

Table 1 The experimental results of MEEABC and six comparison algorithms on 29 functions ($dim=10$)

Fun	MEABC		ABCABC		ABCNG		SHADE		MAPSO		TAPSO		MEEABC	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
F1	7.62E+03	1.01E+04	0.00E+00	0.00E+00	6.71E+03	1.11E+04	0.00E+00	0.00E+00	2.17E+03	2.10E+03	2.31E+03	2.60E+03	0.00E+00	0.00E+00
F3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.74E-06	2.36E-05	8.92E-15	2.09E-14	0.00E+00	0.00E+00
F4	2.75E+00	9.57E+00	8.51E-02	5.53E-01	4.83E-01	1.28E+00	0.00E+00	0.00E+00	1.98E+00	4.30E-01	5.52E-09	9.61E-09	0.00E+00	0.00E+00
F5	3.73E+01	1.88E+01	9.72E+00	4.62E+00	1.70E+01	6.25E+00	1.09E+01	4.83E+00	9.03E+00	3.94E+00	1.13E+01	5.41E+00	2.83E+00	2.46E+00
F6	1.34E+01	1.12E+01	3.74E-06	2.07E-05	1.49E-01	4.54E-01	1.42E-07	4.26E-07	4.92E-06	1.13E-05	8.74E-04	4.43E-03	0.00E+00	0.00E+00
F7	4.98E+01	2.00E+01	1.88E+01	4.18E+00	2.64E+01	6.14E+00	1.77E+01	3.43E+00	2.12E+01	4.33E+00	1.98E+01	4.62E+00	1.23E+01	1.30E+00
F8	3.05E+01	1.15E+01	8.70E+00	5.61E+00	1.81E+01	8.35E+00	8.76E+00	5.68E+00	8.54E+00	3.56E+00	1.12E+01	4.52E+00	2.23E+00	8.29E-01
F9	1.81E+02	1.91E+02	2.85E-02	1.07E-01	5.82E+00	9.27E+00	0.00E+00	0.00E+00	3.51E-03	1.76E-02	7.45E-02	1.85E-01	0.00E+00	0.00E+00
F10	9.84E+02	3.76E+02	4.99E+02	2.97E+02	5.16E+02	2.68E+02	5.41E+02	1.45E+02	2.98E+02	2.18E+02	4.39E+02	2.22E+02	4.21E+02	4.34E+02
F11	4.73E+01	3.54E+01	2.24E+00	1.76E+00	6.47E+00	5.36E+00	2.69E+00	1.84E+00	5.38E+00	3.29E+00	7.56E+00	4.98E+00	1.66E-01	3.71E-01
F12	2.06E+04	1.72E+04	2.03E+03	5.43E+03	1.69E+04	1.63E+04	2.52E+02	1.37E+02	1.37E+04	1.11E+04	1.08E+04	7.79E+03	5.50E+01	5.86E+01
F13	1.28E+04	2.00E+04	7.30E+00	3.32E+00	8.38E+03	9.91E+03	5.61E+00	1.72E+00	7.48E+01	8.82E+01	3.49E+03	3.08E+03	6.23E+00	6.98E-01
F14	2.04E+03	3.12E+03	6.92E+01	1.01E+02	1.84E+02	3.23E+02	1.68E+01	1.30E+01	1.36E+01	9.60E+00	6.52E+02	5.04E+02	1.91E+00	3.67E+00
F15	2.79E+03	3.78E+03	1.87E+00	1.21E+00	1.14E+01	1.56E+01	1.15E+00	9.78E-01	6.14E+00	3.95E+00	6.30E+02	7.44E+02	3.64E-01	1.66E-01
F16	2.71E+02	1.52E+02	2.49E+01	3.49E+01	1.48E+02	9.65E+01	6.51E+01	6.21E+01	5.50E+00	2.34E+01	1.67E+02	1.35E+02	4.19E+00	6.76E+00
F17	1.20E+02	8.02E+01	2.86E+01	2.16E+01	6.36E+01	5.18E+01	2.18E+01	1.44E+01	6.67E+00	8.19E+00	3.03E+01	3.61E+01	1.79E+01	9.47E+00
F18	8.76E+03	1.55E+04	2.94E+02	9.83E+02	5.96E+03	1.29E+04	2.17E+01	9.96E+00	2.86E+01	1.49E+01	1.04E+04	1.17E+04	4.62E-01	7.47E-02
F19	1.27E+04	1.90E+04	2.65E+01	1.32E+02	7.53E+00	9.84E+00	2.90E+00	3.68E+00	1.65E+00	1.01E+00	5.94E+03	7.58E+03	1.86E-01	2.92E-01
F20	1.27E+02	8.77E+01	2.21E+01	9.10E+00	4.83E+01	4.72E+01	3.72E+00	6.04E+00	1.10E+00	9.32E-01	5.76E+00	5.95E+00	1.03E+01	1.05E+01
F21	2.23E+02	4.25E+01	1.96E+02	3.78E+01	2.05E+02	4.19E+01	1.80E+02	5.26E+01	1.30E+02	4.83E+01	1.94E+02	4.42E+01	1.64E+02	5.00E+01
F22	1.12E+02	8.79E+01	9.87E+01	1.18E+01	1.29E+02	1.66E+02	7.70E+01	3.66E+01	1.00E+02	1.08E+01	1.14E+02	8.82E+01	1.00E+02	3.86E-01
F23	3.40E+02	1.66E+01	3.13E+02	4.79E+00	3.22E+02	8.30E+00	3.18E+02	6.72E+00	3.10E+02	3.60E+00	3.19E+02	7.59E+00	3.04E+02	2.06E+00
F24	3.71E+02	6.21E+01	3.37E+02	3.40E+01	3.44E+02	5.06E+01	3.43E+02	7.47E+00	3.15E+02	7.18E+01	3.30E+02	6.85E+01	3.23E+02	4.15E+01
F25	4.43E+02	2.51E+01	4.27E+02	2.35E+01	4.33E+02	2.94E+01	4.16E+02	2.26E+01	4.13E+02	2.18E+01	4.30E+02	2.26E+01	4.23E+02	2.29E+01
F26	6.77E+02	3.67E+02	3.69E+02	8.59E+01	4.22E+02	1.74E+02	3.00E+02	0.00E+00	3.05E+02	1.46E+01	3.41E+02	2.50E+02	3.02E+02	8.46E+00
F27	4.22E+02	5.59E+01	4.26E+02	5.53E+01	4.10E+02	5.35E+01	3.72E+02	1.45E+00	3.90E+02	2.11E-01	3.96E+02	1.10E+01	3.90E+02	2.34E+00
F28	4.27E+02	6.22E+01	4.76E+02	9.24E+00	4.51E+02	5.77E+01	4.64E+02	2.63E+01	3.80E+02	1.30E+02	4.91E+02	1.33E+02	4.20E+02	8.09E+01
F29	3.96E+02	1.15E+02	2.60E+02	2.90E+01	3.32E+02	6.30E+01	2.54E+02	2.01E+01	2.55E+02	1.57E+01	2.85E+02	3.28E+01	2.42E+02	4.43E+00
F30	1.87E+03	3.52E+03	2.75E+02	9.59E+01	4.07E+02	7.30E+02	2.03E+02	7.99E-01	1.48E+05	3.13E+05	2.55E+05	3.63E+05	4.27E+02	1.02E+02

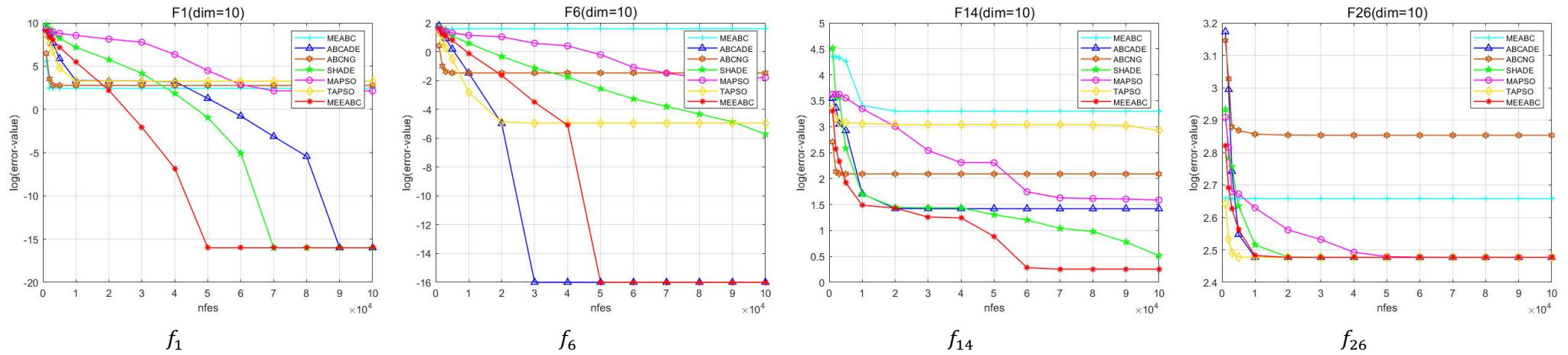


Fig. 1. Convergence curves of MEEABC and comparison algorithms on typical functions (10 dim)

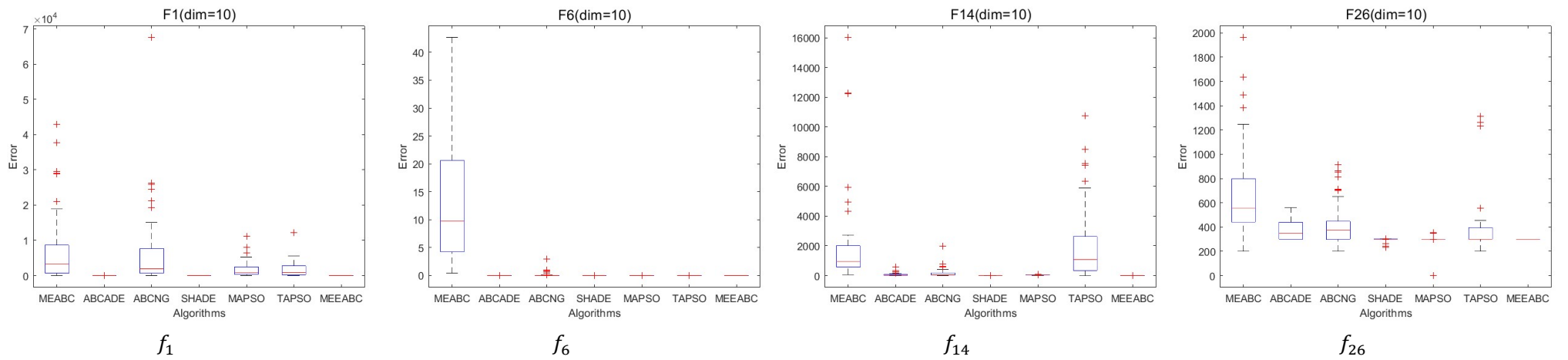


Fig. 2. Box-plots of MEEABC and comparison algorithms on typical functions (10 dim)

Table 2 The experimental results of MEEABC and six comparison algorithms on 29 functions ($dim=30$)

Fun	MEABC		ABCAGE		ABCNG		SHADE		MAPSO		TAPSO		MEEABC	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
F1	7.32E+04	2.86E+05	9.16E-06	3.01E-05	1.18E+04	1.63E+04	0.00E+00	0.00E+00	1.47E+08	5.16E+08	2.90E+03	3.28E+03	0.00E+00	0.00E+00
F3	4.89E+02	1.70E+03	5.45E+04	9.71E+04	5.12E+02	8.61E+02	0.00E+00	0.00E+00	2.05E+05	6.07E+04	2.50E+01	1.78E+02	0.00E+00	0.00E+00
F4	6.14E+01	3.50E+01	3.27E+01	2.52E+01	7.25E+00	1.28E+01	2.79E+01	3.10E+01	8.96E+01	5.35E+00	2.95E+01	3.00E+01	5.96E+01	2.27E+00
F5	2.04E+02	5.26E+01	6.01E+01	1.80E+01	9.82E+01	2.77E+01	6.58E+01	7.18E+00	8.95E+01	2.10E+01	6.42E+01	1.73E+01	1.71E+01	8.95E+00
F6	5.24E+01	1.37E+01	1.49E-03	3.45E-03	4.34E+00	3.49E+00	5.78E-04	1.66E-04	3.10E-01	4.18E-01	2.96E-02	2.19E-02	1.44E-07	4.39E-07
F7	3.37E+02	7.78E+01	8.58E+01	2.02E+01	1.44E+02	3.51E+01	9.97E+01	9.07E+00	1.14E+02	2.71E+01	9.60E+01	1.83E+01	4.84E+01	5.10E+00
F8	1.74E+02	5.12E+01	6.42E+01	2.09E+01	9.66E+01	2.11E+01	6.05E+01	9.66E+00	3.52E+01	1.05E+01	6.48E+01	1.76E+01	1.62E+01	5.41E+00
F9	4.35E+03	1.71E+03	5.99E+00	1.80E+01	4.78E+02	3.71E+02	1.14E+00	1.34E+00	4.23E+01	3.61E+01	2.54E+02	2.26E+02	2.39E-01	2.47E-01
F10	4.49E+03	7.64E+02	4.42E+03	1.68E+03	4.83E+03	2.17E+03	2.89E+03	2.57E+02	2.78E+03	5.56E+02	2.62E+03	5.25E+02	3.37E+03	8.61E+02
F11	2.39E+02	1.49E+02	2.05E+01	8.17E+00	5.88E+01	3.43E+01	2.33E+02	1.09E+02	8.31E+01	3.72E+01	9.12E+01	3.91E+01	2.82E+01	2.66E+01
F12	6.56E+05	8.01E+05	1.27E+05	1.04E+05	1.44E+05	1.56E+05	4.69E+03	6.40E+03	3.86E+04	2.88E+04	2.56E+04	2.23E+04	5.32E+03	7.94E+03
F13	2.84E+04	2.95E+04	1.89E+04	2.46E+04	2.43E+04	3.95E+04	4.35E+01	2.14E+01	1.51E+04	1.32E+04	1.84E+04	1.88E+04	8.50E+01	1.17E+02
F14	5.58E+04	6.15E+04	1.80E+02	3.10E+02	9.76E+03	8.52E+03	3.27E+01	6.20E+00	2.21E+03	3.04E+03	6.73E+03	1.84E+04	2.45E+01	1.17E+00
F15	1.75E+04	2.14E+04	4.01E+02	6.54E+02	1.36E+04	1.99E+04	3.22E+01	2.11E+01	4.24E+03	6.45E+03	6.54E+03	9.93E+03	1.20E+01	4.66E+00
F16	1.33E+03	3.25E+02	8.77E+02	2.93E+02	8.67E+02	3.02E+02	7.04E+02	1.37E+02	1.01E+03	2.86E+02	9.00E+02	2.23E+02	2.21E+02	1.43E+02
F17	8.98E+02	3.00E+02	3.37E+02	2.15E+02	5.18E+02	2.28E+02	1.85E+02	6.51E+01	2.38E+02	1.41E+02	3.42E+02	1.77E+02	1.00E+02	3.99E+01
F18	2.67E+05	2.21E+05	7.70E+04	7.53E+04	8.50E+04	6.52E+04	7.94E+01	5.86E+01	8.15E+04	6.60E+04	3.47E+04	2.00E+04	2.70E+01	3.03E+00
F19	1.31E+04	1.85E+04	1.07E+04	1.17E+04	1.05E+04	1.44E+04	1.96E+01	2.20E+01	4.19E+03	5.47E+03	4.95E+03	6.34E+03	1.30E+01	2.70E+00
F20	7.94E+02	2.28E+02	3.26E+02	1.93E+02	3.86E+02	1.96E+02	2.21E+02	6.79E+01	1.37E+02	6.53E+01	3.08E+02	1.72E+02	9.12E+01	1.06E+02
F21	3.91E+02	5.86E+01	2.60E+02	1.82E+01	2.95E+02	2.53E+01	2.59E+02	3.11E+01	2.87E+02	2.91E+01	2.66E+02	1.64E+01	2.21E+02	4.30E+00
F22	3.99E+03	1.70E+03	4.10E+03	1.25E+03	3.76E+03	2.88E+03	2.20E+02	5.62E+02	1.16E+02	2.02E+00	7.04E+02	1.26E+03	7.29E+02	1.68E+03
F23	6.85E+02	9.59E+01	4.12E+02	2.18E+01	4.85E+02	4.07E+01	4.07E+02	9.90E+00	4.25E+02	1.40E+01	4.43E+02	2.75E+01	3.70E+02	6.39E+00
F24	7.34E+02	8.45E+01	4.87E+02	1.94E+01	5.64E+02	4.23E+01	4.97E+02	1.48E+01	4.93E+02	2.29E+01	5.41E+02	3.18E+01	4.41E+02	3.94E+00
F25	3.90E+02	1.77E+01	3.79E+02	1.09E+00	3.80E+02	5.87E+00	3.89E+02	7.08E+00	3.88E+02	4.47E-01	3.97E+02	1.74E+01	3.87E+02	8.56E-02
F26	4.07E+03	1.14E+03	1.38E+03	2.67E+02	2.32E+03	4.62E+02	1.57E+03	2.84E+02	1.26E+03	4.04E+02	1.44E+03	8.41E+02	1.18E+03	6.80E+01
F27	5.00E+02	2.15E-04	5.00E+02	3.66E-04	5.00E+02	3.27E-04	5.13E+02	4.78E+00	5.10E+02	9.66E+00	5.27E+02	1.70E+01	5.03E+02	7.26E+00
F28	4.80E+02	4.26E+01	4.98E+02	3.87E+00	4.86E+02	4.22E+01	3.33E+02	5.73E+01	4.09E+02	3.15E+01	3.55E+02	6.59E+01	3.21E+02	4.78E+01
F29	1.37E+03	3.30E+02	6.44E+02	2.77E+02	8.44E+02	2.58E+02	5.99E+02	5.39E+01	5.18E+02	7.91E+01	7.90E+02	1.97E+02	6.02E+02	6.69E+01
F30	1.16E+04	1.77E+04	2.34E+02	6.33E+01	7.36E+03	1.03E+04	2.13E+03	1.35E+02	5.15E+03	2.22E+03	5.51E+03	3.13E+03	2.03E+03	6.28E+01

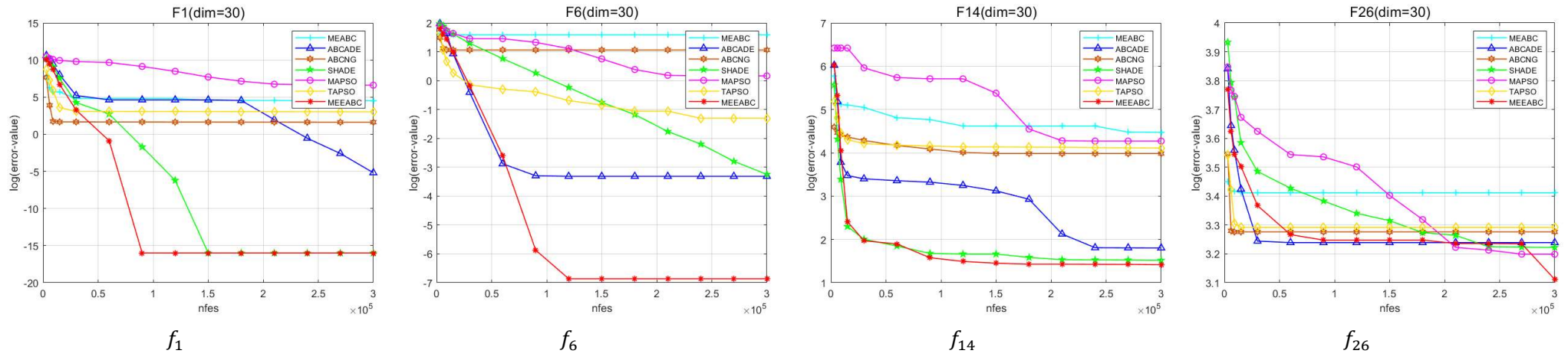


Fig. 3. Convergence curves of MEEABC and comparison algorithms on typical functions (30 dim)

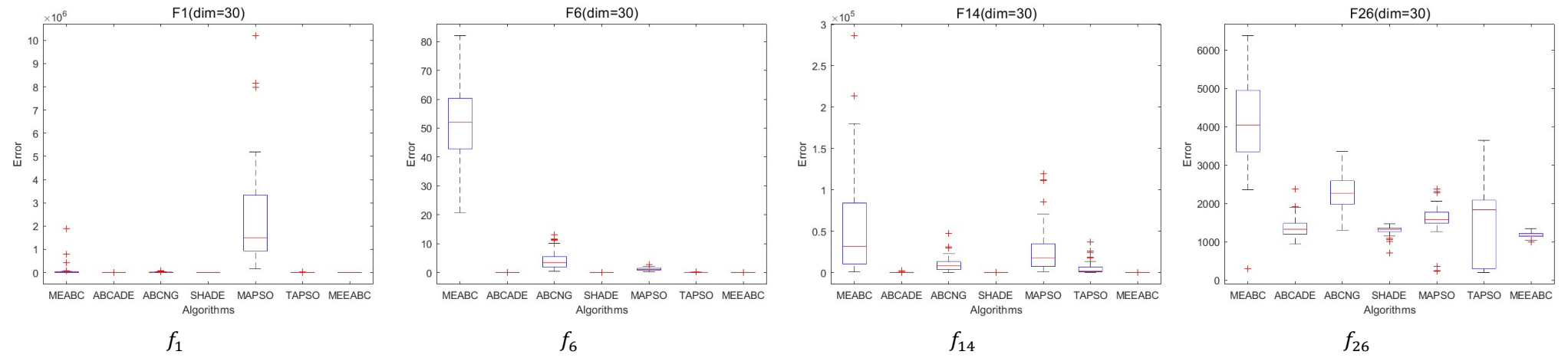


Fig. 4. Box-plots of MEEABC and comparison algorithms on typical functions (30 dim)

Table 3 The experimental results of MEEABC and six comparison algorithms on 29 functions ($dim=50$)

Fun	MEABC		ABCABC		ABCNG		SHADE		MAPSO		TAPSO		MEEABC	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
F1	3.11E+06	1.86E+07	9.16E+03	1.31E+04	6.67E+03	7.40E+03	0.00E+00	3.46E-08	1.55E+09	4.73E+09	2.95E+03	4.42E+03	0.00E+00	0.00E+00
F3	1.65E+05	1.24E+05	3.45E+05	2.36E+05	9.62E+04	6.34E+04	1.56E+05	1.89E+04	3.39E+05	1.03E+05	3.69E+03	4.03E+03	0.00E+00	0.00E+00
F4	9.99E+01	4.66E+01	5.20E+01	2.72E+01	2.01E+01	1.98E+01	5.77E+01	4.24E+01	1.49E+02	3.66E+01	3.96E+01	4.13E+01	4.88E+01	4.55E+01
F5	3.76E+02	8.73E+01	1.44E+02	3.96E+01	2.19E+02	4.83E+01	1.38E+02	1.38E+01	2.02E+02	6.07E+01	1.49E+02	3.31E+01	3.90E+01	6.56E+00
F6	6.67E+01	1.09E+01	1.48E-01	2.42E-01	1.12E+01	6.02E+00	1.80E-03	4.64E-04	1.25E+00	5.29E-01	7.74E-02	4.25E-02	1.92E-06	2.62E-06
F7	7.65E+02	1.48E+02	1.95E+02	4.07E+01	3.57E+02	1.02E+02	2.07E+02	2.13E+01	1.95E+02	3.28E+01	2.20E+02	3.50E+01	9.87E+01	1.17E+01
F8	3.90E+02	8.25E+01	1.53E+02	3.52E+01	2.30E+02	5.16E+01	1.39E+02	1.55E+01	2.66E+02	5.43E+01	1.51E+02	2.40E+01	3.96E+01	9.02E+00
F9	1.27E+04	4.55E+03	5.39E+02	1.81E+03	3.67E+03	2.93E+03	1.08E+03	6.22E+02	2.17E+02	1.28E+02	1.83E+03	1.26E+03	7.36E+00	7.57E+00
F10	8.13E+03	1.24E+03	6.62E+03	9.24E+02	9.89E+03	4.00E+03	5.27E+03	3.48E+02	4.85E+03	7.89E+02	4.60E+03	7.25E+02	6.57E+03	1.37E+03
F11	2.93E+02	9.80E+01	6.21E+01	2.03E+01	1.28E+02	5.88E+01	1.89E+02	5.38E+01	1.62E+02	4.06E+01	1.67E+02	4.68E+01	6.15E+01	1.69E+01
F12	7.27E+06	7.39E+06	1.11E+06	7.24E+05	1.18E+06	1.40E+06	2.02E+04	1.52E+04	5.70E+05	4.68E+05	8.63E+04	4.24E+04	8.45E+03	5.70E+03
F13	3.94E+04	3.21E+04	8.32E+03	1.24E+04	1.65E+04	2.10E+04	4.27E+02	3.24E+02	5.89E+03	7.31E+03	5.11E+03	6.37E+03	2.82E+02	4.89E+02
F14	1.93E+05	2.01E+05	1.27E+04	1.09E+04	3.24E+04	3.69E+04	4.90E+05	2.94E+05	3.22E+04	2.83E+04	2.40E+04	3.81E+04	4.38E+01	8.09E+00
F15	3.47E+04	4.28E+04	1.48E+04	2.32E+04	3.06E+04	3.50E+04	2.83E+02	1.65E+02	3.68E+03	3.56E+03	7.17E+03	7.43E+03	1.38E+02	1.11E+02
F16	2.21E+03	5.72E+02	1.82E+03	4.34E+02	1.68E+03	3.77E+02	1.34E+03	1.95E+02	1.37E+03	2.15E+02	1.44E+03	3.78E+02	6.61E+02	1.68E+02
F17	2.31E+03	5.10E+02	1.15E+03	3.29E+02	1.56E+03	3.53E+02	9.36E+02	1.28E+02	1.32E+03	2.38E+02	1.12E+03	3.19E+02	5.54E+02	1.71E+02
F18	3.96E+05	2.75E+05	2.57E+05	2.14E+05	1.52E+05	1.22E+05	5.96E+02	6.43E+02	1.55E+05	1.09E+05	7.27E+04	1.10E+05	6.19E+01	2.76E+01
F19	2.73E+04	2.42E+04	2.46E+04	2.12E+04	2.49E+04	4.43E+04	1.34E+02	4.31E+01	1.08E+04	5.15E+03	1.44E+04	1.08E+04	1.28E+02	7.00E+01
F20	1.71E+03	4.00E+02	9.55E+02	3.36E+02	9.78E+02	3.54E+02	8.04E+02	1.40E+02	9.55E+02	2.44E+02	7.76E+02	3.02E+02	3.63E+02	1.16E+02
F21	6.69E+02	1.02E+02	3.51E+02	4.21E+01	4.31E+02	5.46E+01	3.49E+02	1.65E+01	3.79E+02	3.68E+01	3.55E+02	2.98E+01	2.58E+02	1.33E+01
F22	8.53E+03	9.19E+02	7.94E+03	2.64E+03	1.09E+04	4.23E+03	4.19E+03	2.62E+03	7.75E+03	4.03E+03	5.61E+03	8.27E+02	6.97E+03	3.41E+03
F23	1.16E+03	1.66E+02	5.45E+02	4.45E+01	7.29E+02	1.01E+02	5.77E+02	2.42E+01	5.98E+02	5.41E+01	6.55E+02	4.58E+01	4.93E+02	3.19E+01
F24	1.23E+03	1.35E+02	6.58E+02	3.57E+01	7.98E+02	6.36E+01	6.90E+02	3.70E+01	5.87E+02	6.77E+01	7.62E+02	6.40E+01	5.50E+02	1.61E+01
F25	4.83E+02	3.56E+01	4.48E+02	2.21E+01	4.51E+02	2.84E+01	5.28E+02	4.30E+01	5.52E+02	1.89E+01	5.45E+02	3.73E+01	5.08E+02	3.05E+01
F26	6.78E+03	1.52E+03	2.07E+03	5.27E+02	3.86E+03	1.29E+03	2.61E+03	1.92E+02	2.07E+03	5.83E+02	2.99E+03	1.12E+03	1.65E+03	1.25E+02
F27	5.00E+02	2.15E-04	5.00E+02	3.16E-04	5.00E+02	3.02E-04	6.23E+02	6.13E+01	6.34E+02	6.66E+01	6.80E+02	7.39E+01	5.40E+02	4.66E+01
F28	4.99E+02	4.28E+00	5.00E+02	3.76E-04	5.00E+02	2.95E+00	5.01E+02	3.19E+01	5.14E+02	2.42E+01	4.96E+02	2.68E+01	4.90E+02	2.11E+01
F29	2.61E+03	7.13E+02	1.20E+03	3.34E+02	1.55E+03	4.08E+02	8.01E+02	1.01E+02	1.46E+03	4.25E+02	1.18E+03	2.90E+02	8.48E+02	1.63E+02
F30	1.48E+04	3.40E+04	1.09E+03	3.96E+03	8.19E+03	7.44E+03	1.28E+06	2.06E+05	1.10E+06	6.87E+05	7.74E+05	8.45E+04	6.83E+05	1.24E+05

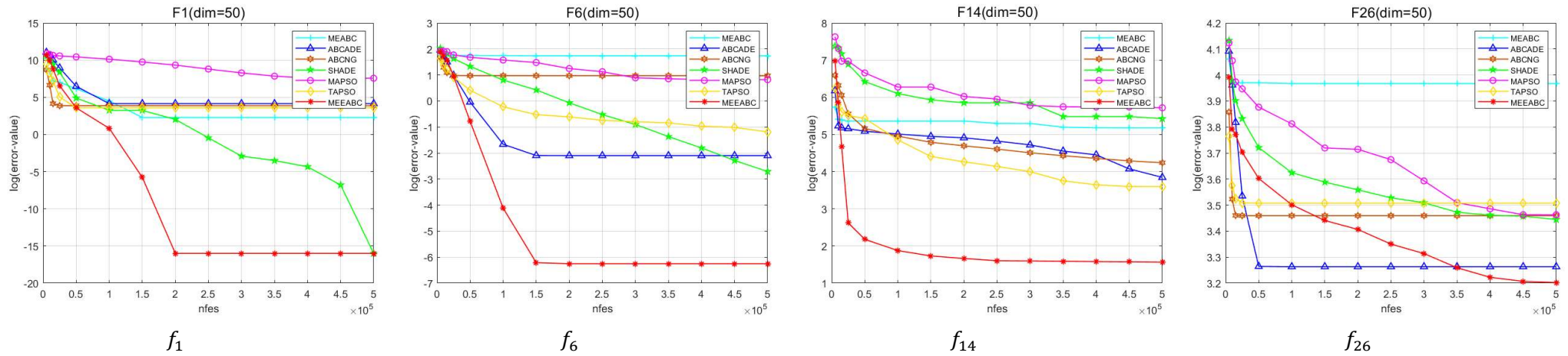


Fig. 5. Convergence curves of MEEABC and comparison algorithms on typical functions (50 dim)

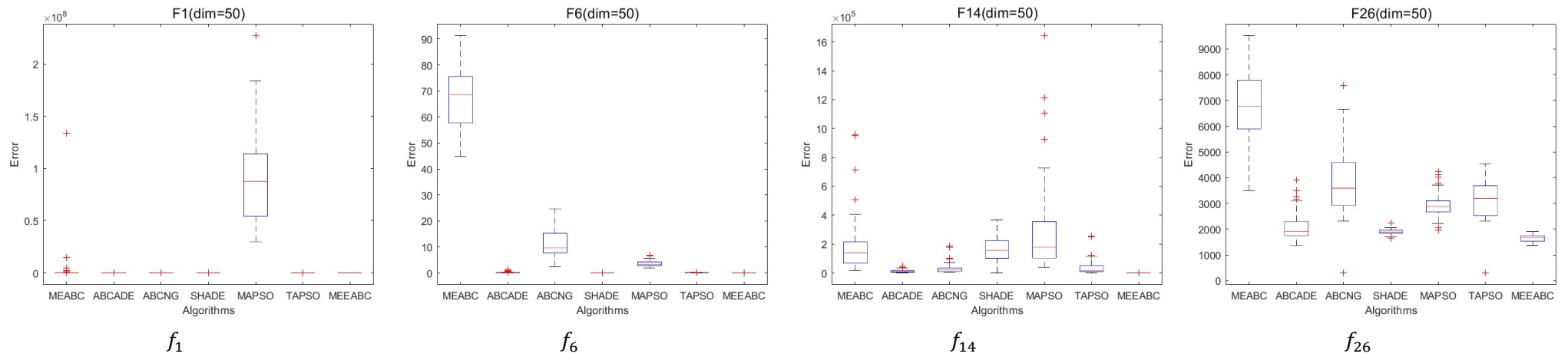


Fig. 6. Box-plots of MEEABC and comparison algorithms on typical functions (50 dim)