APPENDIX A. THE PROCEDURE OF THE OVERALL PERFORMANCE COMPARISONS OF THE FIVE MOEA-BASED RESCHEDULING METHODS IN DYNAMIC ENVIRONMENTS OF THE 21 MODPSP INSTANCES

This group of experiments gives the overall performance comparisons of dε-MOEA with the other four rescheduling methods during the dynamic process of the project. On each MODPSP instances, the procedure is given below:

Step 1: At the initial time of the project, the proactive scheduling method ε-MOEA-r was used to find a predictive schedule. Then it was implemented.

Step 2: Once a critical dynamic event occurred, a rescheduling method is triggered. At each scheduling point, the following substeps were performed:

Substep 2.1: 30 independent runs of each method were replicated. Note that the non-dominated solutions obtained by dε-MOEA-Deterministic just had two objective values (without *robustness* and *stability*), and those of dε-MOEA-No-Sta just had three objective values (without *stability*). In order to compare the five methods within a multi-objective framework, firstly, the value of the objective "*robustness*" was calculated for the five methods using the same 100 randomly sampled efforts. Secondly, the value of "*stability*" was calculated for dε-MOEA-Deterministic and dε-MOEA-No-Sta, respectively. In this way, all the non-dominated sets of the five methods had four objective values so that they could be compared to each other in terms of Pareto domination.

Substep 2.2: All the non-dominated sets obtained by the five methods in the 30 runs were merged, and the new non-dominated solutions were determined from them to form the reference Pareto front.

Substep 2.3: For each method in each of the 30 runs, the performance values (*HVR*, *GD*, *Spacing*, *Spread*) were calculated using the reference Pareto front and its generated solution set. Thus, for each method, there were 30 values of each metric, and they were recorded. As shown in Fig. A.1, at the scheduling point t_l, the 30 values were: $metric_j^{k,i}(t_l)$, $j=1,2,\ldots,30$, where $metric_j^{k,i}(t_l)$ denotes the i^{th} performance metric value of the k^{th} method in the j^{th} run at t_l, $k=1,2,3,4,5$, $i=1,2,3,4$, and *HVR*, *GD*, *Spacing* and *Spread* were regarded as the 1st to the 4th metric, and dε-MOEA, dCOEA, dε-MOEA-Deterministic, dε-MOEA-No-Sta, dε-MOEA-No-HI were regarded as the 1st to the 5th method, respectively.

Substep 2.4: One solution was selected from the reference Pareto front as the new schedule to be implemented in the project based on the decision making method. In this way, it could be guaranteed that at each scheduling point, the five methods were compared in the same project environment.

Step 3: If the whole project had not been completed yet, then move to the next scheduling point and go to Step 2; otherwise, go to Step 4.

Step 4: To significantly compare the five methods in terms of the overall performance across different scheduling points and runs, Wilcoxon signed-rank tests with the significance level of 0.05 were employed. For the j^{th} ($j=1,2,\ldots,30$) run of the k^{th} ($k=1,2,3,4,5$) method, the i^{th} ($i=1,2,3,4$) performance values were averaged over all the scheduling points, as $mean_j^{k,i}$ shown in Fig. A.1. The 30 mean values $mean_j^{k,i}$ ($j=1,2,\ldots,30$) form the vector $Vec^{k,i}$. Then for the i^{th} metric, the pairwise comparisons between the vector $Vec^{1,i}$ of our method dε-MOEA and that of the other method ($Vec^{k,i}$, $k=2,3,4,5$) were performed by the Wilcoxon signed-rank tests. The results are listed in Table B.1 in Appendix B.

Step 5: To check the overall performance improvement (or deterioration) of our method dε-MOEA over the other four methods in each objective, the non-dominated solutions of dε-MOEA were averaged along each of the four objectives, respectively, and also for the other four methods. At t_l, the quantitative improvement (or deterioration) of our method dε-MOEA over the k^{th} method ($k=2,3,4,5$) on each objective is calculated as follows:

$$Imp_r(t_l)=-\frac{\left(Avg\_f_r^{\text{d}\varepsilon-\text{MOEA}}(t_l)\ -\ Avg\_f_r^{method_k}(t_l)\right)}{Avg\_f_r^{method_k}(t_l)}\times 100\%, \quad (A.1)$$

$r=1,2,3,4$

where $Avg\_f_r^{\text{d}\varepsilon-\text{MOEA}}(t_l)$ and $Avg\_f_r^{method_k}(t_l)$ represent the average values of the non-dominated solutions obtained by dε-MOEA and the k^{th} ($k=2,3,4,5$) method in the objective f_r at t_l, respectively. The overall improvement (or deterioration) in each objective f_r during the whole dynamic process is the average value of $Imp_r(t_l)$ over all the scheduling points, which are listed in Table B.2 in Appendix B.

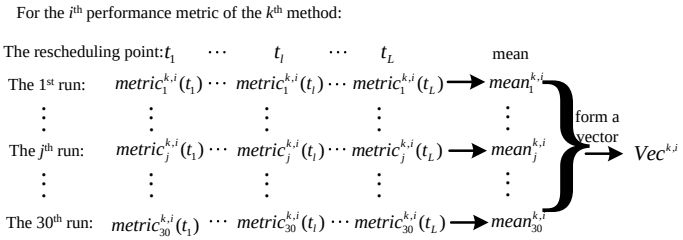

Fig. A.1. An illustration for the overall performance comparisons of five rescheduling methods in one MODPSP instance (*L* is the total number of scheduling points in the considered instance, and different instances may have different number of scheduling points).

APPENDIX B. THE OVERALL PERFORMANCE COMPARISON RESULTS OF THE FIVE MOEA-BASED RESCHEDULING METHODS IN DYNAMIC ENVIRONMENTS OF THE 21 MODPSP INSTANCES

TABLE B.1

STATISTICAL TEST RESULTS OF FIVE METHODS ACROSS SCHEDULING POINTS ON THE 21 TEST INSTANCES (THE SIGN OF '+/−/=' IN A VS. B INDICATES THAT ACCORDING TO THE METRIC CONSIDERED, ALGORITHM A IS SIGNIFICANTLY BETTER THAN B, SIGNIFICANTLY WORSE THAN B, OR THERE IS NO SIGNIFICANT DIFFERENCE BETWEEN A AND B BASED ON THE WILCOXON RANK SUM TEST WITH THE SIGNIFICANCE LEVEL OF 0.05).

Average Performance across Scheduling points		*HVR*	*GD*	*Spacing*	*Spread*	*HVR*	*GD*	*Spacing*	*Spread*
Instance		sT10_dT10_E5_SK4-5				sT10_dT10_E10_SK4-5			
dε-MOEA vs. dCOEA	*p*-value	4.50E-11	1.78E-10	0.0798	4.94E-5	3.02E-11	3.34E-11	1. 25E-7	0.3403
	sign	+	+	=	+	+	+	−	=
dε-MOEA vs. dε-MOEA-Deterministic	*p*-value	4.50E-11	1.11E-6	2.28E-5	6.53E-8	3.02E-11	7.74E-6	5.53E-8	0.2062
	sign	+	+	−	+	+	+	−	=
dε-MOEA vs. dε- MOEA-No-Sta	*p*-value	0.0255	0.7062	0.5201	0.4464	0.0412	0.7062	0.1761	0.0228
	sign	+	=	=	=	+	=	=	+
dε-MOEA vs. dε-MOEA-No-HI	*p*-value	5.97E-9	9.83E-8	0.5011	0.3711	3.69E-11	4.57E-9	1.73E-7	5.57E-10
	sign	+	+	=	=	+	+	−	−
Instance		sT10_dT10_E15_SK4-5				sT10_dT10_E5_SK6-7			
dε-MOEA vs. dCOEA	*p*-value	3.02E-11	3.02E-11	0.7845	9.52E-4	8.48E-9	2.33E-9	3.46E-4	1.21E-5
	sign	+	+	=	+	+	+	−	+
dε-MOEA vs. dε-MOEA-Deterministic	*p*-value	3.02E-11	6.70E-11	0.7506	0.7172	7.11E-9	2.28E-7	0.0047	4.88E-8
	sign	+	+	=	=	+	+	−	+
dε-MOEA vs. dε- MOEA-No-Sta	*p*-value	0.0153	0.9234	0.0491	0.1580	0.0185	0.4420	0.0311	0.0228
	sign	+	=	+	=	+	=	+	+
dε-MOEA vs. dε- MOEA-No-HI	*p*-value	3.34E-11	8.15E-11	0.0501	2.88E-6	9.06E-8	1.81E-5	0.0246	0.4779
	sign	+	+	=	−	+	+	+	=
Instance		sT10_dT10_E10_SK6-7				sT10_dT10_E15_SK6-7			
dε-MOEA vs. dCOEA	*p*-value	3.02E-11	3.02E-11	0.0144	1.49E-6	3.02E-11	3.02E-11	0.4119	0.2062
	sign	+	+	+	+	+	+	=	=
dε-MOEA vs. dε-MOEA-Deterministic	*p*-value	3.02E-11	7.39E-11	0.4204	2.78E-7	3.02E-11	5.09E-8	4.11E-7	0.7172
	sign	+	+	=	+	+	+	−	=
dε-MOEA vs. dε- MOEA-No-Sta	*p*-value	0.0077	0.0339	0.1335	0.0059	0.0333	0.7394	0.6204	0.9587
	sign	+	+	=	+	+	=	=	=
dε-MOEA vs. dε-MOEA-No-HI	*p*-value	1.09E-10	1.70E-8	0.0701	0.6204	4.98E-11	2.39E-8	2.39E-4	2.20E-7
	sign	+	+	=	=	+	+	−	−
Instance		sT20_dT10_E5_SK4-5				sT20_dT10_E10_SK4-5			
dε-MOEA vs. dCOEA	*p*-value	3.34E-11	4.50E-11	0.4464	7.09E-8	3.02E-11	3.02E-11	0.0657	6.01E-8
	sign	+	+	=	+	+	+	=	+
dε-MOEA vs. dε-MOEA-Deterministic	*p*-value	3.69E-11	8.89E-10	0.0303	1.07E-9	3.02E-11	4.20E-10	0.3871	5.60E-7
	sign	+	+	−	+	+	+	=	+
dε-MOEA vs. dε- MOEA-No-Sta	*p*-value	0.0446	0.9117	0.0228	0.0258	0.0396	0.9823	0.0024	0.0097
	sign	+	=	+	+	+	=	+	+
dε-MOEA vs. dε-MOEA-No-HI	*p*-value	1.33E-10	1.07E-9	0.0099	0.0611	6.70E-11	3.82E-10	0.9234	6.53E-7
	sign	+	+	+	=	+	+	=	+
Instance		sT20_dT10_E15_SK4-5				sT20_dT10_E5_SK6-7			
dε-MOEA vs. dCOEA	*p*-value	3.02E-11	3.69E-11	0.0748	3.50E-9	3.02E-11	3.02E-11	8.20E-7	7.39E-11
	sign	+	+	=	+	+	+	+	+
dε-MOEA vs. dε-MOEA-Deterministic	*p*-value	3.02E-11	3.69E-11	0.4290	4.42E-6	3.02E-11	3.34E-11	3.18E-4	3.02E-11
	sign	+	+	=	+	+	+	+	+
dε-MOEA vs. dε- MOEA-No-Sta	*p*-value	0.6735	0.9352	0.2226	0.0304	0.0242	0.0020	8.29E-6	2.78E-7
	sign	=	=	=	+	+	+	+	+
dε-MOEA vs. dε-MOEA-No-HI	*p*-value	3.02E-11	4.08E-11	3.37E-4	0.8650	3.02E-11	3.34E-11	3.08E-8	0.0016
	sign	+	+	+	=	+	+	+	+
Instance		sT20_dT10_E10_SK6-7				sT20_dT10_E15_SK6-7			
dε-MOEA vs. dCOEA	*p*-value	3.02E-11	3.02E-11	0.7172	4.74E-6	3.02E-11	3.02E-11	2.3704	1.85E-8
	sign	+	+	=	+	+	+	+	+
dε-MOEA vs. dε-MOEA-Deterministic	*p*-value	3.02E-11	1.85E-8	0.1958	2.88E-6	3.02E-11	2.37E-10	0.4284	1.70E-8
	sign	+	+	=	+	+	+	=	+
dε-MOEA vs. dε- MOEA-No-Sta	*p*-value	0.0149	0.9823	0.0436	0.0451	0.0234	0.0137	0.0752	0.0080
	sign	+	=	+	+	+	+	=	+
dε-MOEA vs. dε-MOEA-No-HI	*p*-value	3.02E-11	4.62E-10	0.8650	0.0364	3.02E-11	3.34E-11	0.7189	6.53E-7
	sign	+	+	=	−	+	+	=	−

Instance		sT30_dT10_E5_SK4-5				sT30_dT10_E10_SK4-5			
dε-MOEA vs. dCOEA	*p*-value	3.68E-11	4.18E-9	0.0169	0.0010	3.02E-11	3.02E-11	3.37E-5	0.0317
	sign	+	+	−	+	+	+	−	+
dε-MOEA vs. dε-MOEA-Deterministic	*p*-value	1.19E-10	5.97E-9	0.0037	3.35E-4	3.02E-11	1.29E-9	7.20E-5	0.9705
	sign	+	+	+	+	+	+	−	=
dε-MOEA vs. dε- MOEA-No-Sta	*p*-value	0.0115	0.0217	0.6681	0.0176	0.7958	0.7958	0.9470	0.9000
	sign	+	+	=	+	=	=	=	=
dε-MOEA vs. dε-MOEA-No-HI	*p*-value	2.61E-10	1.85E-8	0.9646	0.1223	3.02E-11	1.21E-10	0.0024	6.73E-6
	sign	+	+	=	+	+	+	−	−
Instance		sT30_dT10_E15_SK4-5				sT30_dT10_E5_SK6-7			
dε-MOEA vs. dCOEA	*p*-value	3.02E-11	4.08E-11	5.09E-6	6.91E-4	3.02E-11	3.02E-11	3.83E-5	1.75E-5
	sign	+	+	−	+	+	+	−	+
dε-MOEA vs. dε-MOEA-Deterministic	*p*-value	3.02E-11	4.62E-10	2.01E-4	0.2973	3.02E-11	1.09E-10	1.25E-4	9.51E-6
	sign	+	+	−	=	+	+	−	+
dε-MOEA vs. dε- MOEA-No-Sta	*p*-value	0.0348	0.0378	0.0056	0.0479	0.5997	0.9941	0.0172	0.4290
	sign	+	+	+	+	=	=	+	=
dε-MOEA vs. dε- MOEA-No-HI	*p*-value	3.69E-11	6.52E-9	1.17E-4	3.82E-10	3.02E-11	6.70E-11	0.0364	0.2581
	sign	+	+	−	−	+	+	−	=
Instance		sT30_dT10_E10_SK6-7				sT30_dT10_E15_SK6-7			
dε-MOEA vs. dCOEA	*p*-value	3.02E-11	3.02E-11	0.9705	0.0042	3.02E-11	4.50E-11	0.0091	0.0519
	sign	+	+	=	+	+	+	+	=
dε-MOEA vs. dε-MOEA-Deterministic	*p*-value	3.02E-11	4.08E-11	0.0436	0.0993	3.02E-11	1.41E-9	0.8303	0.0032
	sign	+	+	−	=	+	+	=	−
dε-MOEA vs. dε- MOEA-No-Sta	*p*-value	0.5201	0.5011	0.0877	0.0455	0.8187	0.6204	0.0170	0.3871
	sign	=	=	=	+	=	=	+	=
dε-MOEA vs. dε-MOEA-No-HI	*p*-value	3.02E-11	3.02E-11	0.0056	1.09E-5	3.02E-11	6.70E-11	0.5895	1.61E-10
	sign	+	+	−	−	+	+	=	−
Instance		Real_1				Real_2			
dε-MOEA vs. dCOEA	*p*-value	0.0015	2.87E-5	0.2066	0.0972	3.23E-7	3.23E-7	1.56E-4	0.0354
	sign	+	+	=	=	+	+	+	+
dε-MOEA vs. dε- MOEA-Deterministic	*p*-value	0.0059	0.0404	3.59E-6	6.10E-5	3.23E-7	3.23E-7	0.0598	1.64E-6
	sign	+	+	−	+	+	+	=	+
dε-MOEA vs. dε-MOEA-No-Sta	*p*-value	0.0215	0.9399	0.2343	0.4739	0.0489	0.0302	0.0257	0.1592
	sign	+	=	=	=	+	+	+	=
dε-MOEA vs. dε-MOEA-No-HI	*p*-value	0.0022	9.10E-4	0.5094	2.34E-5	3.23E-7	3.23E-7	0.0480	0.3038
	sign	+	+	=	+	+	+	+	=
Instance		Real_3							
dε-MOEA vs. dCOEA	*p*-value	6.64E-9	6.64E-9	0.1188	0.4958				
	sign	+	+	=	=				
dε-MOEA vs. dε- MOEA-Deterministic	*p*-value	6.64E-9	6.50E-8	3.99E-5	5.18E-4				
	sign	+	+	−	+				
dε-MOEA vs. dε- MOEA-No-Sta	*p*-value	0.0388	0.7252	0.2355	0.2817				
	sign	+	=	=	=				
dε-MOEA vs. dε- MOEA-No-HI	*p*-value	6.64E-9	1.06E-7	0.8951	0.0028				
	sign	+	+	=	−				

TABLE B.2
THE OVERALL PERFORMANCE IMPROVEMENT (OR DETERIORATION) OF dε-MOEA OVER OTHER METHODS AND STATISTICAL TESTS OF THE OVERALL PERFORMANCE ON EACH OBJECTIVE ON THE 21 MODPSP INSTANCES (THE POSITIVE VALUE MEANS IMPROVEMENT AND IS IN BOLD. THE NEGATIVE VALUE MEANS DETERIORATION. THE SIGN OF '+/−/=' IN A VS. B INDICATES THAT ACCORDING TO THE OVERALL PERFORMANCE ON EACH OBJECTIVE, ALGORITHM A IS SIGNIFICANTLY BETTER THAN B, SIGNIFICANTLY WORSE THAN B, OR THERE IS NO SIGNIFICANT DIFFERENCE BETWEEN A AND B BASED ON THE WILCOXON RANK SUM TEST WITH THE SIGNIFICANCE LEVEL OF 0.05)

Objective	$duration_l$	$cost_l$	*robustness*	*stability*	$duration_l$	$cost_l$	*robustness*	*stability*
Instance	sT10_dT10_E5_SK4-5				sT10_dT10_E10_SK4-5			
dε-MOEA vs. dCOEA	**7.32%** (2.62E-11+)	**1.41%** (8.57E-7+)	**35.38%** (4.19E-17+)	**53.34%** (6.91E-16+)	**11.31%** (2.02E-18+)	**6.42%** (1.06E-19+)	**15.27%** (2.59E-14+)	**50.64%** (1.02E-22+)
dε-MOEA vs. dε- MOEA-Deterministic	-8.57% (0.0058−)	-4.06% (0.2969=)	**22.87%** (2.87E-17+)	**61.74%** (3.73E-16+)	-3.53% (0.0404−)	-0.32% (0.2110=)	**4.05%** (3.11E-12+)	**67.15%** (9.51E-23+)
dε-MOEA vs. dε- MOEA-No-Sta	-3.54% (4.21E-7−)	-2.04% (0.0031−)	-4.46% (0.0029−)	**20.21%** (5.91E-13+)	-5.31% (0.0035−)	-0.86% (0.0730=)	-2.08% (0.5286=)	**9.57%** (6.15E-6+)
dε-MOEA vs. dε- MOEA-No-HI	**2.79%** (0.0012+)	**1.37%** (4.71E-4+)	-2.71% (0.4692=)	**55.45%** (7.15E-16+)	**10.33%** (9.86E-16+)	**6.39%** (3.37E-17+)	-0.54% (0.0920=)	**49.87%** (1.05E-22+)
Instance	sT10_dT10_E15_SK4-5				sT10_dT10_E5_SK6-7			
dε-MOEA vs. dCOEA	**35.62%** (1.94E-21+)	**22.80%** (1.44E-21+)	**10.32%** (1.64E-10+)	**66.89%** (9.24E-22+)	**9.74%** (2.46E-17+)	**1.32%** (2.86E-9+)	**32.40%** (4.80E-22+)	**55.32%** (7.99E-21+)
dε-MOEA vs.	**12.13%**	**10.67%**	**23.00%**	**77.70%**	-5.20%	-0.11%	**23.37%**	**51.03%**

dε- MOEA-Deterministic	(6.70E-12+)	(8.91E-12+)	(1.02E-21+)	(9.24E-22+)	(0.0156−)	(0.0763=)	(3.04E-22+)	(4.74E-21+)
dε-MOEA vs. dε- MOEA-No-Sta	-3.88% (0.0204−)	-1.28% (0.0577=)	-2.42% (0.0094−)	**11.83%** (4.60E-6+)	-2.26% (9.70E-10−)	-1.00% (5.31E-6−)	-1.46% (1.10E-4−)	**26.36%** (1.94E-21+)
dε-MOEA vs. dε- MOEA-No-HI	**28.39%** (8.76E-21+)	**20.16%** (1.64E-20+)	-3.44% (1.07E-5−)	**64.82%** (9.24E-22+)	**1.51%** (1.59E-4+)	**1.43%** (4.25E-6+)	-1.29% (0.8428=)	**54.49%** (6.08E-21+)
Instance	sT10_dT10_E10_SK6-7				sT10_dT10_E15_SK6-7			
dε-MOEA vs. dCOEA	**24.17%** (2.28E-19+)	**9.17%** (3.09E-19+)	**17.39%** (8.91E-17+)	**60.70%** (1.94E-19+)	**27.04%** (7.81E-23+)	**13.53%** (2.33E-23+)	**0.30%** (0.2294=)	**65.50%** (2.16E-24+)
dε-MOEA vs. dε- MOEA-Deterministic	**1.23%** (6.90E-4+)	-0.25% (0.1514=)	**12.12%** (7.59E-18+)	**73.54%** (1.43E-19+)	-4.10% (0.1422=)	-0.58% (0.0560=)	**20.16%** (2.28E-18+)	**72.46%** (2.16E-24+)
dε-MOEA vs. dε- MOEA-No-Sta	-1.21% (3.91E-9−)	-2.79% (4.59E-10−)	-1.74% (0.0021−)	**24.91%** (3.43E-15+)	**2.32%** (0.0284+)	**1.92%** (0.0018+)	-0.01% (0.6546=)	**12.76%** (1.32E-6+)
dε-MOEA vs. dε- MOEA-No-HI	**10.39%** (3.66E-16+)	**3.09%** (1.03E-9+)	-1.37% (0.1870=)	**59.28%** (1.28E-19+)	**16.00%** (4.49E-21+)	**8.37%** (1.69E-21+)	-0.68% (0.6107=)	**60.18%** (2.16E-24+)
Instance	sT20_dT10_E5_SK4-5				sT20_dT10_E10_SK4-5			
dε-MOEA vs. dCOEA	**6.03%** (1.13E-7+)	**0.77%** (0.1652=)	**33.39%** (1.05E-18+)	**53.40%** (9.04E-19+)	**19.32%** (8.34E-18+)	**14.30%** (1.93E-20+)	**22.30%** (1.43E-17+)	**67.32%** (5.58E-21+)
dε-MOEA vs. dε- MOEA-Deterministic	-3.84% (0.0719=)	-1.13% (0.7140=)	**9.99%** (1.28E-16+)	**67.39%** (8.53E-19+)	-2.19% (0.2016=)	**1.79%** (9.32E-6+)	**11.96%** (4.00E-14+)	**80.16%** (4.21E-21+)
dε-MOEA vs. dε- MOEA-No-Sta	-3.50% (7.99E-10−)	-1.23% (7.93E-5−)	-2.73% (2.74E-4−)	**19.78%** (1.31E-14+)	-1.24% (8.89E-8−)	-3.89% (6.45E-9−)	-3.33% (0.0012−)	**19.58%** (5.98E-13+)
dε-MOEA vs. dε- MOEA-No-HI	**1.28%** (0.0374+)	**1.43%** (0.0064+)	**0.077%** (0.6639=)	**54.09%** (8.78E-19+)	**12.67%** (2.22E-11+)	**10.68%** (2.11E-17+)	**4.35%** (5.34E-4+)	**66.00%** (6.84E-21+)
Instance	sT20_dT10_E15_SK4-5				sT20_dT10_E5_SK6-7			
dε-MOEA vs. dCOEA	**33.28%** (2.53E-32+)	**18.22%** (7.69E-32+)	**10.46%** (1.70E-20+)	**64.87%** (4.41E-32+)	**9.52%** (5.59E-17+)	**5.78%** (6.39E-23+)	**23.68%** (1.00E-23+)	**66.19%** (1.43E-23+)
dε-MOEA vs. dε- MOEA-Deterministic	**6.34%** (4.85E-14+)	**4.20%** (2.28E-16+)	**13.96%** (6.12E-30+)	**79.65%** (1.35E-32+)	-5.60% (3.24E-7−)	**1.14%** (1.49E-4+)	**21.40%** (9.80E-24+)	**80.40%** (1.43E-23+)
dε-MOEA vs. dε- MOEA-No-Sta	-2.72% (2.40E-7−)	-0.57% (0.3135=)	-2.34% (2.93E-7−)	**8.24%** (2.04E-8+)	-5.89% (2.81E-23−)	-1.79% (4.67E-19−)	-2.90% (4.83E-9−)	**48.15%** (1.43E-23+)
dε-MOEA vs. dε- MOEA-No-HI	**21.31%** (5.84E-31+)	**11.45%** (1.13E-29+)	**5.23%** (5.32E-14+)	**65.86%** (2.02E-32+)	**0.60%** (0.0862=)	**2.71%** (1.44E-13+)	-2.82% (4.16E-5−)	**64.96%** (1.43E-23+)
Instance	sT20_dT10_E10_SK6-7				sT20_dT10_E15_SK6-7			
dε-MOEA vs. dCOEA	**17.35%** (2.19E-29+)	**9.63%** (3.02E-29+)	**22.48%** (5.05E-27+)	**61.74%** (1.91E-31+)	**18.29%** (1.80E-25+)	**9.37%** (2.49E-24+)	**28.05%** (2.38E-25+)	**64.06%** (1.90E-27+)
dε-MOEA vs. dε- MOEA-Deterministic	-0.67% (0.0631=)	**3.79%** (2.66E-15+)	**14.3%** (6.26E-25+)	**75.69%** (1.87E-31+)	-12.32% (5.72E-9−)	-0.60% (0.0640=)	**26.08%** (1.73E-27+)	**70.02%** (1.63E-27+)
dε-MOEA vs. dε- MOEA-No-Sta	-2.41% (6.63E-10−)	-0.72% (0.1225=)	-2.14% (0.0103−)	**16.66%** (9.19E-15+)	-2.66% (3.22E-4−)	-0.26% (0.0877=)	-6.68% (1.53E-4−)	**21.05%** (9.04E-17+)
dε-MOEA vs. dε- MOEA-No-HI	**11.22%** (1.79E-20+)	**9.01%** (2.30E-27+)	-0.99% (0.2769=)	**60.97%** (1.87E-31+)	**6.76%** (1.03E-14+)	**4.89%** (4.10E-18+)	-1.15% (0.6979=)	**62.66%** (1.66E-27+)
Instance	sT30_dT10_E5_SK4-5				sT30_dT10_E10_SK4-5			
dε-MOEA vs. dCOEA	**5.98%** (4.69E-5+)	**2.45%** (0.0045+)	**43.13%** (2.10E-19+)	**62.90%** (2.15E-19+)	**14.60%** (1.46E-13+)	**10.22%** (1.20E-19+)	**23.01%** (5.44E-19+)	**62.78%** (9.24E-22+)
dε-MOEA vs. dε- MOEA-Deterministic	-7.10% (0.0017−)	**0.13%** (0.1761=)	**21.65%** (3.11E-17+)	**69.46%** (1.87E-19+)	-5.50% (0.0069−)	**1.93%** (4.85E-4+)	**19.22%** (1.21E-21+)	**74.34%** (9.71E-22+)
dε-MOEA vs. dε- MOEA-No-Sta	-3.97% (2.33E-7−)	-1.62% (6.14E-7−)	-5.92% (4.21E-7−)	**24.69%** (2.13E-16+)	-1.28% (0.0100−)	-0.0052% (0.3458=)	-2.28% (0.0268−)	**22.46%** (5.60E-12+)
dε-MOEA vs. dε- MOEA-No-HI	**0.34%** (0.7844=)	**2.16%** (9.07E-4+)	-0.013% (0.8906=)	**66.72%** (1.87E-19+)	**8.63%** (2.37E-7+)	**8.04%** (2.38E-17+)	-0.93% (0.7993=)	**63.80%** (9.47E-22+)
Instance	sT30_dT10_E15_SK4-5				sT30_dT10_E5_SK6-7			
dε-MOEA vs. dCOEA	**18.78%** (3.29E-30+)	**8.45%** (6.66E-26+)	**8.74%** (1.53E-22+)	**64.34%** (5.82E-31+)	**6.00%** (1.65E-18+)	**3.03%** (4.40E-15+)	**3.082%** (9.06E-31+)	**63.00%** (6.24E-32+)
dε-MOEA vs. dε- MOEA-Deterministic	-3.91% (1.61E-10−)	**1.97%** (9.28E-8+)	**41.17%** (5.82E-31+)	**83.53%** (5.82E-31+)	-1.34% (0.0768=)	**2.11%** (6.96E-11+)	**13.45%** (1.72E-30+)	**75.90%** (6.04E-32+)
dε-MOEA vs. dε- MOEA-No-Sta	-2.66% (7.23E-4−)	-0.96% (0.0673=)	-0.41% (0.5855=)	**38.70%** (6.12E-28+)	-1.31% (3.77E-11−)	-0.84% (1.23E-7−)	-1.97% (0.0022−)	**17.39%** (1.28E-17+)
dε-MOEA vs. dε- MOEA-No-HI	**8.73%** (1.37E-20+)	**5.39%** (8.66E-13+)	-5.42% (0.0398−)	**64.71%** (5.92E-31+)	**3.22%** (5.56E-8+)	**4.38%** (2.46E-23+)	-2.62% (3.51E-4+)	**64.68%** (6.24E-32+)
Instance	sT30_dT10_E10_SK6-7				sT30_dT10_E15_SK6-7			
dε-MOEA vs. dCOEA	**16.37%** (1.78E-32+)	**4.69%** (2.95E-29+)	**19.78%** (5.28E-33+)	**65.01%** (1.38E-33+)	**20.35%** (2.30E-28+)	**8.19%** (2.47E-28+)	**2.49%** (3.69E-4+)	**69.50%** (5.42E-29+)
dε-MOEA vs. dε- MOEA-Deterministic	**1.00%** (6.40E-11+)	**0.52%** (1.69E-11+)	**20.39%** (1.52E-33+)	**75.56%** (1.38E-33+)	**0.98%** (0.0618=)	**1.42%** (7.77E-4+)	**15.62%** (3.12E-28+)	**79.48%** (5.42E-29+)
dε-MOEA vs. dε- MOEA-No-Sta	-1.71% (8.54E-6−)	-1.59% (3.22E-10−)	-1.25% (0.0153−)	**10.58%** (4.72E-7+)	-0.96% (1.29E-4−)	-0.37% (0.0266=)	-1.29% (0.0080−)	**9.71%** (2.46E-7+)
dε-MOEA vs. dε- MOEA-No-HI	**10.11%** (8.10E-30+)	**3.24%** (1.19E-25+)	**0.63%** (0.0841=)	**64.01%** (1.47E-33+)	**10.86%** (5.02E-22+)	**4.72%** (1.15E-24+)	**2.80%** (7.83E-5+)	**68.89%** (5.42E-29+)
Instance	Real_1				Real_2			
dε-MOEA vs. dCOEA	**16.89%** (1.83E-4+)	**13.46%** (1.83E-4+)	**38.41%** (0.0054+)	**64.87%** (4.88E-4+)	**18.48%** (1.96E-4+)	**28.51%** (1.96E-4+)	**67.20%** (2.33E-4+)	**68.34%** (1.96E-4+)
dε-MOEA vs. dε- MOEA-Deterministic	-9.04% (0.0554−)	-8.72% (0.0353−)	**43.97%** (6.10E-5+)	**80.40%** (2.44E-4+)	**1.88%** (0.2311=)	**6.73%** (3.27E-4+)	**38.24%** (1.96E-4+)	**90.24%** (1.96E-4+)
dε-MOEA vs. dε- MOEA-No-Sta	**0.90%** (0.6788=)	**0.82%** (0.5245=)	-2.45% (0.3591=)	**37.43%** (0.0012+)	-1.16% (0.0311−)	-0.42% (0.0707=)	-2.08% (0.3061=)	**32.08%** (8.63E-4+)

dε-MOEA vs. dε- MOEA-No-HI	**6.76%** (4.27E-4+)	**9.57%** (8.54E-4+)	**2.30%** (0.1876=)	**67.99%** (2.44E-4+)	**9.73%** (1.96E-4+)	**9.37%** (1.96E-4+)	-2.03% (0.5862=)	**66.17%** (1.96E-4+)
Instance	Real_3							
dε-MOEA vs. dCOEA	**15.81%** (2.70E-5+)	**28.01%** (3.09E-5+)	**45.64%** (5.95E-5+)	**67.41%** (2.70E-5+)				
dε-MOEA vs. dε- MOEA-Deterministic	**8.68%** (0.0026+)	**3.39%** (0.0308+)	**43.58%** (2.70E-5+)	**82.47%** (2.70E-5+)				
dε-MOEA vs. dε- MOEA-No-Sta	-0.68% (0.4291=)	-0.31% (0.6482=)	-8.60% (0.0017−)	**28.15%** (3.73E-11+)				
dε-MOEA vs. dε- MOEA-No-HI	**16.88%** (1.44E-4+)	**9.29%** (1.27E-4+)	-1.64% (0.4842=)	**66.63%** (2.70E-5+)				

The values in the parentheses are *p*-values obtained from Wilcoxon rank sum tests.