Output tables for the test of Multiple comparisons.

June 6, 2025

1 Average rankings of Friedman test

Average ranks obtained by applying the Friedman procedure

Friedman statistic considering reduction performance (distributed according to chi-square with 17 degrees of freedom: 353.454737.

P-value computed by Friedman Test: 1.3014056499116577E-10.

Iman and Davenport statistic considering reduction performance (distributed according to F-distribution with 17 and 408 degrees of freedom: 118.56709.

P-value computed by Iman and Daveport Test: -8.881784197001252E-16.

Algorithm	Ranking
BestCyclicAssignment	13.44
BestNearest	7.5
CLARA	12.12
CoefficientPropagation	12.52
CyclicAssignment	15.08
Farthest-First	5.38
KMEANS	5.86
NearestByCustomer	7.2
NearestByDepot	11.2
PAM	1
Parallel	7.2
RandomByElement	17.92
RandomSequentialCyclic	16.16
SequentialCyclic	16.04
Simplified	6.08
Sweep	6.18
ThreeCriteriaClustering	4.76
UPGMC	5.36

Table 1: Average Rankings of the algorithms

2 Post hoc comparisons

Results achieved on post hoc comparisons for $\alpha = 0.05$, $\alpha = 0.10$ and adjusted p-values.

2.1 P-values for $\alpha = 0.05$

Nemenyi's procedure rejects those hypotheses that have an unadjusted p-value ≤ 0.000327.
Holm's procedure rejects those hypotheses that have an unadjusted p-value ≤ 0.000667.
Shaffer's procedure rejects those hypotheses that have an unadjusted p-value ≤ 0.000327.

i	algorithms	$z = (R_0 - R_i)/SE$	p	Holm
153	PAM vs. RandomByElement	11.205544	0	0.000327
152	PAM vs. RandomSequentialCyclic	10.039955	0	0.000329
151	PAM vs. SequentialCyclic	9.960483	0	0.000331
150	CyclicAssignment vs. PAM	9.324708	0	0.000333
149	RandomByElement vs. ThreeCriteriaClustering	8.715423	0	0.000336
148	RandomByElement vs. UPGMC	8.318063	0	0.000338
147	Farthest-First vs. RandomByElement	8.304818	0	0.00034
146	BestCyclicAssignment vs. PAM	8.238591	0	0.000342
145	KMEANS vs. RandomByElement	7.98693	0	0.000345
144	RandomByElement vs. Simplified	7.841232	0	0.000347
143	RandomByElement vs. Sweep	7.775005	0	0.00035
142	CoefficientPropagation vs. PAM	7.629306	0	0.000352
141	RandomSequentialCyclic vs. ThreeCriteriaClustering	7.549834	0	0.000355
140	SequentialCyclic vs. ThreeCriteriaClustering	7.470362	0	0.000357
139	CLARA vs. PAM	7.3644	0	0.00036
138	RandomSequentialCyclic vs. UPGMC	7.152475	0	0.000362
137	Farthest-First vs. RandomSequentialCyclic	7.139229	0	0.000365
136	NearestByCustomer vs. RandomByElement	7.099493	0	0.000368
135	Parallel vs. RandomByElement	7.099493	0	0.00037
134	SequentialCyclic vs. UPGMC	7.073003	0	0.000373
133	Farthest-First vs. SequentialCyclic	7.059757	0	0.000376
132	BestNearest vs. RandomByElement	6.900814	0	0.000379
131	CyclicAssignment vs. ThreeCriteriaClustering	6.834587	0	0.000382
130	KMEANS vs. RandomSequentialCyclic	6.821342	0	0.000385
129	NearestByDepot vs. PAM	6.755115	0	0.000388
128	KMEANS vs. SequentialCyclic	6.74187	0	0.000391
127	RandomSequentialCyclic vs. Simplified	6.675643	0	0.000394
126	RandomSequentialCyclic vs. Sweep	6.609416	0	0.000397
125	SequentialCyclic vs. Simplified	6.596171	0	0.0004
124	SequentialCyclic vs. Sweep	6.529945	0	0.000403
123	CyclicAssignment vs. UPGMC	6.437227	0	0.000407
122	CyclicAssignment vs. Farthest-First	6.423982	0	0.00041
121	CyclicAssignment vs. KMEANS	6.106094	0	0.000413
120	CyclicAssignment vs. Simplified	5.960396	0	0.000417
119	NearestByCustomer vs. RandomSequentialCyclic	5.933905	0	0.00042
118	Parallel vs. RandomSequentialCyclic	5.933905	0	0.000424
117	CyclicAssignment vs. Sweep	5.894169	0	0.000427
116	NearestByCustomer vs. SequentialCyclic	5.854433	0	0.000431
115	Parallel vs. SequentialCyclic	5.854433	0	0.000435
114	BestCyclicAssignment vs. ThreeCriteriaClustering	5.74847	0	0.000439
113	BestNearest vs. RandomSequentialCyclic	5.735225	0	0.000442
112	BestNearest vs. SequentialCyclic	5.655753	0	0.000446
111	BestCyclicAssignment vs. UPGMC	5.351111	0	0.00045
110	BestCyclicAssignment vs. Farthest-First	5.337865	0	0.000455
109	CyclicAssignment vs. NearestByCustomer	5.218657	0	0.000459
108	CyclicAssignment vs. Parallel	5.218657	0	0.000463
107	CoefficientPropagation vs. ThreeCriteriaClustering	5.139186	0	0.000467
106	BestCyclicAssignment vs. KMEANS	5.019978	0.000001	0.000472
105	BestNearest vs. CyclicAssignment	5.019978	0.000001	0.000476
104	BestCyclicAssignment vs. Simplified	4.874279	0.000001	0.000481
103	CLARA vs. ThreeCriteriaClustering	4.874279	0.000001	0.000485
102	BestCyclicAssignment vs. Sweep	4.808052	0.000002	0.00049
101	CoefficientPropagation vs. UPGMC	4.741826	0.000002	0.000495
100	CoefficientPropagation vs. Farthest-First	4.728581	0.000002	0.0005
99	CLARA vs. UPGMC	4.476919	0.000008	0.000505
98	CLARA vs. Farthest-First	4.463674	0.000008	0.00051
97	NearestByDepot vs. RandomByElement	4.450429	0.000009	0.000515
96	CoefficientPropagation vs. KMEANS	4.410693	0.00001	0.000521
95	BestNearest vs. PAM	4.30473	0.000017	0.000526
94	NearestByDepot vs. ThreeCriteriaClustering	4.264994	0.00002	0.000532
93	CoefficientPropagation vs. Simplified	4.264994	0.00002	0.000538
92	CoefficientPropagation vs. Sweep	4.198768	0.000027	0.000543
91	CLARA vs. KMEANS	4.145786	0.000034	0.000549
90	BestCyclicAssignment vs. NearestByCustomer	4.132541	0.000036	0.000556
89	BestCyclicAssignment vs. Parallel	4.132541	0.000036	0.000562
88	NearestByCustomer vs. PAM	4.10605	0.00004	0.000568
87	PAM vs. Parallel	4.10605	0.00004	0.000575
86	CLARA vs. Simplified	4.000088	0.000063	0.000581
85	BestCyclicAssignment vs. BestNearest	3.933861	0.000084	0.000588
84	CLARA vs. Sweep	3.933861	0.000084	0.000595
83	NearestByDepot vs. UPGMC	3.867634	0.00011	0.000602
82	Farthest-First vs. NearestByDepot	3.854389	0.000116	0.00061
81	CLARA vs. RandomByElement	3.841144	0.000122	0.000617
80	CoefficientPropagation vs. RandomByElement	3.576237	0.000349	0.000625
79	KMEANS vs. NearestByDepot	3.536501	0.000405	0.000633
78	CoefficientPropagation vs. NearestByCustomer	3.523256	0.000426	0.000641
77	CoefficientPropagation vs. Parallel	3.523256	0.000426	0.000649
76	PAM vs. Sweep	3.430539	0.000602	0.000658
75	NearestByDepot vs. Simplified	3.390803	0.000697	0.000667
74	PAM vs. Simplified	3.364312	0.000767	0.000676
73	NearestByDepot vs. Sweep	3.324576	0.000886	0.000685
72	BestNearest vs. CoefficientPropagation	3.324576	0.000886	0.000694
71	NearestByDepot vs. RandomSequentialCyclic	3.28484	0.00102	0.000704
70	CLARA vs. NearestByCustomer	3.25835	0.001121	0.000714
69	CLARA vs. Parallel	3.25835	0.001121	0.000725
68	KMEANS vs. PAM	3.218614	0.001288	0.000735
67	NearestByDepot vs. SequentialCyclic	3.205368	0.001349	0.000746
66	BestNearest vs. CLARA	3.05967	0.002216	0.000758
65	BestCyclicAssignment vs. RandomByElement	2.966952	0.003008	0.000769

2.2 P-values for $\alpha = 0.10$

Nemenyi's procedure rejects those hypotheses that have an unadjusted p-value ≤ 0.000654.

Holm's procedure rejects those hypotheses that have an unadjusted p-value ≤ 0.001515.

Shaffer's procedure rejects those hypotheses that have an unadjusted p-value ≤ 0.000654.

i	algorithms	$z = (R_0 - R_i)/SE$	p	Holm
153	PAM vs. RandomByElement	11.205544	0	0.000654
152	PAM vs. RandomSequentialCyclic	10.039955	0	0.000658
151	PAM vs. SequentialCyclic	9.960483	0	0.000662
150	CyclicAssignment vs. PAM	9.324708	0	0.000667
149	RandomByElement vs. ThreeCriteriaClustering	8.715423	0	0.000671
148	RandomByElement vs. UPGMC	8.318063	0	0.000676
147	Farthest-First vs. RandomByElement	8.304818	0	0.00068
146	BestCyclicAssignment vs. PAM	8.238591	0	0.000685
145	KMEANS vs. RandomByElement	7.98693	0	0.00069
144	RandomByElement vs. Simplified	7.841232	0	0.000694
143	RandomByElement vs. Sweep	7.775005	0	0.000699
142	CoefficientPropagation vs. PAM	7.629306	0	0.000704
141	RandomSequentialCyclic vs. ThreeCriteriaClustering	7.549834	0	0.000709
140	SequentialCyclic vs. ThreeCriteriaClustering	7.470362	0	0.000714
139	CLARA vs. PAM	7.3644	0	0.000719
138	RandomSequentialCyclic vs. UPGMC	7.152475	0	0.000725
137	Farthest-First vs. RandomSequentialCyclic	7.139229	0	0.00073
136	NearestByCustomer vs. RandomByElement	7.099493	0	0.000735
135	Parallel vs. RandomByElement	7.099493	0	0.000741
134	SequentialCyclic vs. UPGMC	7.073003	0	0.000746
133	Farthest-First vs. SequentialCyclic	7.059757	0	0.000752
132	BestNearest vs. RandomByElement	6.900814	0	0.000758
131	CyclicAssignment vs. ThreeCriteriaClustering	6.834587	0	0.000763
130	KMEANS vs. RandomSequentialCyclic	6.821342	0	0.000769
129	NearestByDepot vs. PAM	6.755115	0	0.000775
128	KMEANS vs. SequentialCyclic	6.74187	0	0.000781
127	RandomSequentialCyclic vs. Simplified	6.675643	0	0.000787
126	RandomSequentialCyclic vs. Sweep	6.609416	0	0.000794
125	SequentialCyclic vs. Simplified	6.596171	0	0.0008
124	SequentialCyclic vs. Sweep	6.529945	0	0.000806
123	CyclicAssignment vs. UPGMC	6.437227	0	0.000813
122	CyclicAssignment vs. Farthest-First	6.423982	0	0.00082
121	CyclicAssignment vs. KMEANS	6.106094	0	0.000826
120	CyclicAssignment vs. Simplified	5.960396	0	0.000833
119	NearestByCustomer vs. RandomSequentialCyclic	5.933905	0	0.00084
118	Parallel vs. RandomSequentialCyclic	5.933905	0	0.000847
117	CyclicAssignment vs. Sweep	5.894169	0	0.000855
116	NearestByCustomer vs. SequentialCyclic	5.854433	0	0.000862
115	Parallel vs. SequentialCyclic	5.854433	0	0.00087
114	BestCyclicAssignment vs. ThreeCriteriaClustering	5.74847	0	0.000877
113	BestNearest vs. RandomSequentialCyclic	5.735225	0	0.000885
112	BestNearest vs. SequentialCyclic	5.655753	0	0.000893
111	BestCyclicAssignment vs. UPGMC	5.351111	0	0.000901
110	BestCyclicAssignment vs. Farthest-First	5.337865	0	0.000909
109	CyclicAssignment vs. NearestByCustomer	5.218657	0	0.000917
108	CyclicAssignment vs. Parallel	5.218657	0	0.000926
107	CoefficientPropagation vs. ThreeCriteriaClustering	5.139186	0	0.000935
106	BestCyclicAssignment vs. KMEANS	5.019978	0.000001	0.000943
105	BestNearest vs. CyclicAssignment	5.019978	0.000001	0.000952
104	BestCyclicAssignment vs. Simplified	4.874279	0.000001	0.000962
103	CLARA vs. ThreeCriteriaClustering	4.874279	0.000001	0.000971
102	BestCyclicAssignment vs. Sweep	4.808052	0.000002	0.00098
101	CoefficientPropagation vs. UPGMC	4.741826	0.000002	0.00099
100	CoefficientPropagation vs. Farthest-First	4.728581	0.000002	0.001
99	CLARA vs. UPGMC	4.476919	0.000008	0.00101
98	CLARA vs. Farthest-First	4.463674	0.000008	0.00102
97	NearestByDepot vs. RandomByElement	4.450429	0.000009	0.001031
96	CoefficientPropagation vs. KMEANS	4.410693	0.00001	0.001042
95	BestNearest vs. PAM	4.30473	0.000017	0.001053
94	NearestByDepot vs. ThreeCriteriaClustering	4.264994	0.00002	0.001064
93	CoefficientPropagation vs. Simplified	4.264994	0.00002	0.001075
92	CoefficientPropagation vs. Sweep	4.198768	0.000027	0.001087
91	CLARA vs. KMEANS	4.145786	0.000034	0.001099
90	BestCyclicAssignment vs. NearestByCustomer	4.132541	0.000036	0.001111
89	BestCyclicAssignment vs. Parallel	4.132541	0.000036	0.001124
88	NearestByCustomer vs. PAM	4.10605	0.00004	0.001136
87	PAM vs. Parallel	4.10605	0.00004	0.001149
86	CLARA vs. Simplified	4.000088	0.000063	0.001163
85	BestCyclicAssignment vs. BestNearest	3.933861	0.000084	0.001176
84	CLARA vs. Sweep	3.933861	0.000084	0.00119
83	NearestByDepot vs. UPGMC	3.867634	0.00011	0.001205
82	Farthest-First vs. NearestByDepot	3.854389	0.000116	0.00122
81	CLARA vs. RandomByElement	3.841144	0.000122	0.001235
80	CoefficientPropagation vs. RandomByElement	3.576237	0.000349	0.00125
79	KMEANS vs. NearestByDepot	3.536501	0.000405	0.001266
78	CoefficientPropagation vs. NearestByCustomer	3.523256	0.000426	0.001282
77	CoefficientPropagation vs. Parallel	3.523256	0.000426	0.001299
76	PAM vs. Sweep	3.430539	0.000602	0.001316
75	NearestByDepot vs. Simplified	3.390803	0.000697	0.001333
74	PAM vs. Simplified	3.364312	0.000767	0.001351
73	NearestByDepot vs. Sweep	3.324576	0.000886	0.00137
72	BestNearest vs. CoefficientPropagation	3.324576	0.000886	0.001389
71	NearestByDepot vs. RandomSequentialCyclic	3.28484	0.00102	0.001408
70	CLARA vs. NearestByCustomer	3.25835	0.001121	0.001429
69	CLARA vs. Parallel	3.25835	0.001121	0.001449
68	KMEANS vs. PAM	3.218614	0.001288	0.001471
67	NearestByDepot vs. SequentialCyclic	3.205368	0.001349	0.001493
66	BestNearest vs. CLARA	3.05967	0.002216	0.001515
65	BestCyclicAssignment vs. RandomByElement	2.966952	0.003008	0.001538

2.3 Adjusted p-values

i	hypothesis	unadjusted p	p_{Neme}	p_{Holm}	p_{Sh}
1	PAM vs .RandomByElement	0	0	0	0
2	PAM vs .RandomSequentialCyclic	0	0	0	0
3	PAM vs .SequentialCyclic	0	0	0	0
4	CyclicAssignment vs .PAM	0	0	0	0
5	RandomByElement vs .ThreeCriteriaClustering	0	0	0	0
6	RandomByElement vs .UPGMC	0	0	0	0
7	Farthest-First vs .RandomByElement	0	0	0	0
8	BestCyclicAssignment vs .PAM	0	0	0	0
9	KMEANS vs .RandomByElement	0	0	0	0
10	RandomByElement vs .Simplified	0	0	0	0
11	RandomByElement vs .Sweep	0	0	0	0
12	CoefficientPropagation vs .PAM	0	0	0	0
13	RandomSequentialCyclic vs .ThreeCriteriaClustering	0	0	0	0
14	SequentialCyclic vs .ThreeCriteriaClustering	0	0	0	0
15	CLARA vs .PAM	0	0	0	0
16	RandomSequentialCyclic vs .UPGMC	0	0	0	0
17	Farthest-First vs .RandomSequentialCyclic	0	0	0	0
18	NearestByCustomer vs .RandomByElement	0	0	0	0
19	Parallel vs .RandomByElement	0	0	0	0
20	SequentialCyclic vs .UPGMC	0	0	0	0
21	Farthest-First vs .SequentialCyclic	0	0	0	0
22	BestNearest vs .RandomByElement	0	0	0	0
23	CyclicAssignment vs .ThreeCriteriaClustering	0	0	0	0
24	KMEANS vs .RandomSequentialCyclic	0	0	0	0
25	NearestByDepot vs .PAM	0	0	0	0
26	KMEANS vs .SequentialCyclic	0	0	0	0
27	RandomSequentialCyclic vs .Simplified	0	0	0	0
28	RandomSequentialCyclic vs .Sweep	0	0	0	0
29	SequentialCyclic vs .Simplified	0	0	0	0
30	SequentialCyclic vs .Sweep	0	0	0	0
31	CyclicAssignment vs .UPGMC	0	0	0	0
32	CyclicAssignment vs .Farthest-First	0	0	0	0
33	CyclicAssignment vs .KMEANS	0	0	0	0
34	CyclicAssignment vs .Simplified	0	0	0	0
35	NearestByCustomer vs .RandomSequentialCyclic	0	0	0	0
36	Parallel vs .RandomSequentialCyclic	0	0	0	0
37	CyclicAssignment vs .Sweep	0	0.000001	0	0
38	NearestByCustomer vs .SequentialCyclic	0	0.000001	0.000001	0.000
39	Parallel vs .SequentialCyclic	0	0.000001	0.000001	0.000
40	BestCyclicAssignment vs .ThreeCriteriaClustering	0	0.000001	0.000001	0.000
41	BestNearest vs .RandomSequentialCyclic	0	0.000001	0.000001	0.000
42	BestNearest vs .SequentialCyclic	0	0.000002	0.000002	0.000
43	BestCyclicAssignment vs .UPGMC	0	0.000013	0.00001	0.000
44	BestCyclicAssignment vs .Farthest-First	0	0.000014	0.00001	0.000
45	CyclicAssignment vs .NearestByCustomer	0	0.000028	0.00002	0.000
46	CyclicAssignment vs .Parallel	0	0.000028	0.00002	0.000
47	CoefficientPropagation vs .ThreeCriteriaClustering	0	0.000042	0.00003	0.000
48	BestCyclicAssignment vs .KMEANS	0.000001	0.000079	0.000055	0.000
49	BestNearest vs .CyclicAssignment	0.000001	0.000079	0.000055	0.000
50	BestCyclicAssignment vs .Simplified	0.000001	0.000167	0.000114	0.000
51	CLARA vs .ThreeCriteriaClustering	0.000001	0.000167	0.000114	0.000
52	BestCyclicAssignment vs .Sweep	0.000002	0.000233	0.000155	0.000
53	CoefficientPropagation vs .UPGMC	0.000002	0.000324	0.000214	0.000
54	CoefficientPropagation vs .Farthest-First	0.000002	0.000346	0.000226	0.000
55	CLARA vs .UPGMC	0.000008	0.001159	0.00075	0.000
56	CLARA vs .Farthest-First	0.000008	0.001233	0.00079	0.000
57	NearestByDepot vs .RandomByElement	0.000009	0.001311	0.000831	0.000
58	CoefficientPropagation vs .KMEANS	0.00001	0.001577	0.000989	0.000
59	BestNearest vs .PAM	0.000017	0.002558	0.001588	0.001
60	NearestByDepot vs .ThreeCriteriaClustering	0.00002	0.003059	0.001879	0.001
61	CoefficientPropagation vs .Simplified	0.00002	0.003059	0.001879	0.001
62	CoefficientPropagation vs .Sweep	0.000027	0.004106	0.002469	0.002
63	CLARA vs .KMEANS	0.000034	0.005181	0.003082	0.003
64	BestCyclicAssignment vs .NearestByCustomer	0.000036	0.005489	0.003229	0.003
65	BestCyclicAssignment vs .Parallel	0.000036	0.005489	0.003229	0.003
66	NearestByCustomer vs .PAM	0.00004	0.006158	0.003542	0.003
67	PAM vs .Parallel	0.00004	0.006158	0.003542	0.003
68	CLARA vs .Simplified	0.000063	0.009688	0.005445	0.005
69	BestCyclicAssignment vs .BestNearest	0.000084	0.01279	0.007105	0.007
70	CLARA vs .Sweep	0.000084	0.01279	0.007105	0.007
71	NearestByDepot vs .UPGMC	0.00011	0.016814	0.009121	0.009
72	Farthest-First vs .NearestByDepot	0.000116	0.017751	0.009514	0.009
73	CLARA vs .RandomByElement	0.000122	0.018737	0.009919	0.009
74	CoefficientPropagation vs .RandomByElement	0.000349	0.053332	0.027886	0.027
75	KMEANS vs .NearestByDepot	0.000405	0.062036	0.032032	0.032
76	CoefficientPropagation vs .NearestByCustomer	0.000426	0.065221	0.03325	0.033
77	CoefficientPropagation vs .Parallel	0.000426	0.065221	0.03325	0.033
78	PAM vs .Sweep	0.000602	0.092165	0.045781	0.045
79	NearestByDepot vs .Simplified	0.000697	0.106623	0.052266	0.050
80	PAM vs .Simplified	0.000767	0.117404	0.056784	0.056
81	NearestByDepot vs .Sweep	0.000886	0.135486	0.064644	0.064
82	BestNearest vs .CoefficientPropagation	0.000886	0.135486	0.064644	0.064
83	NearestByDepot vs .RandomSequentialCyclic	0.00102	0.156122	0.072449	0.071
84	CLARA vs .NearestByCustomer	0.001121	0.171455	0.078444	0.078
85	CLARA vs .Parallel	0.001121	0.171455	0.078444	0.078
86	KMEANS vs .PAM	0.001288	0.197082	0.087592	0.087
87	NearestByDepot vs .SequentialCyclic	0.001349	0.206381	0.090376	0.090
88	BestNearest vs .CLARA	0.002216	0.339019	0.146244	0.146
89	BestCyclicAssignment vs .RandomByElement	0.003008	0.460174	0.195499	0.195