E-02)+ ≈
F15	2.44E+00 (4.50E-01)	1.89E+00 (3.79E-01)+	2.07E+00 (2.91E-01)+ ≈	2.02E+00 (3.73E-01)+ ≈
F16	7.73E+00 (9.36E-01)	6.86E+00 (4.89E-01)+	6.68E+00 (6.82E-01)+ ≈	6.85E+00 (5.94E-01)+ ≈
F17	1.43E+03 (1.88E+03)	4.31E+02 (1.46E+02)+	3.30E+02 (1.22E+02)++	3.36E+02 (1.44E+02)++
F18	1.48E+02 (3.96E+02)	1.63E+01 (4.91E+00)+	1.78E+01 (6.09E+00)+ ≈	6.46E+01 (2.08E+02)+ ≈
F19	2.55E+00 (9.24E-01)	2.73E+00 (6.09E-01)≈	2.69E+00 (6.99E-01)≈≈	2.74E+00 (6.67E-01)≈≈
F20	9.79E+00 (4.01E+00)	1.01E+01 (3.98E+00)≈	7.63E+00 (3.06E+00)++	7.90E+00 (3.94E+00)++
F21	9.43E+02 (2.10E+03)	1.02E+03 (3.04E+03)−	2.79E+03 (6.39E+03)− ≈	2.69E+03 (6.65E+03)− ≈
F22	1.21E+02 (7.55E+01)	4.51E+01 (4.79E+01)+	5.11E+01 (6.01E+01)+ ≈	5.97E+01 (5.69E+01)+ ≈
F23	3.15E+02 (1.11E-13)	3.15E+02 (5.78E-14)≈	3.15E+02 (1.11E-13)≈≈	3.15E+02 (5.78E-14)≈≈
F24	2.24E+02 (1.16E+00)	2.23E+02 (6.45E-01)+	2.23E+02 (7.85E-01)+ ≈	2.09E+02 (1.07E+01)++
F25	2.04E+02 (1.25E+00)	2.03E+02 (3.83E-02)+	2.03E+02 (3.50E-02)++	2.03E+02 (3.67E-02)++
F26	1.03E+02 (1.82E+01)	1.00E+02 (1.65E-02)+	1.00E+02 (2.24E-02)≈ −	1.00E+02 (2.17E-02)+−
F27	3.34E+02 (4.26E+01)	3.00E+02 (8.69E-04)+	3.25E+02 (3.92E+01)≈ −	3.24E+02 (4.09E+01)≈ −
F28	7.63E+02 (5.20E+01)	6.85E+02 (4.25E+01)+	7.36E+02 (3.27E+01)+−	7.25E+02 (3.19E+01)+−
F29	7.39E+02 (8.20E+01)	7.94E+02 (2.58E+02)−	6.86E+02 (1.90E+02)++	7.14E+02 (1.26E+02)++
F30	1.57E+03 (7.13E+02)	7.02E+02 (1.38E+02)+	4.91E+02 (9.04E+01)++	6.35E+02 (2.42E+02)++

		Individuals redistribution		
1.00E-02	5.00E-03	1.00E-03	5.00E-04	1.00E-04
2.58E-13 (2.25E-13)− ≈	1.72E-13 (1.16E-13)≈≈	2.21E-13 (1.23E-13)− ≈	2.13E-13 (1.53E-13)− ≈	1.99E-13 (1.34E-13)− ≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
0.00E+00 (0.00E+00)≈≈	1.89E-15 (1.04E-14)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
5.68E-15 (1.73E-14)≈≈	5.68E-15 (1.73E-14)≈≈	1.14E-14 (2.31E-14)≈≈	1.14E-14 (2.31E-14)≈≈	1.14E-14 (2.31E-14)≈≈
2.00E+01 (2.69E-05)≈≈	2.00E+01 (3.96E-05)≈≈	2.00E+01 (1.54E-05)≈≈	2.00E+01 (2.28E-05)≈≈	2.00E+01 (2.57E-05)≈≈
2.11E-01 (3.99E-01)≈≈	1.41E-01 (3.04E-01)≈≈	0.00E+00 (0.00E+00)≈≈	8.07E-02 (2.25E-01)≈≈	1.67E-01 (3.61E-01)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	3.29E-04 (1.80E-03)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
1.83E+01 (3.48E+00)+−	1.62E+01 (3.82E+00)+ ≈	1.75E+01 (3.73E+00)+−	1.94E+01 (4.05E+00)+−	1.74E+01 (4.15E+00)+ ≈
6.94E-03 (1.14E-02)+ ≈	1.53E-02 (1.33E-02)+−	3.19E-02 (1.71E-02)≈ −	3.27E-02 (2.72E-02)≈ −	3.40E-02 (2.59E-02)≈ −
5.66E+02 (1.71E+02)+ ≈	5.53E+02 (2.04E+02)+ ≈	5.27E+02 (2.06E+02)++	5.15E+02 (2.19E+02)++	5.53E+02 (2.43E+02)+ ≈
2.56E-02 (1.17E-02)+ ≈	2.27E-02 (1.06E-02)+ ≈	2.06E-02 (7.53E-03)+ ≈	1.72E-02 (1.27E-02)+ ≈	1.18E-02 (6.70E-03)++
1.10E-01 (2.34E-02)+−	1.21E-01 (2.64E-02)≈ −	1.15E-01 (2.26E-02)+−	1.16E-01 (2.06E-02)+−	1.08E-01 (2.06E-02)+−
1.13E-01 (1.84E-02)+ ≈	1.04E-01 (1.97E-02)++	1.09E-01 (2.08E-02)+ ≈	1.09E-01 (2.04E-02)+ ≈	1.03E-01 (1.85E-02)++
2.16E+00 (4.45E-01)+−	2.18E+00 (3.65E-01)+−	2.10E+00 (3.42E-01)+ ≈	2.13E+00 (3.55E-01)+−	1.92E+00 (3.73E-01)+ ≈
6.42E+00 (5.90E-01)++	6.70E+00 (5.57E-01)+ ≈	6.07E+00 (7.78E-01)++	6.32E+00 (7.77E-01)++	6.24E+00 (9.39E-01)++
4.51E+02 (1.71E+02)+ ≈	4.98E+02 (2.33E+02)+ ≈	1.19E+03 (1.13E+03)≈ −	9.78E+02 (2.89E+02)≈ −	1.06E+03 (4.35E+02)≈ −
1.04E+01 (8.41E+00)++	6.37E+01 (2.05E+02)+−	5.27E+01 (4.42E+01)≈ −	1.18E+02 (2.62E+02)≈ −	4.00E+01 (3.05E+01)+−
2.71E+00 (7.91E-01)≈≈	2.57E+00 (5.45E-01)≈≈	2.68E+00 (8.11E-01)≈≈	2.63E+00 (7.59E-01)≈≈	2.92E+00 (6.34E-01)− ≈
9.19E+00 (4.63E+00)≈≈	8.32E+00 (3.15E+00)≈≈	1.04E+01 (4.39E+00)≈≈	1.02E+01 (4.92E+00)≈≈	9.87E+00 (3.89E+00)≈≈
9.43E+02 (2.30E+03)−+	3.83E+03 (8.23E+03)≈ −	9.48E+02 (2.29E+03)≈ +	6.60E+02 (1.50E+03)≈ +	3.84E+02 (1.04E+03)++
6.93E+01 (7.01E+01)+ ≈	7.75E+01 (6.43E+01)+ ≈	9.14E+01 (7.17E+01)≈≈	9.5E+01 (8.76E+01)≈≈	8.79E+01 (7.23E+01)≈≈
3.15E+02 (5.78E-14)≈≈	3.15E+02 (8.44E-14)≈≈	2.00E+02 (1.45E-13)++	2.00E+02 (1.45E-13)++	2.00E+02 (1.45E-13)++
2.00E+02 (2.47E-02)++	2.00E+02 (2.06E-02)++	2.00E+02 (1.36E-02)++	2.00E+02 (1.04E-02)++	2.00E+02 (1.57E-02)++
2.03E+02 (3.63E-02)++	2.02E+02 (9.50E-01)+ ≈	2.00E+02 (1.45E-13)++	2.00E+02 (1.45E-13)++	2.00E+02 (1.45E-13)++
1.03E+02 (1.82E+01)+−	1.03E+02 (1.82E+01)+−	1.00E+02 (2.54E-02)+−	1.03E+02 (1.82E+01)+−	1.00E+02 (1.94E-02)+−
3.33E+02 (4.61E+01)≈ −	3.31E+02 (4.17E+01)≈ −	2.42E+02 (6.54E+01)++	2.26E+02 (5.97E+01)++	2.57E+02 (9.01E+01)++
7.20E+02 (2.81E+01)+−	7.14E+02 (3.96E+01)+−	7.32E+02 (2.44E+01)+−	7.26E+02 (3.53E+01)+−	6.77E+02 (1.65E+02)++
8.31E+02 (2.83E+02)− ≈	7.15E+02 (1.60E+02)+ ≈	7.17E+02 (4.43E+00)+ ≈	7.20E+02 (1.45E+02)+ ≈	6.91E+02 (2.31E+02)+ ≈
1.05E+03 (3.99E+02)+−	1.38E+03 (4.66E+02)≈ −	1.50E+03 (7.29E+02)≈ −	1.42E+03 (5.38E+02)≈ −	1.26E+03 (3.42E+02)≈ −

Table 14: The results of the three versions of ETI-JADE for the CEC 2014 benchmark test suite. The symbol behind the results based on complete restart shows the difference to the original results, while the two symbols behind the results with individuals redistribution show the difference to the original results and the results with complete restart, respectively. "+" and "−" denote significantly better and statistically worse than the peer in terms of Wilcoxon's rank sum test at a 0.05 significance level, respectively. Meanwhile, "≈" represents no significantly difference

Function	Original	Complete restart	Individuals redistribution	
			1.00E-01	5.00E-02
F1	8.61E-13 (3.20E-12)	3.53E-13 (3.69E-13)≈	3.15E-13 (5.18E-13)≈≈	4.59E-13 (8.79E-13)≈≈
F2	9.47E-16 (5.19E-15)	9.47E-16 (5.19E-15)≈	9.47E-16 (5.19E-15)≈≈	2.84E-15 (8.67E-15)≈≈
F3	2.10E-13 (6.88E-13)	0.00E+00 (0.00E+00)+	0.00E+00 (0.00E+00)+ ≈	0.00E+00 (0.00E+00)+ ≈
F4	1.20E+00 (1.86E+00)	1.46E+00 (1.95E+00)≈	1.46E+00 (1.95E+00)≈≈	1.73E+00 (2.01E+00)≈≈
F5	2.00E+01 (8.00E-02)	2.02E+01 (1.15E-01)−	2.00E+01 (6.43E-04)++	2.00E+01 (8.29E-02)++
F6	1.77E+00 (1.21E+00)	3.79E-01 (6.69E-01)+	5.65E-01 (7.98E-01)+ ≈	7.43E-01 (8.03E-01)+ ≈
F7	1.97E-03 (6.33E-03)	8.21E-04 (3.12E-03)≈	1.48E-03 (3.4E-03)≈≈	1.48E-03 (4.90E-03)≈≈
F8	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F9	2.77E+01 (6.12E+00)	1.66E+01 (2.06E+00)+	1.46E+01 (2.59E+00)++	1.51E+01 (3.38E+00)++
F10	4.79E-02 (3.55E-02)	1.68E-02 (1.60E-02)+	0.00E+00 (0.00E+00)++	0.00E+00 (0.00E+00)++
F11	2.19E+03 (4.38E+02)	1.80E+03 (2.39E+02)+	1.56E+03 (2.97E+02)++	1.52E+03 (3.37E+02)++
F12	1.15E-01 (6.45E-02)	7.23E-02 (2.22E-02)+	5.64E-02 (2.47E-02)++	5.76E-02 (3.56E-02)++
F13	2.12E-01 (4.31E-02)	1.13E-01 (2.02E-02)+	1.19E-01 (2.15E-02)+ ≈	1.20E-01 (3.16E-02)+ ≈
F14	2.14E-01 (4.52E-02)	1.32E-01 (1.59E-02)+	1.16E-01 (1.60E-02)++	1.15E-01 (2.04E-02)++
F15	2.91E+00 (4.90E-01)	1.81E+00 (3.14E-01)+	2.28E+00 (5.79E-01)+−	2.30E+00 (4.94E-01)+−
F16	9.92E+00 (6.29E-01)	9.31E+00 (5.12E-01)+	8.46E+00 (6.44E-01)++	8.77E+00 (7.71E-01)++
F17	3.66E+02 (2.70E+02)	1.40E+02 (7.10E+01)+	3.58E+02 (2.50E+02)≈ −	3.61E+02 (2.70E+02)≈ −
F18	7.66E+01 (1.03E+02)	8.36E+00 (3.36E+00)+	7.69E+00 (2.81E+00)+ ≈	1.61E+01 (3.83E+01)+ ≈
F19	3.81E+00 (1.33E+00)	4.33E+00 (2.92E+00)≈	3.51E+00 (1.68E+00)≈≈	3.12E+00 (1.13E+00)+ ≈
F20	7.00E+00 (2.90E+00)	5.08E+00 (1.83E+00)+	4.83E+00 (1.93E+00)+ ≈	4.56E+00 (2.77E+00)+ ≈
F21	1.29E+02 (1.32E+02)	3.77E+01 (4.90E+01)+	1.36E+02 (1.44E+02)≈≈	9.88E+01 (1.26E+02)≈≈
F22	2.71E+01 (5.99E+00)	2.49E+01 (3.41E+00)≈	2.44E+01 (3.51E+00)+ ≈	2.39E+01 (2.89E+00)+ ≈
F23	3.30E+02 (3.00E-12)	3.30E+02 (1.73E-13)≈	3.30E+02 (3.75E-13)≈≈	3.30E+02 (3.35E-13)≈≈
F24	2.01E+02 (7.52E-02)	2.01E+02 (3.63E-02)+	2.01E+02 (3.76E-02)++	2.01E+02 (4.11E-02)+ ≈
F25	2.00E+02 (3.28E-03)	2.00E+02 (2.09E-03)≈	2.00E+02 (7.57E-03)≈≈	2.00E+02 (3.20E-03)≈≈
F26	1.00E+02 (3.29E-02)	1.00E+02 (1.94E-02)+	1.00E+02 (1.68E-02)+ ≈	1.00E+02 (2.26E-02)+ ≈
F27	3.34E+02 (2.96E+01)	3.02E+02 (2.79E+00)+	3.31E+02 (2.95E+01)≈ −	3.14E+02 (1.46E+01)+−
F28	3.95E+02 (2.13E+01)	3.73E+02 (1.03E+00)+	3.83E+02 (5.30E+00)≈ −	3.83E+02 (5.92E+00)≈ −
F29	2.09E+02 (1.47E+00)	2.08E+02 (1.55E+00)+	2.09E+02 (1.23E+00)≈ −	2.09E+02 (1.25E+00)≈ −
F30	3.76E+02 (7.96E+01)	2.43E+02 (1.30E+01)+	2.80E+02 (4.33E+01)+−	2.72E+02 (3.93E+01)+−

		Individuals redistribution		
1.00E-02	5.00E-03	1.00E-03	5.00E-04	1.00E-04
2.88E-13 (2.62E-13)≈≈	2.61E-12 (1.25E-11)≈≈	4.90E-09 (2.68E-08)≈≈	2.47E-13 (2.81E-13)≈≈	1.19E-11 (6.35E-11)≈≈
2.84E-15 (1.14E-14)≈≈	1.89E-15 (7.21E-15)≈≈	1.89E-15 (7.21E-15)≈≈	3.79E-15 (9.83E-15)≈≈	5.68E-15 (1.38E-14)≈≈
0.00E+00 (0.00E+00)+ ≈	0.00E+00 (0.00E+00)+ ≈	1.89E-15 (1.04E-14)+ ≈	5.68E-15 (1.73E-14)≈≈	5.68E-15 (1.73E-14)≈≈
1.59E+00 (1.99E+00)≈ −	1.86E+00 (2.02E+00)≈ −	1.33E+00 (1.91E+00)≈≈	1.73E+00 (2.01E+00)≈ −	1.33E+00 (1.91E+00)≈≈
2.00E+01 (8.67E-02)++	2.00E+01 (7.97E-02)++	2.00E+01 (5.42E-02)++	2.00E+01 (9.12E-02)≈ +	2.00E+01 (7.37E-02)++
1.43E+00 (1.31E+00)≈ −	1.64E+00 (1.32E+00)≈ −	1.37E+00 (1.05E+00)≈ −	2.05E+00 (1.57E+00)≈ −	1.23E+00 (1.03E+00)≈ −
2.22E-03 (4.45E-03)≈≈	1.56E-03 (4.36E-03)≈≈	1.14E-03 (6.27E-03)≈≈	1.15E-03 (3.02E-03)≈≈	1.23E-03 (3.76E-03)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
1.40E+01 (3.66E+00)++	2.34E+01 (6.05E+00)+−	2.57E+01 (6.51E+00)≈ −	2.79E+01 (7.33E+00)≈ −	2.62E+01 (4.63E+00)≈ −
0.00E+00 (0.00E+00)++	0.00E+00 (0.00E+00)++	1.94E-02 (2.62E-02)+ ≈	3.54E-02 (3.00E-02)≈ −	4.30E-02 (2.78E-02)≈ −
1.23E+03 (4.05E+02)++	1.87E+03 (4.60E+02)+ ≈	1.88E+03 (4.56E+02)+ ≈	2.02E+03 (3.84E+02)≈ −	1.86E+03 (4.11E+02)+ ≈
5.45E-02 (3.18E-02)++	3.71E-02 (2.76E-02)++	3.66E-02 (1.74E-02)++	5.29E-02 (3.64E-02)++	7.57E-02 (4.63E-02)+ ≈
1.26E-01 (2.72E-02)+−	1.12E-01 (2.49E-02)+ ≈	1.07E-01 (2.54E-02)+ ≈	1.08E-01 (2.76E-02)+ ≈	1.11E-01 (2.86E-02)+ ≈
1.02E-01 (1.69E-02)++	9.79E-02 (1.70E-02)++	8.68E-02 (1.66E-02)++	9.55E-02 (2.28E-02)++	9.60E-02 (1.65E-02)++
2.46E+00 (5.22E-01)+−	2.44E+00 (5.30E-01)+−	2.53E+00 (5.13E-01)+−	2.70E+00 (6.52E-01)≈ −	2.74E+00 (6.90E-01)≈ −
8.73E+00 (8.58E-01)++	8.74E+00 (7.25E-01)++	8.80E+00 (6.11E-01)++	9.09E+00 (6.25E-01)+ ≈	9.12E+00 (5.79E-01)++
3.55E+02 (2.99E+02)≈ −	4.34E+02 (3.73E+02)≈ −	4.00E+02 (3.47E+02)≈ −	3.65E+02 (3.17E+02)≈ −	2.54E+02 (1.74E+02)≈ −
1.02E+01 (6.88E+00)+ ≈	1.46E+01 (1.44E+01)+ ≈	3.67E+01 (4.88E+01)≈ −	3.42E+01 (4.80E+01)≈≈	3.83E+01 (3.51E+01)≈ −
2.99E+00 (9.05E-01)+ ≈	3.14E+00 (1.29E+00)+ ≈	3.69E+00 (1.18E+00)≈≈	3.39E+00 (1.30E+00)≈≈	3.79E+00 (1.63E+00)≈≈
4.27E+00 (2.13E+00)+ ≈	4.29E+00 (1.25E+00)+ ≈	4.99E+00 (1.88E+00)+ ≈	6.11E+00 (4.65E+00)+ ≈	5.76E+00 (2.91E+00)+ ≈
1.52E+02 (1.64E+02)≈ −	1.53E+02 (2.03E+02)≈≈	1.58E+02 (1.45E+02)≈ −	1.80E+02 (1.65E+02)≈ −	1.52E+02 (1.95E+02)≈≈
2.42E+01 (3.76E+00)+ ≈	2.31E+01 (2.90E+00)++	2.47E+01 (4.79E+00)≈≈	2.49E+01 (5.75E+00)+ ≈	2.47E+01 (3.90E+00)≈≈
3.30E+02 (3.47E-13)≈≈	3.30E+02 (3.07E-13)≈≈	3.30E+02 (2.83E-13)≈≈	3.30E+02 (4.04E-13)≈≈	3.30E+02 (3.36E-13)≈≈
2.01E+02 (4.80E-02)++	1.99E+02 (8.45E+00)+ ≈	2.01E+02 (3.39E-02)++	2.01E+02 (5.09E-02)++	2.01E+02 (4.26E-02)++
2.00E+02 (3.19E-03)≈≈	2.00E+02 (7.58E-03)≈≈	2.00E+02 (6.45E-01)≈≈	2.00E+02 (6.32E-01)≈≈	2.00E+02 (5.91E-01)≈≈
1.00E+02 (2.20E-02)++	1.00E+02 (1.62E-02)++	1.00E+02 (2.13E-02)++	1.00E+02 (1.78E-02)+ ≈	1.00E+02 (1.76E-02)++
3.29E+02 (2.77E+01)≈ −	3.23E+02 (2.49E+01)≈ −	3.43E+02 (3.78E+01)≈ −	3.26E+02 (2.70E+01)≈ −	3.44E+02 (3.63E+01)≈ −
3.82E+02 (7.52E+00)+−	3.83E+02 (5.70E+00)≈ −	3.84E+02 (5.36E+00)≈ −	3.85E+02 (8.59E+00)≈ −	3.85E+02 (4.56E+00)≈ −
2.10E+02 (1.31E+00)≈ −	2.09E+02 (1.20E+00)≈ −	2.09E+02 (1.32E+00)≈ −	2.09E+02 (1.31E+00)≈ −	2.09E+02 (1.24E+00)≈ −
2.70E+02 (4.09E+01)+−	2.57E+02 (1.93E+01)+−	2.68E+02 (4.00E+01)+−	2.63E+02 (3.20E+01)+−	2.64E+02 (3.50E+01)+−

Table 15: The results of the three versions of EDEV for the CEC 2014 benchmark test suite. The symbol behind the results based on complete restart shows the difference to the original results, while the two symbols behind the results with individuals redistribution show the difference to the original results and the results with complete restart, respectively. "+" and "−" denote significantly better and statistically worse than the peer in terms of Wilcoxon's rank sum test at a 0.05 significance level, respectively. Meanwhile, "≈" represents no significantly difference

Function	Original	Complete restart	Individuals redistribution	
			1.00E-01	5.00E-02
F1	7.23E-13 (5.89E-13)	7.30E-04 (8.07E-04)−	5.55E-03 (1.94E-02)− ≈	2.01E-03 (4.40E-03)− ≈
F2	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	3.79E-14 (6.35E-14)−−	2.56E-14 (2.28E-14)−−
F3	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	1.42E-12 (5.99E-12)−−	2.84E-13 (7.12E-13)−−
F4	5.50E-14 (3.50E-14)	1.34E-09 (1.12E-09)−	1.36E-12 (2.93E-12)−+	4.98E-13 (5.00E-13)−+
F5	2.00E+01 (3.26E-04)	2.02E+01 (4.94E-02)−	2.02E+01 (5.10E-02)− ≈	2.02E+01 (4.38E-02)− ≈
F6	6.11E-01 (1.73E+00)	2.35E-13 (8.93E-13)≈	5.83E-02 (2.66E-01)+−	6.42E-01 (1.24E+00)−−
F7	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F8	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F9	2.11E+01 (3.99E+00)	2.23E+01 (2.96E+00)≈	2.87E+01 (8.22E+00)−−	2.59E+01 (6.12E+00)−−
F10	2.78E-03 (9.04E-03)	2.24E-01 (2.94E-01)−	7.68E-02 (3.98E-02)−+	5.83E-02 (3.84E-02)−+
F11	1.49E+03 (2.67E+02)	1.23E+03 (2.61E+02)+	1.73E+03 (3.79E+02)−−	1.64E+03 (4.19E+02)≈ −
F12	3.63E-02 (1.77E-02)	2.28E-02 (8.78E-03)+	3.50E-02 (1.83E-02)≈ −	3.07E-02 (1.31E-02)≈ −
F13	6.42E-02 (1.22E-02)	1.17E-01 (1.61E-02)−	1.19E-01 (2.01E-02)− ≈	1.12E-01 (1.53E-02)− ≈
F14	1.23E-01 (2.29E-02)	1.79E-01 (1.35E-02)−	1.69E-01 (2.03E-02)−+	1.71E-01 (1.71E-02)− ≈
F15	2.28E+00 (6.09E-01)	1.98E+00 (2.86E-01)+	2.58E+00 (5.88E-01)−−	2.56E+00 (6.40E-01)≈ −
F16	7.97E+00 (9.59E-01)	7.21E+00 (6.01E-01)+	7.66E+00 (9.16E-01)≈ −	8.07E+00 (5.54E-01)≈ −
F17	1.89E+02 (1.25E+02)	8.54E+01 (5.31E+01)+	2.24E+02 (1.49E+02)≈ −	1.88E+02 (1.18E+02)≈ −
F18	8.56E+00 (2.65E+00)	6.28E+00 (1.57E+00)+	8.19E+00 (2.88E+00)≈ −	9.94E+00 (3.32E+00)≈ −
F19	1.98E+00 (3.43E-01)	1.76E+00 (3.68E-01)+	2.09E+00 (5.63E-01)≈ −	2.05E+00 (4.26E-01)≈ −
F20	5.12E+00 (1.82E+00)	3.52E+00 (9.94E-01)+	7.12E+00 (2.83E+00)−−	6.45E+00 (2.12E+00)−−
F21	8.95E+01 (8.47E+01)	2.41E+01 (4.09E+01)+	1.10E+02 (6.61E+01)≈ −	1.00E+02 (7.89E+01)≈ −
F22	4.38E+01 (4.92E+01)	1.82E+01 (2.57E+01)+	2.97E+01 (4.63E+01)≈≈	3.33E+01 (4.90E+01)+ ≈
F23	3.15E+02 (1.98E-13)	3.15E+02 (6.25E-12)≈	3.15E+02 (1.11E-13)≈≈	3.15E+02 (5.78E-14)≈≈
F24	2.23E+02 (7.79E-01)	2.22E+02 (1.59E-01)+	2.00E+02 (1.68E-05)++	2.00E+02 (4.84E-02)++
F25	2.03E+02 (2.50E-01)	2.03E+02 (2.85E-02)+	2.03E+02 (9.92E-01)≈ −	2.03E+02 (9.46E-01)≈ −
F26	1.00E+02 (1.02E-02)	1.00E+02 (1.76E-02)≈	1.00E+02 (3.81E-02)− ≈	1.00E+02 (4.42E-02)−−
F27	3.30E+02 (4.68E+01)	3.00E+02 (3.54E-11)+	3.73E+02 (4.49E+01)−−	3.22E+02 (4.12E+01)≈≈
F28	7.93E+02 (3.12E+01)	7.68E+02 (2.97E+01)+	7.93E+02 (5.80E+01)≈ −	7.80E+02 (1.14E+02)≈ −
F29	7.18E+02 (7.17E+00)	4.21E+02 (2.80E+02)+	6.27E+02 (2.12E+02)≈ −	6.71E+02 (2.81E+02)≈ −
F30	4.51E+02 (6.90E+01)	4.07E+02 (2.69E+01)+	5.34E+02 (1.42E+02)−−	6.76E+02 (4.18E+02)−−

		Individuals redistribution		
1.00E-02	5.00E-03	1.00E-03	5.00E-04	1.00E-04
4.58E-04 (4.36E-04)− ≈	3.73E-04 (3.08E-04)− ≈	3.68E-04 (4.21E-04)−+	5.28E-04 (7.09E-04)− ≈	9.49E-04 (2.02E-03)− ≈
2.56E-14 (2.62E-14)−−	2.08E-14 (1.66E-14)−−	1.42E-14 (1.45E-14)−−	1.61E-14 (1.43E-14)−−	1.52E-14 (1.44E-14)−−
3.30E-13 (8.18E-13)−−	2.56E-13 (4.58E-13)−−	5.50E-14 (3.16E-14)−−	5.68E-14 (3.95E-14)−−	4.74E-14 (2.62E-14)−−
8.28E-13 (1.14E-12)−+	5.06E-13 (6.00E-13)−+	1.61E-12 (5.19E-12)−+	5.36E-13 (5.59E-13)−+	4.58E-13 (3.28E-13)−+
2.02E+01 (5.67E-02)− ≈	2.02E+01 (4.33E-02)− ≈	2.02E+01 (5.39E-02)− ≈	2.02E+01 (4.77E-02)− ≈	2.02E+01 (5.30E-02)− ≈
2.17E-01 (5.69E-01)+−	2.16E-01 (5.88E-01)+−	1.25E-01 (4.16E-01)+−	5.33E-02 (2.00E-01)+−	4.50E-02 (1.91E-01)+−
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
2.47E+01 (5.72E+00)− ≈	2.39E+01 (4.86E+00)≈≈	2.31E+01 (5.68E+00)≈≈	2.48E+01 (5.17E+00)−−	2.16E+01 (4.34E+00)≈≈
6.75E-02 (3.65E-02)−+	7.23E-02 (4.98E-02)−+	6.81E-02 (3.94E-02)−+	7.65E-02 (3.64E-02)−+	8.88E-02 (5.07E-02)−+
1.61E+03 (3.71E+02)≈ −	1.47E+03 (3.23E+02)≈ −	1.39E+03 (3.53E+02)≈ −	1.31E+03 (2.14E+02)+ ≈	1.37E+03 (2.66E+02)≈ −
3.25E-02 (1.57E-02)≈ −	2.37E-02 (1.35E-02)+ ≈	2.56E-02 (9.63E-03)+ ≈	2.73E-02 (8.92E-03)+−	2.60E-02 (1.14E-02)+ ≈
1.17E-01 (1.44E-02)− ≈	1.22E-01 (1.73E-02)− ≈	1.20E-01 (1.66E-02)− ≈	1.22E-01 (1.57E-02)− ≈	1.22E-01 (1.91E-02)− ≈
1.75E-01 (2.09E-02)− ≈	1.77E-01 (2.09E-02)− ≈	1.80E-01 (1.34E-02)− ≈	1.80E-01 (1.69E-02)− ≈	1.78E-01 (2.01E-02)− ≈
2.29E+00 (4.15E-01)≈ −	2.31E+00 (3.52E-01)≈ −	2.24E+00 (3.36E-01)≈ −	2.10E+00 (3.29E-01)≈≈	2.11E+00 (3.47E-01)≈≈
8.11E+00 (4.47E-01)≈ −	8.12E+00 (5.55E-01)≈ −	7.94E+00 (6.53E-01)≈ −	8.00E+00 (6.50E-01)≈ −	8.09E+00 (6.76E-01)≈ −
1.50E+02 (1.54E+02)+ ≈	1.26E+02 (1.03E+02)+ ≈	1.09E+02 (8.40E+01)+ ≈	1.06E+02 (8.58E+01)+ ≈	8.60E+01 (7.48E+01)+ ≈
7.48E+00 (2.16E+00)≈ −	7.56E+00 (2.62E+00)≈ −	6.81E+00 (1.62E+00)+ ≈	5.76E+00 (1.69E+00)+ ≈	5.99E+00 (1.41E+00)+ ≈
2.23E+00 (3.96E-01)−−	1.91E+00 (5.81E-01)≈≈	1.92E+00 (4.08E-01)≈≈	1.90E+00 (3.87E-01)≈≈	1.65E+00 (4.89E-01)+ ≈
5.26E+00 (1.73E+00)≈ −	5.04E+00 (1.50E+00)≈ −	4.39E+00 (1.55E+00)≈ −	4.39E+00 (1.34E+00)≈ −	4.31E+00 (1.11E+00)≈ −
6.57E+01 (7.13E+01)≈ −	3.25E+01 (4.27E+01)+ ≈	3.96E+01 (4.89E+01)≈ −	4.06E+01 (5.15E+01)+ ≈	2.40E+01 (3.65E+01)+ ≈
2.26E+01 (2.02E+01)≈ −	3.22E+01 (3.77E+01)≈ −	2.50E+01 (3.78E+01)+ ≈	3.02E+01 (3.61E+01)≈ −	2.85E+01 (3.01E+01)≈ −
3.15E+02 (5.78E-14)≈≈	3.11E+02 (2.10E+01)≈≈	3.08E+02 (2.92E+01)≈≈	3.11E+02 (2.10E+01)≈≈	3.15E+02 (1.11E-13)≈≈
2.02E+02 (6.07E+00)++	2.00E+02 (9.20E-02)++	2.00E+02 (3.44E-06)++	2.00E+02 (6.07E-06)++	2.00E+02 (1.40E-06)++
2.03E+02 (2.14E-01)≈ −	2.02E+02 (8.74E-01)≈ +	2.03E+02 (5.70E-01)≈ −	2.02E+02 (1.07E+00)++	2.03E+02 (7.56E-01)≈ −
1.00E+02 (2.79E-02)−−	1.00E+02 (2.60E-02)−−	1.00E+02 (3.00E-02)−−	1.00E+02 (2.63E-02)−−	1.00E+02 (2.90E-02)−−
3.14E+02 (2.92E+01)≈ −	3.10E+02 (4.33E+01)≈≈	3.10E+02 (2.45E+01)≈ −	3.07E+02 (1.59E+01)≈ −	3.06E+02 (1.32E+01)≈≈
7.31E+02 (4.12E+01)++	7.23E+02 (3.34E+01)++	7.24E+02 (3.69E+01)++	7.38E+02 (4.32E+01)++	7.22E+02 (4.00E+01)++
7.10E+02 (1.12E+02)≈ −	6.84E+02 (1.95E+02)≈ −	5.93E+02 (2.34E+02)≈ −	6.64E+02 (1.66E+02)≈ −	7.03E+02 (1.62E+02)≈ −
5.78E+02 (2.45E+02)−−	5.06E+02 (1.26E+02)≈ −	5.53E+02 (2.22E+02)−−	5.00E+02 (1.38E+02)≈ −	4.65E+02 (7.99E+01)≈ −

Table 16: The results of the three versions of MLCC-SI for the CEC 2014 benchmark test suite. The symbol behind the results based on complete restart shows the difference to the original results, while the two symbols behind the results with individuals redistribution show the difference to the original results and the results with complete restart, respectively. "+" and "−" denote significantly better and statistically worse than the peer in terms of Wilcoxon's rank sum test at a 0.05 significance level, respectively. Meanwhile, "≈" represents no significantly difference

Function	Original	Complete restart	Individuals redistribution	
			1.00E-01	5.00E-02
F1	0.00E+00 (0.00E+00)	4.80E-01 (8.49E-01)−	6.52E-02 (9.33E-02)−+	6.03E-02 (8.07E-02)−+
F2	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F3	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F4	5.89E+01 (1.41E+00)	5.47E+01 (1.49E+01)≈	5.08E+01 (2.02E+01)≈≈	4.49E+01 (2.52E+01)≈≈
F5	2.01E+01 (1.04E-01)	2.00E+01 (2.87E-02)+	2.00E+01 (2.82E-02)+ ≈	2.00E+01 (5.80E-03)++
F6	1.68E+00 (1.86E+00)	6.82E-01 (2.09E+00)+	7.08E-02 (2.71E-01)++	6.66E-01 (8.53E-01)+ ≈
F7	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
F8	5.74E+00 (2.76E+00)	3.32E-02 (1.82E-01)+	1.09E+00 (1.96E+00)+ ≈	2.72E+00 (2.62E+00)+−
F9	4.66E+01 (1.63E+01)	2.57E+01 (4.37E+00)+	2.50E+01 (6.08E+00)+ ≈	2.33E+01 (5.02E+00)+ ≈
F10	6.05E+00 (2.15E+01)	4.13E-01 (2.26E+00)+	1.32E-02 (3.02E-02)+ ≈	4.16E-03 (1.38E-02)+ ≈
F11	2.70E+03 (6.59E+02)	1.69E+03 (3.73E+02)+	1.75E+03 (2.85E+02)+ ≈	1.57E+03 (2.92E+02)+ ≈
F12	3.05E-02 (1.99E-02)	2.10E-02 (9.82E-03)≈	2.38E-02 (8.42E-03)≈≈	2.43E-02 (1.10E-02)≈≈
F13	8.36E-02 (9.30E-02)	1.42E-01 (2.45E-02)−	1.51E-01 (3.20E-02)− ≈	1.66E-01 (3.58E-02)−−
F14	1.45E-01 (5.60E-02)	1.75E-01 (2.20E-02)−	1.83E-01 (2.36E-02)− ≈	1.76E-01 (2.57E-02)− ≈
F15	3.26E+00 (9.48E-01)	2.18E+00 (3.84E-01)+	2.24E+00 (3.23E-01)+ ≈	2.32E+00 (4.71E-01)+ ≈
F16	1.04E+01 (8.76E-01)	9.32E+00 (7.38E-01)+	9.17E+00 (7.17E-01)+ ≈	9.38E+00 (4.92E-01)+ ≈
F17	3.29E+02 (2.09E+02)	9.40E+01 (7.76E+01)+	9.45E+01 (6.04E+01)+ ≈	8.91E+01 (6.95E+01)+ ≈
F18	8.61E+00 (3.38E+00)	9.42E+00 (3.06E+00)≈	1.05E+01 (3.32E+00)− ≈	9.19E+00 (2.59E+00)≈≈
F19	2.33E+00 (1.00E+00)	3.12E+00 (6.28E-01)−	2.39E+00 (4.53E-01)≈ +	2.48E+00 (3.46E-01)≈ +
F20	6.24E+00 (2.72E+00)	4.49E+00 (1.49E+00)+	4.53E+00 (1.21E+00)+ ≈	4.47E+00 (1.13E+00)+ ≈
F21	1.16E+02 (1.09E+02)	5.10E+00 (3.75E+00)+	2.00E+01 (4.13E+01)+ ≈	9.65E+00 (2.20E+01)+ ≈
F22	6.17E+01 (5.18E+01)	2.64E+01 (3.49E+00)+	2.55E+01 (4.08E+00)+ ≈	2.49E+01 (3.67E+00)++
F23	3.36E+02 (0.00E+00)	3.36E+02 (2.27E-13)≈	3.36E+02 (1.88E-13)≈≈	3.36E+02 (2.38E-13)≈≈
F24	2.01E+02 (8.01E-02)	2.01E+02 (5.13E-02)−	2.01E+02 (5.97E-02)− ≈	2.01E+02 (5.79E-02)− ≈
F25	2.00E+02 (8.33E-01)	2.00E+02 (1.45E-13)≈	2.00E+02 (1.45E-13)≈≈	2.00E+02 (1.54E-13)≈≈
F26	1.00E+02 (7.96E-02)	1.00E+02 (3.12E-02)−	1.00E+02 (2.84E-02)− ≈	1.00E+02 (2.33E-02)− ≈
F27	3.57E+02 (4.58E+01)	3.01E+02 (2.49E+00)+	3.36E+02 (4.39E+01)≈ −	3.61E+02 (4.50E+01)≈ −
F28	4.19E+02 (2.93E+00)	4.15E+02 (1.66E+00)+	4.15E+02 (1.79E+00)+ ≈	4.15E+02 (1.41E+00)+ ≈
F29	4.27E+02 (3.05E+00)	4.26E+02 (2.02E-01)≈	4.26E+02 (1.21E-01)≈≈	4.26E+02 (4.36E-01)≈≈
F30	3.97E+02 (1.16E+01)	3.94E+02 (9.37E+00)≈	4.02E+02 (9.21E+00)−−	4.01E+02 (1.13E+01)−−

		Individuals redistribution		
1.00E-02	5.00E-03	1.00E-03	5.00E-04	1.00E-04
4.59E-02 (1.05E-01)−+	2.89E-02 (5.68E-02)−+	6.09E-03 (7.92E-03)−+	2.36E-03 (3.99E-03)−+	1.19E-04 (2.05E-04)−+
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
1.61E+01 (2.60E+01)++	4.93E+01 (2.21E+01)≈≈	5.08E+01 (2.02E+01)≈≈	5.66E+01 (1.07E+01)≈≈	5.09E+01 (2.03E+01)≈≈
2.00E+01 (4.83E-03)++	2.00E+01 (1.23E-02)++	2.00E+01 (6.00E-03)++	2.00E+01 (3.55E-03)++	2.00E+01 (3.58E-05)++
1.79E+00 (1.80E+00)≈ −	1.89E+00 (1.46E+00)≈ −	1.95E+00 (1.71E+00)≈ −	1.52E+00 (1.64E+00)≈ −	1.82E+00 (1.48E+00)≈ −
0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈	0.00E+00 (0.00E+00)≈≈
1.26E+00 (1.22E+00)+−	4.31E-01 (6.75E-01)+−	9.95E-02 (3.04E-01)+ ≈	3.32E-02 (1.82E-01)+ ≈	0.00E+00 (0.00E+00)+ ≈
3.12E+01 (7.47E+00)+−	4.40E+01 (1.55E+01)≈ −	4.28E+01 (1.74E+01)≈ −	4.24E+01 (1.68E+01)≈ −	4.42E+01 (1.33E+01)≈ −
4.97E-01 (1.08E+00)≈ −	1.69E+00 (1.94E+00)≈ −	2.50E+00 (2.84E+00)≈ −	1.91E+00 (1.84E+00)≈ −	7.81E-01 (6.43E-01)≈ −
1.83E+03 (4.12E+02)+ ≈	2.12E+03 (5.51E+02)+−	2.53E+03 (4.56E+02)≈ −	2.48E+03 (5.25E+02)≈ −	2.55E+03 (5.62E+02)≈ −
1.94E-02 (8.74E-03)+ ≈	5.29E-03 (3.29E-03)++	2.59E-03 (3.28E-03)++	7.70E-03 (4.96E-03)++	3.22E-02 (2.18E-02)≈≈
1.51E-01 (2.97E-02)− ≈	1.46E-01 (2.87E-02)− ≈	1.33E-01 (2.47E-02)− ≈	1.19E-01 (2.73E-02)−+	1.29E-01 (3.19E-02)− ≈
1.71E-01 (2.27E-02)− ≈	1.64E-01 (2.34E-02)≈≈	1.65E-01 (2.20E-02)≈≈	1.63E-01 (2.24E-02)≈ +	1.68E-01 (3.33E-02)≈≈
2.29E+00 (4.30E-01)+ ≈	2.18E+00 (3.85E-01)+ ≈	2.45E+00 (7.40E-01)+ ≈	3.25E+00 (9.75E-01)≈ −	3.37E+00 (1.03E+00)≈ −
8.88E+00 (5.48E-01)++	8.81E+00 (8.96E-01)++	9.86E+00 (7.82E-01)+−	1.00E+01 (7.17E-01)+−	1.03E+01 (8.65E-01)≈ −
7.96E+01 (5.84E+01)+ ≈	1.29E+02 (9.82E+01)+ ≈	2.71E+02 (1.83E+02)≈ −	3.56E+02 (2.15E+02)≈ −	3.29E+02 (2.03E+02)≈ −
7.38E+00 (2.29E+00)≈ +	6.50E+00 (2.49E+00)++	8.12E+00 (1.98E+00)≈ +	8.67E+00 (3.03E+00)≈≈	1.22E+01 (5.10E+00)−−
2.58E+00 (4.04E-01)≈ +	2.73E+00 (6.26E-01)≈ +	2.95E+00 (6.79E-01)−+	2.91E+00 (6.59E-01)− ≈	3.04E+00 (5.42E-01)− ≈
4.50E+00 (1.18E+00)+ ≈	4.87E+00 (1.25E+00)≈≈	5.81E+00 (2.21E+00)≈ −	6.87E+00 (3.49E+00)≈ −	8.17E+00 (3.25E+00)−−
7.38E+01 (9.71E+01)≈ −	5.66E+01 (6.91E+01)≈ −	1.12E+02 (9.14E+01)≈ −	1.28E+02 (1.04E+02)≈ −	1.66E+02 (9.93E+01)≈ −
3.31E+01 (2.37E+01)+ ≈	4.10E+01 (3.61E+01)≈≈	4.91E+01 (4.13E+01)≈ −	4.43E+01 (3.15E+01)≈ −	5.98E+01 (5.08E+01)≈ −
3.36E+02 (1.39E-13)≈≈	3.36E+02 (1.18E-13)≈≈	3.36E+02 (1.46E-13)≈≈	3.36E+02 (1.46E-13)≈≈	3.36E+02 (1.19E-13)≈≈
2.01E+02 (4.47E-02)− ≈	1.97E+02 (1.36E+01)+ ≈	2.01E+02 (6.55E-02)−+	2.00E+02 (2.69E+00)++	2.01E+02 (5.02E-02)−+
2.00E+02 (9.26E-01)≈≈	2.00E+02 (1.03E+00)≈≈	2.00E+02 (9.38E-01)≈≈	2.00E+02 (1.01E+00)≈≈	2.00E+02 (8.78E-01)≈≈
1.00E+02 (2.96E-02)−+	1.00E+02 (2.73E-02)−+	1.00E+02 (2.79E-02)−+	1.00E+02 (2.24E-02)−+	1.00E+02 (2.96E-02)−+
3.53E+02 (4.57E+01)≈ −	3.56E+02 (4.63E+01)≈ −	3.47E+02 (4.19E+01)≈ −	3.43E+02 (4.06E+01)≈ −	3.37E+02 (3.84E+01)≈ −
4.16E+02 (2.74E+00)+ ≈	4.18E+02 (3.24E+00)≈ −	4.20E+02 (4.48E+00)≈ −	4.20E+02 (4.02E+00)≈ −	4.20E+02 (3.46E+00)≈ −
4.26E+02 (5.92E-01)≈≈	4.26E+02 (3.00E-01)≈≈	4.29E+02 (7.01E+00)≈≈	4.28E+02 (3.67E+00)≈≈	4.29E+02 (4.13E+00)−−
3.90E+02 (1.05E+01)≈≈	3.91E+02 (9.36E+00)+ ≈	4.14E+02 (3.01E+01)−−	4.24E+02 (4.25E+01)−−	4.31E+02 (4.19E+01)−−

Table 17: The results of the three versions of NDE for the CEC 2014 benchmark test suite. The symbol behind the results based on complete restart shows the difference to the original results, while the two symbols behind the results with individuals redistribution show the difference to the original results and the results with complete restart, respectively. "+" and "−" denote significantly better and statistically worse than the peer in terms of Wilcoxon's rank sum test at a 0.05 significance level, respectively. Meanwhile, "≈" represents no significantly difference