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: 342.757193.

P-value computed by Friedman Test: 1.5225865013235307E-10.

Iman and Davenport statistic considering reduction performance (distributed according to F-distribution with 17 and 408 degrees of freedom: 100.023004.

P-value computed by Iman and Daveport Test: 4.440892098500626E-16.

Algorithm	Ranking
BestCyclicAssignment	13.12
BestNearest	7.1
CLARA	12.72
CoefficientPropagation	12.36
CyclicAssignment	14.84
Farthest-First	5.42
KMEANS	5.78
NearestByCustomer	6.88
NearestByDepot	10.68
PAM	1
Parallel	6.88
RandomByElement	18
RandomSequentialCyclic	15.96
SequentialCyclic	15.96
Simplified	5.88
Sweep	5.74
ThreeCriteriaClustering	4.92
UPGMC	7.76

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 ≤ 0.000685.
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	11.258525	0	0.000327
152	PAM vs. RandomSequentialCyclic	9.907502	0	0.000329
151	PAM vs. SequentialCyclic	9.907502	0	0.000331
150	CyclicAssignment vs. PAM	9.165764	0	0.000333
149	RandomByElement vs. ThreeCriteriaClustering	8.662442	0	0.000336
148	Farthest-First vs. RandomByElement	8.331309	0	0.000338
147	RandomByElement vs. Sweep	8.119383	0	0.00034
146	KMEANS vs. RandomByElement	8.092893	0	0.000342
145	RandomByElement vs. Simplified	8.026666	0	0.000345
144	BestCyclicAssignment vs. PAM	8.026666	0	0.000347
143	CLARA vs. PAM	7.76176	0	0.00035
142	CoefficientPropagation vs. PAM	7.523344	0	0.000352
141	NearestByCustomer vs. RandomByElement	7.3644	0	0.000355
140	Parallel vs. RandomByElement	7.3644	0	0.000357
139	RandomSequentialCyclic vs. ThreeCriteriaClustering	7.311419	0	0.00036
138	SequentialCyclic vs. ThreeCriteriaClustering	7.311419	0	0.000362
137	BestNearest vs. RandomByElement	7.218701	0	0.000365
136	Farthest-First vs. RandomSequentialCyclic	6.980286	0	0.000368
135	Farthest-First vs. SequentialCyclic	6.980286	0	0.00037
134	RandomByElement vs. UPGMC	6.781606	0	0.000373
133	RandomSequentialCyclic vs. Sweep	6.76836	0	0.000376
132	SequentialCyclic vs. Sweep	6.76836	0	0.000379
131	KMEANS vs. RandomSequentialCyclic	6.74187	0	0.000382
130	KMEANS vs. SequentialCyclic	6.74187	0	0.000385
129	RandomSequentialCyclic vs. Simplified	6.675643	0	0.000388
128	SequentialCyclic vs. Simplified	6.675643	0	0.000391
127	CyclicAssignment vs. ThreeCriteriaClustering	6.56968	0	0.000394
126	NearestByDepot vs. PAM	6.410737	0	0.000397
125	CyclicAssignment vs. Farthest-First	6.238547	0	0.0004
124	CyclicAssignment vs. Sweep	6.026622	0	0.000403
123	NearestByCustomer vs. RandomSequentialCyclic	6.013377	0	0.000407
122	Parallel vs. RandomSequentialCyclic	6.013377	0	0.00041
121	NearestByCustomer vs. SequentialCyclic	6.013377	0	0.000413
120	Parallel vs. SequentialCyclic	6.013377	0	0.000417
119	CyclicAssignment vs. KMEANS	6.000132	0	0.00042
118	CyclicAssignment vs. Simplified	5.933905	0	0.000424
117	BestNearest vs. RandomSequentialCyclic	5.867678	0	0.000427
116	BestNearest vs. SequentialCyclic	5.867678	0	0.000431
115	BestCyclicAssignment vs. ThreeCriteriaClustering	5.430583	0	0.000435
114	RandomSequentialCyclic vs. UPGMC	5.430583	0	0.000439
113	SequentialCyclic vs. UPGMC	5.430583	0	0.000442
112	CyclicAssignment vs. NearestByCustomer	5.271639	0	0.000446
111	CyclicAssignment vs. Parallel	5.271639	0	0.00045
110	CLARA vs. ThreeCriteriaClustering	5.165676	0	0.000455
109	BestNearest vs. CyclicAssignment	5.12594	0	0.000459
108	BestCyclicAssignment vs. Farthest-First	5.09945	0	0.000463
107	CoefficientPropagation vs. ThreeCriteriaClustering	4.92726	0.000001	0.000467
106	BestCyclicAssignment vs. Sweep	4.887524	0.000001	0.000472
105	BestCyclicAssignment vs. KMEANS	4.861034	0.000001	0.000476
104	NearestByDepot vs. RandomByElement	4.847788	0.000001	0.000481
103	CLARA vs. Farthest-First	4.834543	0.000001	0.000485
102	BestCyclicAssignment vs. Simplified	4.794807	0.000002	0.00049
101	CyclicAssignment vs. UPGMC	4.688845	0.000003	0.000495
100	CLARA vs. Sweep	4.622618	0.000004	0.0005
99	CLARA vs. KMEANS	4.596127	0.000004	0.000505
98	CoefficientPropagation vs. Farthest-First	4.596127	0.000004	0.00051
97	CLARA vs. Simplified	4.529901	0.000006	0.000515
96	PAM vs. UPGMC	4.476919	0.000008	0.000521
95	CoefficientPropagation vs. Sweep	4.384202	0.000012	0.000526
94	CoefficientPropagation vs. KMEANS	4.357711	0.000013	0.000532
93	CoefficientPropagation vs. Simplified	4.291485	0.000018	0.000538
92	BestCyclicAssignment vs. NearestByCustomer	4.132541	0.000036	0.000543
91	BestCyclicAssignment vs. Parallel	4.132541	0.000036	0.000549
90	BestNearest vs. PAM	4.039824	0.000053	0.000556
89	BestCyclicAssignment vs. BestNearest	3.986842	0.000067	0.000562
88	NearestByCustomer vs. PAM	3.894125	0.000099	0.000568
87	PAM vs. Parallel	3.894125	0.000099	0.000575
86	CLARA vs. NearestByCustomer	3.867634	0.00011	0.000581
85	CLARA vs. Parallel	3.867634	0.00011	0.000588
84	NearestByDepot vs. ThreeCriteriaClustering	3.814653	0.000136	0.000595
83	CoefficientPropagation vs. RandomByElement	3.735181	0.000188	0.000602
82	BestNearest vs. CLARA	3.721936	0.000198	0.00061
81	CoefficientPropagation vs. NearestByCustomer	3.629219	0.000284	0.000617
80	CoefficientPropagation vs. Parallel	3.629219	0.000284	0.000625
79	BestCyclicAssignment vs. UPGMC	3.549747	0.000386	0.000633
78	CLARA vs. RandomByElement	3.496765	0.000471	0.000641
77	NearestByDepot vs. RandomSequentialCyclic	3.496765	0.000471	0.000649
76	NearestByDepot vs. SequentialCyclic	3.496765	0.000471	0.000658
75	Farthest-First vs. NearestByDepot	3.48352	0.000495	0.000667
74	BestNearest vs. CoefficientPropagation	3.48352	0.000495	0.000676
73	CLARA vs. UPGMC	3.28484	0.00102	0.000685
72	NearestByDepot vs. Sweep	3.271595	0.001069	0.000694
71	KMEANS vs. NearestByDepot	3.245104	0.001174	0.000704
70	BestCyclicAssignment vs. RandomByElement	3.231859	0.00123	0.000714
69	PAM vs. Simplified	3.231859	0.00123	0.000725
68	NearestByDepot vs. Simplified	3.178878	0.001478	0.000735
67	KMEANS vs. PAM	3.165632	0.001547	0.000746
66	PAM vs. Sweep	3.139142	0.001694	0.000758
65	CoefficientPropagation vs. UPGMC	3.046424	0.002316	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 ≤ 0.001471.

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	11.258525	0	0.000654
152	PAM vs. RandomSequentialCyclic	9.907502	0	0.000658
151	PAM vs. SequentialCyclic	9.907502	0	0.000662
150	CyclicAssignment vs. PAM	9.165764	0	0.000667
149	RandomByElement vs. ThreeCriteriaClustering	8.662442	0	0.000671
148	Farthest-First vs. RandomByElement	8.331309	0	0.000676
147	RandomByElement vs. Sweep	8.119383	0	0.00068
146	KMEANS vs. RandomByElement	8.092893	0	0.000685
145	RandomByElement vs. Simplified	8.026666	0	0.00069
144	BestCyclicAssignment vs. PAM	8.026666	0	0.000694
143	CLARA vs. PAM	7.76176	0	0.000699
142	CoefficientPropagation vs. PAM	7.523344	0	0.000704
141	NearestByCustomer vs. RandomByElement	7.3644	0	0.000709
140	Parallel vs. RandomByElement	7.3644	0	0.000714
139	RandomSequentialCyclic vs. ThreeCriteriaClustering	7.311419	0	0.000719
138	SequentialCyclic vs. ThreeCriteriaClustering	7.311419	0	0.000725
137	BestNearest vs. RandomByElement	7.218701	0	0.00073
136	Farthest-First vs. RandomSequentialCyclic	6.980286	0	0.000735
135	Farthest-First vs. SequentialCyclic	6.980286	0	0.000741
134	RandomByElement vs. UPGMC	6.781606	0	0.000746
133	RandomSequentialCyclic vs. Sweep	6.76836	0	0.000752
132	SequentialCyclic vs. Sweep	6.76836	0	0.000758
131	KMEANS vs. RandomSequentialCyclic	6.74187	0	0.000763
130	KMEANS vs. SequentialCyclic	6.74187	0	0.000769
129	RandomSequentialCyclic vs. Simplified	6.675643	0	0.000775
128	SequentialCyclic vs. Simplified	6.675643	0	0.000781
127	CyclicAssignment vs. ThreeCriteriaClustering	6.56968	0	0.000787
126	NearestByDepot vs. PAM	6.410737	0	0.000794
125	CyclicAssignment vs. Farthest-First	6.238547	0	0.0008
124	CyclicAssignment vs. Sweep	6.026622	0	0.000806
123	NearestByCustomer vs. RandomSequentialCyclic	6.013377	0	0.000813
122	Parallel vs. RandomSequentialCyclic	6.013377	0	0.00082
121	NearestByCustomer vs. SequentialCyclic	6.013377	0	0.000826
120	Parallel vs. SequentialCyclic	6.013377	0	0.000833
119	CyclicAssignment vs. KMEANS	6.000132	0	0.00084
118	CyclicAssignment vs. Simplified	5.933905	0	0.000847
117	BestNearest vs. RandomSequentialCyclic	5.867678	0	0.000855
116	BestNearest vs. SequentialCyclic	5.867678	0	0.000862
115	BestCyclicAssignment vs. ThreeCriteriaClustering	5.430583	0	0.00087
114	RandomSequentialCyclic vs. UPGMC	5.430583	0	0.000877
113	SequentialCyclic vs. UPGMC	5.430583	0	0.000885
112	CyclicAssignment vs. NearestByCustomer	5.271639	0	0.000893
111	CyclicAssignment vs. Parallel	5.271639	0	0.000901
110	CLARA vs. ThreeCriteriaClustering	5.165676	0	0.000909
109	BestNearest vs. CyclicAssignment	5.12594	0	0.000917
108	BestCyclicAssignment vs. Farthest-First	5.09945	0	0.000926
107	CoefficientPropagation vs. ThreeCriteriaClustering	4.92726	0.000001	0.000935
106	BestCyclicAssignment vs. Sweep	4.887524	0.000001	0.000943
105	BestCyclicAssignment vs. KMEANS	4.861034	0.000001	0.000952
104	NearestByDepot vs. RandomByElement	4.847788	0.000001	0.000962
103	CLARA vs. Farthest-First	4.834543	0.000001	0.000971
102	BestCyclicAssignment vs. Simplified	4.794807	0.000002	0.00098
101	CyclicAssignment vs. UPGMC	4.688845	0.000003	0.00099
100	CLARA vs. Sweep	4.622618	0.000004	0.001
99	CLARA vs. KMEANS	4.596127	0.000004	0.00101
98	CoefficientPropagation vs. Farthest-First	4.596127	0.000004	0.00102
97	CLARA vs. Simplified	4.529901	0.000006	0.001031
96	PAM vs. UPGMC	4.476919	0.000008	0.001042
95	CoefficientPropagation vs. Sweep	4.384202	0.000012	0.001053
94	CoefficientPropagation vs. KMEANS	4.357711	0.000013	0.001064
93	CoefficientPropagation vs. Simplified	4.291485	0.000018	0.001075
92	BestCyclicAssignment vs. NearestByCustomer	4.132541	0.000036	0.001087
91	BestCyclicAssignment vs. Parallel	4.132541	0.000036	0.001099
90	BestNearest vs. PAM	4.039824	0.000053	0.001111
89	BestCyclicAssignment vs. BestNearest	3.986842	0.000067	0.001124
88	NearestByCustomer vs. PAM	3.894125	0.000099	0.001136
87	PAM vs. Parallel	3.894125	0.000099	0.001149
86	CLARA vs. NearestByCustomer	3.867634	0.00011	0.001163
85	CLARA vs. Parallel	3.867634	0.00011	0.001176
84	NearestByDepot vs. ThreeCriteriaClustering	3.814653	0.000136	0.00119
83	CoefficientPropagation vs. RandomByElement	3.735181	0.000188	0.001205
82	BestNearest vs. CLARA	3.721936	0.000198	0.00122
81	CoefficientPropagation vs. NearestByCustomer	3.629219	0.000284	0.001235
80	CoefficientPropagation vs. Parallel	3.629219	0.000284	0.00125
79	BestCyclicAssignment vs. UPGMC	3.549747	0.000386	0.001266
78	CLARA vs. RandomByElement	3.496765	0.000471	0.001282
77	NearestByDepot vs. RandomSequentialCyclic	3.496765	0.000471	0.001299
76	NearestByDepot vs. SequentialCyclic	3.496765	0.000471	0.001316
75	Farthest-First vs. NearestByDepot	3.48352	0.000495	0.001333
74	BestNearest vs. CoefficientPropagation	3.48352	0.000495	0.001351
73	CLARA vs. UPGMC	3.28484	0.00102	0.00137
72	NearestByDepot vs. Sweep	3.271595	0.001069	0.001389
71	KMEANS vs. NearestByDepot	3.245104	0.001174	0.001408
70	BestCyclicAssignment vs. RandomByElement	3.231859	0.00123	0.001429
69	PAM vs. Simplified	3.231859	0.00123	0.001449
68	NearestByDepot vs. Simplified	3.178878	0.001478	0.001471
67	KMEANS vs. PAM	3.165632	0.001547	0.001493
66	PAM vs. Sweep	3.139142	0.001694	0.001515
65	CoefficientPropagation vs. UPGMC	3.046424	0.002316	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	Farthest-First vs .RandomByElement	0	0	0	0
7	RandomByElement vs .Sweep	0	0	0	0
8	KMEANS vs .RandomByElement	0	0	0	0
9	RandomByElement vs .Simplified	0	0	0	0
10	BestCyclicAssignment vs .PAM	0	0	0	0
11	CLARA vs .PAM	0	0	0	0
12	CoefficientPropagation vs .PAM	0	0	0	0
13	NearestByCustomer vs .RandomByElement	0	0	0	0
14	Parallel vs .RandomByElement	0	0	0	0
15	RandomSequentialCyclic vs .ThreeCriteriaClustering	0	0	0	0
16	SequentialCyclic vs .ThreeCriteriaClustering	0	0	0	0
17	BestNearest vs .RandomByElement	0	0	0	0
18	Farthest-First vs .RandomSequentialCyclic	0	0	0	0
19	Farthest-First vs .SequentialCyclic	0	0	0	0
20	RandomByElement vs .UPGMC	0	0	0	0
21	RandomSequentialCyclic vs .Sweep	0	0	0	0
22	SequentialCyclic vs .Sweep	0	0	0	0
23	KMEANS vs .RandomSequentialCyclic	0	0	0	0
24	KMEANS vs .SequentialCyclic	0	0	0	0
25	RandomSequentialCyclic vs .Simplified	0	0	0	0
26	SequentialCyclic vs .Simplified	0	0	0	0
27	CyclicAssignment vs .ThreeCriteriaClustering	0	0	0	0
28	NearestByDepot vs .PAM	0	0	0	0
29	CyclicAssignment vs .Farthest-First	0	0	0	0
30	CyclicAssignment vs .Sweep	0	0	0	0
31	NearestByCustomer vs .RandomSequentialCyclic	0	0	0	0
32	Parallel vs .RandomSequentialCyclic	0	0	0	0
33	NearestByCustomer vs .SequentialCyclic	0	0	0	0
34	Parallel vs .SequentialCyclic	0	0	0	0
35	CyclicAssignment vs .KMEANS	0	0	0	0
36	CyclicAssignment vs .Simplified	0	0	0	0
37	BestNearest vs .RandomSequentialCyclic	0	0.000001	0.000001	0
38	BestNearest vs .SequentialCyclic	0	0.000001	0.000001	0
39	BestCyclicAssignment vs .ThreeCriteriaClustering	0	0.000009	0.000006	0.000
40	RandomSequentialCyclic vs .UPGMC	0	0.000009	0.000006	0.000
41	SequentialCyclic vs .UPGMC	0	0.000009	0.000006	0.000
42	CyclicAssignment vs .NearestByCustomer	0	0.000021	0.000015	0.000
43	CyclicAssignment vs .Parallel	0	0.000021	0.000015	0.000
44	CLARA vs .ThreeCriteriaClustering	0	0.000037	0.000026	0.000
45	BestNearest vs .CyclicAssignment	0	0.000045	0.000032	0.000
46	BestCyclicAssignment vs .Farthest-First	0	0.000052	0.000037	0.000
47	CoefficientPropagation vs .ThreeCriteriaClustering	0.000001	0.000128	0.000089	0.000
48	BestCyclicAssignment vs .Sweep	0.000001	0.000156	0.000108	0.000
49	BestCyclicAssignment vs .KMEANS	0.000001	0.000179	0.000123	0.000
50	NearestByDepot vs .RandomByElement	0.000001	0.000191	0.00013	0.000
51	CLARA vs .Farthest-First	0.000001	0.000204	0.000137	0.000
52	BestCyclicAssignment vs .Simplified	0.000002	0.000249	0.000166	0.000
53	CyclicAssignment vs .UPGMC	0.000003	0.00042	0.000277	0.000
54	CLARA vs .Sweep	0.000004	0.00058	0.000379	0.000
55	CLARA vs .KMEANS	0.000004	0.000659	0.000426	0.000
56	CoefficientPropagation vs .Farthest-First	0.000004	0.000659	0.000426	0.000
57	CLARA vs .Simplified	0.000006	0.000903	0.000572	0.000
58	PAM vs .UPGMC	0.000008	0.001159	0.000727	0.000
59	CoefficientPropagation vs .Sweep	0.000012	0.001781	0.001106	0.001
60	CoefficientPropagation vs .KMEANS	0.000013	0.002011	0.001235	0.001
61	CoefficientPropagation vs .Simplified	0.000018	0.002715	0.001651	0.001
62	BestCyclicAssignment vs .NearestByCustomer	0.000036	0.005489	0.003301	0.003
63	BestCyclicAssignment vs .Parallel	0.000036	0.005489	0.003301	0.003
64	BestNearest vs .PAM	0.000053	0.008184	0.004814	0.004
65	BestCyclicAssignment vs .BestNearest	0.000067	0.010245	0.005959	0.005
66	NearestByCustomer vs .PAM	0.000099	0.015079	0.008673	0.008
67	PAM vs .Parallel	0.000099	0.015079	0.008673	0.008
68	CLARA vs .NearestByCustomer	0.00011	0.016814	0.009451	0.009
69	CLARA vs .Parallel	0.00011	0.016814	0.009451	0.009
70	NearestByDepot vs .ThreeCriteriaClustering	0.000136	0.020865	0.011455	0.011
71	CoefficientPropagation vs .RandomByElement	0.000188	0.0287	0.015569	0.015
72	BestNearest vs .CLARA	0.000198	0.030248	0.016211	0.016
73	CoefficientPropagation vs .NearestByCustomer	0.000284	0.043495	0.023027	0.023
74	CoefficientPropagation vs .Parallel	0.000284	0.043495	0.023027	0.023
75	BestCyclicAssignment vs .UPGMC	0.000386	0.058997	0.030463	0.030
76	CLARA vs .RandomByElement	0.000471	0.072053	0.036733	0.036
77	NearestByDepot vs .RandomSequentialCyclic	0.000471	0.072053	0.036733	0.036
78	NearestByDepot vs .SequentialCyclic	0.000471	0.072053	0.036733	0.036
79	Farthest-First vs .NearestByDepot	0.000495	0.075714	0.037115	0.036
80	BestNearest vs .CoefficientPropagation	0.000495	0.075714	0.037115	0.036
81	CLARA vs .UPGMC	0.00102	0.156122	0.074489	0.074
82	NearestByDepot vs .Sweep	0.001069	0.163622	0.076999	0.076
83	KMEANS vs .NearestByDepot	0.001174	0.179634	0.083359	0.082
84	BestCyclicAssignment vs .RandomByElement	0.00123	0.188171	0.086091	0.086
85	PAM vs .Simplified	0.00123	0.188171	0.086091	0.086
86	NearestByDepot vs .Simplified	0.001478	0.226205	0.100536	0.100
87	KMEANS vs .PAM	0.001547	0.236762	0.10368	0.103
88	PAM vs .Sweep	0.001694	0.259249	0.111833	0.111
89	CoefficientPropagation vs .UPGMC	0.002316	0.354318	0.150527	0.150