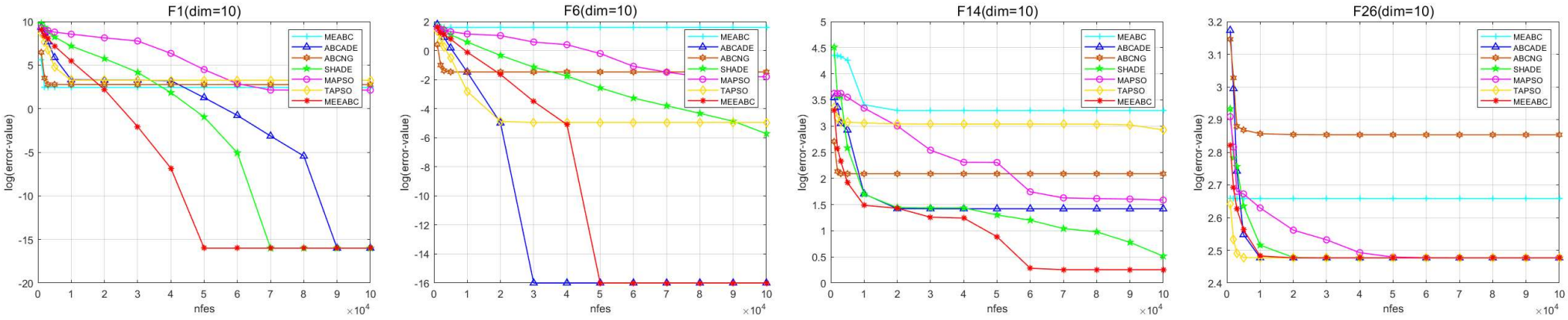
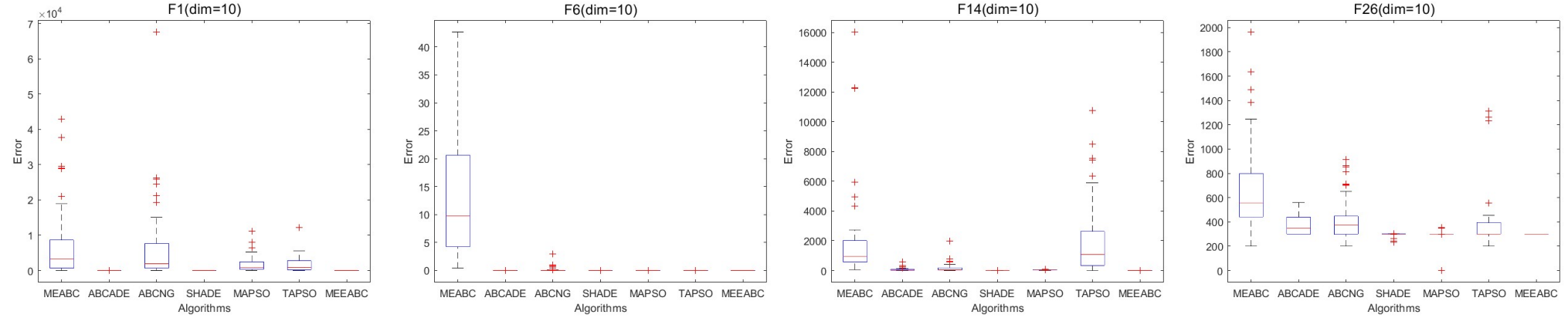
Table 1 The experimental results of MEEABC and six comparison algorithms on 29 functions (dim=10)

Fun	MEABC		ABCADE		ABCNG		SHADE		MAPSO		TAPSO		MEEABC	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
F1	8.21E+03	1.04E+04	3.98E-10	2.14E-09	7.71E+03	1.32E+04	**0.00E+00**	**0.00E+00**	2.11E+03	2.12E+03	2.19E+03	2.53E+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**	2.63E-05	9.69E-05	8.47E-15	2.04E-14	**0.00E+00**	**0.00E+00**
F4	3.61E+00	1.23E+01	1.41E-01	7.16E-01	5.43E-01	1.35E+00	**0.00E+00**	**0.00E+00**	1.99E+00	4.64E-01	4.11E-06	1.08E-05	**0.00E+00**	**0.00E+00**
F5	3.74E+01	2.09E+01	9.65E+00	4.72E+00	1.71E+01	6.48E+00	1.10E+01	4.93E+00	8.97E+00	3.78E+00	1.12E+01	5.38E+00	**2.83E+00**	**2.46E+00**
F6	1.43E+01	1.22E+01	5.07E-06	2.68E-05	1.80E-01	5.54E-01	1.37E-07	4.26E-07	5.94E-06	1.59E-05	8.42E-04	4.17E-03	**0.00E+00**	**0.00E+00**
F7	5.30E+01	2.03E+01	1.93E+01	4.38E+00	2.70E+01	5.71E+00	1.78E+01	3.54E+00	2.11E+01	4.29E+00	1.97E+01	4.61E+00	**1.23E+01**	**1.30E+00**
F8	3.36E+01	1.30E+01	7.69E+00	3.74E+00	1.71E+01	7.86E+00	8.82E+00	5.94E+00	8.43E+00	3.46E+00	1.09E+01	4.50E+00	**2.23E+00**	**8.29E-01**
F9	2.04E+02	2.07E+02	3.33E-02	1.14E-01	7.53E+00	1.13E+01	**0.00E+00**	**0.00E+00**	3.16E-03	1.65E-02	1.17E-01	4.05E-01	**0.00E+00**	**0.00E+00**
F10	9.10E+02	3.78E+02	4.82E+02	2.83E+02	5.46E+02	2.93E+02	5.64E+02	**1.44E+02**	**3.01E+02**	2.17E+02	4.46E+02	2.22E+02	4.21E+02	4.34E+02
F11	5.05E+01	4.05E+01	2.16E+00	1.91E+00	6.00E+00	3.76E+00	2.65E+00	1.80E+00	5.22E+00	3.20E+00	7.87E+00	5.00E+00	**1.66E-01**	**3.71E-01**
F12	1.73E+04	1.37E+04	2.51E+03	6.64E+03	1.81E+04	1.83E+04	2.54E+02	1.38E+02	1.36E+04	1.07E+04	1.07E+04	7.91E+03	**5.50E+01**	**5.86E+01**
F13	1.35E+04	2.31E+04	7.18E+00	3.87E+00	9.78E+03	1.12E+04	**5.89E+00**	1.67E+00	7.26E+01	8.20E+01	3.93E+03	3.57E+03	6.23E+00	**6.98E-01**
F14	1.45E+03	1.24E+03	7.24E+01	1.13E+02	1.56E+02	3.59E+02	1.65E+01	1.26E+01	1.39E+01	9.67E+00	7.48E+02	6.22E+02	**1.91E+00**	**3.67E+00**
F15	3.06E+03	4.37E+03	1.72E+00	1.12E+00	1.17E+01	1.73E+01	1.09E+00	9.31E-01	6.43E+00	4.16E+00	1.01E+03	1.53E+03	**3.64E-01**	**1.66E-01**
F16	2.45E+02	1.44E+02	1.88E+01	3.15E+01	1.56E+02	1.05E+02	6.43E+01	6.39E+01	4.60E+00	1.91E+01	1.67E+02	1.33E+02	**4.19E+00**	**6.76E+00**
F17	1.27E+02	9.08E+01	2.67E+01	1.65E+01	6.22E+01	5.44E+01	2.28E+01	1.50E+01	**6.78E+00**	**8.28E+00**	2.89E+01	3.31E+01	1.79E+01	9.47E+00
F18	8.68E+03	1.74E+04	2.13E+02	7.87E+02	7.33E+03	1.23E+04	2.17E+01	1.01E+01	3.02E+01	1.69E+01	1.02E+04	1.19E+04	**4.62E-01**	**7.47E-02**
F19	1.28E+04	1.70E+04	4.07E+01	1.71E+02	5.99E+00	5.51E+00	3.00E+00	3.53E+00	1.62E+00	9.76E-01	5.69E+03	7.24E+03	**1.86E-01**	**2.92E-01**
F20	1.29E+02	8.51E+01	2.10E+01	9.30E+00	4.09E+01	4.04E+01	3.56E+00	6.21E+00	**1.30E+00**	**1.52E+00**	6.36E+00	6.75E+00	1.03E+01	1.05E+01
F21	2.20E+02	4.88E+01	1.92E+02	4.06E+01	2.14E+02	**3.11E+01**	1.82E+02	5.39E+01	**1.32E+02**	4.88E+01	1.95E+02	4.28E+01	1.64E+02	5.00E+01
F22	1.23E+02	1.12E+02	9.76E+01	1.52E+01	1.51E+02	2.13E+02	**7.68E+01**	3.77E+01	1.00E+02	1.13E+01	1.11E+02	7.33E+01	1.00E+02	**3.86E-01**
F23	3.36E+02	1.45E+01	3.13E+02	5.25E+00	3.23E+02	8.96E+00	3.16E+02	6.45E+00	3.10E+02	3.56E+00	3.18E+02	7.28E+00	**3.04E+02**	**2.06E+00**
F24	3.68E+02	5.32E+01	3.42E+02	**5.68E+00**	3.38E+02	6.42E+01	3.51E+02	7.46E+00	**3.14E+02**	7.29E+01	3.30E+02	6.86E+01	3.23E+02	4.15E+01
F25	4.40E+02	2.28E+01	4.21E+02	2.36E+01	4.35E+02	2.71E+01	**4.01E+02**	2.30E+01	4.15E+02	**2.22E+01**	4.30E+02	2.28E+01	4.23E+02	2.29E+01
F26	6.59E+02	3.58E+02	3.62E+02	8.72E+01	4.54E+02	2.07E+02	**3.00E+02**	**0.00E+00**	3.04E+02	1.30E+01	3.47E+02	2.48E+02	3.02E+02	8.46E+00
F27	4.17E+02	5.48E+01	4.28E+02	5.24E+01	4.13E+02	5.56E+01	**3.55E+02**	1.38E+00	3.90E+02	**2.14E-01**	3.97E+02	1.20E+01	3.90E+02	2.34E+00
F28	4.17E+02	6.49E+01	4.78E+02	**1.09E+01**	4.44E+02	6.34E+01	4.62E+02	2.69E+01	**3.89E+02**	1.33E+02	4.95E+02	1.31E+02	4.20E+02	8.09E+01
F29	4.05E+02	1.20E+02	2.64E+02	3.49E+01	3.26E+02	5.73E+01	2.66E+02	2.00E+01	2.55E+02	1.50E+01	2.88E+02	3.36E+01	**2.42E+02**	**4.43E+00**
F30	1.96E+03	3.62E+03	2.85E+02	1.11E+02	4.78E+02	9.41E+02	**2.06E+02**	**7.63E-01**	1.58E+05	3.20E+05	2.50E+05	3.61E+05	4.27E+02	1.02E+02



f_1 f_6 f_{14} f_{26}

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

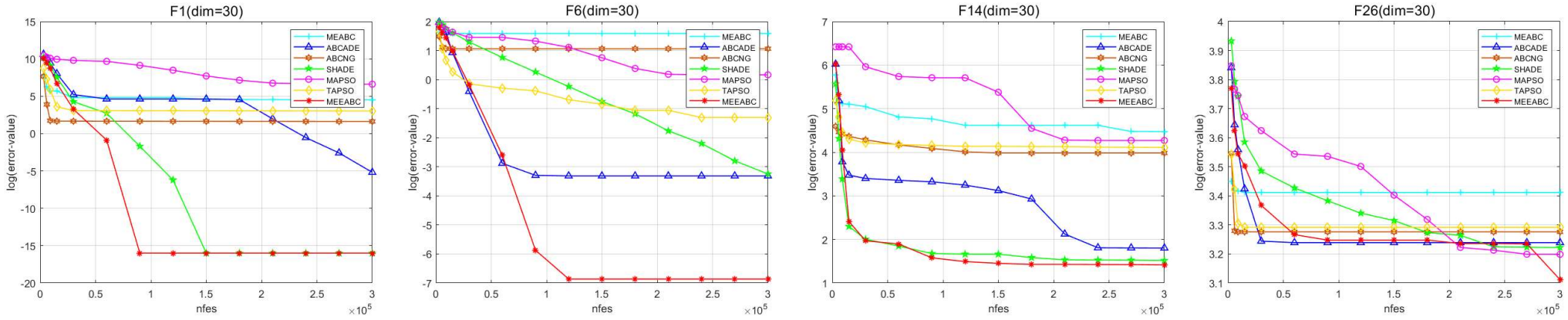


f_1 f_6 f_{14} f_{26}

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

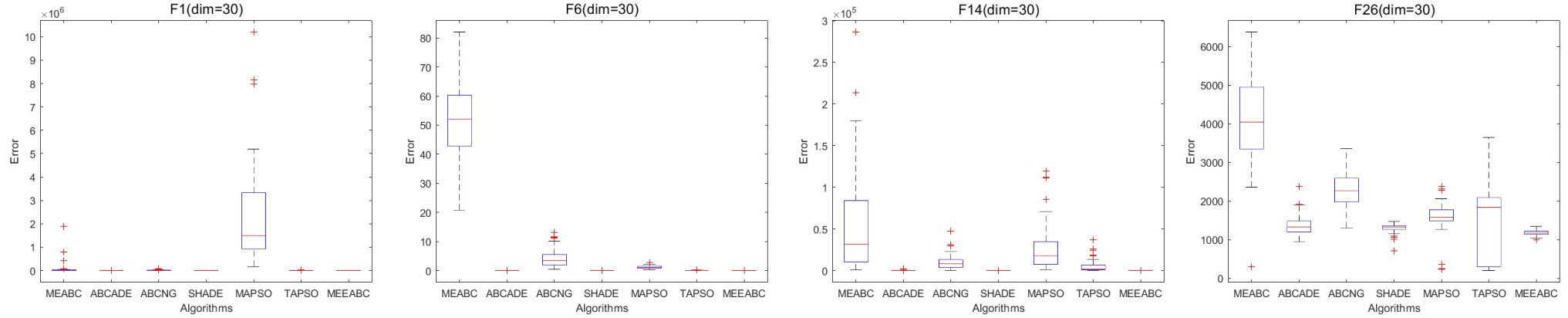
Table 2 The experimental results of MEEABC and six comparison algorithms on 29 functions (dim=30)

Fun	MEABC		ABCADE		ABCNG		SHADE		MAPSO		TAPSO		MEEABC	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
F1	1.16E+05	3.67E+05	1.20E-05	3.77E-05	1.37E+04	1.96E+04	**0.00E+00**	**0.00E+00**	1.17E+08	4.13E+08	2.79E+03	3.23E+03	**0.00E+00**	**0.00E+00**
F3	4.91E+02	1.69E+03	3.48E+04	6.85E+04	5.79E+02	9.46E+02	**0.00E+00**	**0.00E+00**	1.64E+05	4.86E+04	2.68E+01	1.92E+02	**0.00E+00**	**0.00E+00**
F4	5.38E+01	3.04E+01	3.75E+01	2.72E+01	**9.18E+00**	1.64E+01	2.75E+01	3.07E+01	8.99E+01	5.95E+00	2.96E+01	3.00E+01	5.96E+01	**2.27E+00**
F5	1.95E+02	4.81E+01	5.90E+01	1.92E+01	9.17E+01	2.73E+01	6.54E+01	**6.89E+00**	7.84E+01	1.87E+01	6.44E+01	1.77E+01	**1.71E+01**	8.95E+00
F6	5.01E+01	1.47E+01	1.77E-03	3.71E-03	3.74E+00	3.44E+00	5.60E-04	1.73E-04	3.27E-01	4.33E-01	2.81E-02	2.11E-02	**1.44E-07**	**4.39E-07**
F7	3.31E+02	6.95E+01	8.79E+01	2.19E+01	1.37E+02	2.63E+01	1.00E+02	8.93E+00	1.11E+02	2.54E+01	9.63E+01	1.87E+01	**4.84E+01**	**5.10E+00**
F8	1.82E+02	5.72E+01	6.82E+01	2.23E+01	9.58E+01	2.16E+01	5.93E+01	9.60E+00	3.51E+01	1.04E+01	6.47E+01	1.73E+01	**1.62E+01**	**5.41E+00**
F9	4.51E+03	1.72E+03	8.13E+00	2.31E+01	5.37E+02	3.99E+02	1.19E+00	1.35E+00	4.36E+01	3.69E+01	2.47E+02	2.14E+02	**2.39E-01**	**2.47E-01**
F10	4.62E+03	7.11E+02	4.45E+03	1.75E+03	5.07E+03	2.25E+03	2.77E+03	**2.69E+02**	2.77E+03	5.35E+02	**2.59E+03**	5.27E+02	3.37E+03	8.61E+02
F11	2.55E+02	1.72E+02	**1.83E+01**	**7.00E+00**	5.32E+01	2.94E+01	2.37E+02	1.12E+02	8.49E+01	3.66E+01	9.26E+01	3.95E+01	2.82E+01	2.66E+01
F12	6.46E+05	6.35E+05	1.14E+05	9.06E+04	1.63E+05	1.78E+05	**4.67E+03**	**6.46E+03**	3.98E+04	3.20E+04	2.54E+04	2.11E+04	5.32E+03	7.94E+03
F13	2.70E+04	2.39E+04	2.66E+04	2.78E+04	1.73E+04	2.57E+04	**4.50E+01**	**2.10E+01**	1.53E+04	1.36E+04	1.76E+04	1.78E+04	8.50E+01	1.17E+02
F14	6.30E+04	6.60E+04	1.18E+02	1.64E+02	9.88E+03	7.65E+03	3.26E+01	5.97E+00	2.15E+03	2.85E+03	6.18E+03	1.57E+04	**2.45E+01**	**1.17E+00**
F15	1.55E+04	1.85E+04	3.40E+02	3.82E+02	1.11E+04	1.58E+04	3.09E+01	2.13E+01	4.81E+03	6.99E+03	6.45E+03	9.59E+03	**1.20E+01**	**4.66E+00**
F16	1.37E+03	3.42E+02	9.01E+02	3.07E+02	8.56E+02	3.45E+02	6.82E+02	1.44E+02	9.05E+02	2.86E+02	8.90E+02	2.33E+02	**2.21E+02**	**1.43E+02**
F17	8.66E+02	2.95E+02	3.54E+02	2.15E+02	5.02E+02	2.46E+02	1.92E+02	6.83E+01	2.11E+02	1.27E+02	3.47E+02	1.78E+02	**1.00E+02**	**3.99E+01**
F18	2.78E+05	2.50E+05	8.17E+04	7.66E+04	8.45E+04	6.40E+04	8.20E+01	5.73E+01	8.30E+04	6.45E+04	4.08E+04	5.73E+04	**2.70E+01**	**3.03E+00**
F19	9.62E+03	1.28E+04	8.38E+03	9.26E+03	9.74E+03	1.46E+04	2.03E+01	2.10E+01	4.28E+03	5.51E+03	5.44E+03	7.03E+03	**1.30E+01**	**2.70E+00**
F20	8.20E+02	2.61E+02	2.96E+02	1.80E+02	4.21E+02	1.93E+02	2.20E+02	7.01E+01	1.38E+02	**6.44E+01**	3.11E+02	1.70E+02	**9.12E+01**	1.06E+02
F21	3.84E+02	5.60E+01	2.61E+02	2.06E+01	2.92E+02	2.43E+01	2.67E+02	3.18E+01	2.77E+02	2.53E+01	2.65E+02	1.62E+01	**2.21E+02**	**4.30E+00**
F22	3.67E+03	1.88E+03	4.10E+03	1.31E+03	3.80E+03	2.80E+03	2.31E+02	5.76E+02	**1.13E+02**	**1.75E+00**	7.45E+02	1.31E+03	7.29E+02	1.68E+03
F23	6.81E+02	9.69E+01	4.08E+02	2.13E+01	4.74E+02	3.89E+01	3.97E+02	1.03E+01	4.17E+02	1.34E+01	4.42E+02	2.67E+01	**3.70E+02**	**6.39E+00**
F24	7.31E+02	7.92E+01	4.90E+02	2.13E+01	5.65E+02	3.94E+01	4.79E+02	1.44E+01	4.85E+02	2.06E+01	5.39E+02	3.15E+01	**4.41E+02**	**3.94E+00**
F25	3.93E+02	2.00E+01	3.79E+02	9.16E-01	3.81E+02	7.25E+00	**3.78E+02**	6.96E+00	3.88E+02	4.53E-01	3.97E+02	1.67E+01	3.87E+02	**8.56E-02**
F26	4.06E+03	1.19E+03	1.39E+03	2.81E+02	2.40E+03	4.69E+02	1.63E+03	2.96E+02	1.27E+03	3.76E+02	1.46E+03	8.62E+02	**1.18E+03**	**6.80E+01**
F27	5.00E+02	**1.95E-04**	5.00E+02	4.31E-04	**5.00E+02**	3.52E-04	5.27E+02	4.66E+00	5.10E+02	9.85E+00	5.26E+02	1.66E+01	5.03E+02	7.26E+00
F28	4.70E+02	5.06E+01	4.98E+02	**4.16E+00**	4.88E+02	3.91E+01	3.31E+02	5.76E+01	4.06E+02	3.34E+01	3.54E+02	6.46E+01	**3.21E+02**	4.78E+01
F29	1.40E+03	3.36E+02	6.42E+02	3.26E+02	8.28E+02	2.62E+02	5.92E+02	**5.21E+01**	**5.25E+02**	8.64E+01	7.89E+02	1.89E+02	6.02E+02	6.69E+01
F30	9.26E+03	1.11E+04	**2.30E+02**	**5.79E+01**	9.50E+03	1.27E+04	2.04E+03	1.38E+02	5.16E+03	2.23E+03	5.49E+03	3.11E+03	2.03E+03	6.28E+01



f_1 f_6 f_{14} f_{26}

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

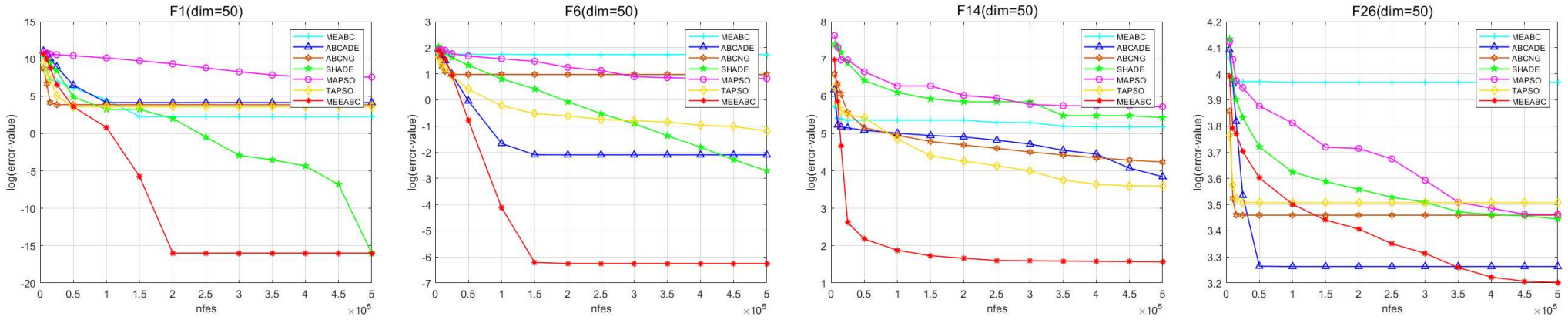


f_1 f_6 f_{14} f_{26}

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

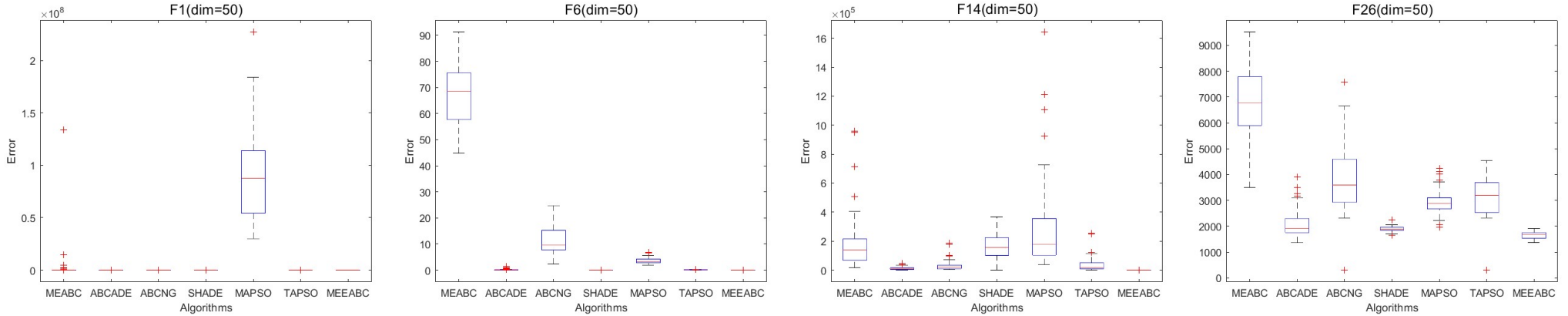
Table 3 The experimental results of MEEABC and six comparison algorithms on 29 functions (dim=50)

Fun	MEABC		ABCADE		ABCNG		SHADE		MAPSO		TAPSO		MEEABC	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
F1	4.53E+06	2.40E+07	8.98E+03	1.33E+04	6.64E+03	7.37E+03	**0.00E+00**	3.55E-08	1.24E+09	3.78E+09	3.10E+03	4.45E+03	**0.00E+00**	**0.00E+00**
F3	1.88E+05	1.41E+05	3.74E+05	2.69E+05	9.16E+04	5.42E+04	1.52E+05	1.97E+04	2.71E+05	8.22E+04	3.30E+03	3.80E+03	**0.00E+00**	**0.00E+00**
F4	1.01E+02	4.09E+01	5.00E+01	2.88E+01	**2.00E+01**	**1.63E+01**	5.70E+01	4.44E+01	1.46E+02	3.70E+01	3.91E+01	4.07E+01	4.88E+01	4.55E+01
F5	3.76E+02	7.91E+01	1.46E+02	4.58E+01	2.12E+02	4.58E+01	1.43E+02	1.42E+01	1.75E+02	5.15E+01	1.50E+02	3.29E+01	**3.90E+01**	**6.56E+00**
F6	6.58E+01	1.03E+01	1.49E-01	2.14E-01	1.09E+01	6.27E+00	1.84E-03	4.72E-04	1.21E+00	5.27E-01	7.17E-02	3.91E-02	**1.92E-06**	**2.62E-06**
F7	7.45E+02	1.55E+02	1.93E+02	4.01E+01	3.46E+02	1.08E+02	2.17E+02	2.17E+01	1.94E+02	3.25E+01	2.20E+02	3.70E+01	**9.87E+01**	**1.17E+01**
F8	3.94E+02	8.60E+01	1.57E+02	3.48E+01	2.26E+02	5.52E+01	1.35E+02	1.55E+01	2.27E+02	4.66E+01	1.51E+02	2.43E+01	**3.96E+01**	**9.02E+00**
F9	1.24E+04	4.04E+03	5.38E+02	2.06E+03	4.12E+03	3.24E+03	1.07E+03	6.24E+02	2.20E+02	1.24E+02	1.80E+03	1.25E+03	**7.36E+00**	**7.57E+00**
F10	8.49E+03	1.26E+03	6.75E+03	8.45E+02	9.48E+03	4.13E+03	5.45E+03	**3.37E+02**	4.85E+03	8.14E+02	**4.61E+03**	7.32E+02	6.57E+03	1.37E+03
F11	2.98E+02	9.66E+01	**5.95E+01**	2.05E+01	1.18E+02	4.79E+01	1.95E+02	5.63E+01	1.60E+02	4.18E+01	1.66E+02	4.90E+01	6.15E+01	**1.69E+01**
F12	9.26E+06	8.65E+06	1.17E+06	8.01E+05	1.05E+06	1.10E+06	2.00E+04	1.57E+04	5.58E+05	4.50E+05	9.13E+04	5.88E+04	**8.45E+03**	**5.70E+03**
F13	4.48E+04	3.15E+04	8.76E+03	1.14E+04	2.06E+04	2.34E+04	4.41E+02	**3.25E+02**	5.79E+03	7.30E+03	5.06E+03	6.20E+03	**2.82E+02**	4.89E+02
F14	2.16E+05	2.40E+05	1.21E+04	1.01E+04	2.35E+04	1.58E+04	4.82E+05	2.85E+05	3.11E+04	2.99E+04	2.42E+04	4.05E+04	**4.38E+01**	**8.09E+00**
F15	4.14E+04	4.97E+04	1.08E+04	1.82E+04	3.59E+04	3.39E+04	2.90E+02	1.66E+02	3.41E+03	3.47E+03	7.12E+03	7.56E+03	**1.38E+02**	**1.11E+02**
F16	2.27E+03	6.34E+02	1.85E+03	4.73E+02	1.69E+03	4.03E+02	1.31E+03	1.93E+02	1.29E+03	2.30E+02	1.44E+03	3.94E+02	**6.61E+02**	**1.68E+02**
F17	2.33E+03	5.41E+02	1.15E+03	2.83E+02	1.53E+03	3.33E+02	9.80E+02	**1.28E+02**	1.23E+03	2.39E+02	1.11E+03	3.26E+02	**5.54E+02**	1.71E+02
F18	4.14E+05	2.76E+05	2.61E+05	1.94E+05	1.37E+05	1.09E+05	5.83E+02	6.13E+02	1.52E+05	1.16E+05	7.98E+04	1.21E+05	**6.19E+01**	**2.76E+01**
F19	3.36E+04	2.75E+04	2.32E+04	2.01E+04	3.23E+04	5.52E+04	1.39E+02	**4.46E+01**	1.13E+04	5.39E+03	1.45E+04	1.05E+04	**1.28E+02**	7.00E+01
F20	1.69E+03	4.21E+02	9.47E+02	3.12E+02	9.35E+02	2.71E+02	8.01E+02	1.43E+02	8.51E+02	2.40E+02	7.72E+02	2.96E+02	**3.63E+02**	**1.16E+02**
F21	6.79E+02	1.09E+02	3.57E+02	4.42E+01	4.31E+02	5.86E+01	3.47E+02	1.62E+01	3.57E+02	3.22E+01	3.55E+02	3.07E+01	**2.58E+02**	**1.33E+01**
F22	8.51E+03	**9.10E+02**	7.16E+03	1.64E+03	1.12E+04	4.32E+03	**4.31E+03**	2.64E+03	7.12E+03	3.60E+03	5.48E+03	9.72E+02	6.97E+03	3.41E+03
F23	1.12E+03	1.53E+02	5.46E+02	3.51E+01	7.37E+02	1.07E+02	6.01E+02	**2.40E+01**	5.77E+02	4.62E+01	6.52E+02	4.45E+01	**4.93E+02**	3.19E+01
F24	1.23E+03	1.27E+02	6.62E+02	3.95E+01	8.15E+02	6.90E+01	6.91E+02	3.61E+01	5.82E+02	5.76E+01	7.62E+02	6.15E+01	**5.50E+02**	**1.61E+01**
F25	4.85E+02	3.84E+01	4.51E+02	2.12E+01	**4.48E+02**	2.69E+01	5.05E+02	4.46E+01	5.46E+02	**1.96E+01**	5.44E+02	3.66E+01	5.08E+02	3.05E+01
F26	6.67E+03	1.56E+03	1.98E+03	4.12E+02	3.96E+03	1.15E+03	2.62E+03	2.01E+02	2.03E+03	5.00E+02	2.93E+03	1.17E+03	**1.65E+03**	**1.25E+02**
F27	5.00E+02	**2.23E-04**	5.00E+02	2.73E-04	**5.00E+02**	2.76E-04	6.38E+02	5.85E+01	6.23E+02	6.36E+01	6.75E+02	7.26E+01	5.40E+02	4.66E+01
F28	4.99E+02	5.51E+00	5.00E+02	**3.57E-04**	5.00E+02	4.75E-04	**4.82E+02**	3.18E+01	5.08E+02	2.40E+01	4.94E+02	2.76E+01	4.90E+02	2.11E+01
F29	2.54E+03	6.79E+02	1.21E+03	3.46E+02	1.49E+03	3.74E+02	**7.63E+02**	**1.06E+02**	1.32E+03	3.83E+02	1.17E+03	2.89E+02	8.48E+02	1.63E+02
F30	1.99E+04	4.33E+04	**6.91E+02**	**1.89E+03**	7.43E+03	7.32E+03	1.27E+06	2.15E+05	1.04E+06	5.70E+05	7.68E+05	8.70E+04	6.83E+05	1.24E+05



f_1 f_6 f_{14} f_{26}

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



f_1 f_6 f_{14} f_{26}

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