

Blanca, M.J., Bono, R., Arnau, J., García-Castro, F. J., Alarcón, R., & Vallejo, G. (2024). When to use Bootstrap- F in one-way repeated measures ANOVA. Type I error and power

N = sample size

K = number of repeated measures

ε = Greenhouse-Geisser epsilon

γ_1 = asymmetry coefficient

γ_2 = kurtosis coefficient

TYPE I ERROR

Table 1. Type I error rates (in percentages) for the Bootstrap- F by N and epsilon values (ε) for $K = 3$ and distribution 1 ($\gamma_1 = 0.4$, $\gamma_2 = 0.8$). Type I error rates > 7.5 are in bold (liberal) and < 2.5 are in italics (conservative).

	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$	$\varepsilon = 1$
N	$B-F$	$B-F$	$B-F$	$B-F$	$B-F$	$B-F$
10	4.10	4.58	4.46	4.44	3.96	3.78
15	4.34	4.16	4.30	4.04	4.16	3.86
20	4.68	5.20	5.20	4.32	4.50	4.00
25	4.64	4.84	4.80	4.18	4.66	4.04
30	4.78	5.16	5.08	4.14	4.54	4.50
40	4.62	4.92	5.02	4.74	5.12	4.62
50	5.12	4.64	5.28	5.06	4.56	5.14
60	4.92	5.02	5.10	5.34	4.82	5.28
70	4.98	5.38	5.24	5.60	5.16	5.54
80	4.82	5.60	5.62	5.40	5.64	5.62
90	5.04	5.32	5.84	4.86	5.12	5.56
100	4.92	5.22	5.42	4.82	4.90	5.22
120	5.10	5.28	5.40	5.02	5.40	5.34
150	4.36	5.70	5.28	5.06	5.38	4.68
180	4.94	5.26	5.22	4.94	5.30	5.04

Table 2. Type I error rates (in percentages) for the Bootstrap-F by N and epsilon values (ε) for $K = 3$ and distribution 2 ($\gamma_1 = 1, \gamma_2 = 1.5$). Type I error rates > 7.5 are in bold (liberal) and < 2.5 are in italics (conservative).

	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$	$\varepsilon = 1$
N	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>
10	5.14	5.36	4.46	4.20	3.86	3.64
15	5.20	4.60	4.48	3.78	3.90	3.50
20	5.14	5.48	4.84	4.34	4.18	3.84
25	4.82	5.08	4.50	4.16	4.64	3.88
30	5.20	4.96	4.94	4.34	4.74	4.62
40	5.16	5.08	5.00	4.70	4.80	4.42
50	5.30	4.94	5.44	4.92	4.86	5.22
60	5.36	5.30	5.26	5.28	4.96	5.06
70	5.06	5.74	5.40	5.58	5.42	5.40
80	4.78	5.66	5.74	5.44	5.86	5.54
90	5.38	5.42	5.88	4.82	5.16	5.44
100	5.10	5.18	5.70	4.78	4.90	5.22
120	5.22	5.38	5.68	4.96	5.12	5.12
150	4.46	5.76	4.92	5.24	5.32	4.90
180	4.72	5.24	4.98	5.26	5.44	5.20

Table 3. Type I error rates (in percentages) for the Bootstrap-F by N and epsilon values (ε) for $K = 3$ and distribution 3 ($\gamma_1 = 1.41, \gamma_2 = 3$). Type I error rates > 7.5 are in bold (liberal) and < 2.5 are in italics (conservative).

	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$	$\varepsilon = 1$
N	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>
10	5.90	5.86	4.18	3.56	3.58	3.20
15	5.94	5.46	4.30	3.78	3.90	3.30
20	5.66	5.92	4.58	4.26	4.28	3.54
25	4.96	5.24	4.66	4.12	4.26	3.60
30	5.22	5.10	4.76	4.08	4.72	4.36
40	5.46	5.22	4.74	4.52	4.78	4.24
50	5.46	5.14	5.22	4.64	4.90	4.94
60	5.40	5.22	5.24	5.08	4.82	4.78
70	5.24	5.86	5.54	5.46	5.38	5.42
80	5.10	5.58	5.52	5.36	5.68	5.48
90	5.28	5.32	5.90	5.06	5.32	5.26
100	5.12	5.32	5.72	4.82	5.10	5.10
120	5.36	5.38	5.74	5.06	5.06	5.16
150	4.38	5.64	5.00	5.18	5.24	4.96
180	4.86	5.30	5.06	5.32	5.24	5.08

Table 4. Type I error rates (in percentages) for the Bootstrap-F by N and epsilon values (ϵ) for $K = 3$ and distribution 4 ($\gamma_1 = 1.63, \gamma_2 = 4$). Type I error rates > 7.5 are in bold (liberal) and < 2.5 are in italics (conservative).

	$\epsilon = .50$	$\epsilon = .60$	$\epsilon = .70$	$\epsilon = .80$	$\epsilon = .90$	$\epsilon = 1$
N	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>
10	6.12	6.34	4.02	3.42	3.32	2.74
15	6.48	5.56	4.04	3.50	3.80	3.02
20	5.96	6.16	4.34	4.14	4.14	3.36
25	5.14	5.32	4.44	4.00	4.10	3.40
30	5.50	5.34	4.68	4.06	4.46	4.10
40	5.52	5.30	4.72	4.52	4.54	4.08
50	5.76	5.22	5.28	4.54	4.86	4.94
60	5.56	5.24	5.30	5.04	4.94	4.82
70	5.38	5.74	5.52	5.60	5.28	5.48
80	5.18	5.78	5.28	5.40	5.68	5.18
90	5.28	5.62	5.82	5.32	5.62	5.28
100	5.12	5.52	5.60	4.88	5.32	5.14
120	5.28	5.46	5.80	4.96	5.08	4.96
150	4.50	5.74	4.94	5.32	5.24	4.96
180	4.90	5.42	5.20	5.40	5.22	5.22

Table 5. Type I error rates (in percentages) for the Bootstrap-F by N and epsilon values (ϵ) for $K = 3$ and distribution 5 ($\gamma_1 = 2, \gamma_2 = 6$). Type I error rates outside the boundary of Bradley's criterion are in bold (conservative: < 2.5 ; liberal: > 7.5). Type I error rates > 7.5 are in bold (liberal) and < 2.5 are in italics (conservative).

	$\epsilon = .50$	$\epsilon = .60$	$\epsilon = .70$	$\epsilon = .80$	$\epsilon = .90$	$\epsilon = 1$
N	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>
10	6.76	6.76	3.64	2.94	3.26	2.18
15	6.78	6.08	3.88	2.88	3.52	2.66
20	6.22	6.56	3.94	3.66	4.12	2.96
25	5.60	5.82	4.00	3.76	3.78	3.08
30	6.24	5.80	4.82	4.06	3.78	3.86
40	5.60	5.54	4.56	4.14	4.36	4.00
50	5.94	5.42	5.08	4.48	4.82	4.52
60	5.56	5.34	5.00	4.70	4.98	4.76
70	5.42	5.74	5.34	5.56	5.10	5.20
80	5.32	6.02	5.10	5.28	5.76	5.18
90	5.38	5.66	5.66	5.40	5.62	5.30
100	5.18	5.60	5.58	4.80	5.52	5.00
120	5.20	5.50	5.98	4.92	5.38	4.96
150	4.48	5.52	4.94	5.32	5.28	4.82
180	4.80	5.32	5.06	5.64	5.08	5.40

Table 6. Type I error rates (in percentages) for the Bootstrap-F by N and epsilon values (ε) for $K = 3$ and distribution 6 ($\gamma_1 = 2.31, \gamma_2 = 8$). Type I error rates > 7.5 are in bold (liberal) and < 2.5 are in italics (conservative).

	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$	$\varepsilon = 1$
N	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>
10	7.52	7.60	3.44	2.54	3.22	<i>1.76</i>
15	7.14	6.68	3.64	2.52	3.34	<i>2.34</i>
20	6.82	7.04	3.56	3.48	3.84	2.64
25	5.98	6.16	3.88	3.48	3.66	2.90
30	6.42	5.96	4.76	3.72	4.34	3.66
40	5.78	5.86	4.48	3.94	4.08	3.70
50	6.20	5.76	4.84	4.20	4.68	4.28
60	5.96	5.50	4.98	4.68	4.80	4.44
70	5.34	5.78	5.26	5.38	5.06	5.02
80	5.44	6.16	5.12	5.36	5.46	5.04
90	5.40	5.82	5.56	5.46	5.52	5.10
100	5.44	5.74	5.36	4.84	5.24	4.86
120	5.20	5.46	5.74	5.02	5.22	4.96
150	4.64	5.80	4.74	5.14	5.14	4.80
180	4.84	5.64	5.00	5.38	5.10	5.06

Table 7. Type I error rates (in percentages) for the Bootstrap-F by N and epsilon values (ε) for $K = 4$ and distribution 1 ($\gamma_1 = 0.4, \gamma_2 = 0.8$). Type I error rates > 7.5 are in bold (liberal) and < 2.5 are in italics (conservative).

	$\varepsilon = .33$	$\varepsilon = .40$	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$	$\varepsilon = 1$
N	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>
10	4.80	5.24	4.74	4.46	4.12	4.02	3.58	3.60
15	4.54	4.56	5.06	4.00	4.28	3.96	3.50	3.60
20	4.78	4.50	4.76	4.58	4.22	4.40	3.98	3.90
25	4.90	4.94	4.78	4.84	4.54	4.90	4.68	4.24
30	5.22	5.02	5.20	4.98	4.96	5.00	5.02	4.62
40	4.90	5.16	5.08	4.78	4.98	5.24	5.08	4.72
50	5.34	5.56	4.96	5.24	4.88	5.70	5.60	5.28
60	5.30	6.04	5.10	5.74	5.16	5.64	5.82	5.30
70	4.78	5.32	4.88	5.60	4.90	5.68	5.64	5.36
80	4.56	5.36	4.56	5.64	4.76	5.08	5.02	4.84
90	4.78	5.76	4.78	5.40	5.06	5.16	5.22	5.04
100	4.92	5.12	4.74	5.24	4.72	5.22	4.88	5.04
120	4.76	5.12	4.84	5.20	4.72	4.80	4.80	4.68
150	4.86	5.20	5.06	5.28	5.36	4.96	5.10	4.90
180	4.74	5.34	5.00	5.20	4.92	4.98	4.84	5.06

Table 8. Type I error rates (in percentages) for the Bootstrap-F by N and epsilon values (ϵ) for $K = 4$ and distribution 2 ($\gamma_1 = 1, \gamma_2 = 1.5$). Type I error rates outside the boundary of Bradley's criterion are in bold (conservative: < 2.5 ; liberal: > 7.5). Type I error rates > 7.5 are in bold (liberal) and < 2.5 are in italics (conservative).

	$\epsilon = .33$	$\epsilon = .40$	$\epsilon = .50$	$\epsilon = .60$	$\epsilon = .70$	$\epsilon = .80$	$\epsilon = .90$	$\epsilon = 1$
N	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>
10	5.46	6.02	5.74	5.16	4.30	3.84	3.66	3.10
15	5.14	5.30	5.34	4.64	4.72	4.10	3.62	3.66
20	5.06	5.32	5.02	4.60	4.36	4.32	3.74	3.56
25	5.26	5.10	5.16	5.06	4.68	4.44	4.52	4.02
30	5.44	5.20	5.42	4.90	5.12	4.64	4.68	4.36
40	5.08	5.16	5.30	4.78	5.00	5.14	5.20	4.28
50	5.40	5.74	5.06	5.50	5.12	5.50	5.42	5.08
60	5.36	6.00	5.40	5.80	5.46	5.46	5.82	5.14
70	4.98	5.56	4.96	5.56	5.04	5.56	5.66	5.12
80	4.74	5.20	4.68	5.22	4.66	5.24	5.06	4.94
90	4.54	5.52	4.74	5.38	4.96	5.22	5.28	5.02
100	4.68	4.98	4.78	4.94	4.78	5.02	4.88	5.08
120	4.64	5.02	4.62	5.04	4.66	4.76	4.78	4.52
150	5.00	5.22	5.34	5.48	5.06	4.98	5.02	4.74
180	4.68	5.28	4.82	5.20	4.92	4.94	4.84	5.06

Table 9. Type I error rates (in percentages) for the Bootstrap-F by N and epsilon values (ϵ) for $K = 4$ and distribution 3 ($\gamma_1 = 1.41, \gamma_2 = 3$). Type I error rates > 7.5 are in bold (liberal) and < 2.5 are in italics (conservative).

	$\epsilon = .33$	$\epsilon = .40$	$\epsilon = .50$	$\epsilon = .60$	$\epsilon = .70$	$\epsilon = .80$	$\epsilon = .90$	$\epsilon = 1$
N	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>
10	6.02	6.74	5.86	5.28	4.30	3.70	3.26	2.84
15	5.50	5.68	5.92	4.64	4.68	3.74	3.50	3.24
20	5.58	5.64	5.68	4.84	4.30	4.10	3.78	3.32
25	5.62	5.56	5.44	4.92	4.72	4.30	4.12	3.78
30	5.88	5.38	5.80	5.12	5.08	4.38	4.40	4.04
40	5.34	5.26	5.36	4.98	5.16	5.02	4.96	4.10
50	5.62	5.92	5.46	5.66	5.18	5.44	5.44	4.70
60	5.22	6.14	5.50	5.80	5.54	5.42	5.64	4.86
70	5.20	5.32	5.10	5.48	5.18	5.54	5.58	4.62
80	4.86	5.34	5.06	5.14	4.58	5.24	5.10	4.80
90	4.60	5.24	4.86	5.20	4.92	5.10	5.30	5.06
100	4.68	4.96	4.76	4.88	4.70	4.86	4.86	5.12
120	4.62	5.10	4.68	4.98	4.48	4.56	4.76	4.26
150	5.08	5.32	5.24	5.18	5.16	4.98	5.04	4.66
180	4.84	5.36	4.80	5.22	5.08	5.06	4.92	5.00

Table 10. Type I error rates (in percentages) for the Bootstrap-F by N and epsilon values (ε) for $K = 4$ and distribution 4 ($\gamma_1 = 1.63, \gamma_2 = 4$). Type I error rates > 7.5 are in bold (liberal) and < 2.5 are in italics (conservative).

	$\varepsilon = .33$	$\varepsilon = .40$	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$	$\varepsilon = 1$
N	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>
10	6.52	7.28	6.42	5.30	4.32	3.46	2.94	2.66
15	6.04	6.22	6.16	4.80	4.78	3.60	3.26	2.94
20	5.82	5.76	6.16	5.16	4.48	3.98	3.66	3.08
25	5.82	5.78	5.74	5.18	4.86	4.10	3.90	3.44
30	6.08	5.50	6.06	4.94	5.24	4.22	4.40	3.74
40	5.60	5.34	5.48	4.92	5.38	4.88	4.76	3.94
50	5.70	6.10	5.60	5.66	5.20	5.42	5.20	4.64
60	5.26	6.18	5.40	5.82	5.32	5.42	5.52	4.74
70	5.34	5.42	5.30	5.36	5.30	5.30	5.36	4.52
80	5.04	5.40	5.02	5.24	4.82	5.08	4.84	4.84
90	4.90	5.22	4.92	5.06	4.78	5.04	5.18	5.02
100	4.72	4.94	4.82	4.84	4.94	4.88	4.94	5.00
120	4.76	5.22	4.72	5.02	4.58	4.46	4.68	4.22
150	5.14	5.40	5.34	5.14	5.22	4.84	4.92	4.76
180	4.84	5.48	4.64	5.36	5.08	5.08	4.96	4.84

Table 11. Type I error rates (in percentages) for the Bootstrap-F by N and epsilon values (ε) for $K = 4$ and distribution 5 ($\gamma_1 = 2, \gamma_2 = 6$). Type I error rates > 7.5 are in bold (liberal) and < 2.5 are in italics (conservative).

	$\varepsilon = .33$	$\varepsilon = .40$	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$	$\varepsilon = 1$
N	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>
10	7.52	8.44	7.12	5.40	4.26	2.96	2.46	1.94
15	6.50	6.90	6.60	5.12	4.76	3.48	2.92	2.56
20	6.38	6.52	6.32	5.16	4.72	3.60	3.24	2.54
25	6.16	6.18	6.32	5.20	4.92	3.92	3.38	2.80
30	6.50	5.90	6.48	4.94	5.28	4.16	4.08	3.36
40	5.92	5.82	6.00	5.06	5.50	4.54	4.38	3.68
50	5.70	6.62	5.82	5.82	5.12	5.42	4.96	4.26
60	5.38	5.94	5.60	5.64	5.20	5.50	5.16	4.68
70	5.34	5.56	5.52	5.38	5.28	5.08	5.16	4.08
80	5.36	5.66	5.26	5.30	4.82	4.94	4.84	4.50
90	4.94	5.26	4.90	5.18	4.76	4.84	5.16	4.90
100	4.96	4.94	5.02	4.90	5.10	4.76	4.76	4.76
120	4.96	5.24	5.12	4.92	4.82	4.42	4.80	4.24
150	5.10	5.26	5.42	5.20	5.14	4.56	4.80	4.50
180	4.70	5.48	4.78	5.40	5.12	4.72	4.84	4.52

Table 12. Type I error rates (in percentages) for the Bootstrap-F by N and epsilon values (ϵ) for $K = 4$ and distribution 6 ($\gamma_1 = 2.31, \gamma_2 = 8$). Type I error rates > 7.5 are in bold (liberal) and < 2.5 are in italics (conservative).

	$\epsilon = .33$	$\epsilon = .40$	$\epsilon = .50$	$\epsilon = .60$	$\epsilon = .70$	$\epsilon = .80$	$\epsilon = .90$	$\epsilon = 1$
N	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>
10	8.16	9.00	7.64	5.42	4.32	2.58	<i>2.12</i>	<i>1.68</i>
15	7.16	7.50	7.26	5.24	4.46	3.10	2.60	2.00
20	6.82	7.00	6.82	5.40	4.60	3.24	2.82	2.18
25	6.52	6.42	6.60	5.18	4.76	3.58	3.04	2.42
30	6.88	6.30	7.04	5.18	5.50	3.96	3.58	3.00
40	6.34	6.20	6.38	5.28	5.44	4.26	4.04	3.28
50	5.86	6.62	6.06	5.96	5.28	5.08	4.76	4.00
60	5.62	6.16	5.78	5.66	5.28	5.36	5.00	4.52
70	5.44	5.56	5.60	5.34	5.18	5.04	4.82	4.00
80	5.44	5.78	5.60	5.30	4.86	4.82	4.88	4.42
90	5.06	5.36	5.00	5.16	4.86	4.96	4.94	4.56
100	5.18	5.12	5.16	4.72	4.96	4.92	4.72	4.42
120	5.30	5.20	5.32	4.72	4.90	4.52	4.40	4.04
150	5.28	5.40	5.60	5.04	5.18	4.50	4.76	4.44
180	4.60	5.66	4.98	5.26	5.06	4.64	4.72	4.40

Table 13. Type I error rates (in percentages) for the Bootstrap-F by N and epsilon values (ϵ) for $K = 6$ and distribution 1 ($\gamma_1 = 0.4, \gamma_2 = 0.8$). Type I error rates > 7.5 are in bold (liberal) and < 2.5 are in italics (conservative).

	$\epsilon = .20$	$\epsilon = .30$	$\epsilon = .40$	$\epsilon = .50$	$\epsilon = .60$	$\epsilon = .70$	$\epsilon = .80$	$\epsilon = .90$	$\epsilon = 1$
N	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>
10	4.44	4.86	4.68	3.90	3.76	3.32	3.10	2.90	2.76
15	4.58	4.94	4.84	4.10	3.80	3.22	3.10	2.76	2.76
20	5.00	5.12	5.14	4.66	4.04	3.84	3.82	3.52	3.78
25	5.48	5.72	5.54	4.94	4.52	4.54	3.66	4.36	3.64
30	5.38	5.62	5.56	5.24	4.54	5.24	4.06	4.26	4.20
40	5.02	4.92	5.00	4.96	4.82	5.02	4.48	4.34	4.44
50	5.30	5.58	5.54	5.38	5.12	4.98	4.60	4.66	4.36
60	5.70	5.90	5.86	4.98	5.32	5.32	4.94	5.22	4.74
70	5.70	5.88	5.60	5.40	5.12	5.16	4.98	5.02	4.88
80	5.34	5.46	5.60	5.02	4.72	4.80	4.56	4.86	4.88
90	5.36	5.48	5.44	5.18	5.06	4.88	4.60	5.14	4.84
100	5.52	5.54	5.50	5.06	5.22	5.22	4.96	5.28	4.76
120	5.50	5.54	5.28	4.66	5.12	5.00	4.84	4.96	4.52
150	5.68	5.68	5.80	4.86	5.32	5.30	4.60	5.06	4.86
180	5.66	5.56	5.60	4.54	4.50	5.20	4.30	4.90	4.84

Table 14. Type I error rates (in percentages) for the Bootstrap-F by N and epsilon values (ε) for $K = 6$ and distribution 2 ($\gamma_1 = 1, \gamma_2 = 1.5$). Type I error rates > 7.5 are in bold (liberal) and < 2.5 are in italics (conservative).

	$\varepsilon = .20$	$\varepsilon = .30$	$\varepsilon = .40$	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$	$\varepsilon = 1$
N	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>
10	5.26	5.74	5.36	4.06	4.08	3.44	3.10	2.52	2.28
15	5.28	5.70	5.22	4.04	3.96	3.20	2.76	2.62	2.24
20	5.56	5.82	5.66	4.44	4.26	3.88	3.46	3.14	3.26
25	5.72	5.98	5.90	4.84	4.72	4.72	3.58	3.88	3.28
30	5.46	5.64	5.56	5.32	4.44	5.24	4.24	4.16	4.24
40	5.24	5.42	5.60	5.18	4.76	4.52	4.46	4.32	4.24
50	5.70	5.82	5.84	5.34	5.08	5.06	4.68	4.26	4.12
60	6.10	6.36	6.36	5.38	5.24	5.48	5.04	4.92	4.90
70	5.84	5.92	5.82	5.26	4.92	5.14	4.88	5.02	4.76
80	5.90	6.04	5.90	5.04	4.68	4.92	4.72	4.84	4.72
90	5.62	5.70	5.78	5.28	4.84	4.88	4.78	5.04	4.74
100	5.66	5.56	5.62	4.98	5.04	5.16	4.76	5.32	4.82
120	5.50	5.42	5.54	4.80	5.24	4.94	4.64	5.06	4.52
150	5.70	5.54	5.66	4.94	5.12	5.16	4.60	4.94	4.64
180	5.90	5.92	5.68	4.54	4.68	4.92	4.30	4.88	4.76

Table 15. Type I error rates (in percentages) for the Bootstrap-F by N and epsilon values (ε) for $K = 6$ and distribution 3 ($\gamma_1 = 1.41, \gamma_2 = 3$). Type I error rates > 7.5 are in bold (liberal) and < 2.5 are in italics (conservative).

	$\varepsilon = .20$	$\varepsilon = .30$	$\varepsilon = .40$	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$	$\varepsilon = 1$
N	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>
10	5.98	6.26	5.78	4.00	3.98	3.38	2.98	2.20	1.96
15	5.62	6.12	5.68	3.98	3.98	3.16	2.68	2.22	2.10
20	5.96	6.24	6.00	4.42	4.30	4.06	3.40	2.68	2.76
25	6.12	6.36	6.18	4.90	4.82	4.58	3.34	3.38	3.22
30	5.56	5.78	5.94	5.06	4.58	4.90	4.22	3.94	3.98
40	5.66	5.92	5.92	5.00	4.96	4.44	4.26	4.16	4.00
50	5.84	6.16	5.94	5.14	4.80	4.84	4.48	4.04	3.80
60	6.34	6.76	6.56	5.12	5.02	5.32	4.88	4.92	4.56
70	5.98	6.14	6.22	5.28	4.86	5.08	4.78	5.02	4.68
80	5.84	6.06	6.12	4.96	4.62	4.92	4.48	4.66	4.36
90	5.82	5.84	5.86	5.02	4.78	4.80	4.70	4.94	4.74
100	5.86	6.02	5.86	4.84	5.00	5.24	4.68	5.02	4.68
120	5.62	5.66	5.74	4.74	5.32	4.86	4.44	4.92	4.56
150	5.60	5.78	6.00	4.86	5.16	4.94	4.50	4.90	4.54
180	5.72	5.82	5.72	4.60	4.64	4.76	4.24	4.78	4.66

Table 16. Type I error rates (in percentages) for the Bootstrap-F by N and epsilon values (ε) for $K = 6$ and distribution 4 ($\gamma_1 = 1.63, \gamma_2 = 4$). Type I error rates > 7.5 are in bold (liberal) and < 2.5 are in italics (conservative).

	$\varepsilon = .20$	$\varepsilon = .30$	$\varepsilon = .40$	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$	$\varepsilon = 1$
N	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>
10	6.32	6.72	6.18	4.02	3.86	3.24	2.66	<i>1.96</i>	<i>1.62</i>
15	6.02	6.34	6.04	4.18	3.98	3.08	<i>2.42</i>	<i>2.08</i>	<i>1.82</i>
20	6.18	6.48	6.12	4.42	4.42	3.90	3.24	<i>2.50</i>	2.60
25	5.94	6.60	6.42	4.80	4.88	4.32	3.20	3.04	2.94
30	5.88	6.04	6.04	5.12	4.58	4.84	3.96	3.80	3.88
40	5.66	6.20	6.32	4.92	5.02	4.42	4.22	4.18	3.78
50	5.90	6.14	6.20	5.06	4.78	4.82	4.34	3.90	3.66
60	6.42	6.78	6.72	5.12	4.98	5.42	4.78	4.62	4.48
70	5.86	6.16	6.32	5.18	4.88	4.94	4.78	4.88	4.40
80	5.86	6.28	6.16	5.02	4.40	4.90	4.24	4.38	4.08
90	5.86	5.96	5.94	5.14	4.38	4.62	4.62	4.82	4.66
100	6.10	6.20	6.24	4.80	4.90	5.12	4.64	4.82	4.62
120	5.62	5.94	6.04	4.82	5.44	4.96	4.50	4.92	4.60
150	5.72	5.96	5.94	4.78	5.08	4.80	4.54	4.76	4.42
180	5.58	5.90	5.80	4.58	4.60	4.52	4.12	4.58	4.32

Table 17. Type I error rates (in percentages) for the Bootstrap-F by N and epsilon values (ε) for $K = 6$ and distribution 5 ($\gamma_1 = 2, \gamma_2 = 6$). Type I error rates > 7.5 are in bold (liberal) and < 2.5 are in italics (conservative).

	$\varepsilon = .20$	$\varepsilon = .30$	$\varepsilon = .40$	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$	$\varepsilon = 1$
N	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>
10	7.28	7.52	6.92	4.10	3.46	2.84	2.54	<i>1.64</i>	<i>1.28</i>
15	6.58	7.02	6.46	4.14	3.76	2.88	2.32	<i>1.74</i>	<i>1.28</i>
20	6.46	6.96	6.54	4.62	4.44	3.70	2.84	<i>2.26</i>	<i>2.12</i>
25	6.32	6.82	6.66	5.10	4.58	3.98	3.12	<i>2.62</i>	<i>2.46</i>
30	6.04	6.50	6.32	5.14	4.62	4.30	3.72	3.54	3.38
40	6.08	6.42	6.50	4.78	5.08	4.46	4.30	3.86	3.60
50	5.92	6.50	6.50	5.06	4.70	4.66	4.22	3.66	3.58
60	6.60	7.00	6.84	5.06	4.92	5.06	4.64	4.24	4.22
70	6.02	6.42	6.32	5.30	4.80	4.64	4.68	4.54	3.96
80	6.16	6.54	6.24	4.98	4.26	5.00	4.20	4.04	3.94
90	6.26	6.28	6.12	5.12	4.34	4.58	4.46	4.52	4.40
100	6.12	6.30	6.34	4.66	4.92	4.94	4.66	4.50	4.36
120	5.88	6.22	6.32	5.02	5.40	4.94	4.48	4.80	4.66
150	5.76	6.14	6.10	4.48	5.14	4.74	4.54	4.70	4.50
180	5.50	5.88	5.72	4.46	4.64	4.74	4.12	4.78	4.28

Table 18. Type I error rates (in percentages) for the Bootstrap-F by N and epsilon values (ε) for $K = 6$ and distribution 6 ($\gamma_1 = 2.31, \gamma_2 = 8$). Type I error rates > 7.5 are in bold (liberal) and < 2.5 are in italics (conservative).

	$\varepsilon = .20$	$\varepsilon = .30$	$\varepsilon = .40$	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$	$\varepsilon = 1$
N	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>	<i>B-F</i>
10	8.12	8.78	7.22	4.22	3.28	2.58	2.26	1.46	.98
15	6.98	7.80	6.96	4.34	3.80	2.72	2.02	1.44	1.04
20	6.76	7.58	7.18	4.86	4.32	3.46	2.62	2.10	1.74
25	6.54	7.26	6.90	4.92	4.50	3.94	3.18	2.24	2.16
30	6.52	7.08	6.82	5.28	4.62	4.16	3.66	3.10	3.22
40	6.32	7.12	7.06	4.60	5.08	4.52	4.10	3.48	3.10
50	6.16	6.72	6.68	4.98	4.68	4.66	4.08	3.56	3.40
60	6.62	6.98	6.88	5.04	4.76	5.06	4.58	3.96	4.00
70	6.26	6.62	6.60	5.06	4.92	4.40	4.40	4.12	3.64
80	6.28	6.60	6.36	4.88	4.18	4.96	4.26	3.84	3.86
90	6.14	6.42	6.30	4.94	4.48	4.46	4.20	4.42	4.16
100	6.22	6.34	6.46	4.42	4.94	4.88	4.50	4.38	3.96
120	5.94	6.42	6.46	5.00	5.30	4.88	4.50	4.72	4.48
150	5.70	5.94	6.22	4.66	5.06	4.76	4.62	4.52	4.46
180	5.52	5.72	5.72	4.54	4.82	4.70	4.30	4.68	4.06

POWER

Table 1. Power (in percentages) for the bootstrap-F by N and epsilon values (ε) for $K = 3$, distribution 2 ($\gamma_1 = 1, \gamma_2 = 1.5$).

N	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$
10	7.28	18.12	13.1	15.88	17.96
15	12.2	24.4	19.94	23.44	25.3
20	18.88	30.22	27.86	32.14	33.52
25	25.44	35.88	36.04	40.92	41.3
30	34.3	42.22	44.6	49.26	48.2
40	48.16	53.92	57.84	63.18	60.4
50	62.3	64.58	70.08	75.6	70.44
60	74.86	72.08	78.84	83.58	77.68
70	83.92	79.2	85.86	89.6	84.3
80	90.52	84.18	90.74	93.48	88.5
90	95.08	89.44	93.76	96.24	91.88
100	97.54	92.84	96.1	97.92	94.62
120	99.74	96.88	98.62	99.36	97.26
150	100	99.24	99.82	99.96	99.2
180	100	99.84	99.94	99.98	99.78

Table 2. Power (in percentages) for the bootstrap-F by N and epsilon values (ε) for $K = 3$, distribution 3 ($\gamma_1 = 1.41, \gamma_2 = 3$).

N	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$
10	6.22	20.2	12.76	16.4	18.3
15	10.3	26	19.94	23.82	25.3
20	16	31.34	28.16	32.78	34.5
25	22.56	36.46	36.48	41.4	41.84
30	31.36	42.7	44.94	49.72	48.46
40	46.04	53.46	58.34	63.28	60.42
50	61.9	63.68	70.22	75.12	69.8
60	75.3	71.38	79.22	83.04	77
70	84.42	77.68	86.42	88.98	83.48
80	91.74	83.22	90.74	93.2	87.86
90	96.16	88.32	94.06	95.76	91.72
100	98.24	91.74	96.08	97.64	94.32
120	99.78	96.26	98.6	99.26	97.1
150	100	98.94	99.8	99.94	99
180	100	99.8	99.96	99.98	99.74

Table 3. Power (in percentages) for the bootstrap-F by N and epsilon values (ε) for $K = 3$, distribution 6 ($\gamma_1 = 2.31, \gamma_2 = 8$).

N	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$
10	5.18	24.88	11.86	16.78	20.26
15	6.88	29.96	18.84	25.94	28.38
20	11.7	33.66	28.42	34.6	36.34
25	17.52	37.66	36.46	43.04	42.78
30	25.2	43.2	45.36	50.76	49.62
40	40.18	52.78	59.22	63.46	59.96
50	58.76	61.52	70.56	74.42	69.6
60	74.48	68.92	79.94	82.28	76.18
70	85.24	74.64	86.42	87.98	81.66
80	92.38	80.22	91.02	92.16	86.3
90	96.68	85.34	94.06	95.08	90.4
100	98.44	88.86	96.36	97.3	93.32
120	99.7	94.14	98.46	99.1	96.44
150	99.96	98.16	99.62	99.82	98.6
180	100	99.46	99.94	99.98	99.52

Table 4. Power (in percentages) for the bootstrap-F by N and epsilon values (ε) for $K = 4$, distribution 2 ($\gamma_1 = 1, \gamma_2 = 1.5$).

N	$\varepsilon = .33$	$\varepsilon = .40$	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$
10	15.44	8.34	18.12	9.36	19.92	12.4	16.04
15	20.68	12.5	23.82	15.06	27.38	20.12	25.8
20	25.32	18.22	29.76	21.56	35.12	30.04	35.52
25	30.42	24.68	35.62	29.48	42.68	39.6	45.1
30	35.22	32.94	41.06	38.64	50.26	50.86	54.78
40	44.26	48.78	52.2	55.1	62.6	67.02	69.24
50	54.96	64.28	63.34	69.84	73.78	79.6	79.64
60	65.02	75.54	73.22	80.62	81.8	88.28	87.26
70	72.32	84.64	80.56	88.26	87.44	93.28	92.14
80	79.44	90.48	86.32	93.18	91.36	96.6	95.06
90	85.24	94.94	91.18	96.84	94.14	98.34	97.26
100	89.52	97.32	94.38	98.3	96.22	99	98.24
120	96.02	99.34	97.9	99.72	98.26	99.8	99.4
150	99.34	99.86	99.58	99.98	99.5	99.96	99.84
180	99.96	100	99.92	100	99.9	100	99.96

Table 5. Power (in percentages) for the bootstrap-F by N and epsilon values (ε) for $K = 4$, distribution 3 ($\gamma_1 = 1.41, \gamma_2 = 3$).

N	$\varepsilon = .33$	$\varepsilon = .40$	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$
10	17.68	7.94	20.5	8.04	21.3	12.06	16.64
15	22.24	11.14	25.72	13.64	28.76	20.34	25.88
20	26.44	16.04	31.08	19.54	36.12	29.62	35.86
25	31.14	22.68	36.5	28.28	43.22	39.8	45.6
30	35.42	31.14	41.8	38.14	50.66	50.54	54.66
40	43.7	47.9	52.08	55.16	62.26	67.24	69.46
50	54.12	64.64	62.64	70.14	72.68	79.92	79.72
60	63.3	76.44	71.74	81.84	80.94	88.34	87.14
70	70.54	85.62	79.02	89.24	86.48	93.54	92.04
80	77.18	91.16	84.9	94	90.46	96.5	95
90	82.86	95.4	89.56	97.1	93.2	98.32	96.98
100	87.36	97.66	92.78	98.68	95.9	99.02	98.2
120	94.3	99.44	97	99.84	97.96	99.8	99.28
150	98.86	99.88	99.36	99.96	99.42	99.98	99.82
180	99.86	100	99.92	100	99.88	100	99.94

Table 6. Power (in percentages) for the bootstrap-F by N and epsilon values (ε) for $K = 4$, distribution 6 ($\gamma_1 = 2.31, \gamma_2 = 8$).

N	$\varepsilon = .33$	$\varepsilon = .40$	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$
10	20.48	7.76	24.9	6.82	24.46	11.68	16.76
15	24.14	9.48	29.2	11.18	31.22	19.94	25.78
20	27.8	13.52	34.16	17.02	38.96	29.5	36.14
25	31.68	19.22	38.3	26.1	44.82	39.2	46.12
30	35.64	27.96	42.96	35.7	50.82	50.5	54.5
40	42.78	45.46	51.54	54.02	61.4	66.58	68.72
50	51.2	62.48	60.72	70.94	70.64	79.42	79.22
60	59.36	75.98	68.58	82.84	78.6	88.12	86.4
70	66.64	85.64	75.06	90.78	83.92	93.22	91.46
80	72.78	91.4	81.22	94.78	88.22	96.16	94.54
90	78.36	95.72	85.64	97.9	91.38	98.1	96.46
100	82.74	97.9	89.52	99.08	93.98	98.98	97.98
120	90.32	99.52	94.62	99.86	97.22	99.68	99.02
150	96.52	99.88	98.52	100	98.96	99.96	99.74
180	99.18	100	99.58	100	99.76	100	99.94

Table 7. Power (in percentages) for the bootstrap-F by N and epsilon values (ε) for $K = 6$, distribution 2 ($\gamma_1 = 1, \gamma_2 = 1.5$).

N	$\varepsilon = .20$	$\varepsilon = .30$	$\varepsilon = .40$	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$
10	13.3	17.6	17.22	9.46	12	16.86	12.38	15.4
15	16.64	22.4	22.32	15.98	19.68	26.64	22.44	27.14
20	21.48	28.42	28.82	24.54	30.58	37.98	35.98	41.94
25	25.92	35.2	35.08	35.16	42.86	50.48	49.3	54.92
30	29.88	41.06	41.12	46.42	55.62	60.98	61.88	65.64
40	39.32	53.54	53.56	66.5	74.58	77.54	79.22	81.74
50	49.54	65.56	65.16	82.92	87.8	87.96	90.34	91.46
60	59.66	76.7	75.56	93.44	95.28	94.12	95.84	96.04
70	68.34	84.28	83.32	97.7	97.98	97.34	98.06	98.18
80	77.2	90.34	89.02	99.16	99.08	98.58	99.16	99.26
90	85.16	94.5	93.58	99.76	99.72	99.46	99.66	99.64
100	90.54	97.02	96.26	99.96	99.96	99.84	99.94	99.92
120	97.48	99.26	98.82	100	100	99.96	99.96	100
150	99.88	100	99.9	100	100	100	100	100
180	100	100	100	100	100	100	100	100

Table 8. Power (in percentages) for the bootstrap-F by N and epsilon values (ε) for $K = 6$, distribution 3 ($\gamma_1 = 1.41, \gamma_2 = 3$).

N	$\varepsilon = .20$	$\varepsilon = .30$	$\varepsilon = .40$	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$
10	15.06	19.66	19.4	8.98	11.66	17.84	11.18	14.48
15	18.26	24.26	24.36	15.2	19.26	26.62	20.98	26.08
20	22.5	29.92	30.22	24.1	30.56	39.16	34.52	41.4
25	27.28	36.24	36.48	34.2	42.38	50.32	48.52	54.2
30	30.58	41.6	41.54	45.8	54.78	60.76	62.06	65.84
40	39.46	53.3	53.46	67.12	74.38	76.7	79.44	81.68
50	48.8	63.86	63.94	83.64	87.9	87.04	90.54	91.26
60	58.4	74.52	74.14	93.76	95.14	93.58	96.2	95.82
70	66.66	82.34	81.68	97.94	97.96	96.84	98.26	98.12
80	74.54	88.44	87.52	99.18	99.12	98.4	99.22	99.16
90	81.96	92.98	92.14	99.78	99.64	99.32	99.68	99.56
100	87.56	95.84	95.04	99.96	99.92	99.74	99.96	99.9
120	95.72	98.66	98.12	100	100	99.98	100	100
150	99.52	99.9	99.76	100	100	100	100	100
180	99.98	100	99.98	100	100	100	100	100

Table 9. Power (in percentages) for the bootstrap-F by N and epsilon values (ε) for $K = 6$, distribution 6 ($\gamma_1 = 2.31, \gamma_2 = 8$).

N	$\varepsilon = .20$	$\varepsilon = .30$	$\varepsilon = .40$	$\varepsilon = .50$	$\varepsilon = .60$	$\varepsilon = .70$	$\varepsilon = .80$	$\varepsilon = .90$
10	18.22	24.42	23.9	8.38	11.56	18.84	8.88	13.24
15	20.7	28.3	28.2	13.82	19.26	28	18.44	25.14
20	24.34	33.2	33.38	22.66	29.78	39.76	32.06	40.44
25	28.4	37.6	38.44	33.32	42.28	50.18	46.56	52.66
30	31.1	42.22	43	43.94	54.64	59.72	60.08	64.7
40	38.66	51.84	53.18	66.16	73.24	74.6	79.48	81.26
50	47.06	60.98	61.6	83.62	86.58	85.52	90.9	90.68
60	55.12	70.26	70.72	93.64	93.96	92.02	96.2	95.38
70	62.58	77.54	77.56	97.8	97.68	95.6	98.42	97.94
80	69.48	83.88	83.54	99.08	98.9	97.8	99.38	98.98
90	76.26	89	88.6	99.78	99.62	99	99.72	99.56
100	81.62	92.28	91.98	99.98	99.92	99.56	99.98	99.88
120	90.5	96.92	96.62	100	99.98	99.84	100	100
150	97.66	99.44	99.2	100	100	100	100	100
180	99.58	99.94	99.9	100	100	100	100	100