

Supplementary Material for “A Triple Population Adaptive Differential Evolution”

Func	EADe		LSHDE		LSHDE-SpacMA		LSHDE-ESP		ATSM-SO		gSO		MSO		TDE		ADE		FADE		TPADE			
	Mean	Sd.	p-value	Mean	Sd.	p-value	Mean	Sd.	p-value	Mean	Sd.	p-value	Mean	Sd.	p-value	Mean	Sd.	p-value	Mean	Sd.	p-value	Mean	Sd.	
F1	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	
F2	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	
F3	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	
F4	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	NaN(+)	0.00E+00	0.00E+00	
F5	2.04E+01	6.82E+02	1.36E+19(+)	1.75E+01	6.43E+00	3.43E+00	1.68E+01	1.86E+01	4.64E+00	3.72E+01	1.95E+01	3.98E+00	5.69E+21(+)	1.93E+01	3.66E+00	2.95E+03	1.73E+01	6.19E+00	1.68E+01	2.01E+01	2.09E+03	2.85E+04(+)	1.90E+01	3.38E+00
F6	4.68E+02	1.01E+01	1.06E+03(+)	0.00E+00	9.01E+00	9.44E+00	0.00E+00	9.01E+00	9.44E+00	0.00E+00	9.01E+00	9.44E+00	5.1E+03	3.6E+02	4.34E+03	0.00E+00	0.00E+00	9.44E+00	1.03E+02	5.13E+02	1.47E+02	4.38E+02	5.15E+02	1.05E+01
F7	7.66E+02	5.51E+02	2.47E+03(+)	1.88E+03	4.71E+05	3.98E+09(+)	2.28E+06	9.05E+12(+)	3.06E+03	5.2E+02	1.21E+03	3.43E+02	9.28E+11(+)	1.21E+03	3.20E+03	2.65E+12(+)	7.25E+04	3.20E+03	1.97E+04	3.32E+02	1.94E+02	4.68E+04	1.76E+01	1.59E+02
F8	7.34E+04	5.23E+04	2.90E+04(+)	3.92E+04(+)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.27E+01	1.59E+02	2.79E+01	1.00E+00	0.00E+00	0.00E+00	3.27E+01	0.00E+00	6.08E+00	3.27E+01	0.00E+00	
F9	1.15E+01	2.84E+00	3.92E+14(+)	2.97E+00	8.33E+00	9.19E+02(+)	1.52E+00	8.45E+00	9.19E+00	8.50E+00	8.50E+00	9.19E+00	8.50E+00	1.38E+01	9.26E+01	9.26E+01	5.96E+01	6.52E+01	2.48E+01	7.25E+01	9.25E+01	1.38E+01	5.37E+00	
F10	1.22E+01	1.11E+01	1.00E+14(+)	6.12E+03	1.88E+02	1.88E+02	1.88E+02	1.88E+02	1.88E+02	3.58E+02	3.58E+02	3.58E+02	3.58E+02	5.1E+03	2.85E+02	5.1E+03	2.85E+02	3.58E+02	7.25E+01	5.18E+02	2.85E+02	2.85E+02	2.85E+02	
F11	1.38E+03	1.52E+02	3.36E+19(+)	7.48E+01	5.90E+01	6.25E+01	5.64E+01	5.78E+01	5.64E+01	5.78E+01	5.64E+01	5.78E+01	5.64E+01	6.63E+01	6.38E+02	6.48E+01	6.38E+02	6.48E+01	5.90E+01	6.48E+01	5.90E+01	5.90E+01	5.90E+01	
F12	1.27E+00	2.17E+01	3.19E+19(+)	8.39E+02	2.80E+02	2.96E+01(+)	4.38E+02	9.02E+00	2.80E+01	2.17E+01	2.41E+01	2.68E+01	1.60E+01	1.64E+01	1.12E+15(+)	8.37E+01	2.01E+01	1.76E+01	4.77E+02	5.77E+02	7.76E+02	1.22E+01	5.08E+02	
F13	1.21E+01	2.65E+02	4.18E+19(+)	5.06E+02	1.77E+02	2.59E+02(+)	4.38E+02	8.98E+01	6.63E+02	1.40E+02	4.96E+01(+)	6.87E+02	1.44E+02	1.40E+02	3.29E+02	5.91E+02	1.31E+02	1.98E+02	6.05E+02	6.05E+02	1.46E+02	1.58E+02	4.55E+02	
F14	1.84E+01	4.65E+02	3.30E+19(+)	9.04E+02	2.68E+02	4.48E+02	4.38E+02	2.18E+01	4.48E+02	3.01E+02	1.78E+02	4.48E+02	1.92E+02	1.92E+02	2.96E+02	7.20E+02	3.03E+02	6.95E+02	7.35E+02	5.57E+02	5.53E+02	5.56E+02		
F15	1.58E+00	3.89E+00	8.05E+18(+)	1.32E+03	3.75E+01	6.27E+20(+)	3.74E+01	6.06E+01	6.06E+01	2.47E+01	5.78E+01	6.06E+01	6.06E+01	6.06E+01	7.01E+01	6.38E+02	7.01E+01	6.38E+02	7.01E+01	6.38E+02	7.01E+01	5.13E+02	5.13E+02	
F16	3.05E+00	2.83E+01	3.36E+19(+)	9.29E+01	8.20E+01	9.02E+00(+)	4.38E+01	8.79E+02	2.39E+02	1.27E+01	2.41E+01	2.68E+01	1.60E+01	1.64E+01	1.12E+15(+)	8.37E+01	2.01E+01	1.76E+01	4.77E+02	5.77E+02	7.76E+02	1.22E+01	5.08E+02	
F17	3.11E+01	1.06E+01	3.63E+19(+)	2.31E+01	1.11E+04	5.26E+00	2.24E+01	1.70E+01	7.84E+01	5.14E+01	4.04E+01	7.85E+01	3.28E+01	3.28E+01	3.75E+01	8.55E+01	7.87E+01	3.30E+01	6.05E+02	6.05E+02	6.05E+02	1.15E+00	2.31E+00	
F18	1.75E+00	8.00E+00	2.06E+19(+)	3.06E+01	3.05E+01	3.34E+01	3.05E+01	3.34E+01	3.34E+01	3.37E+01	3.37E+01	1.58E+01	3.66E+01	3.66E+01	1.54E+01	3.66E+01	3.66E+01	2.93E+01	3.66E+01	2.93E+01	1.15E+01	4.35E+01		
F19	1.20E+01	4.04E+01	2.25E+19(+)	1.50E+01	3.04E+01	3.10E+01	3.24E+01	3.10E+01	3.10E+01	3.17E+01	3.17E+01	3.17E+01	3.17E+01	3.17E+01	3.17E+01	3.17E+01	3.17E+01	3.17E+01	3.17E+01	3.17E+01	3.17E+01	3.17E+01		
F20	1.65E+00	2.02E+01	3.78E+19(+)	8.86E+02	7.95E+02	2.42E+00	1.41E+02	1.73E+01	1.68E+01	4.33E+01	1.30E+01	1.68E+01	2.38E+01	2.38E+01	1.68E+01	3.07E+01	1.68E+01	3.07E+01	1.68E+01	3.07E+01	1.68E+01	3.07E+01	1.68E+01	
F21	1.37E+01	1.74E+01	6.47E+02	2.41E+01	2.08E+01	1.61E+01	2.08E+01	2.08E+01	2.08E+01	2.08E+01	2.08E+01	2.08E+01	2.08E+01	2.08E+01	2.08E+01	2.08E+01	2.08E+01	2.08E+01	2.08E+01	2.08E+01	2.08E+01	2.08E+01		
F22	2.29E+00	3.66E+00	4.79E+01	1.79E+01	1.57E+01	5.44E+00	1.19E+01	9.61E+00	5.54E+00	9.61E+00	9.61E+00	5.01E+00	5.01E+00	9.58E+00	1.52E+01	9.16E+00	1.52E+01	9.16E+00	1.52E+01	9.16E+00	1.52E+01	9.16E+00		
F23	3.68E+02	4.20E+01	6.44E+04	3.07E+01	3.07E+01	1.35E+15(+)	1.92E+01	9.43E+02	5.15E+02	8.47E+02	1.59E+01	9.43E+02	1.59E+01	9.43E+02	1.59E+01	9.43E+02	1.59E+01	9.43E+02	1.59E+01	9.43E+02	1.59E+01	9.43E+02		
F24	1.21E+02	1.78E+01	2.70E+04	1.66E+02	6.92E+01	7.96E+05(+)	1.05E+02	4.10E+01	1.05E+02	6.59E+01	5.37E+01	1.05E+02	6.59E+01	5.37E+01	1.05E+02	6.59E+01	5.37E+01	1.05E+02	6.59E+01	5.37E+01	1.05E+02	6.59E+01		
F25	1.97E+02	1.39E+01	4.30E+04	1.59E+02	1.37E+01	7.00E+02(+)	1.04E+02	1.88E+01	1.88E+01	2.62E+01	1.90E+01	1.88E+01	1.90E+01	1.90E+01	1.90E+01	1.90E+01	1.90E+01	1.90E+01	1.90E+01	1.90E+01	1.90E+01	1.90E+01		
F26	1.00E+02	2.60E+02	6.99E+19(+)	1.60E+02	1.77E+02	10.8E+02(+)	1.04E+02	1.00E+02	1.25E+02	1.79E+00	1.00E+02	1.25E+02	1.79E+00	1.00E+02	1.25E+02	1.79E+00	1.00E+02	1.25E+02	1.79E+00	1.00E+02	1.25E+02	1.79E+00		
F27	3.08E+02	5.71E+01	1.02E+09	3.68E+02	4.07E+01	2.58E+04(+)	3.07E+02	3.70E+02	4.74E+01	1.19E+01	3.70E+02	4.74E+01	1.19E+01	3.70E+02	4.74E+01	1.19E+01	3.70E+02	4.74E+01	1.19E+01	3.70E+02	4.74E+01	1.19E+01		
F28	3.38E+02	6.63E+01	3.66E+05(+)	3.88E+02	4.66E+01	2.04E+06(+)	3.88E+02	3.88E+02	8.67E+01	1.38E+01	3.88E+02	8.67E+01	1.38E+01	3.88E+02	8.67E+01	1.38E+01	3.88E+02	8.67E+01	1.38E+01	3.88E+02	8.67E+01	1.38E+01		
F29	2.13E+02	1.00E+01	5.32E+19(+)	2.21E+02	1.08E+01	1.33E+02(+)	2.13E+02	2.98E+01	2.13E+02	3.69E+02	2.13E+02	3.69E+02	2.13E+02	1.33E+02	2.13E+02	3.69E+02	2.13E+02	3.69E+02	2.13E+02	3.69E+02	2.13E+02	3.69E+02		
F30	2.90E+02	4.29E+01	5.50E+08(+)	2.88E+02	5.04E+01	4.12E+01	2.88E+02	2.58E+02	1.04E+01	2.64E+01	1.31E+01	2.64E+01	1.31E+01	2.64E+01	1.31E+01	2.64E+01	1.31E+01	2.64E+01	1.31E+01	2.64E+01	1.31E+01	2.64E+01		

Table S8: Results between TPADE and ten comparative algorithms on 3D test functions in CEC2017 benchmark suite/Wilcoxon rank-sum test($\alpha=0.05$).																					
Func	EADE	LSHODR					LSHODR-ESP					ATSM-SO					TDOE				
		Mean	Sd.	P-value	Mean	Sd.	P-value	Mean	Sd.	P-value	Mean	Sd.	P-value	Mean	Sd.	P-value	Mean	Sd.	P-value		
F1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Nan(=)	0.00E+00	0.00E+00	Nan(=)											
F3	0.00E+00	0.00E+00	0.00E+00	Nan(=)	0.00E+00	0.00E+00	Nan(=)														
F4	5.85E+00	0.00E+00	0.00E+00	Nan(=)	5.56E+01	0.00E+00	Nan(=)	4.7E+01	2.53E+01	5.57E+01	7.78E+01	3.27E+01	5.57E+01	5.87E+01	7.78E+01	3.27E+01	5.87E+01	5.88E+01	5.88E+01		
F5	1.73E+00	2.45E+00	6.6E+00	7.4E+00	1.53E+00	3.72E+00	5.9E+00	7.1E+00	1.51E+00	9.6E+00	8.3E+00	2.06E+00	1.08E+00	1.51E+00	9.6E+00	2.26E+00	1.4E+00	2.26E+00	1.3E+00		
F6	8.24E+04	2.02E+03	1.98E+02	4.00E+08	1.98E+04	2.18E+06	1.35E+03	1.98E+07	2.18E+07	8.57E+03	4.98E+07	2.11E+07	1.21E+07	4.98E+07	2.11E+07	1.28E+07	1.28E+07	1.28E+07	1.28E+07		
F7	4.60E+00	4.37E+00	2.67E+00	3.77E+01	1.24E+00	3.40E+01	1.06E+00	3.75E+01	1.35E+01	1.25E+00	2.13E+00	4.9E+02	3.71E+01	1.46E+00	2.75E+01	4.06E+01	2.44E+00	6.58E+00	4.43E+01		
F8	1.62E+00	5.68E+00	1.16E+00	1.6E+01	7.10E+00	1.54E+01	9.4E+00	2.79E+00	7.5E+00	1.49E+00	3.99E+00	6.9E+00	7.6E+00	9.4E+00	7.5E+00	6.9E+00	7.6E+00	7.6E+00	3.14E+00		
F9	0.00E+00	0.00E+00	Nan(=)	0.00E+00	0.00E+00	0.00E+00	Nan(=)	0.00E+00	0.00E+00	Nan(=)											
F10	6.23E+05	1.50E+05	9.14E+05	1.6E+06	1.76E+05	5.39E+02	5.54E+05	1.89E+02	1.89E+02	3.02E+01	1.93E+02	3.02E+01	1.93E+02	1.93E+02	3.02E+01	1.93E+02	3.02E+01	1.93E+02	3.02E+01		
F11	2.79E+01	2.93E+01	1.17E+01	3.2E+01	2.94E+01	2.57E+01	6.4E+00	9.3E+00	1.91E+01	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.15E+01			
F12	9.09E+02	3.49E+02	8.36E+02	3.73E+01	4.88E+02	2.63E+02	2.30E+01	2.04E+02	1.26E+02	8.46E+02	1.26E+02	1.26E+02	1.26E+02	1.26E+02	1.26E+02	1.26E+02	1.26E+02	1.26E+02			
F13	2.44E+01	9.24E+00	1.54E+00	1.75E+01	6.96E+00	1.13E+00	1.6E+01	5.7E+00	1.65E+01	1.26E+00	1.36E+01	1.36E+01	1.36E+01	1.36E+01	1.36E+01	1.36E+01	1.36E+01	1.36E+01			
F14	2.58E+01	4.69E+01	7.92E+01	2.27E+01	1.46E+00	2.01E+01	1.01E+00	2.38E+00	2.38E+01	2.10E+01	7.38E+01	2.12E+01	7.38E+01	2.12E+01	7.38E+01	2.12E+01	7.38E+01	2.12E+01			
F15	1.00E+00	5.63E+00	3.50E+00	3.40E+00	1.89E+01	2.9E+01	5.4E+00	3.4E+00	2.87E+01	1.92E+01	3.5E+01	1.92E+01	3.5E+01	1.92E+01	3.5E+01	1.92E+01	3.5E+01	1.92E+01			
F16	8.94E+01	1.05E+02	1.22E+01	1.37E+01	5.93E+01	5.41E+01	5.63E+01	3.6E+01	6.23E+01	3.09E+01	4.12E+01	5.33E+01	4.21E+01	5.33E+01	4.21E+01	5.33E+01	5.33E+01	5.33E+01			
F17	6.54E+01	1.94E+01	1.47E+01	2.90E+01	8.13E+00	3.03E+01	6.94E+00	4.86E+01	8.13E+01	7.67E+00	8.13E+01	7.67E+00	8.13E+01	7.67E+00	8.13E+01	7.67E+00	8.13E+01	7.67E+00			
F18	2.76E+01	4.94E+00	4.76E+01	2.59E+01	1.10E+00	2.08E+01	8.13E+01	7.42E+00	4.23E+01	2.08E+01	7.42E+00	2.08E+01	7.42E+00	2.08E+01	7.42E+00	2.08E+01	7.42E+00	2.08E+01			
F19	7.24E+01	2.60E+00	7.72E+01	5.90E+01	1.73E+00	5.58E+01	6.38E+00	3.42E+00	8.73E+01	1.96E+01	5.33E+01	1.54E+00	5.33E+01	1.54E+00	5.33E+01	1.54E+00	5.33E+01	1.54E+00			
F20	5.62E+01	4.66E+01	5.77E+01	3.71E+01	1.30E+01	1.43E+02	1.50E+01	5.3E+01	6.37E+01	4.60E+01	2.85E+01	3.00E+01	2.85E+01	3.00E+01	2.85E+01	3.00E+01	2.85E+01	3.00E+01			
F21	2.17E+02	4.97E+00	3.22E+01	2.68E+02	1.52E+01	1.60E+05	7.18E+01	2.07E+02	1.73E+01	3.87E+01	2.07E+01	2.07E+01	2.07E+01	2.07E+01	2.07E+01	2.07E+01	2.07E+01	2.07E+01			
F22	1.00E+02	0.00E+00	Nan(=)	1.00E+02	0.00E+00	Nan(=)	1.00E+02	0.00E+00	Nan(=)	1.00E+02	0.00E+00	Nan(=)	1.00E+02	0.00E+00	Nan(=)	1.00E+02	0.00E+00	Nan(=)			
F23	3.47E+02	7.62E+00	1.79E+00	3.54E+02	3.23E+00	3.03E+00	2.8E+00	3.4E+00	3.21E+00	2.11E+00	1.11E+00	3.5E+00	3.5E+00	3.5E+00	3.5E+00	3.5E+00	3.5E+00	3.5E+00			
F24	4.47E+02	6.93E+00	1.84E+00	4.66E+00	1.79E+01	1.81E+00	4.20E+00	4.24E+02	1.64E+00	3.72E+00	4.39E+02	1.64E+00	3.72E+00	4.39E+02	1.64E+00	3.72E+00	4.39E+02	1.64E+00			
F25	3.87E+02	1.12E+01	2.87E+01	5.57E+01	5.71E+02	5.3E+01	5.3E+01	5.87E+02	5.3E+01	5.71E+02	8.95E+01	8.04E+01	8.95E+01	8.04E+01	8.95E+01	8.04E+01	8.95E+01	8.04E+01			
F26	1.10E+03	7.74E+01	1.15E+01	9.79E+02	3.53E+01	4.66E+01	9.93E+01	9.08E+02	3.03E+01	5.21E+01	9.76E+02	4.23E+01	9.76E+02	4.23E+01	9.76E+02	4.23E+01	9.76E+02	4.23E+01			
F27	5.01E+02	6.13E+00	1.34E+01	5.60E+02	4.47E+00	4.47E+00	5.05E+02	5.60E+02	5.79E+00	2.48E+01	5.60E+02	6.40E+00	2.06E+00	5.01E+02	5.88E+00	2.06E+00	5.64E+02	5.88E+00			
F28	3.44E+02	5.72E+01	7.67E+01	5.30E+02	5.34E+01	5.34E+01	6.20E+01	6.00E+02	2.80E+01	1.74E+01	3.1H+02	1.74E+01	3.1H+02	1.74E+01	3.1H+02	1.74E+01	3.1H+02	1.74E+01			
F29	4.42E+02	4.04E+01	5.01E+01	4.91E+02	8.19E+01	2.09E+01	2.08E+01	4.42E+02	4.39E+02	9.2E+00	4.44E+01	4.39E+02	9.2E+00	4.44E+01	4.39E+02	9.2E+00	4.44E+01	4.44E+01			
F30	2.03E+00	6.91E+01	6.14E+00	2.04E+03	6.33E+01	2.06E+01	1.35E+01	1.97E+03	1.97E+01	1.42E+01	1.35E+01	2.06E+00	1.35E+01	2.06E+00	1.35E+01	2.06E+00	1.35E+01	2.06E+00			

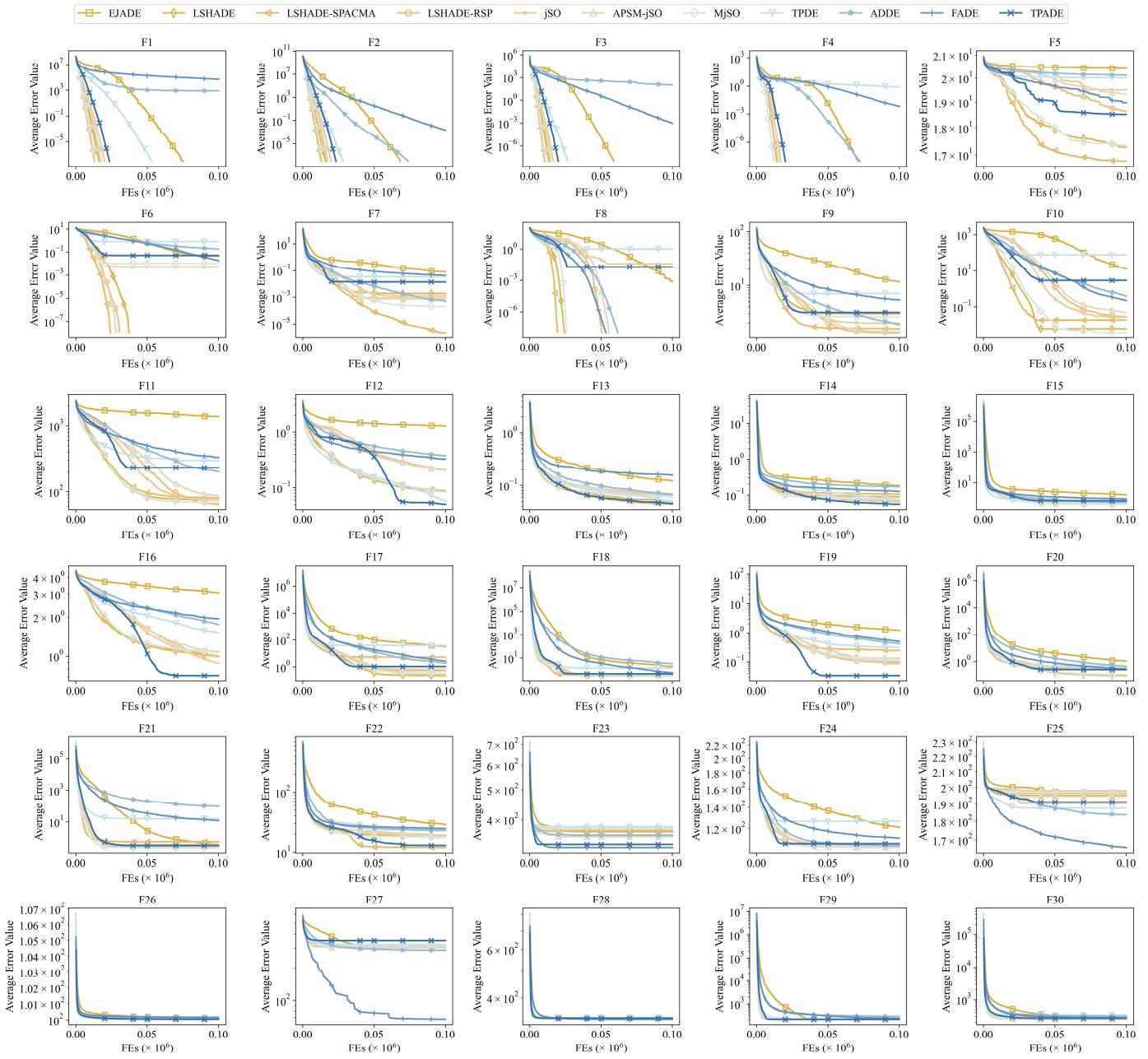


Figure S1. Average convergence curves of TPADE and ten comparative algorithms in CEC2014 benchmark suite ($D=10$).

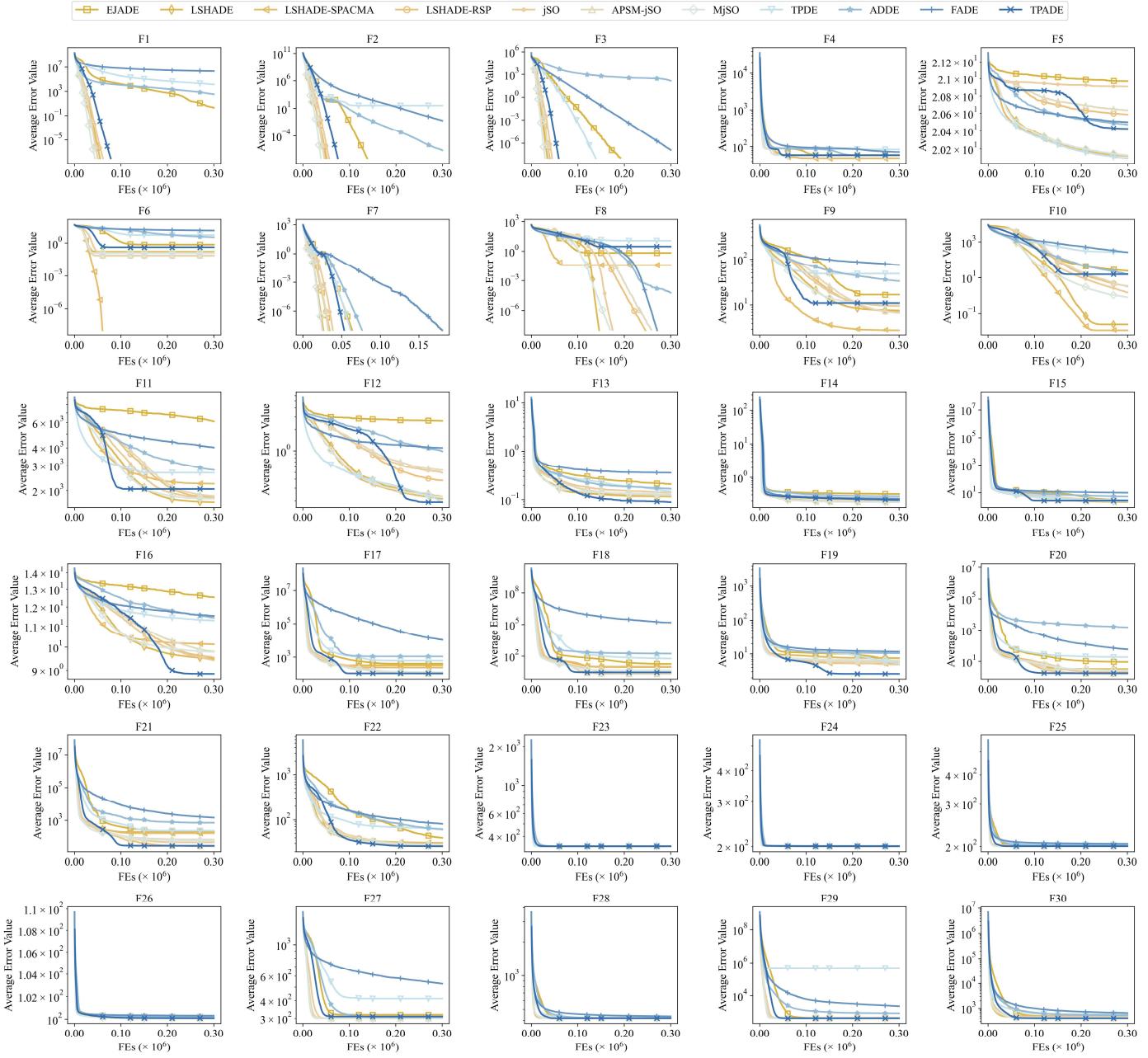


Figure S2. Average convergence curves of TPADE and ten comparative algorithms in CEC2014 benchmark suite (D=30).

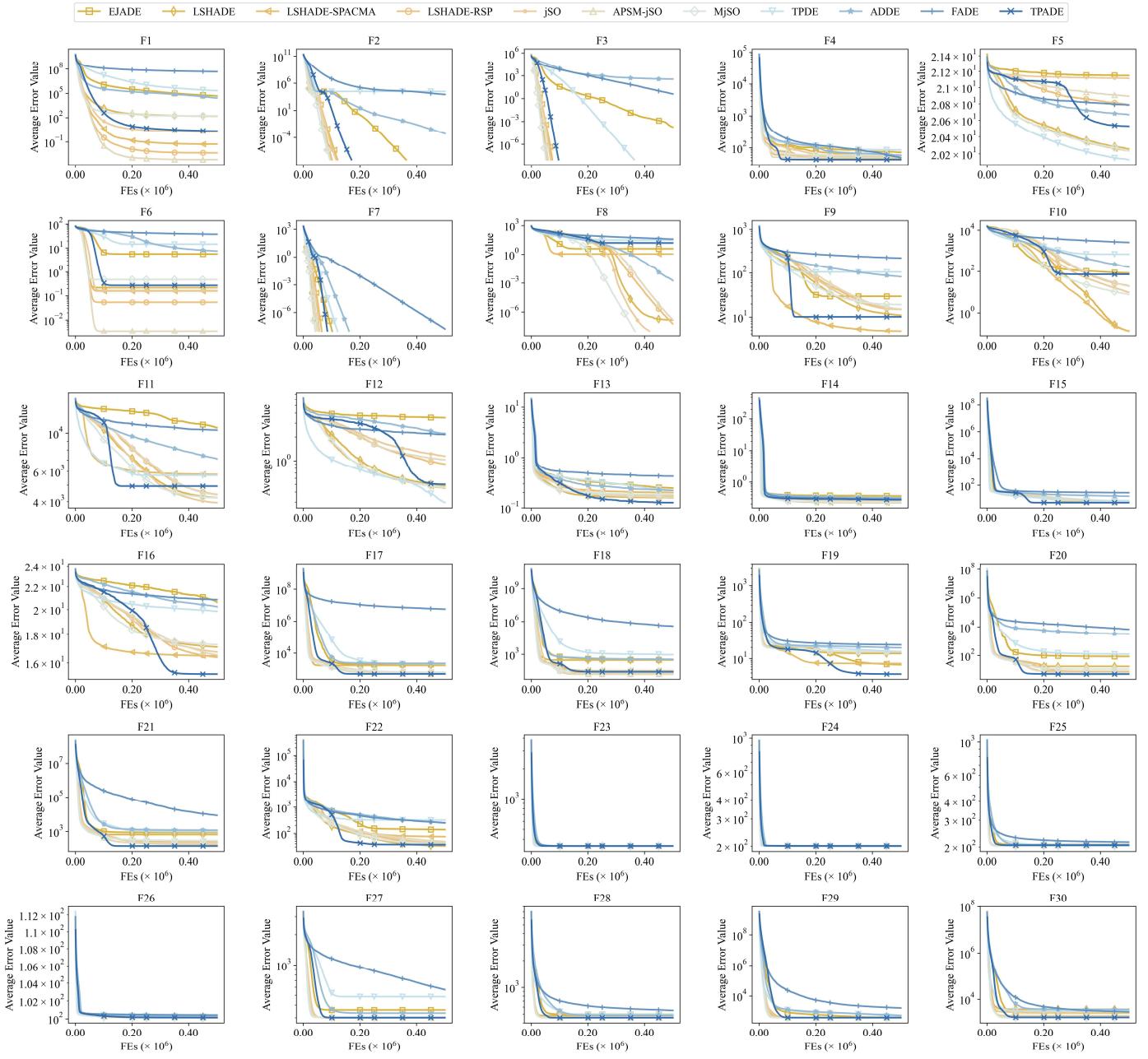


Figure S3. Average convergence curves of TPADE and ten comparative algorithms in CEC2014 benchmark suite (D=50).

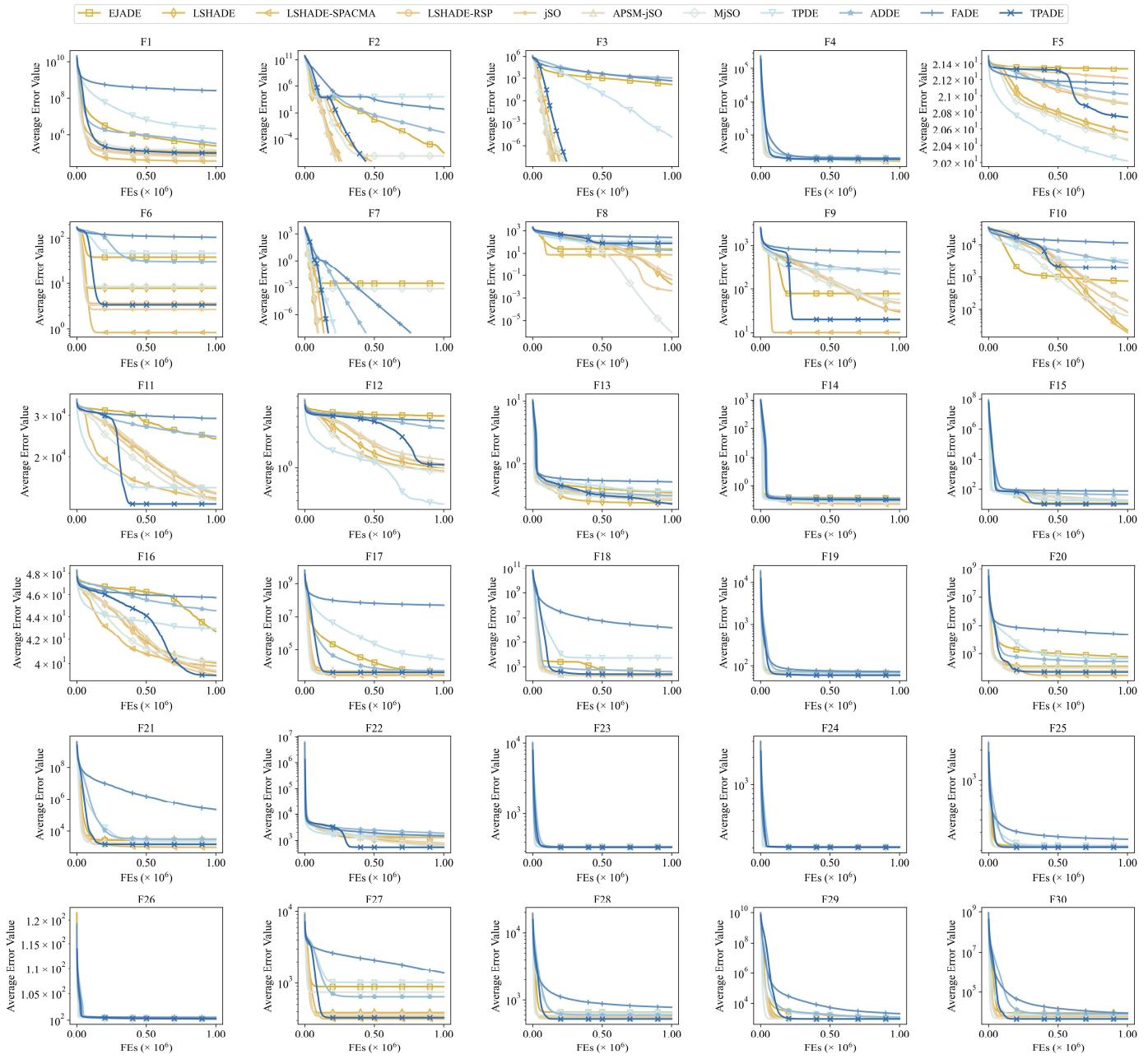


Figure S4. Average convergence curves of TPADE and ten comparative algorithms in CEC2014 benchmark suite (D=100).

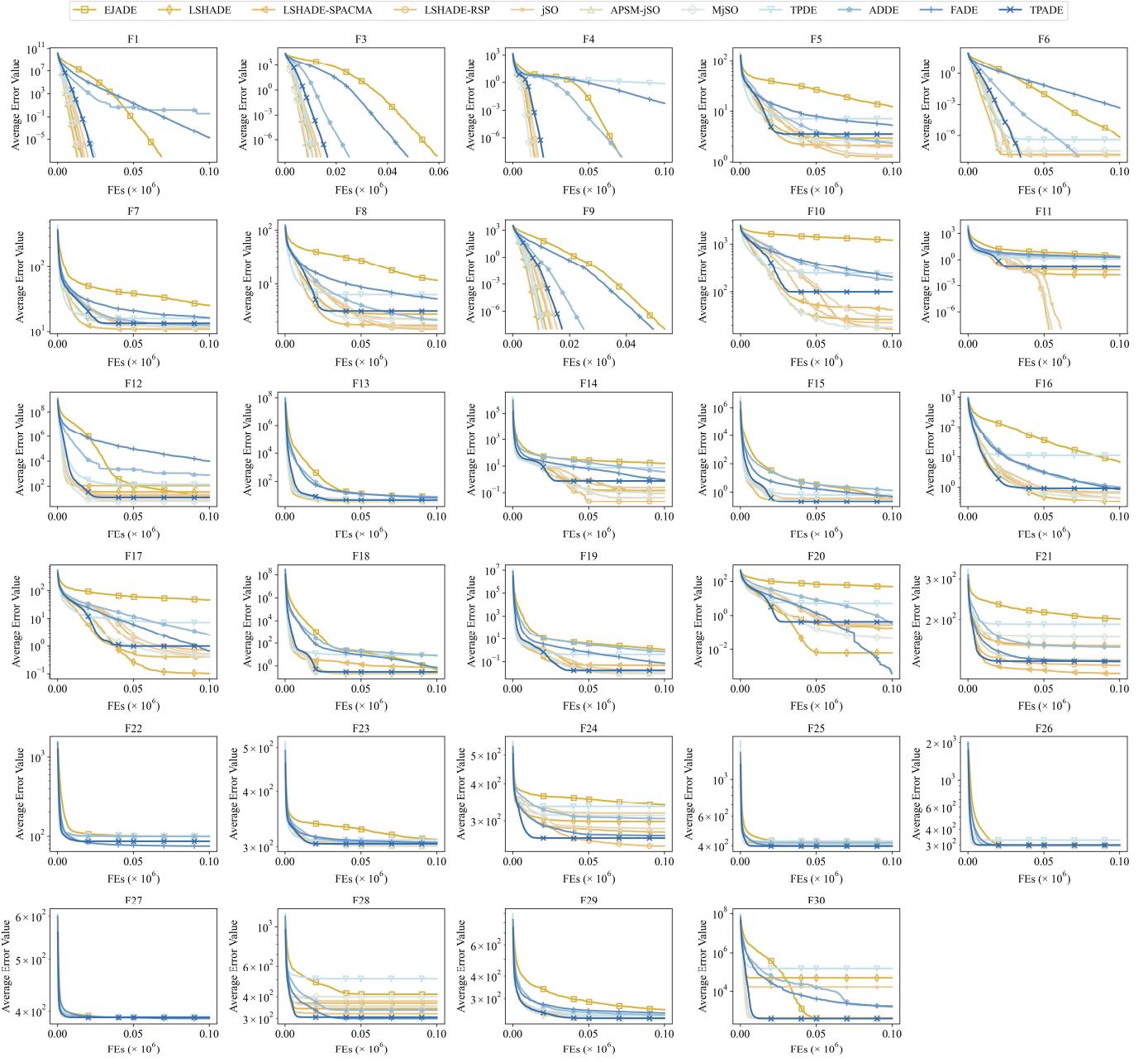


Figure S5. Average convergence curves of TPADE and ten comparative algorithms in CEC2017 benchmark suite ($D=10$).

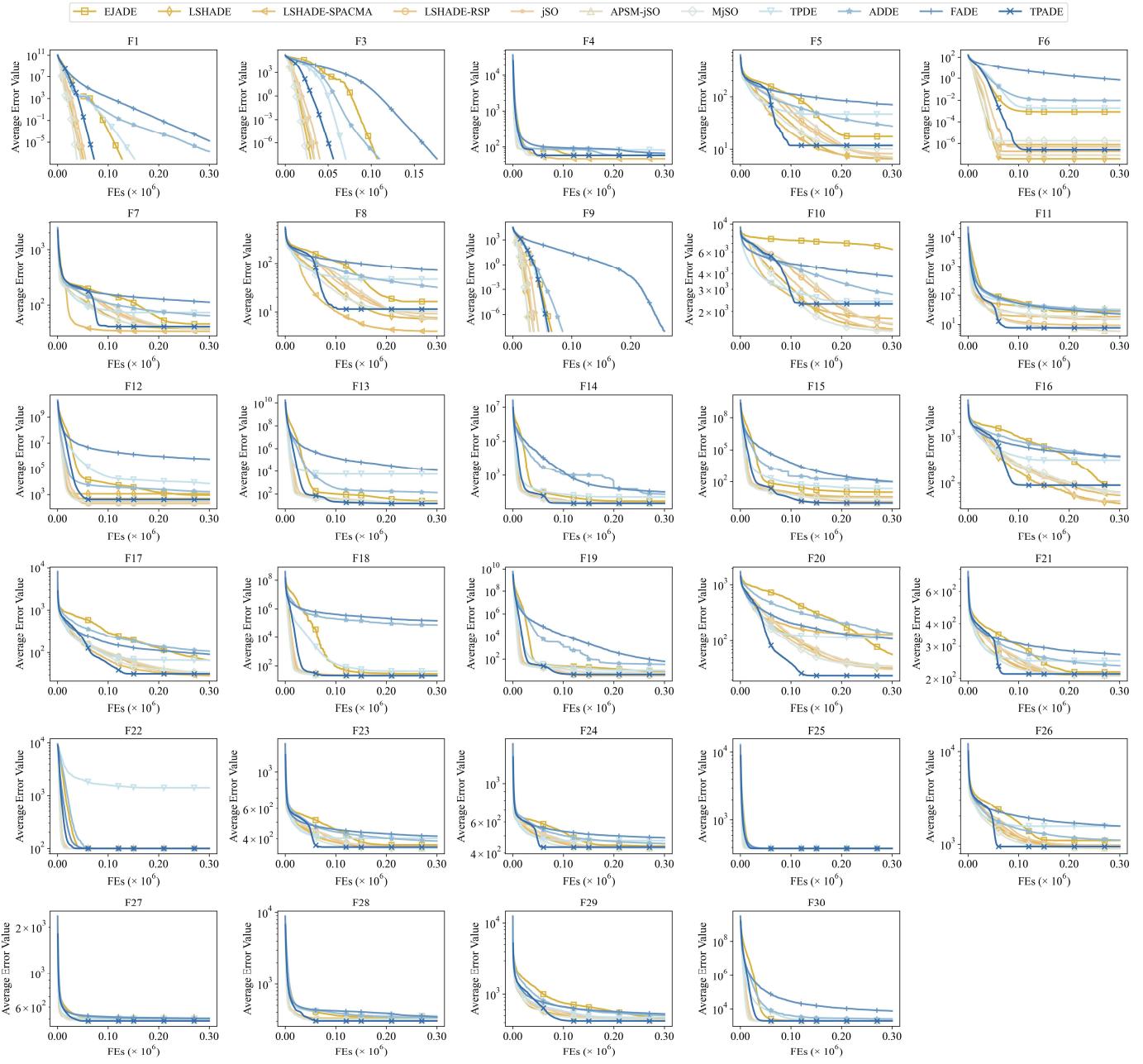


Figure S6. Average convergence curves of TPADE and ten comparative algorithms in CEC2017 benchmark suite (D=30).

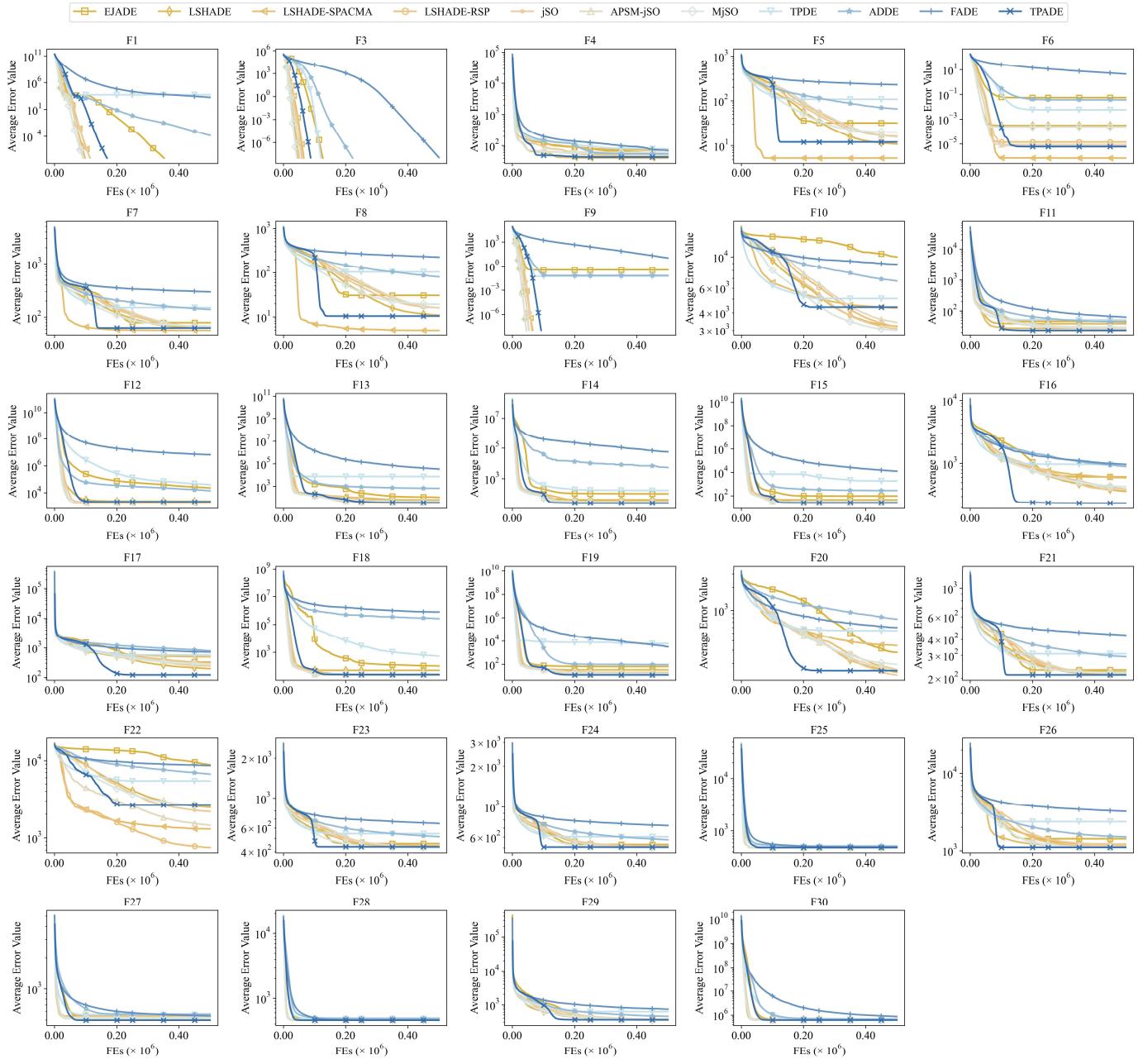


Figure S7. Average convergence curves of TPADE and ten comparative algorithms in CEC2017 benchmark suite (D=50).

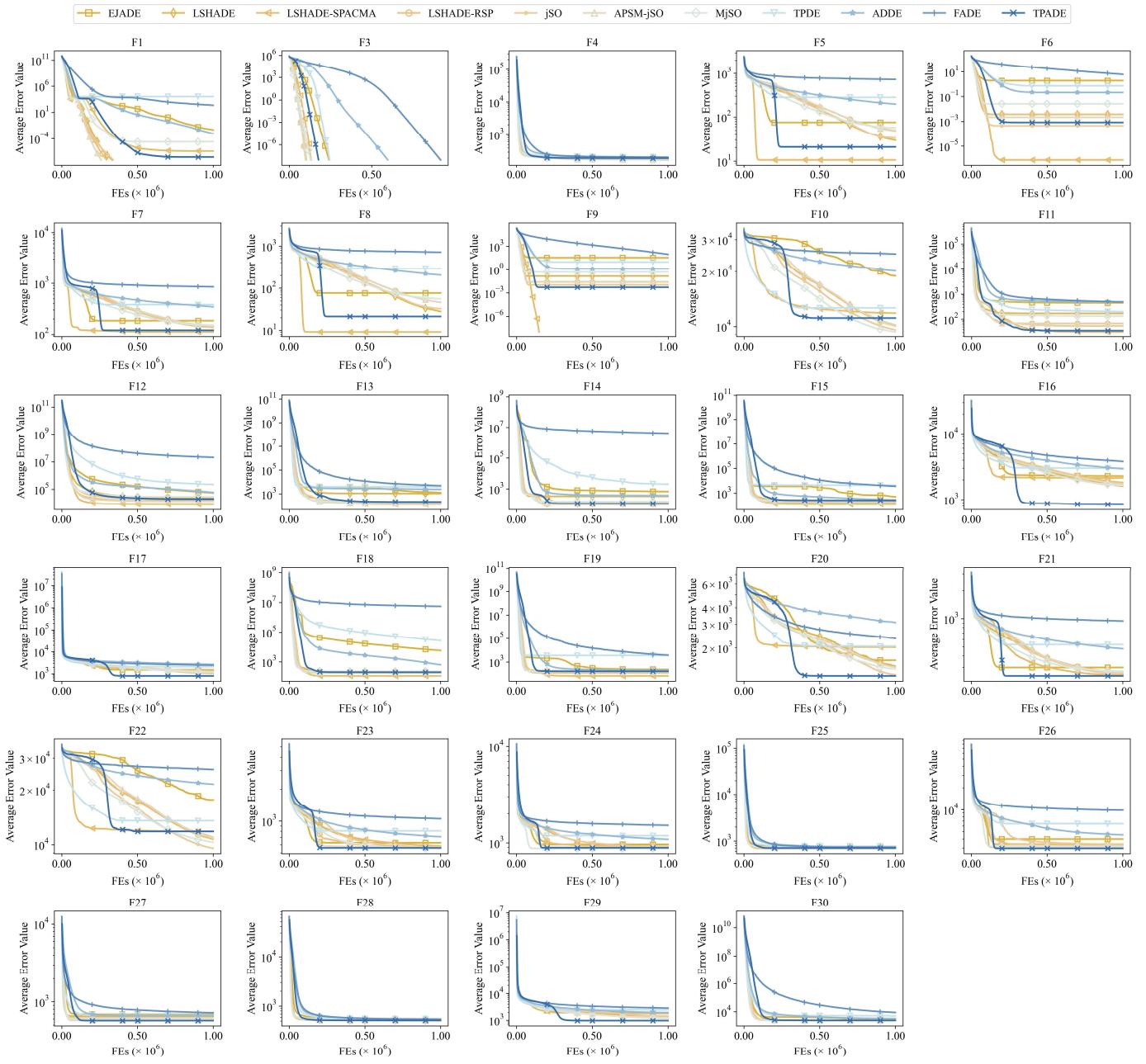


Figure S8. Average convergence curves of TPADE and ten comparative algorithms in CEC2017 benchmark suite (D=100).

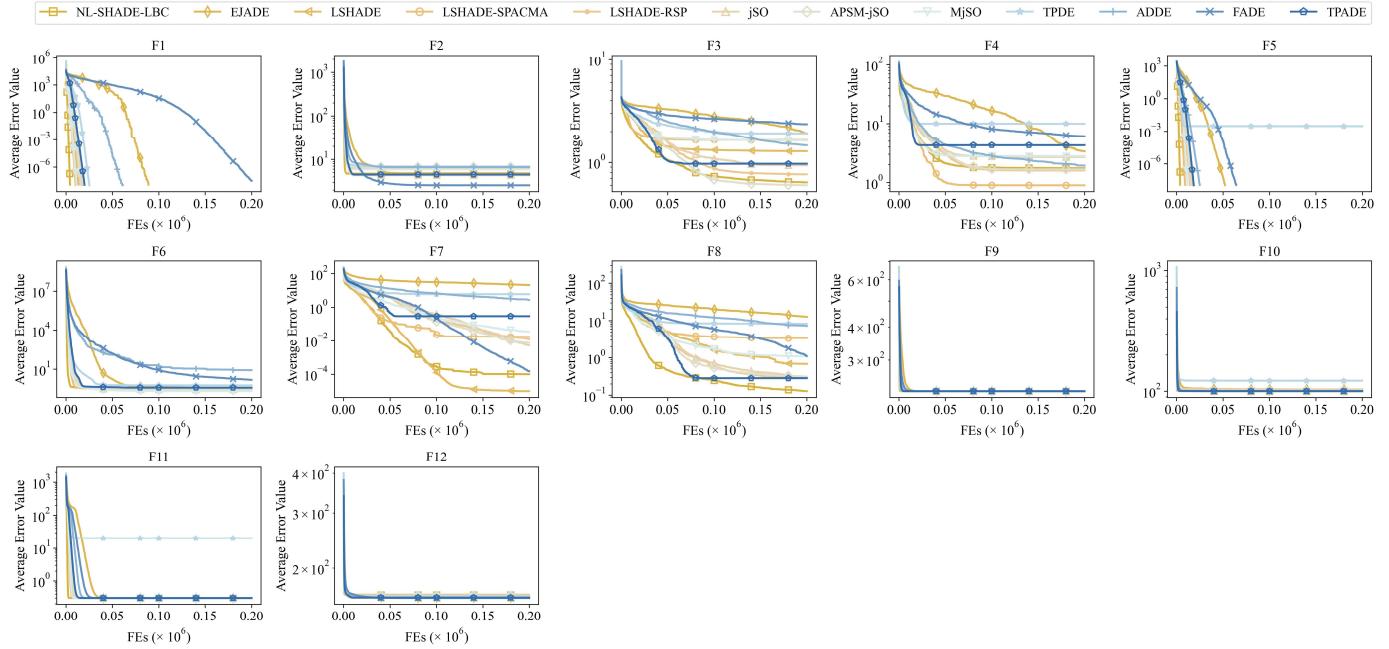


Figure S9. Average convergence curves of TPADE and eleven comparative algorithms in CEC2022 benchmark suite (D=10).

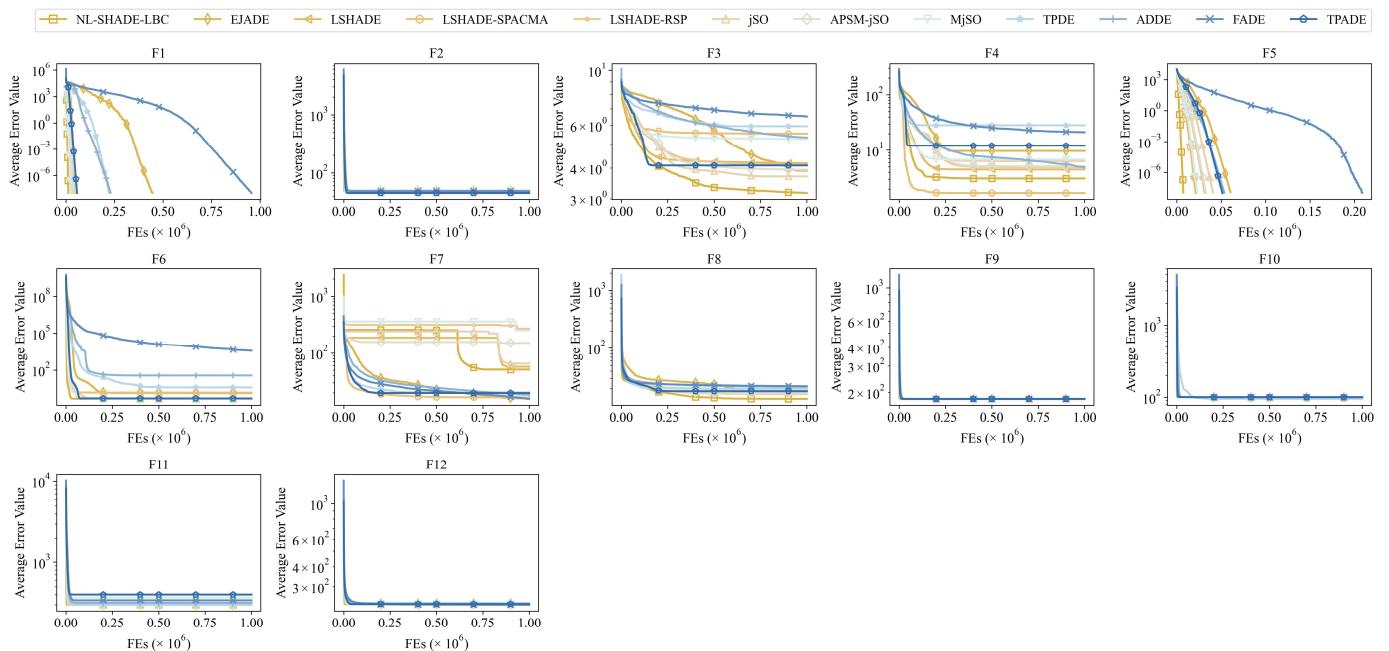


Figure S10. Average convergence curves of TPADE and eleven comparative algorithms in CEC2022 benchmark suite (D=20).