Automatic Component-wise Design of Multi-objective Evolutionary Algorithms

Supplementary Material

Leonardo C. T. Bezerra, Manuel López-Ibáñez, and Thomas Stützle

This supplementary material provides all the data required for the analysis of the main paper that had been omitted for brevity. Tables I and II list the numerical parameters used by the traditional MOEAs when tuned for 10 000 function evaluations or 1-minute runtime, respectively.

Figures 2–12 show the performances of all algorithms in all scenarios when given 10 000 function evaluations. Figures 2–6 depict I_H^{rpd} results, and 8–12 depict I_ϵ results.

Figures 14–18 show the performances of all algorithms in all scenarios when given 10 000 function evaluations. Figures 14–15 depict I_H^{rpd} results, and 17–18 depict I_ϵ results.

Figures 20–30 show the performances of all algorithms in all scenarios when given 10 000 function evaluations when algorithms are tuned for one benchmark and tested on the other. Figures 20–24 depict I_H^{rpd} results, and 26–30 depict I_ϵ results.

Figures 20–30 show the performances of all algorithms in all scenarios when given 10 000 function evaluations when algorithms are tuned for one benchmark and tested on the other. Figures 20–24 depict I_H^{rpd} results, and 26–30 depict I_ϵ results.

Figures 31–33 show the comparison of all MOEAs with a state-of-the-art TP+PLS algorithm on the MO-PFSP bi-objective variants considered in this work.

L. C. T. Bezerra, M. López-Ibáñez, and T. Stützle are with the IRIDIA laboratory at CoDE, Université Libre de Bruxelles, 1050, Belgium.
email: {lteonaci,manuel.lopez-ibanez,stuetzle}@ulb.ac.be
Available at https://iridia.ulb.ac.be/supp/IridiaSupp2014-010/

Table I
NUMERICAL PARAMETERS SELECTED BY IRACE FOR MOEAS GIVEN A MAXIMUM NUMBER OF FUNCTION EVALUATIONS. IBEA USES I_ϵ FOR ALL SCENARIOS. SPEA2 USES $t_{size} = 8$ FOR ALL SCENARIOS.

	Numerical								
HYPE	μ	λ_r	t_{size}	p_c	p_m	*bitwise*	p_v	η_c	η_v
2-obj DTLZ	70	0.1	8	0.62	0.96	T	—	43	4
3-obj DTLZ	90	0.1	8	0.89	0.92	T	—	36	1
5-obj DTLZ	100	0.12	2	0.84	0.27	F	0.61	40	23
2-obj WFG	90	0.11	8	0.75	0.79	F	0.33	35	32
3-obj WFG	100	0.1	8	0.94	0.81	F	0.22	36	28
5-obj WFG	100	1.95	8	0.94	0.13	F	0.42	41	27

IBEA	μ	λ_r	t_{size}	p_c	p_m	*bitwise*	p_v	η_c	η_v
2-obj DTLZ	70	0.56	2	0.02	0.03	T	—	34	13
3-obj DTLZ	90	0.25	8	0.92	1.0	T	—	37	27
5-obj DTLZ	60	1.35	8	0.22	0.44	T	—	16	3
2-obj WFG	90	1.04	4	0.9	0.54	F	0.13	33	27
3-obj WFG	60	0.37	8	0.7	0.91	T	—	31	9
5-obj WFG	80	0.12	8	0.48	0.45	F	0.04	38	11

MOGA	μ	σ_{share}	t_{size}	p_c	p_m	*bitwise*	p_v	η_c	η_v
2-obj DTLZ	100	0.41	4	0.88	0.94	T	—	43	13
3-obj DTLZ	100	0.82	4	0.66	0.18	F	0.39	42	38
5-obj DTLZ	100	0.78	2	0.64	0.12	T	—	42	1
2-obj WFG	100	0.93	4	0.38	0.31	F	0.82	38	42
3-obj WFG	100	0.98	4	0.74	0.09	F	0.41	47	26
5-obj WFG	100	0.98	4	0.89	0.85	F	0.67	15	42

NSGA-II	μ	λ_r	t_{size}	p_c	p_m	*bitwise*	p_v	η_c	η_v
2-obj DTLZ	100	0.11	8	0.32	0.37	T	—	41	27
3-obj DTLZ	50	0.78	8	0.81	0.6	T	—	49	3
5-obj DTLZ	60	0.36	8	0.01	0.07	T	—	34	3
2-obj WFG	20	0.75	8	0.3	0.66	T	—	23	8
3-obj WFG	40	0.28	8	0.54	0.37	F	0.07	48	11
5-obj WFG	70	0.23	8	0.48	0.67	F	0.1	49	30

SMS-EMOA	μ	λ_r	t_{size}	p_c	p_m	*bitwise*	p_v	η_c	η_v
2-obj DTLZ	60	—	—	0.86	0.91	T	—	5	26
3-obj DTLZ	100	—	—	0.88	0.25	F	0.36	47	31
5-obj DTLZ	40	—	—	0.51	0.64	T	—	42	5
2-obj WFG	10	—	—	0.13	0.45	F	0.12	19	20
3-obj WFG	30	—	—	0.75	0.61	F	0.14	45	16
5-obj WFG	50	—	—	1.0	0.9	F	0.05	43	26

SPEA2	μ	λ_r	k_{method}	p_c	p_m	*bitwise*	p_v	η_c	η_v
2-obj DTLZ	80	0.1	*default*	0.04	0.08	T	—	33	11
3-obj DTLZ	90	0.11	$k = 7$	0.46	0.43	T	—	38	17
5-obj DTLZ	50	0.95	*default*	0.01	0.42	T	—	19	4
2-obj WFG	20	0.13	*default*	0.15	0.72	T	—	36	10
3-obj WFG	40	0.1	$k = 6$	0.29	0.75	T	—	35	9
5-obj WFG	60	0.19	*default*	0.05	0.08	T	—	45	10

Table II
NUMERICAL PARAMETERS SELECTED BY IRACE FOR MOEAS FOR MAXIMUM RUNTIME SCENARIOS. IBEA USES I_ϵ AND SPEA2 USES $t_{size} = 8$ FOR ALL SCENARIOS.

	Numerical								
HYPE	μ	λ_r	t_{size}	p_c	p_m	*bitwise*	p_v	η_c	η_v
2-obj WFG	100	0.15	8	0.72	0.98	F	0.16	25	11
3-obj WFG	10	0.1	2	0.94	0.84	F	0.06	18	7
5-obj WFG	100	1.93	8	0.72	0.92	T	—	49	23

IBEA	μ	λ_r	t_{size}	p_c	p_m	*bitwise*	p_v	η_c	η_v
2-obj WFG	90	0.98	2	0.66	0.94	T	—	44	45
3-obj WFG	100	1.22	4	0.66	0.99	T	—	35	27
5-obj WFG	100	1.13	8	0.64	0.85	T	—	40	15

MOGA	μ	σ_{share}	t_{size}	p_c	p_m	*bitwise*	p_v	η_c	η_v
2-obj WFG	100	0.95	4	0.66	0.51	T	—	50	2
3-obj WFG	100	0.99	4	0.82	0.13	T	—	27	16
5-obj WFG	100	0.94	2	0.41	0.09	T	—	41	16

NSGA-II	μ	λ_r	t_{size}	p_c	p_m	*bitwise*	p_v	η_c	η_v
2-obj WFG	100	0.77	8	0.54	0.72	T	—	43	30
3-obj WFG	100	1.34	8	0.81	0.8	F	0.04	40	18
5-obj WFG	100	1.07	8	0.69	0.54	T	—	34	27

SMS-EMOA	μ	λ_r	t_{size}	p_c	p_m	*bitwise*	p_v	η_c	η_v
2-obj WFG	20	—	—	0.31	1.0	F	0.04	32	28
3-obj WFG	40	—	—	0.65	0.96	T	—	32	24
5-obj WFG	20	—	—	0.38	0.96	F	0.04	37	32

SPEA2	μ	λ_r	k_{method}	p_c	p_m	*bitwise*	p_v	η_c	η_v
2-obj WFG	40	0.45	*default*	0.57	0.52	T	—	41	39
3-obj WFG	50	0.26	$k = 6$	0.77	0.97	T	—	44	37
5-obj WFG	50	0.19	*default*	0.72	0.8	T	—	50	18

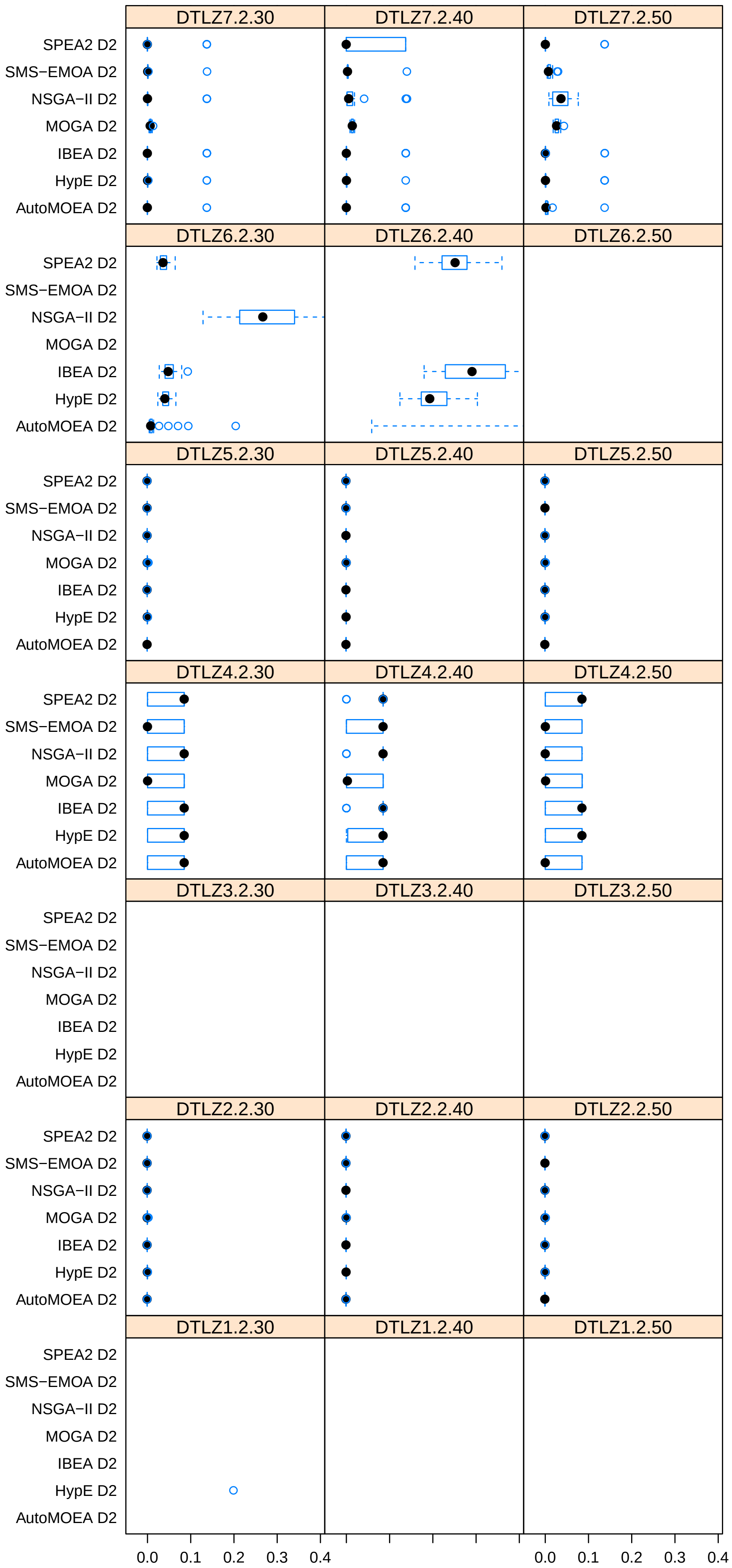

Figure 1. Boxplots of the I_H^{rpd} for 2-objective DTLZ problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations.

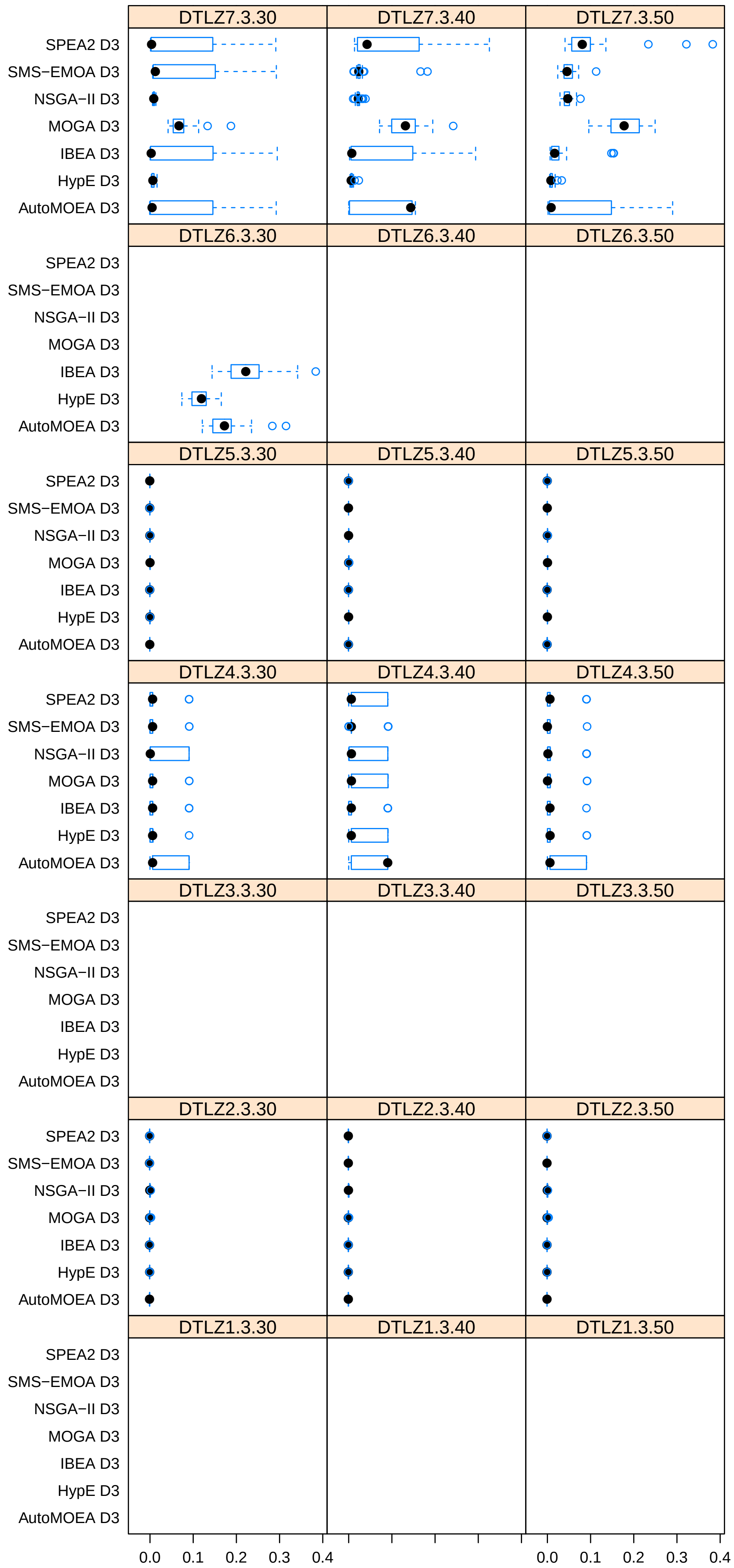

Figure 2. Boxplots of the I_H^{rpd} for 3-objective DTLZ problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations.

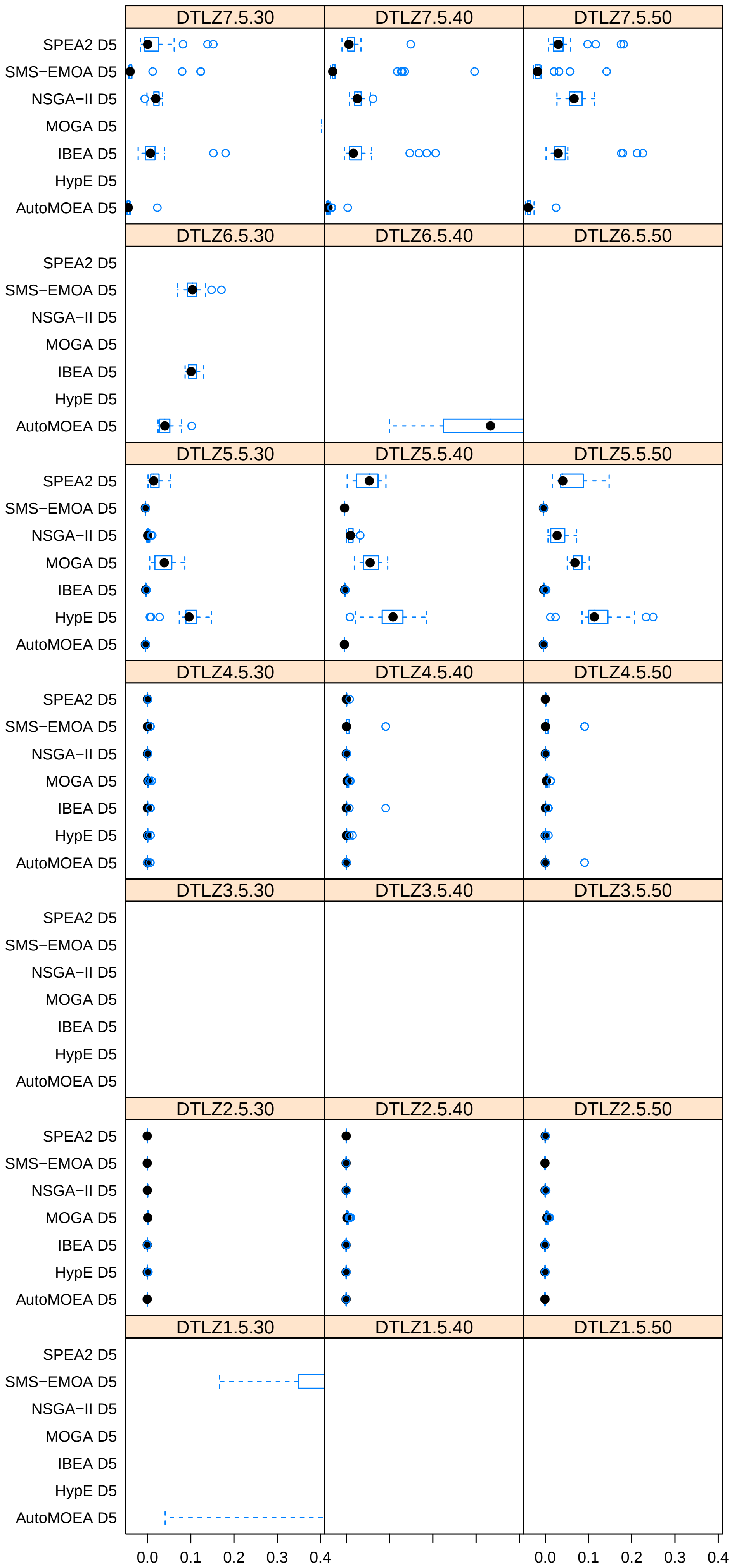

Figure 3. Boxplots of the I_H^{rpd} for 5-objective DTLZ problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations.

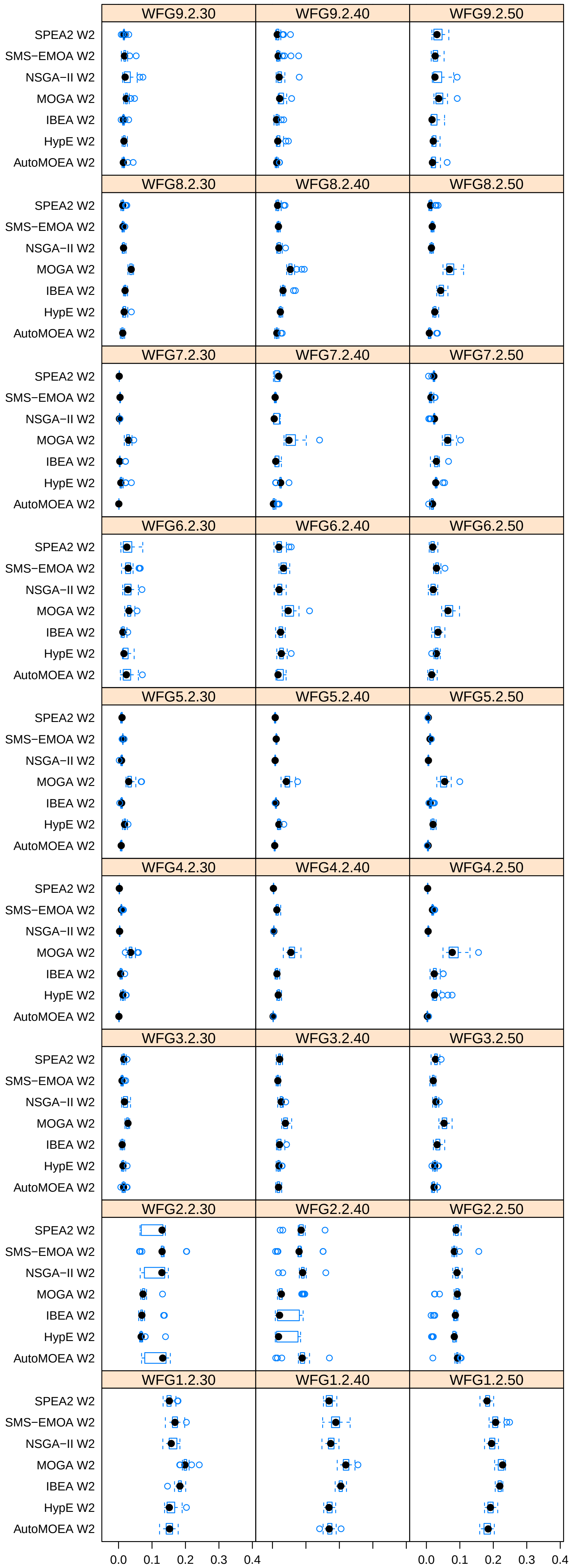

Figure 4. Boxplots of the I_H^{rpd} for 2-objective WFG problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations.

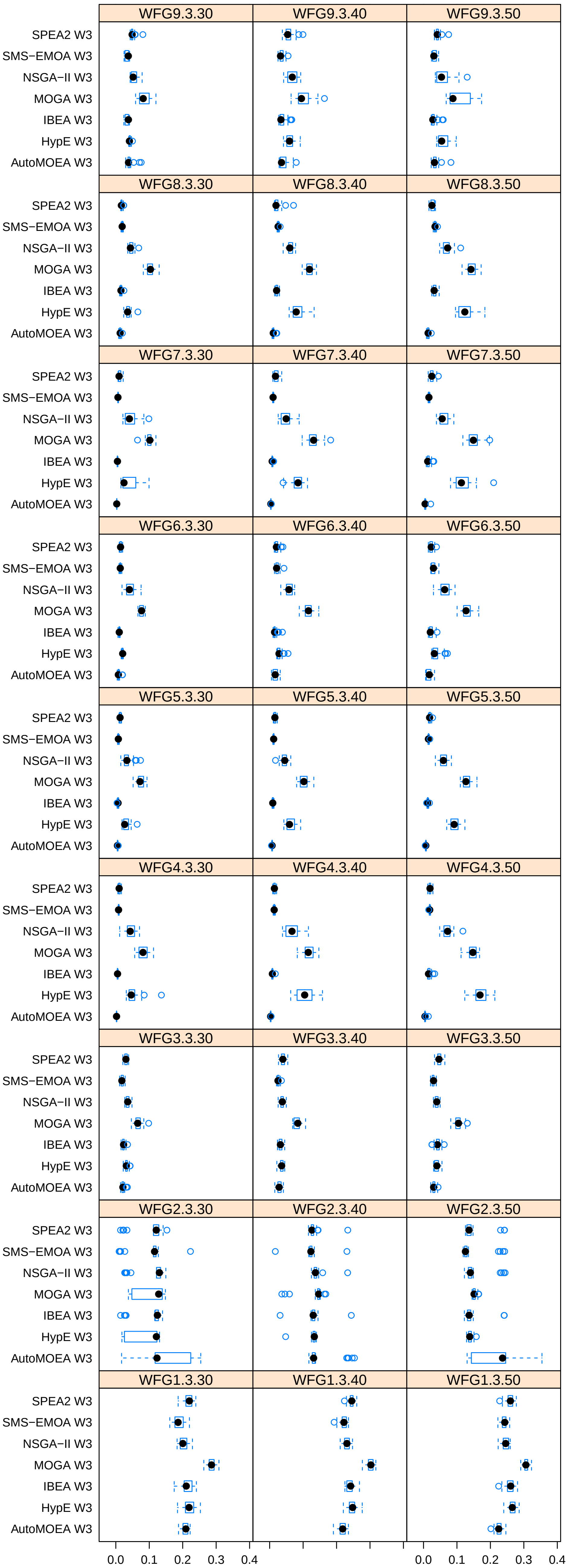

Figure 5. Boxplots of the I_H^{rpd} for 3-objective WFG problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations.

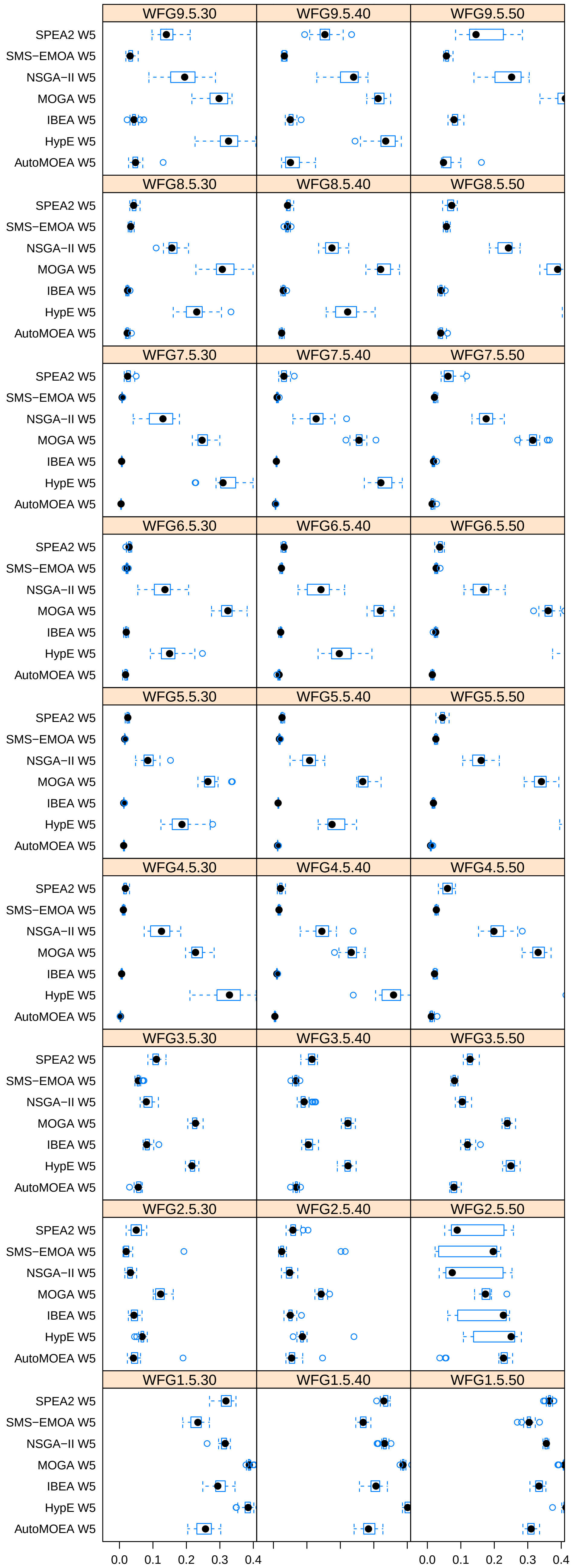

Figure 6. Boxplots of the I_H^{rpd} for 5-objective WFG problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations.

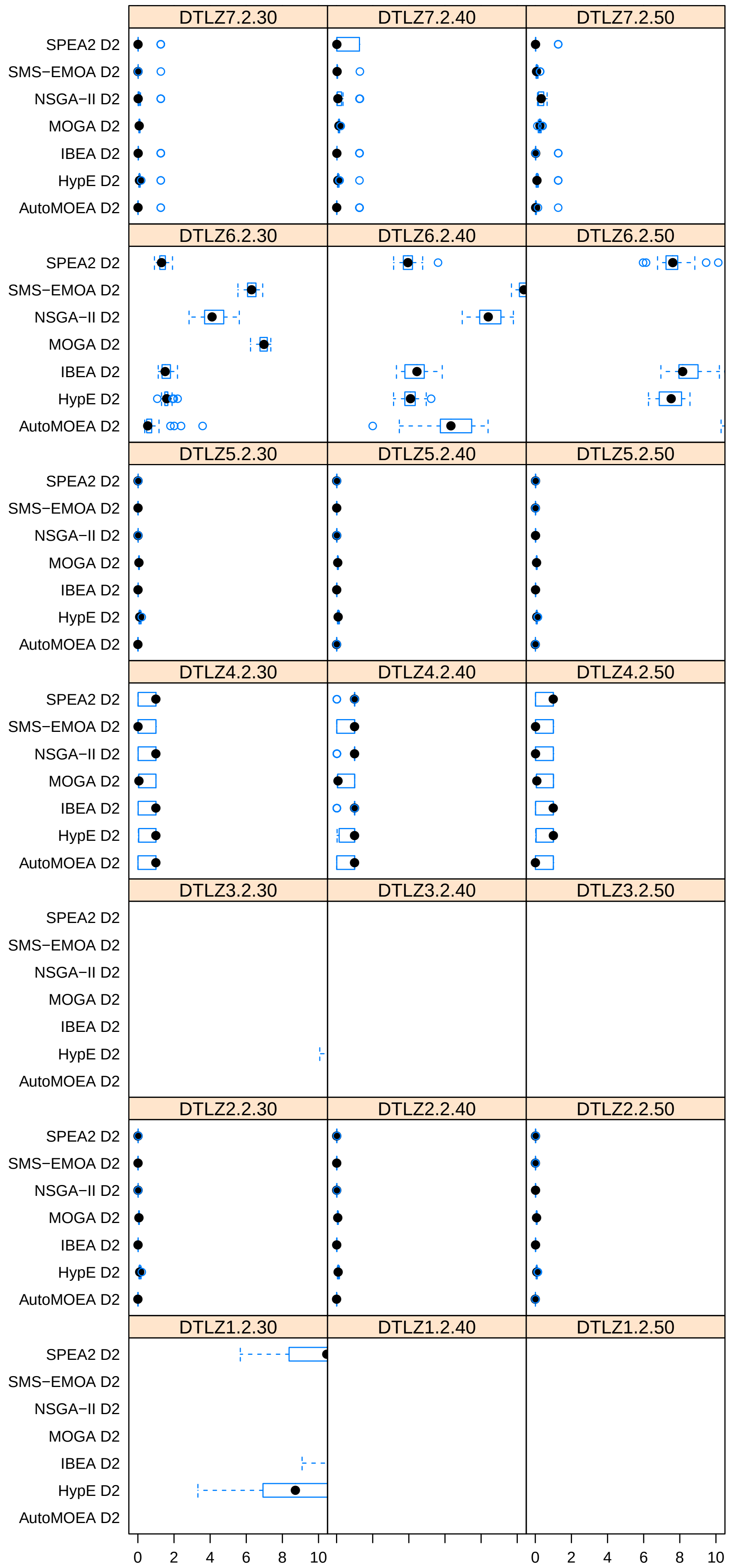

Figure 7. Boxplots of the I_ϵ for 2-objective DTLZ problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations.

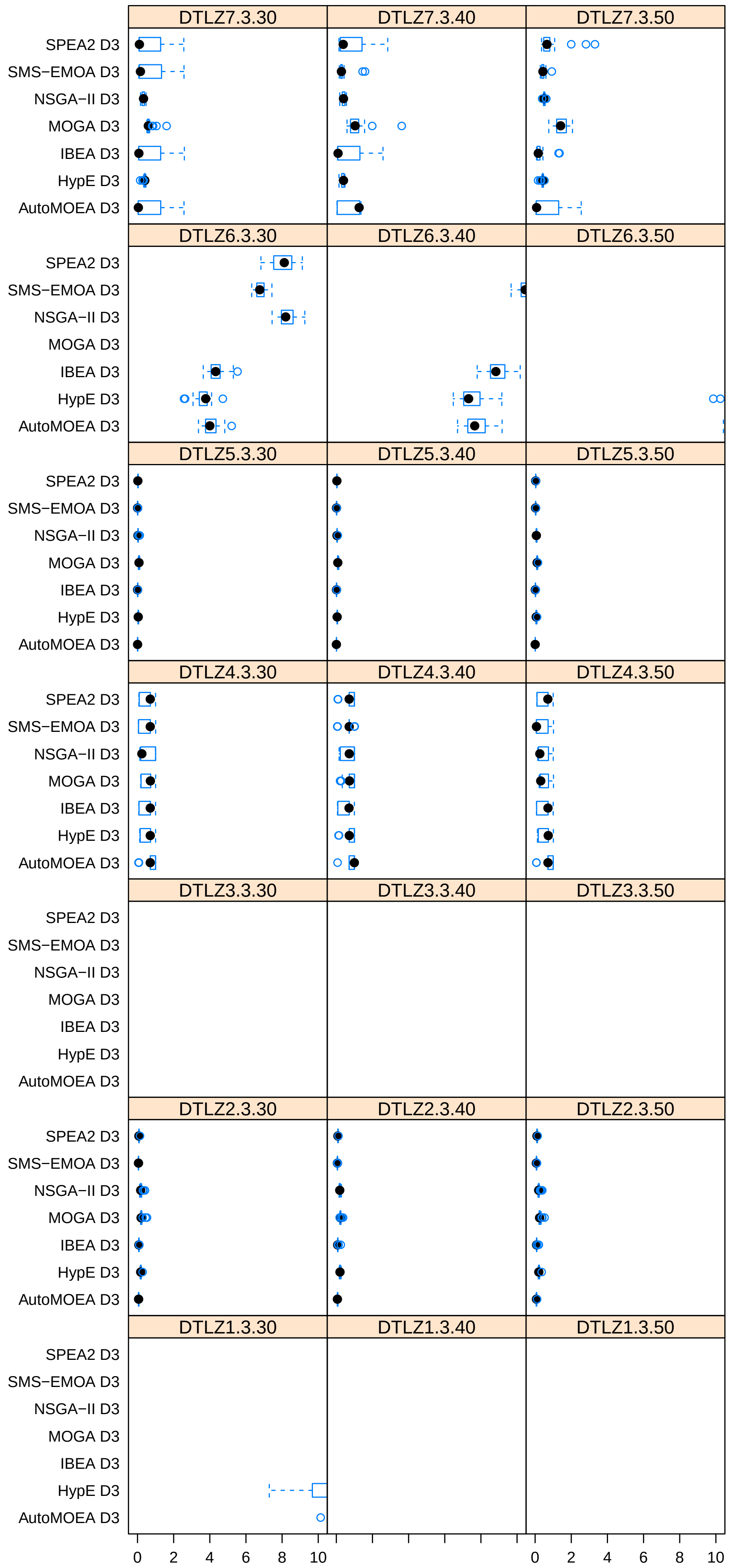

Figure 8. Boxplots of the I_ϵ for 3-objective DTLZ problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations.

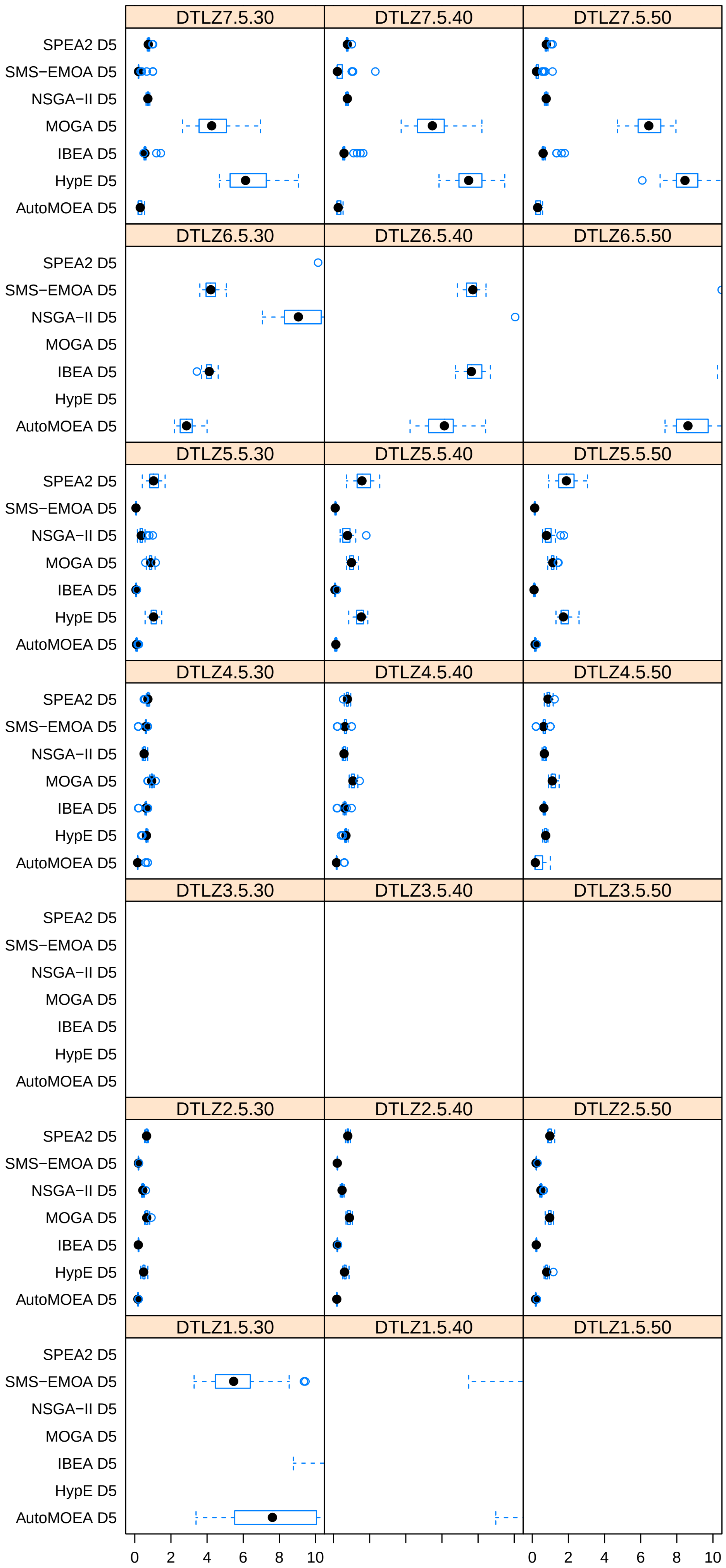

Figure 9. Boxplots of the I_ϵ for 5-objective DTLZ problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations.

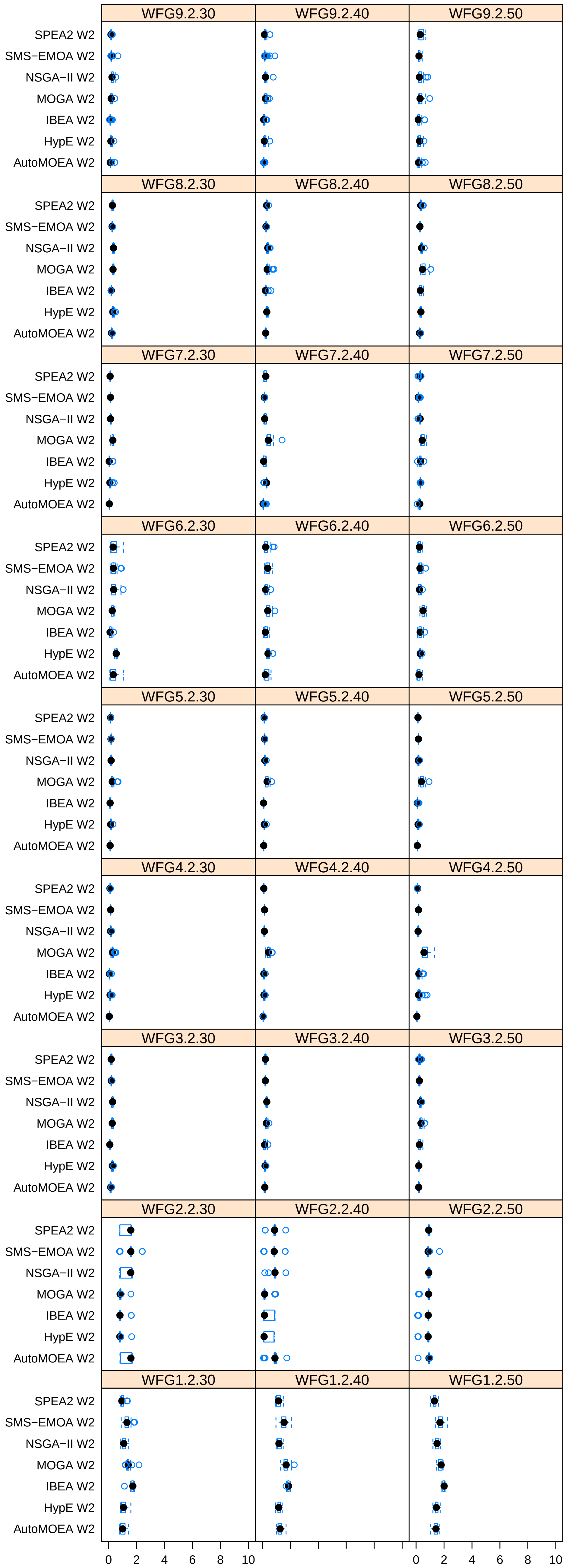

Figure 10. Boxplots of the I_ϵ for 2-objective WFG problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations.

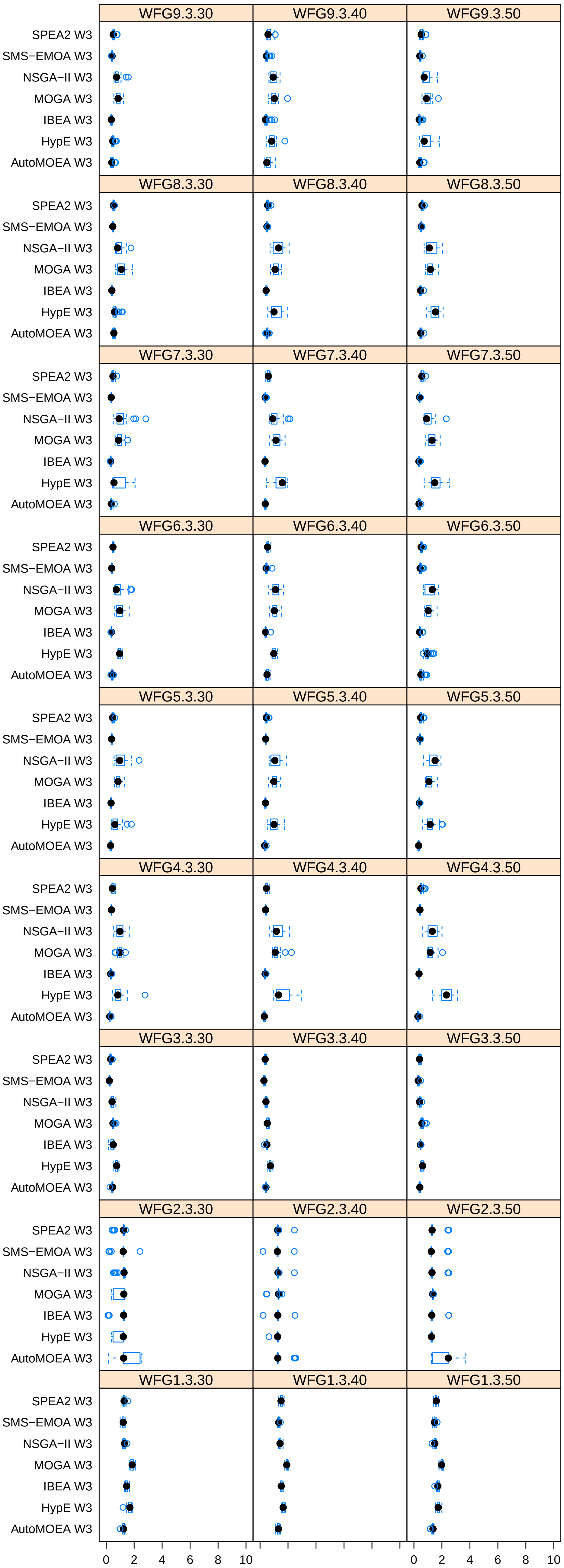

Figure 11. Boxplots of the I_ϵ for 3-objective WFG problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations.

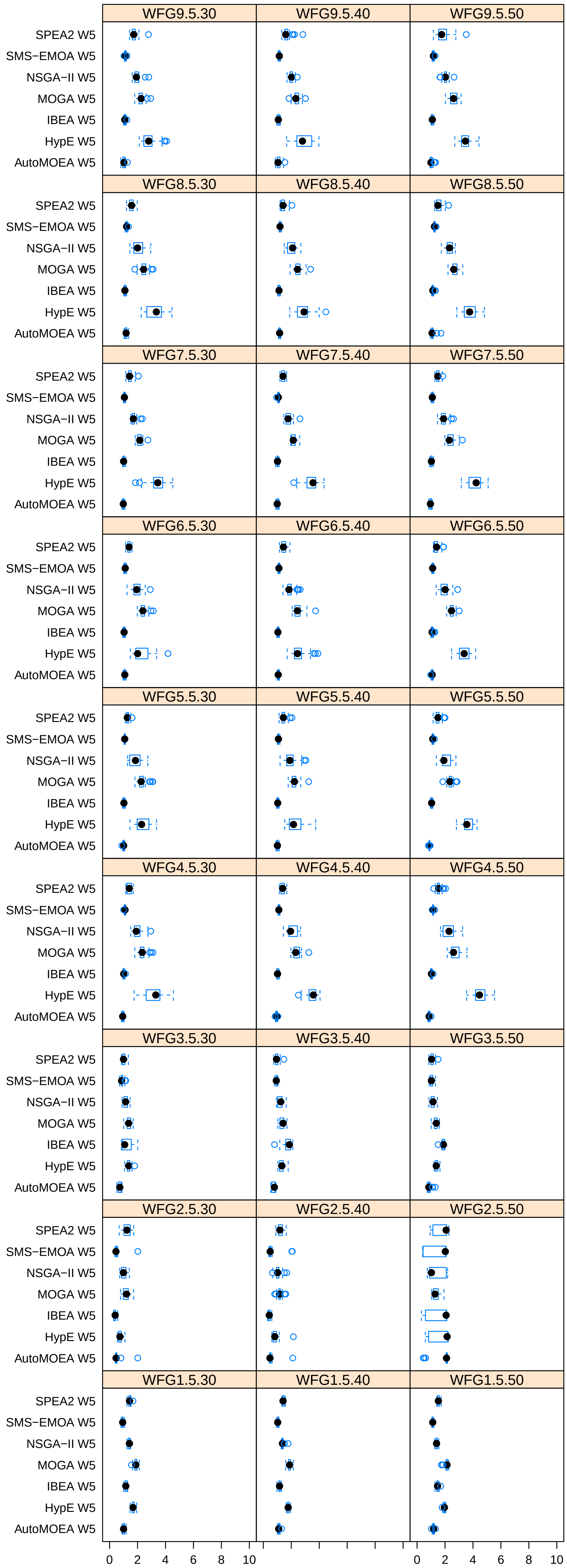

Figure 12. Boxplots of the I_ϵ for 5-objective WFG problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations.

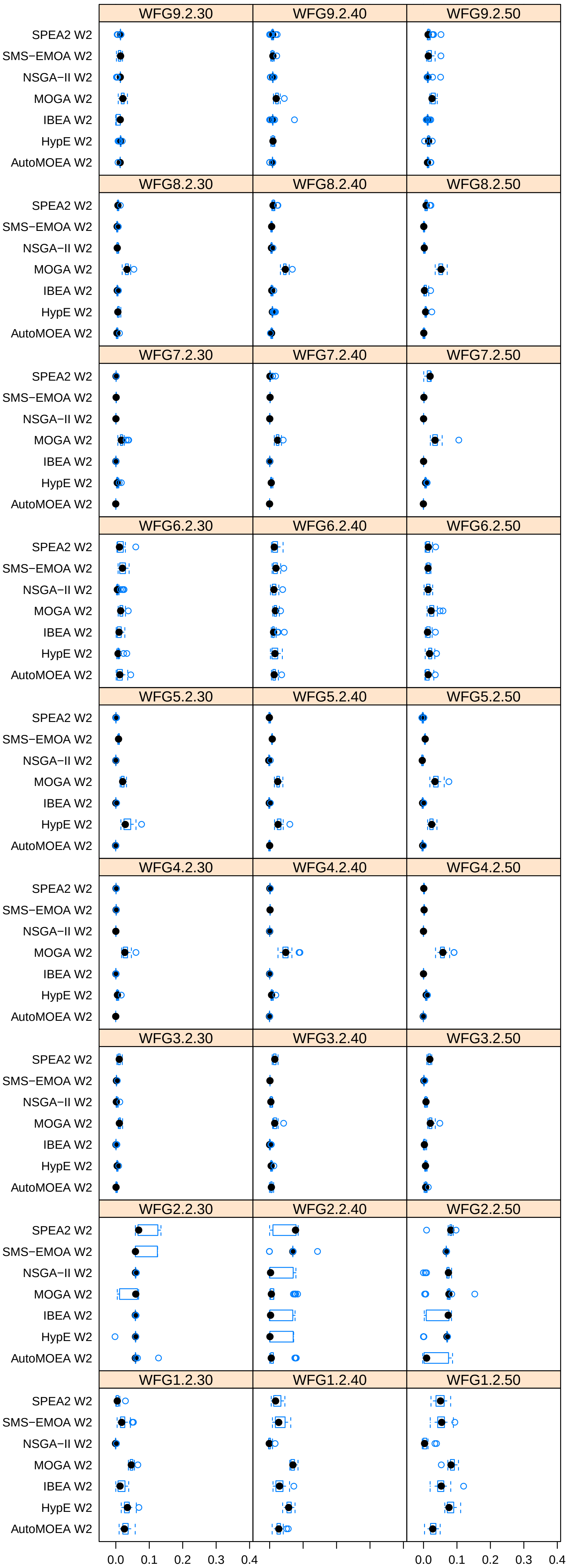

Figure 13. Boxplots of the I_H^{rpd} for 2-objective WFG problems with $\{30, 40, 50\}$ variables and a maximum runtime of one minute.

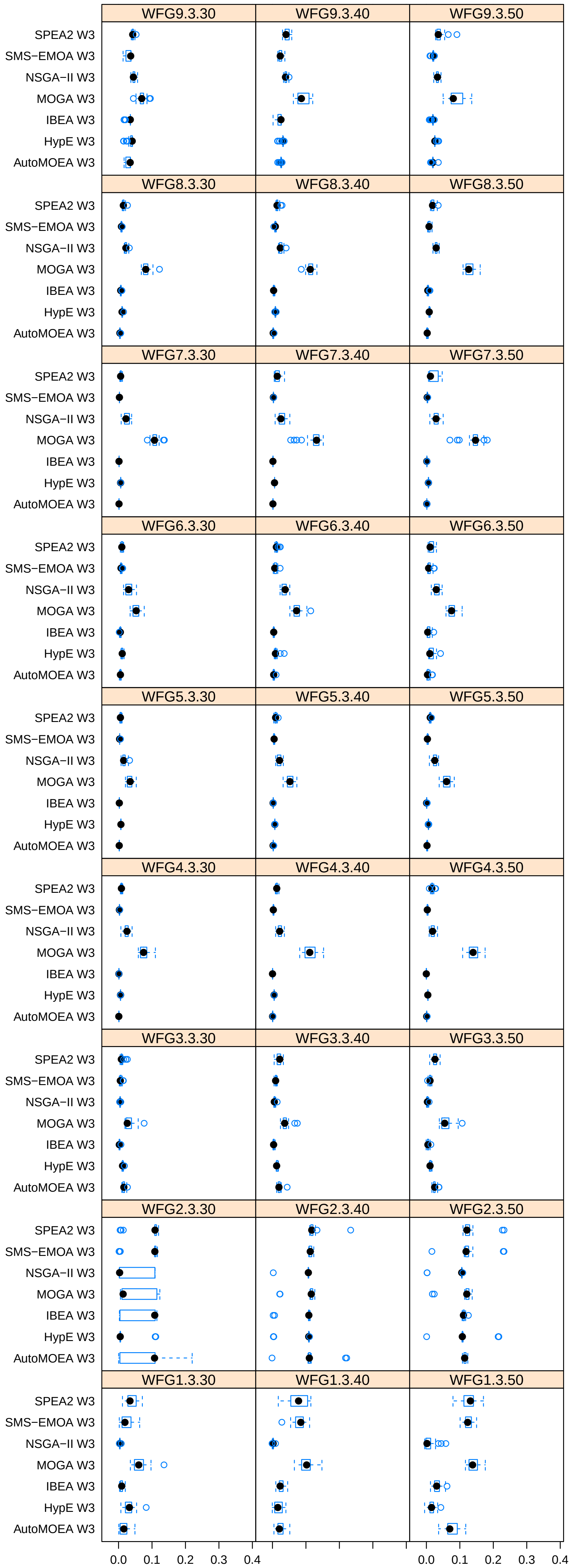

Figure 14. Boxplots of the I_H^{rpd} for 3-objective WFG problems with $\{30, 40, 50\}$ variables and a maximum runtime of one minute.

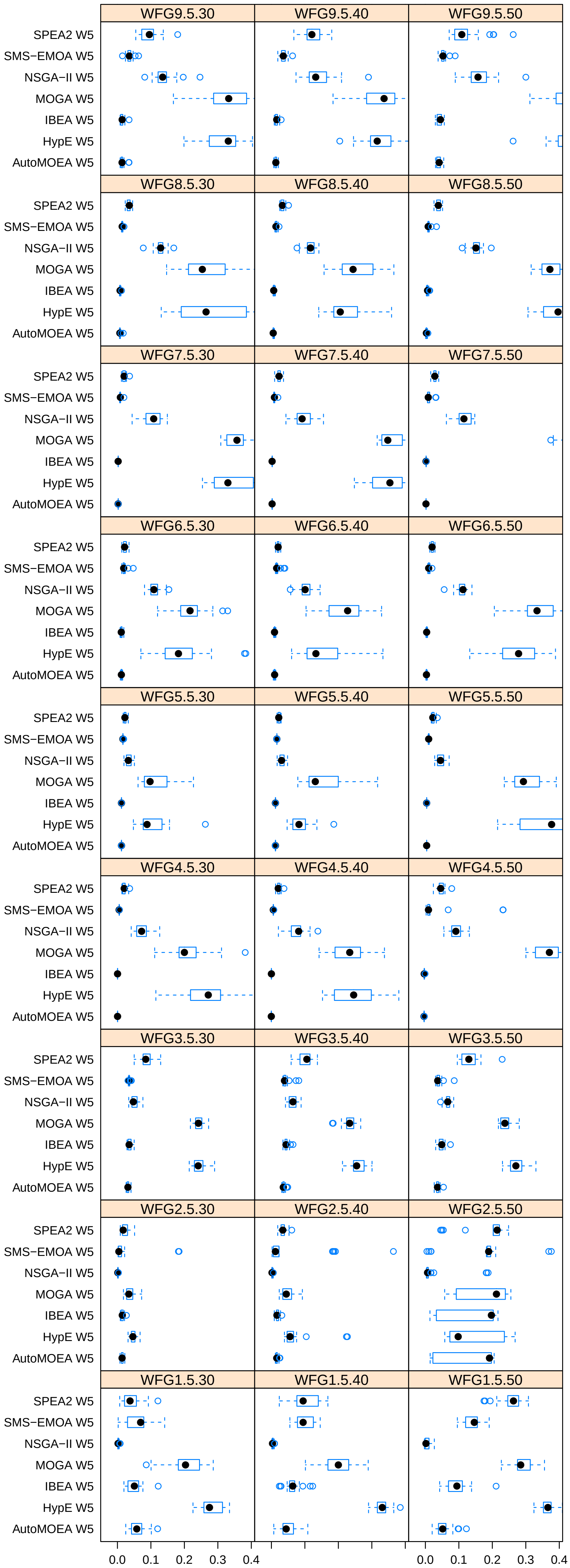

Figure 15. Boxplots of the I_H^{rpd} for 5-objective WFG problems with $\{30, 40, 50\}$ variables and a maximum runtime of one minute.

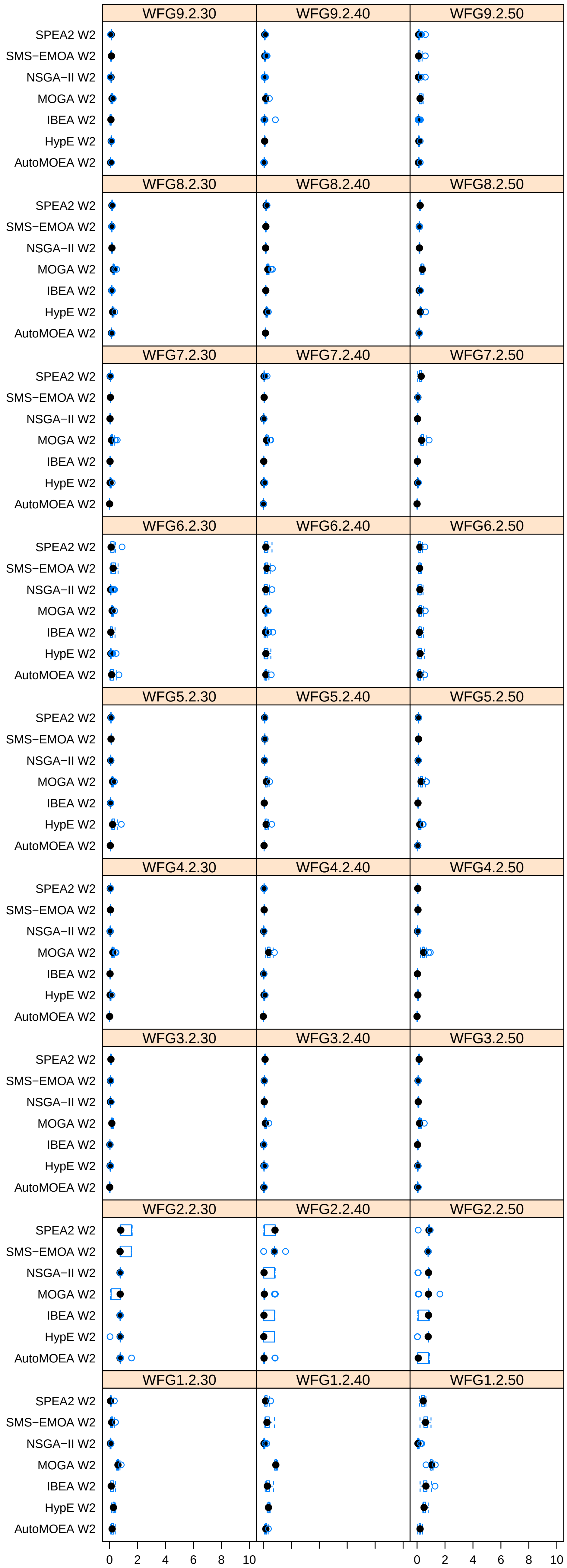

Figure 16. Boxplots of the I_ϵ for 2-objective WFG problems with $\{30, 40, 50\}$ variables and a maximum runtime of one minute.

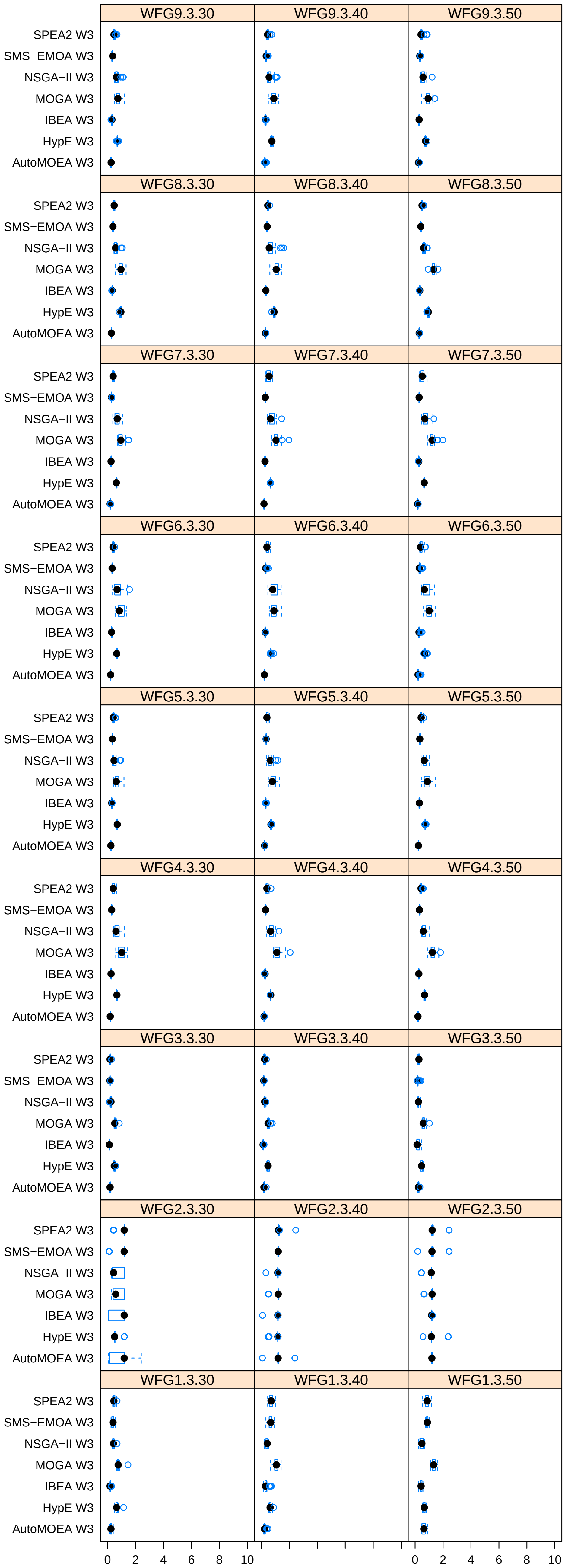

Figure 17. Boxplots of the I_ϵ for 3-objective WFG problems with $\{30, 40, 50\}$ variables and a maximum runtime of one minute.

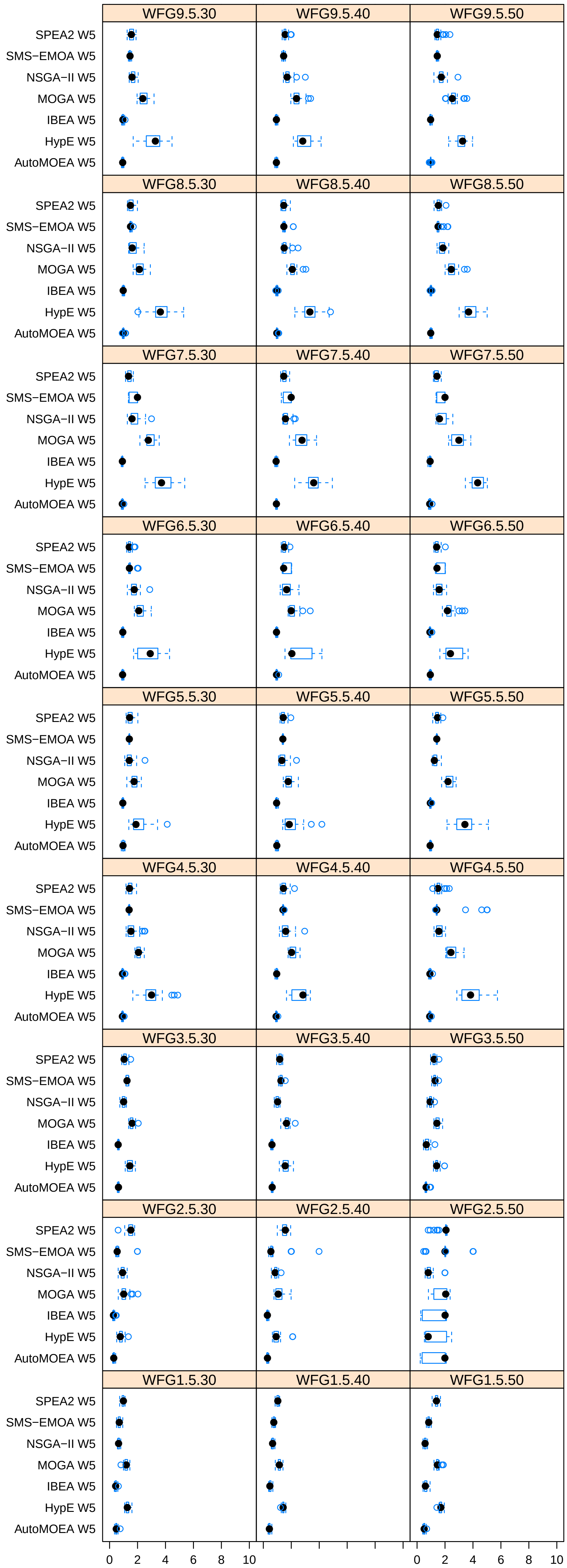

Figure 18. Boxplots of the I_ϵ for 5-objective WFG problems with $\{30, 40, 50\}$ variables and a maximum runtime of one minute.

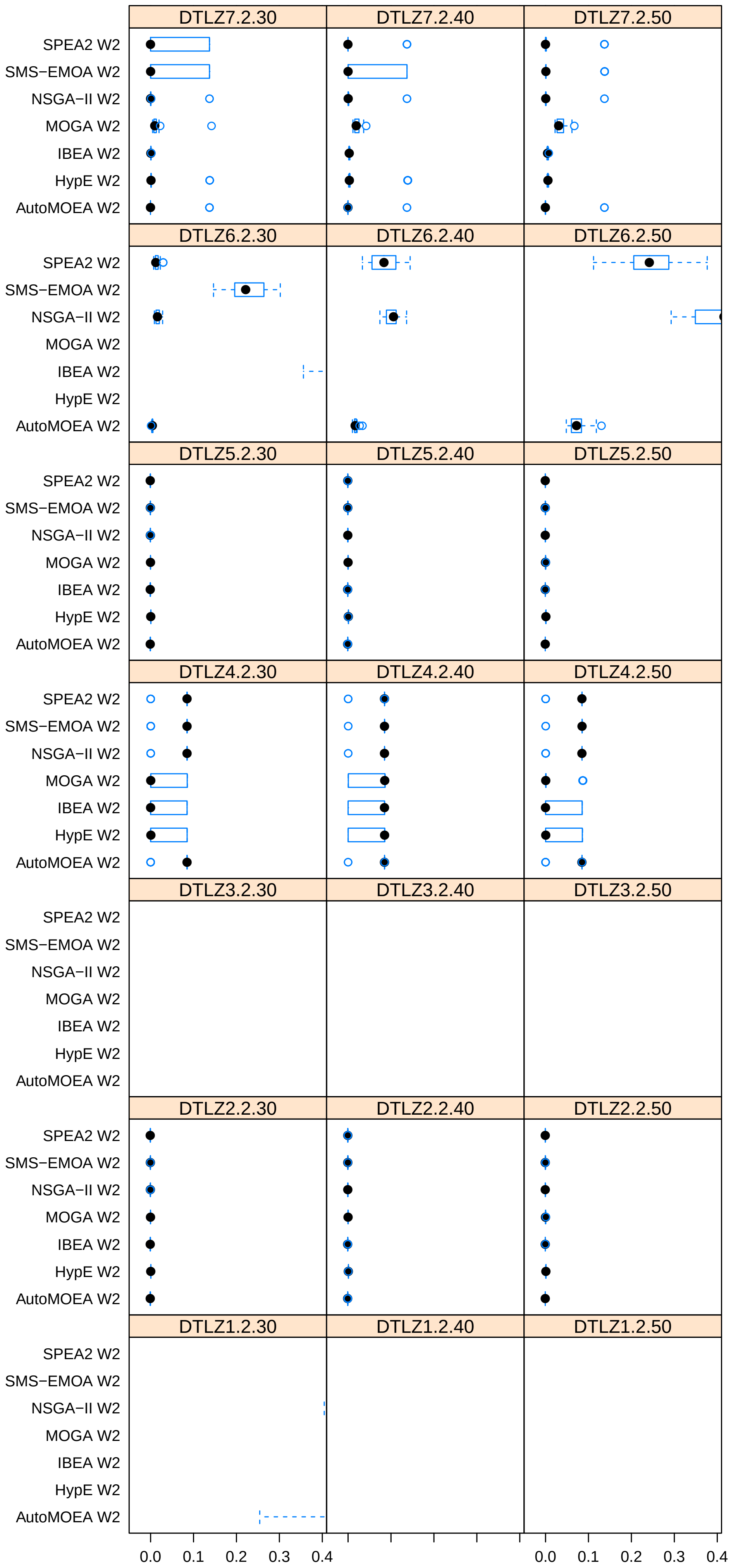

Figure 19. Boxplots of the I_H^{rpd} for 2-objective DTLZ problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations, when algorithms are tuned for the WFG benchmark.

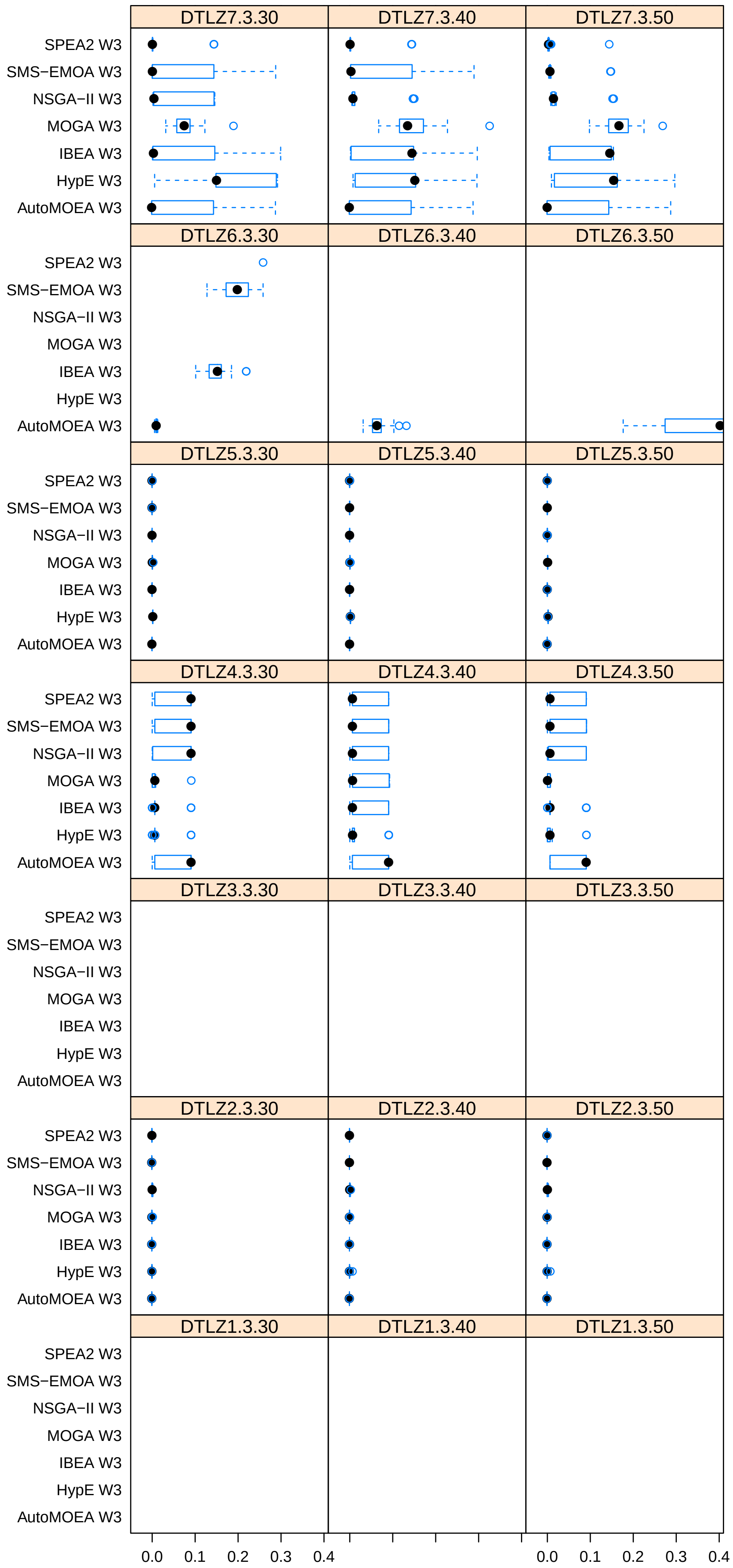

Figure 20. Boxplots of the I_H^{rpd} for 3-objective DTLZ problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations, when algorithms are tuned for the WFG benchmark.

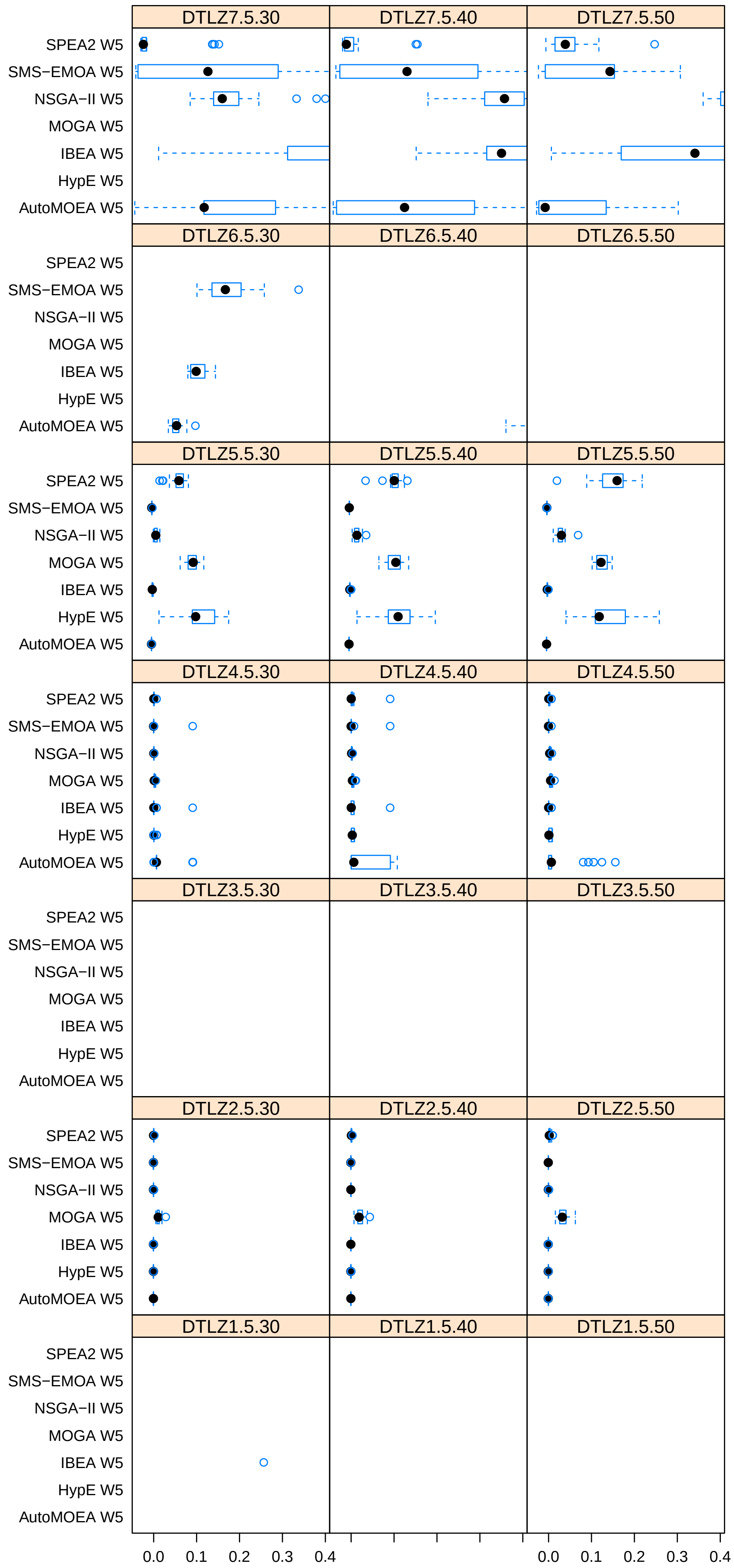

Figure 21. Boxplots of the I_H^{rpd} for 5-objective DTLZ problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations, when algorithms are tuned for the WFG benchmark.

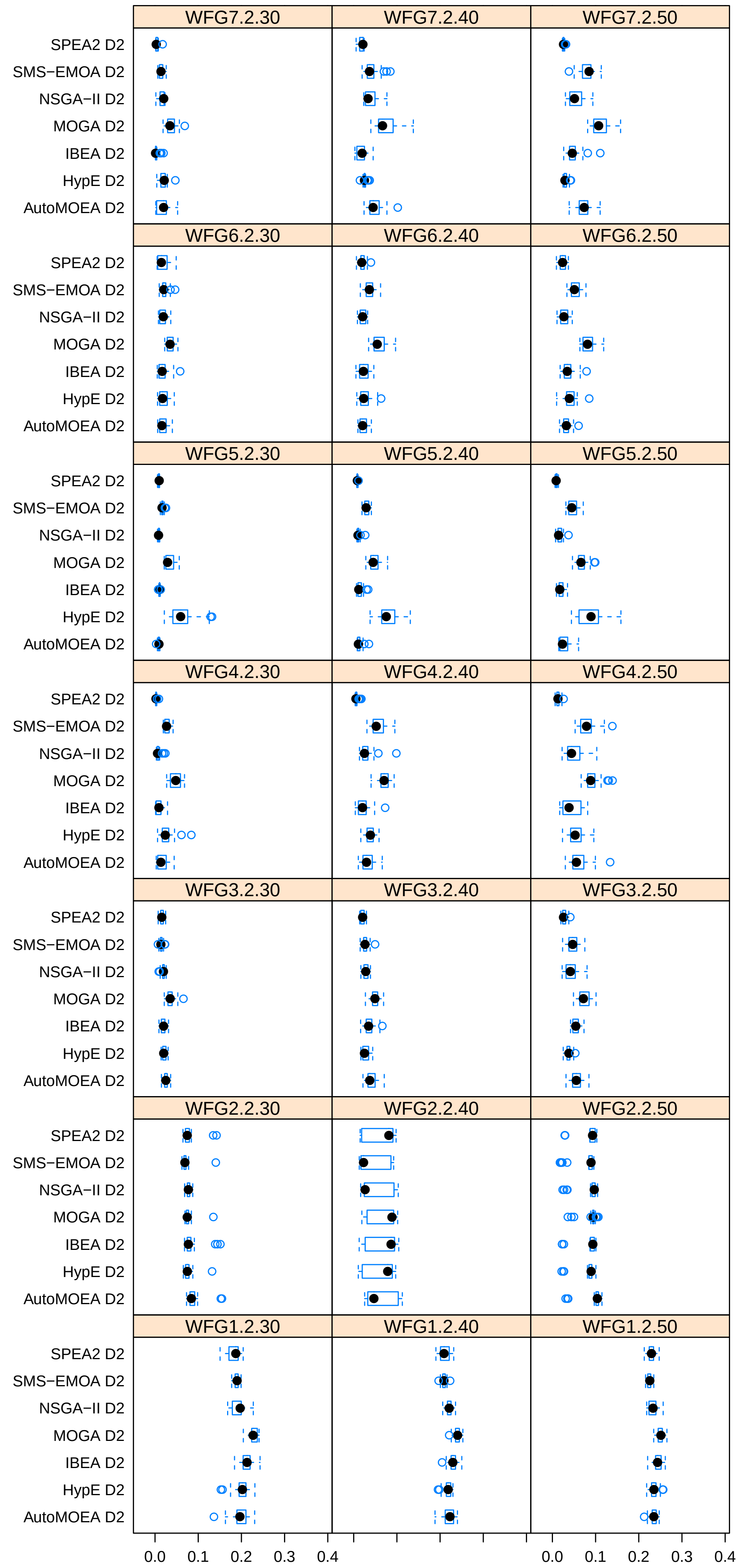

Figure 22. Boxplots of the I_H^{rpd} for 2-objective WFG problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations, when algorithms are tuned for the DTLZ benchmark.

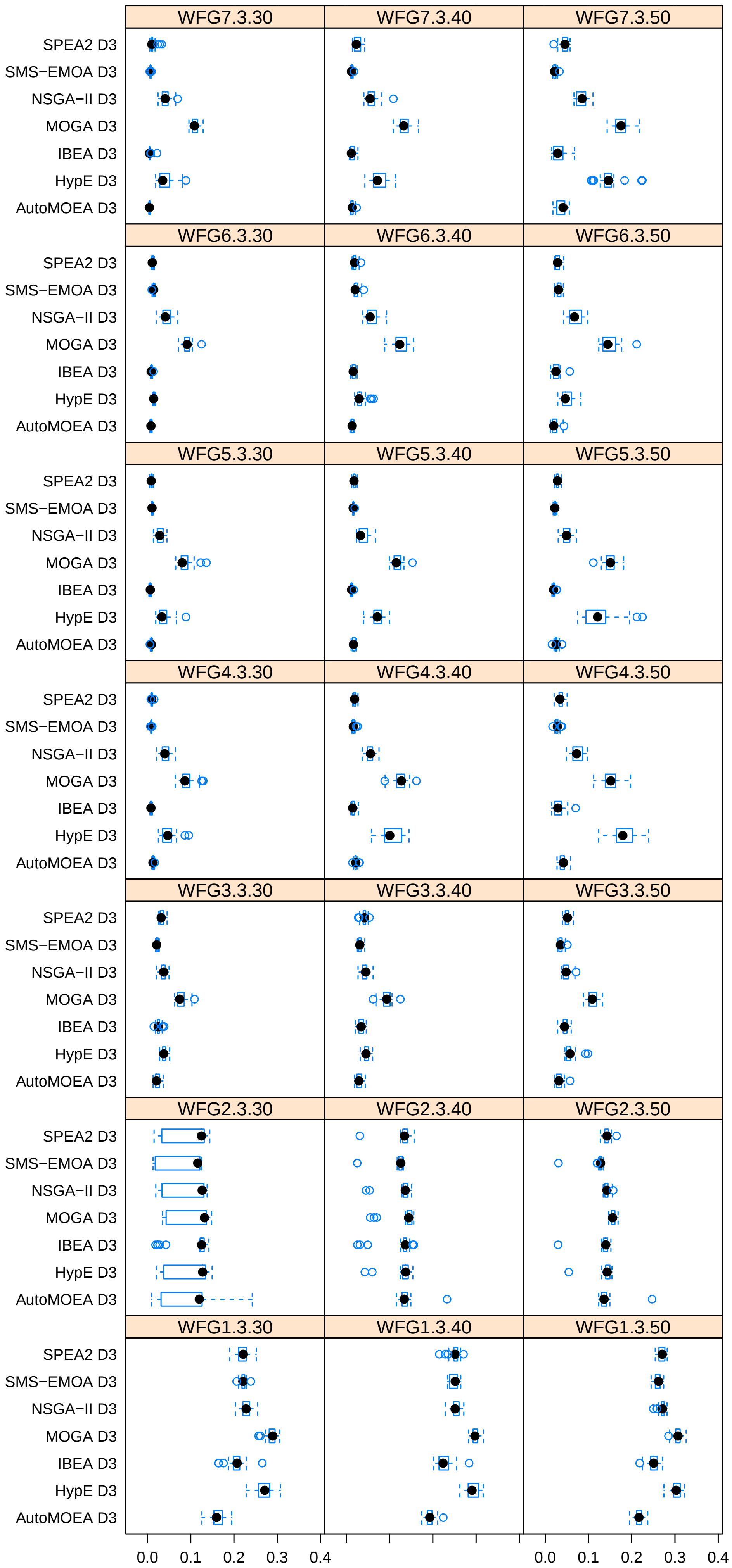

Figure 23. Boxplots of the I_H^{rpd} for 3-objective WFG problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations, when algorithms are tuned for the DTLZ benchmark.

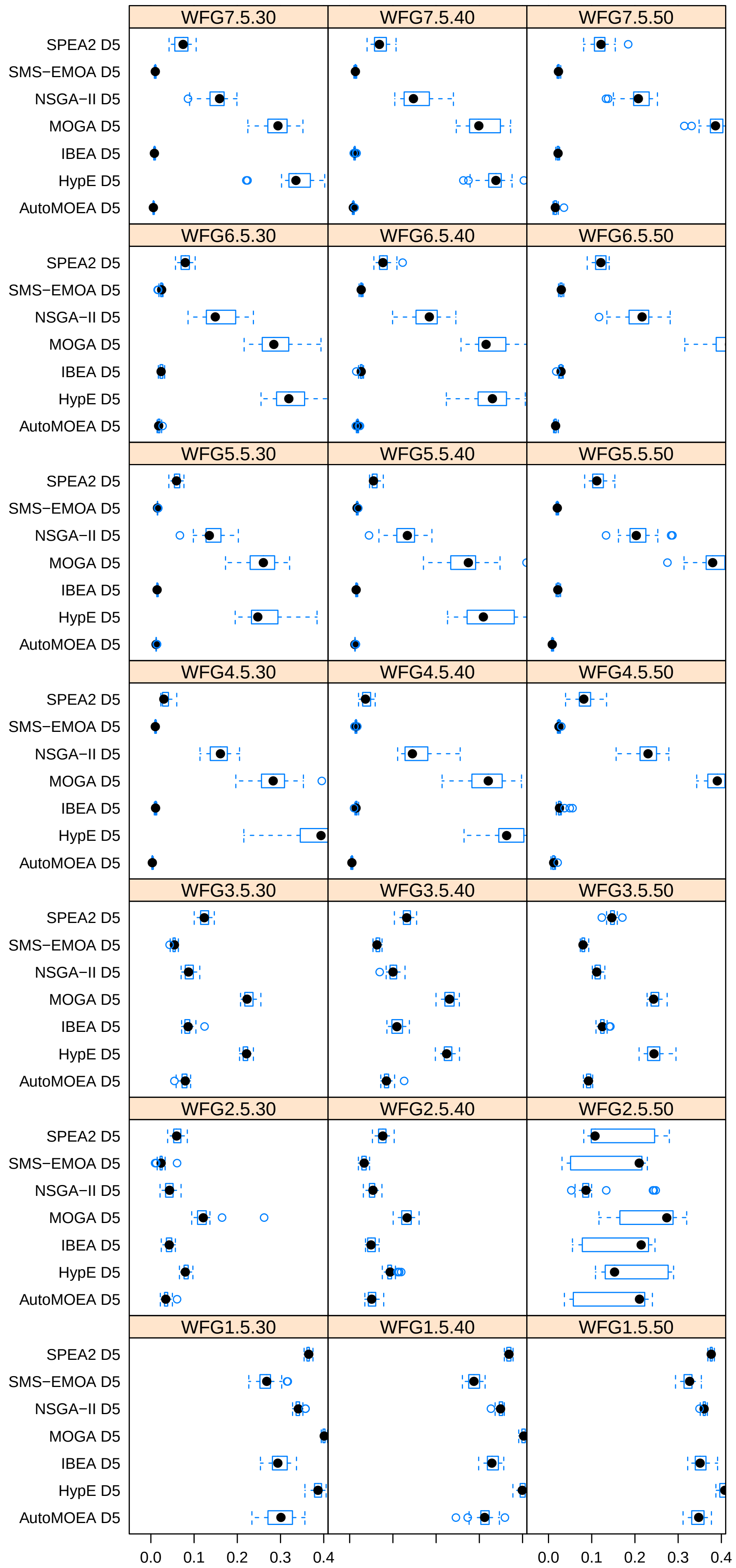

Figure 24. Boxplots of the I_H^{rpd} for 5-objective WFG problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations, when algorithms are tuned for the DTLZ benchmark.

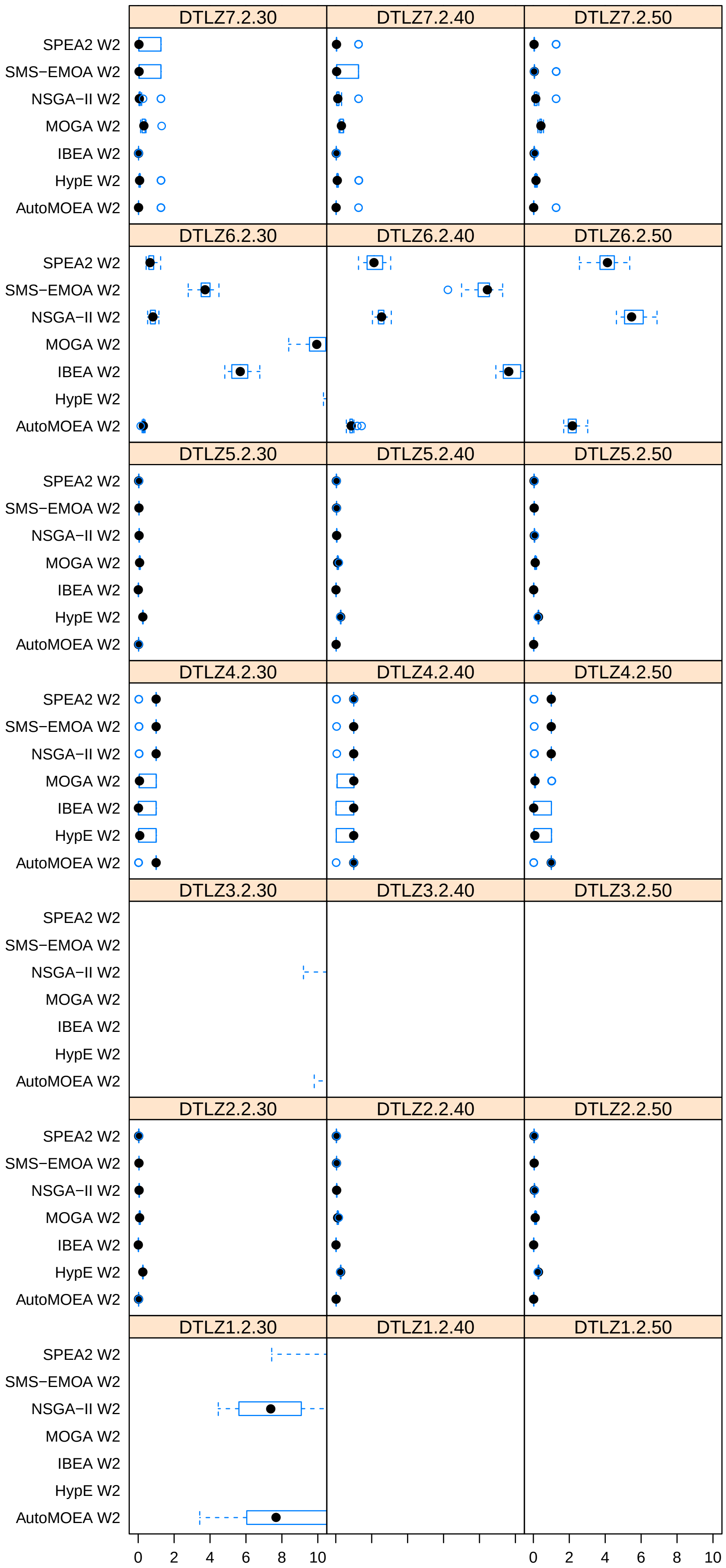

Figure 25. Boxplots of the I_ϵ for 2-objective DTLZ problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations, when algorithms are tuned for the WFG benchmark.

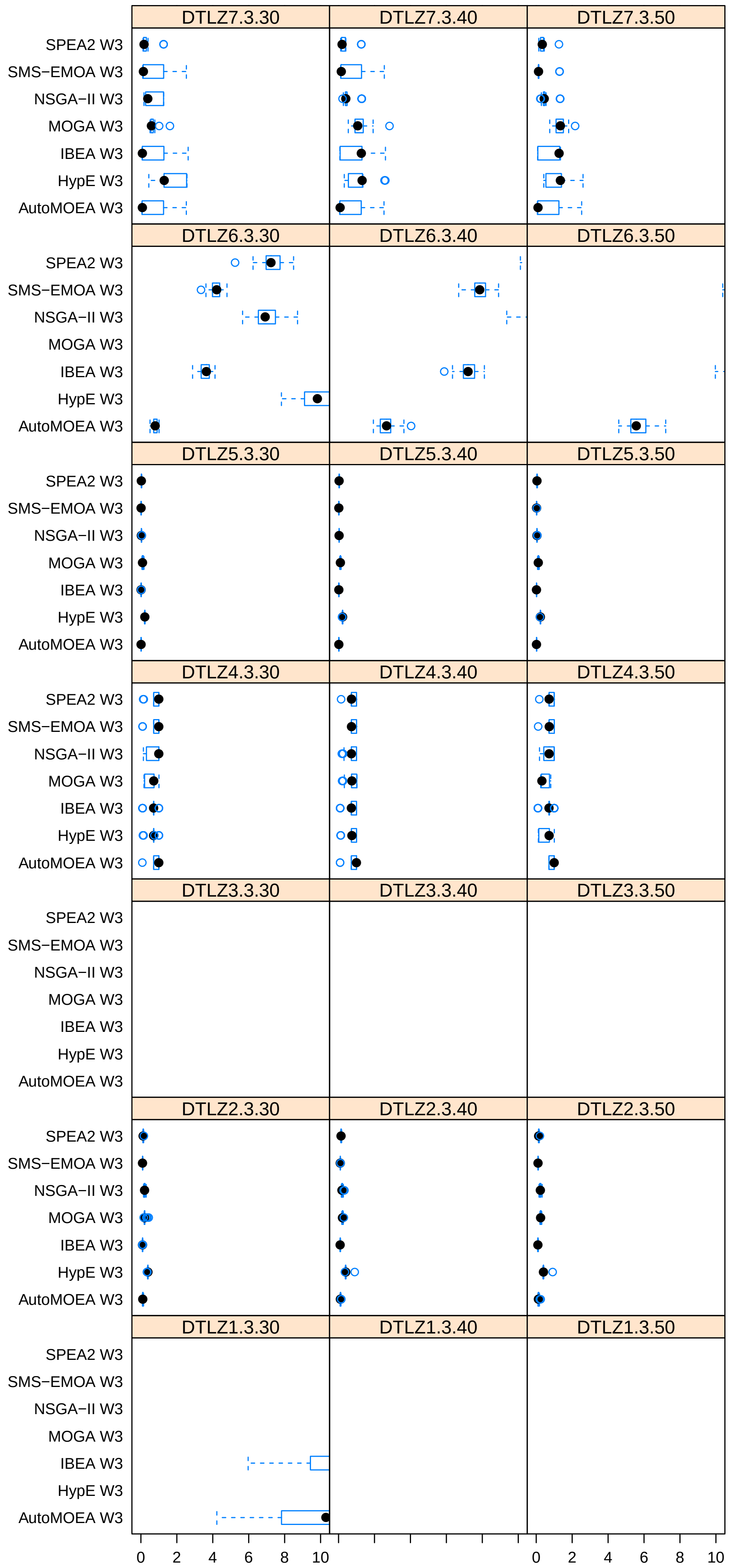

Figure 26. Boxplots of the I_ϵ for 3-objective DTLZ problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations, when algorithms are tuned for the WFG benchmark.

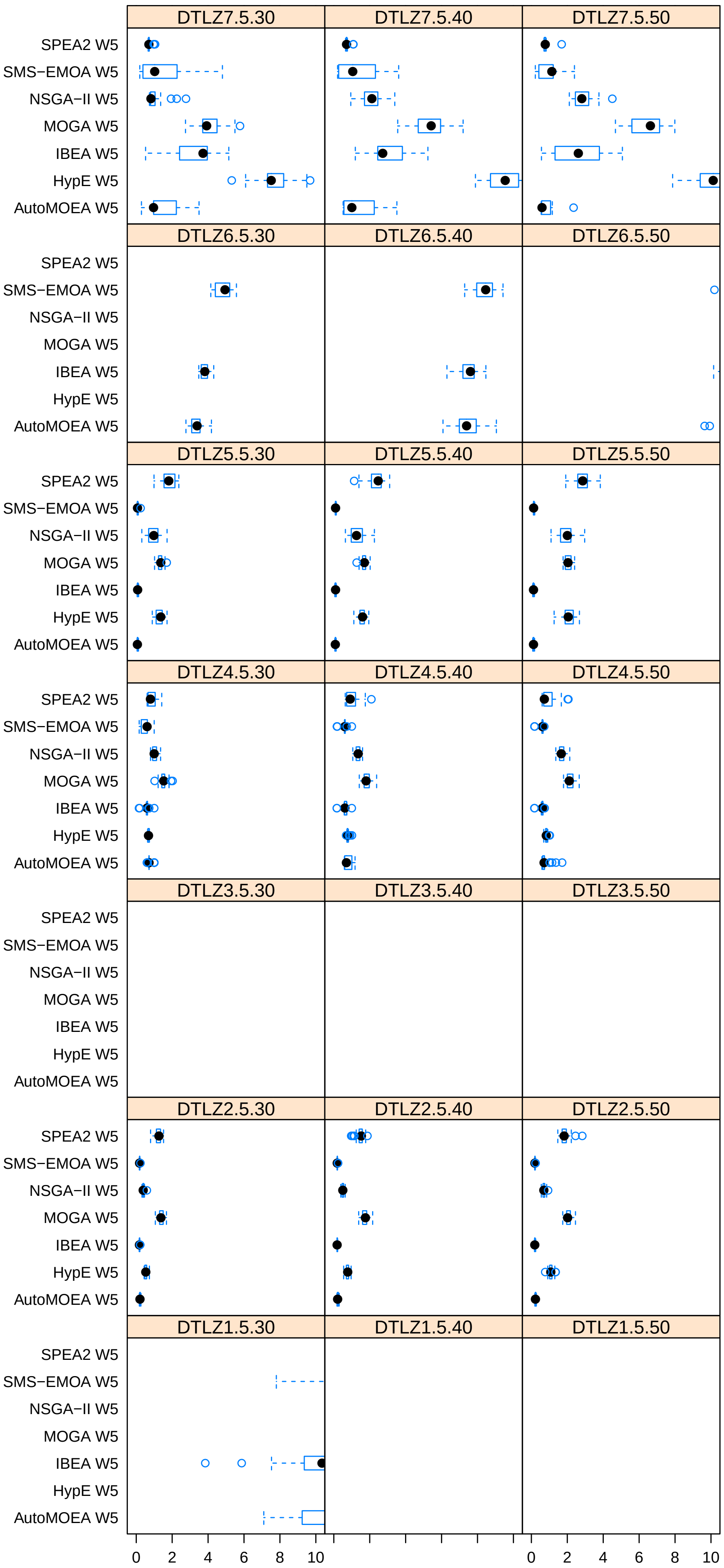

Figure 27. Boxplots of the I_ϵ for 5-objective DTLZ problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations, when algorithms are tuned for the WFG benchmark.

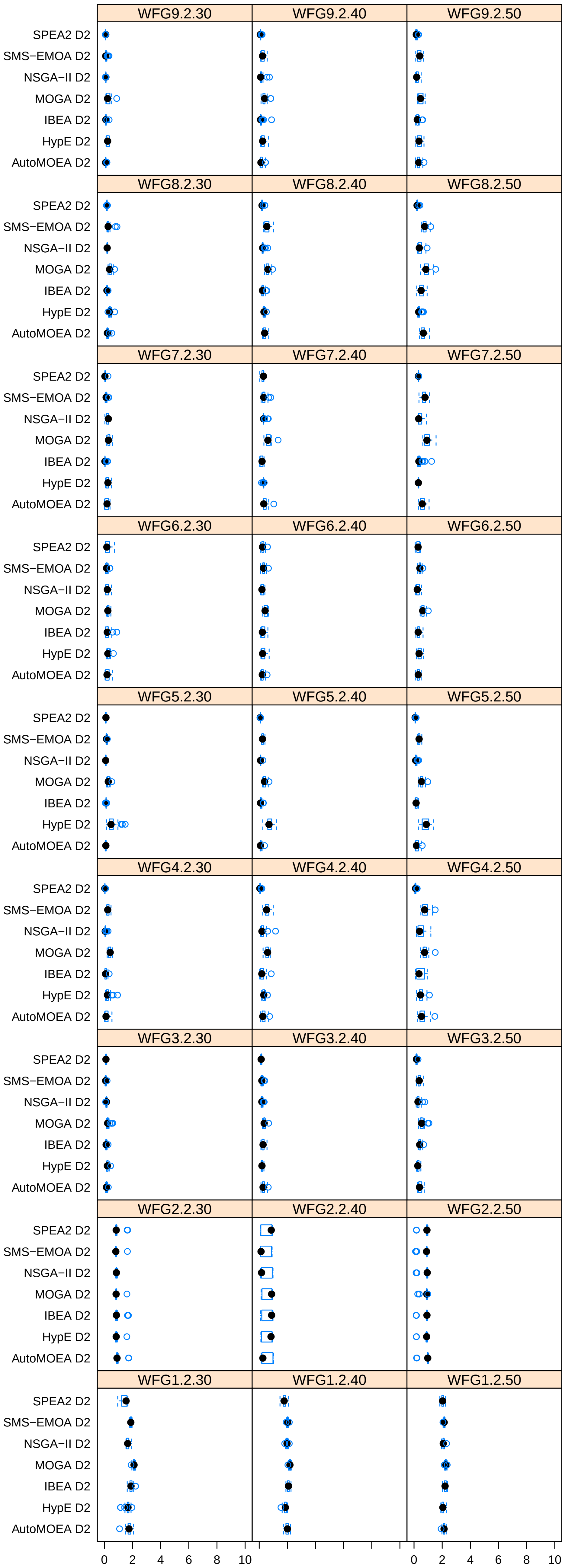

Figure 28. Boxplots of the I_ϵ for 2-objective WFG problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations, when algorithms are tuned for the DTLZ benchmark.

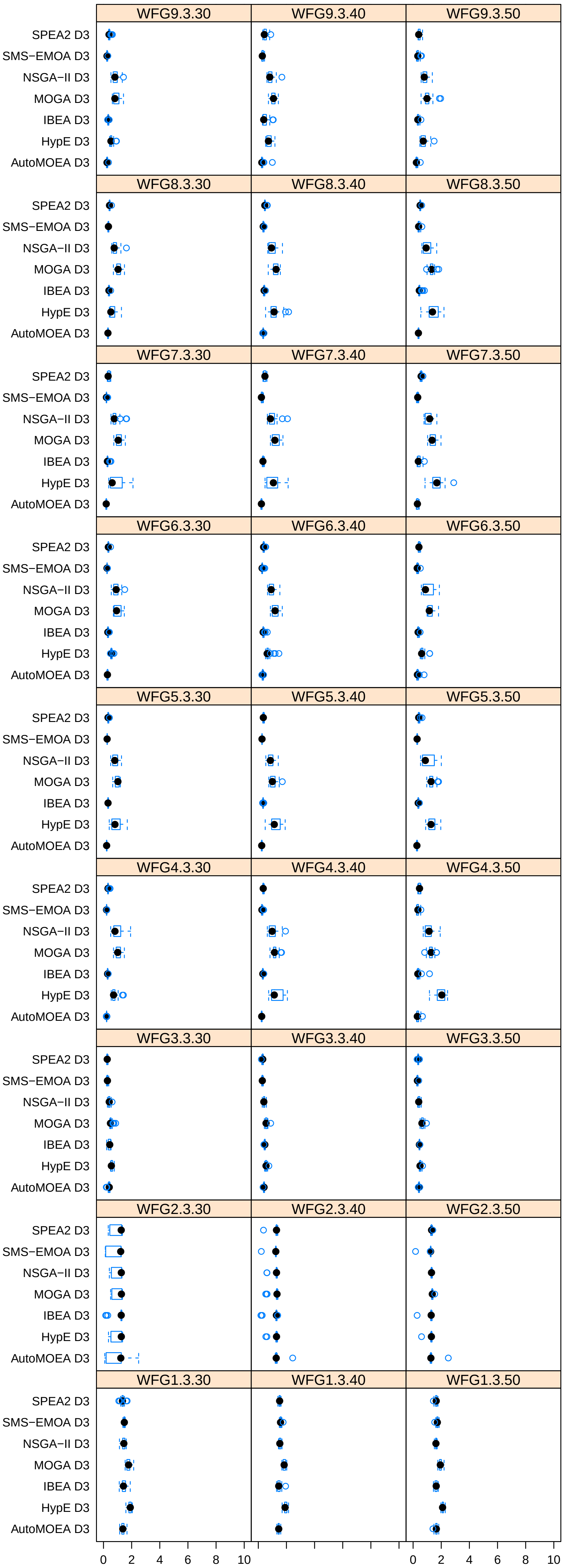

Figure 29. Boxplots of the I_ϵ for 3-objective WFG problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations, when algorithms are tuned for the DTLZ benchmark.

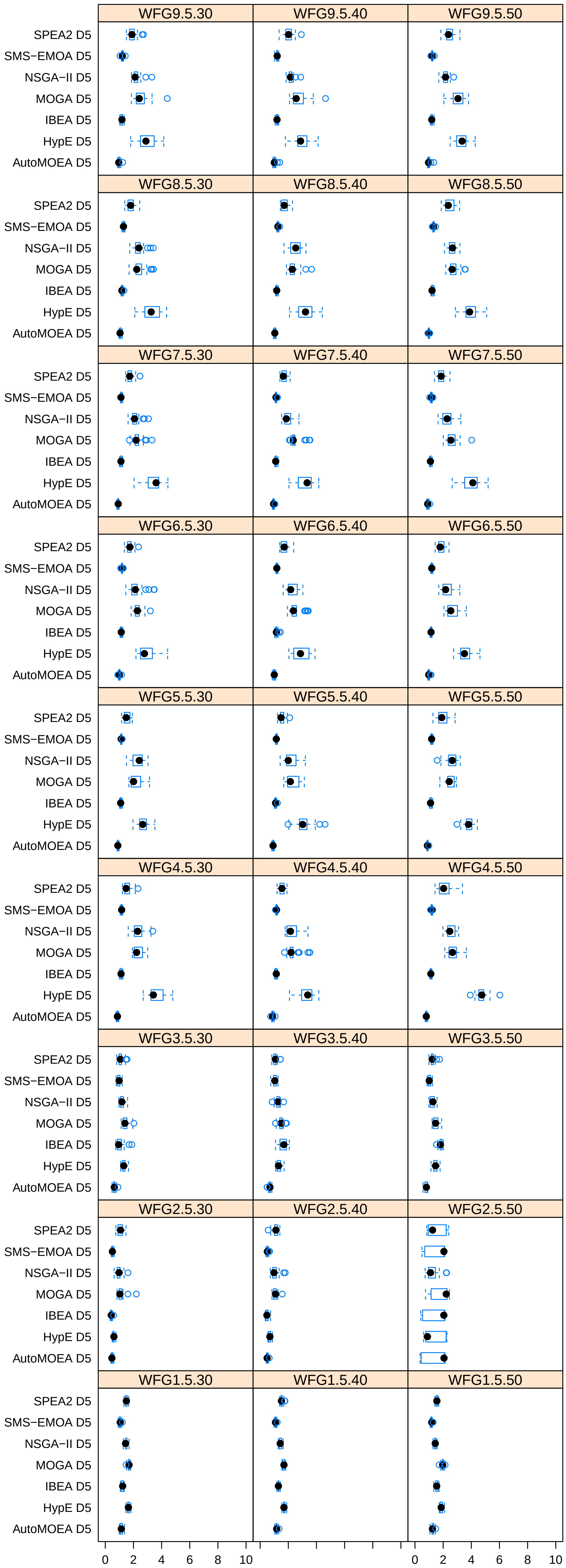

Figure 30. Boxplots of the I_ϵ for 5-objective WFG problems with $\{30, 40, 50\}$ variables and a maximum of 10 000 function evaluations, when algorithms are tuned for the DTLZ benchmark.

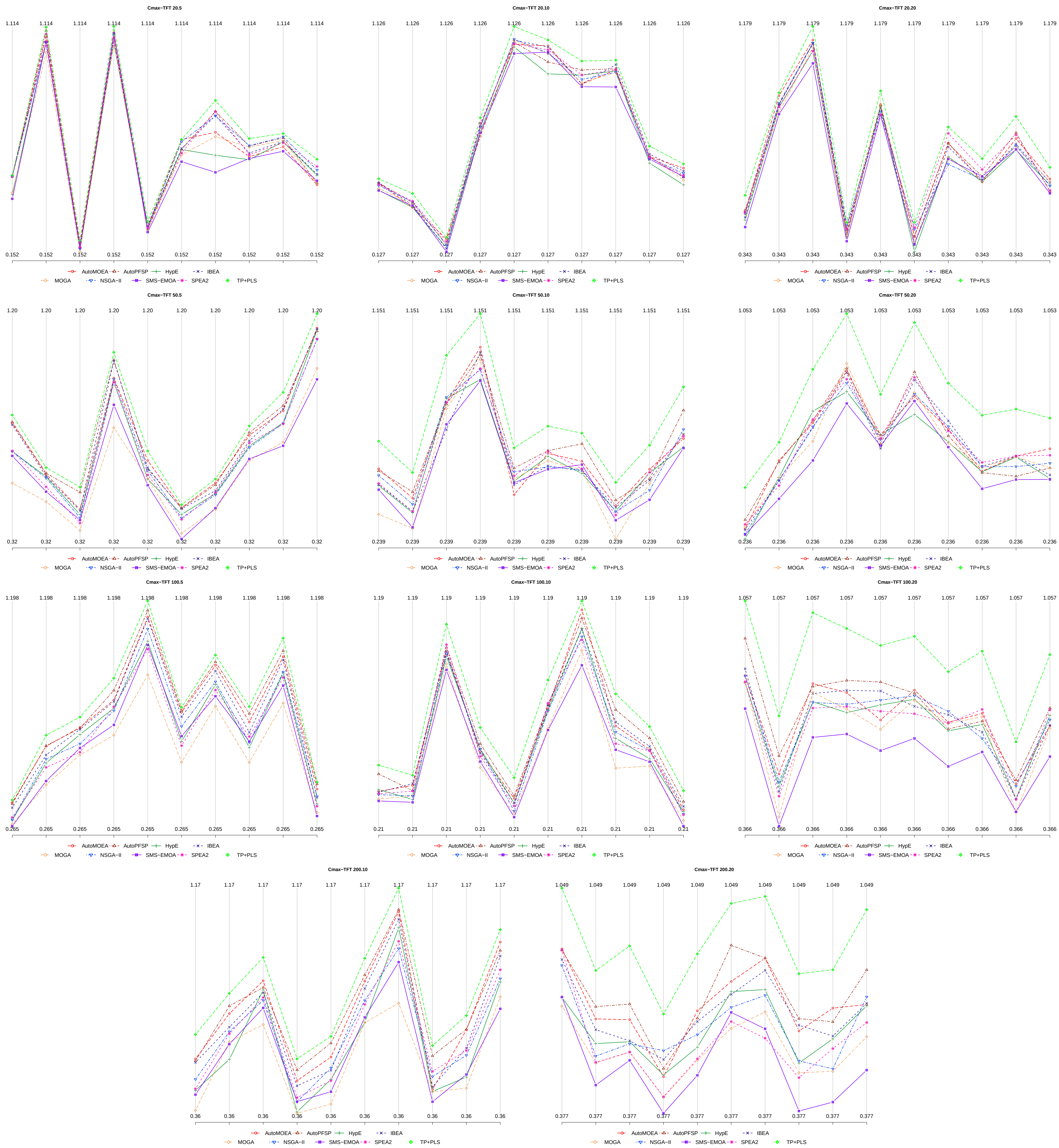

Figure 31. Boxplots of the mean I_H over 10 runs for all algorithms on the Cmax-TFT variant.

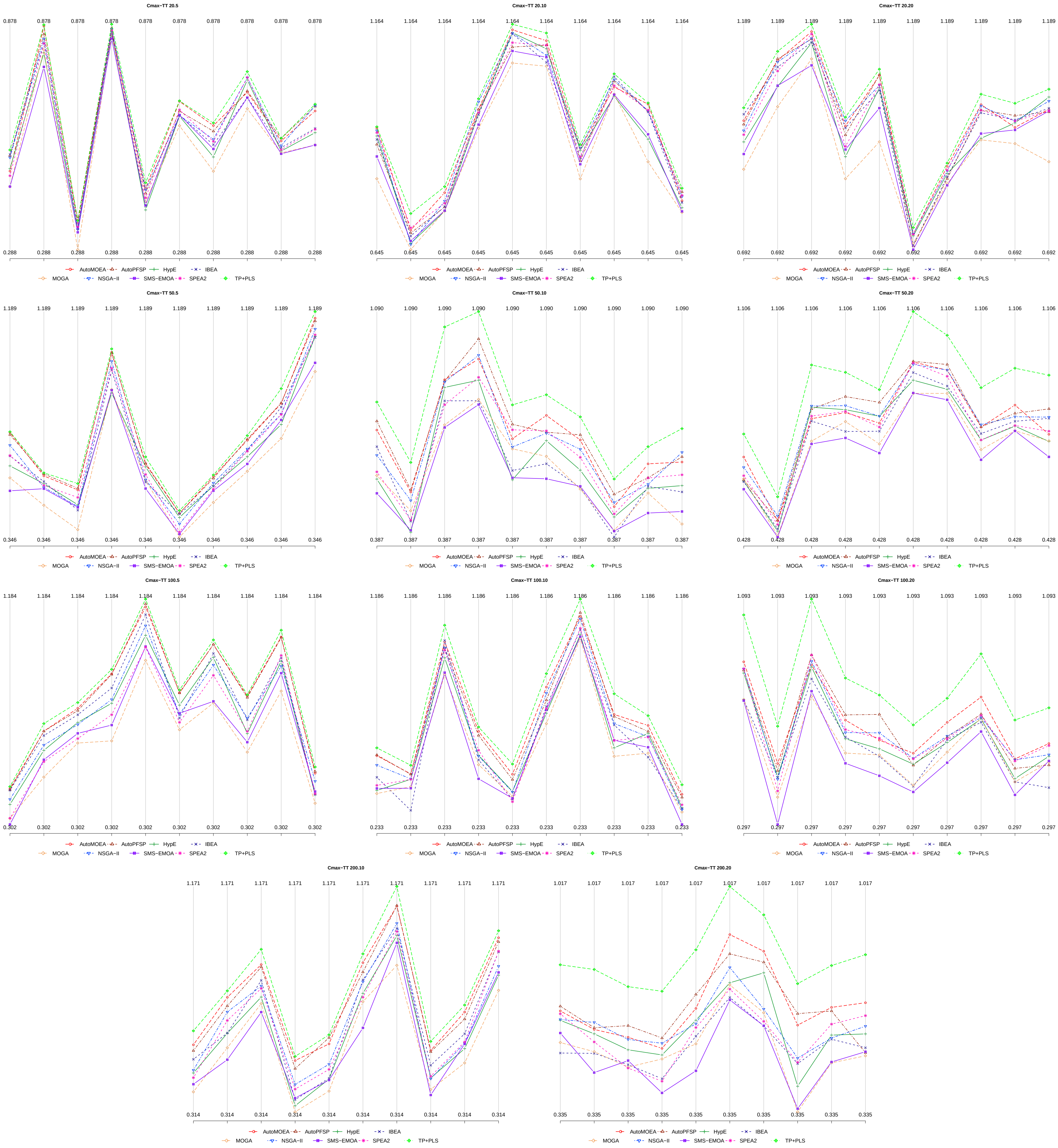

Figure 32. Boxplots of the mean I_H over 10 runs for all algorithms on the Cmax-TT variant.

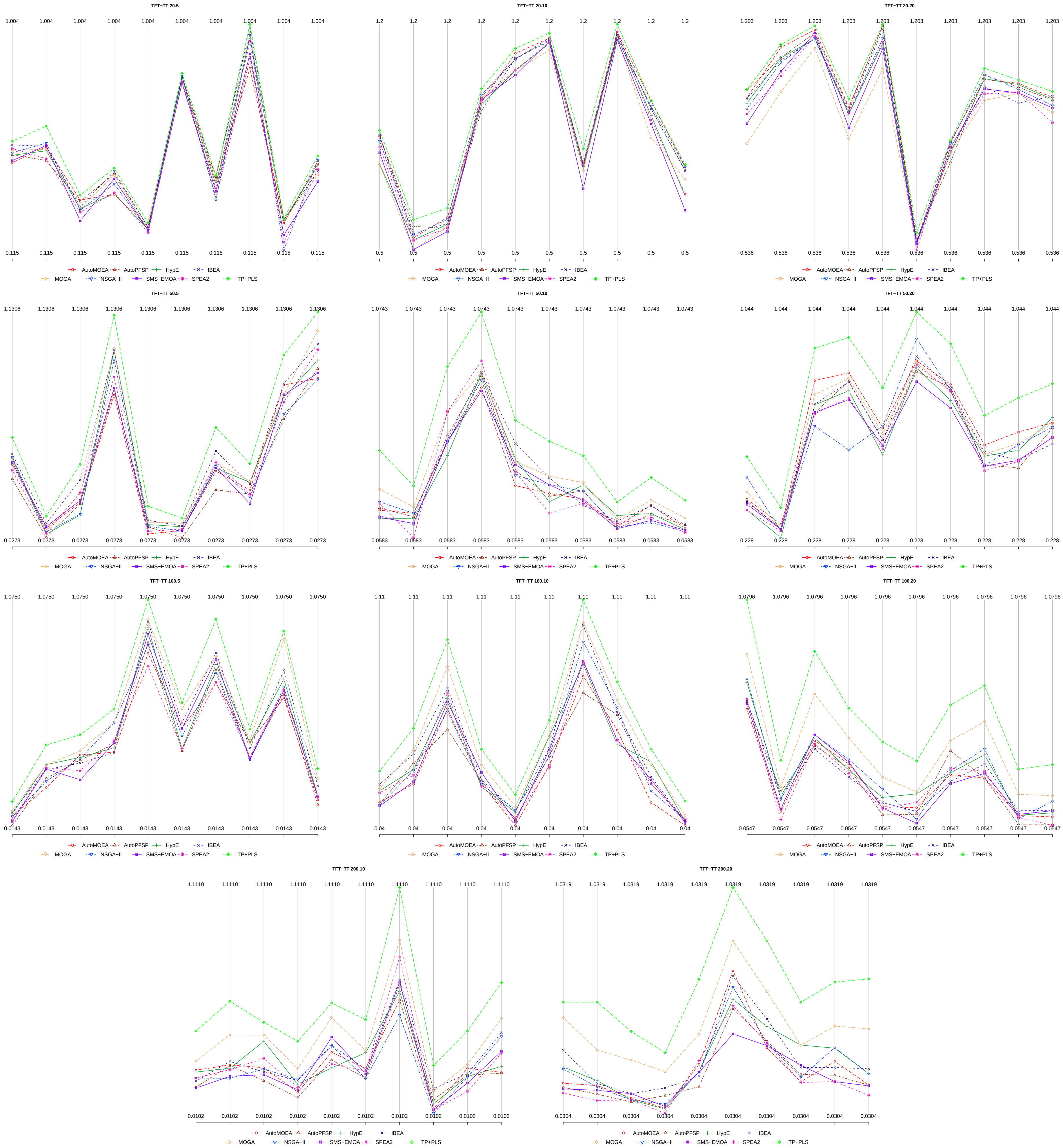

Figure 33. Boxplots of the mean I_H over 10 runs for all algorithms on the TFT-TT variant.