Two-Stream Graph Convolutional Network-Incorporated Latent Feature Analysis Supplementary File

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This is the supplementary file for the paper entitled "Two-Stream Graph Convolutional Network-Incorporated Latent Feature Analysis". Additional tables and figures are put into this file and cited by the paper.

1. SUPPLEMENTARY TABLES

TABLE S1
NONLINEARITIES OF ALL THE INVOLVED MODELS IN OUR EXPERIMENTS.

M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15
√	√	√	√	√	×	×	√	×	×	√	×	×	√	√

√ denotes the corresponding model is nonlinear, and × is versa.

TABLE S2
THE RMSE/MAE OF TGLFA-W/O-A&H, TGLFA-W/O-A, TGLFA-W/O-H, AND TGLFA ON ALL TESTING CASES.

	No.	D1.1	D1.2	D1.3	D1.4	D2.1	D2.2	D2.3	D2.4
RMSE	TGLFA-w/o-A&H	$1.5826_{\pm1.3E\text{-}2}$	$1.3340_{\pm2.9E\text{-}3}$	$1.2420_{\pm2.5E\text{-}3}$	$1.1931_{\pm1.9E\text{-}3}$	$0.6365_{\pm3.2E\text{-}3}$	$0.4996_{\pm8.2E\text{-}4}$	$0.4665_{\pm9.8E\text{-}4}$	$0.4444_{\pm9.6E\text{-}4}$
	TGLFA-w/o-A	$1.5312_{\pm7.8E\text{-}3}$	$1.3180_{\pm1.5E\text{-}3}$	$1.1988_{\pm2.1E\text{-}4}$	$1.1711_{\pm1.7E\text{-}4}$	$0.5778_{\pm1.1E\text{-}3}$	$0.4831_{\pm1.5E\text{-}4}$	$0.4508_{\pm5.2E\text{-}4}$	$0.4293_{\pm2.2E\text{-}4}$
	TGLFA-w/o-H	$1.4313_{\pm1.6E\text{-}3}$	$1.2786_{\pm2.3E\text{-}3}$	$1.1994_{\pm1.5E\text{-}3}$	$1.1535_{\pm7.3E\text{-}4}$	$0.5934_{\pm1.1E\text{-}3}$	$0.4879_{\pm1.3E\text{-}4}$	$0.4536_{\pm4.9E\text{-}4}$	$0.4313_{\pm7.9E\text{-}4}$
	TGLFA	$\mathbf{1.2613_{\pm8.1E\text{-}4}}$	$\mathbf{1.1986_{\pm1.0E\text{-}3}}$	$\mathbf{1.1566_{\pm8.3E\text{-}4}}$	$\mathbf{1.1223_{\pm1.3E\text{-}3}}$	$\mathbf{0.5266_{\pm4.5E\text{-}4}}$	$\mathbf{0.4650_{\pm7.3E\text{-}4}}$	$\mathbf{0.4352_{\pm5.3E\text{-}4}}$	$\mathbf{0.4176_{\pm7.0E\text{-}4}}$
MAE	TGLFA-w/o-A&H	$0.7437_{\pm1.1E\text{-}2}$	$0.5698_{\pm2.0E\text{-}3}$	$0.5224_{\pm1.0E\text{-}3}$	$0.5053_{\pm5.8E\text{-}4}$	$0.2381_{\pm1.1E\text{-}3}$	$0.1915_{\pm4.3E\text{-}4}$	$0.1789_{\pm2.6E\text{-}4}$	$0.1733_{\pm5.7E\text{-}4}$
	TGLFA-w/o-A	$0.6530_{\pm5.0E\text{-}3}$	$0.5497_{\pm1.3E\text{-}3}$	$0.4679_{\pm1.6E\text{-}3}$	$0.4582_{\pm1.7E\text{-}3}$	$0.1995_{\pm3.4E\text{-}4}$	$0.1691_{\pm2.2E\text{-}4}$	$0.1554_{\pm5.0E\text{-}4}$	$0.1476_{\pm3.4E\text{-}4}$
	TGLFA-w/o-H	$0.5767_{\pm1.1E\text{-}3}$	$0.5014_{\pm2.0E\text{-}3}$	$0.4605_{\pm1.6E\text{-}3}$	$0.4400_{\pm6.8E\text{-}4}$	$0.2094_{\pm6.0E\text{-}4}$	$0.1756_{\pm3.1E\text{-}4}$	$0.1631_{\pm2.8E\text{-}4}$	$0.1567_{\pm7.9E\text{-}4}$
	TGLFA	$\mathbf{0.4992_{\pm1.3E\text{-}3}}$	$\mathbf{0.4581_{\pm1.5E\text{-}3}}$	$\mathbf{0.4378_{\pm1.4E\text{-}3}}$	$\mathbf{0.4214_{\pm1.6E\text{-}3}}$	$\mathbf{0.1879_{\pm6.0E\text{-}4}}$	$\mathbf{0.1636_{\pm4.6E\text{-}4}}$	$\mathbf{0.1510_{\pm4.1E\text{-}4}}$	$\mathbf{0.1441_{\pm5.2E\text{-}4}}$

w/o denotes the removal operation; A denotes the attribute characteristics extraction module (Module (a)); and H denotes the high-order connectivity information extraction module (Module (b)).

TABLE S3
THE RMSE/MAE OF TGLFA WITH DIFFERENT LAYER COMBINATION STRATEGIES ON ALL TESTING CASES.

	No.	D1.1	D1.2	D1.3	D1.4	D2.1	D2.2	D2.3	D2.4
RMSE	TGLFA-single-A	$1.2630_{\pm9.6E\text{-}4}$	$1.2100_{\pm5.1E\text{-}4}$	$1.1837_{\pm1.4E\text{-}3}$	$1.1290_{\pm1.9E\text{-}3}$	$0.5512_{\pm6.5E\text{-}4}$	$0.4650_{\pm7.3E\text{-}4}$	$0.4479_{\pm6.2E\text{-}4}$	$0.4261_{\pm4.6E\text{-}4}$
	TGLFA-Single-H	$1.3930_{\pm7.2E\text{-}5}$	$1.3808_{\pm2.4E\text{-}5}$	$1.3743_{\pm5.6E\text{-}5}$	$1.3698_{\pm1.8E\text{-}5}$	$0.6389_{\pm7.1E\text{-}5}$	$0.6295_{\pm5.8E\text{-}5}$	$0.6289_{\pm3.6E\text{-}5}$	$0.6264_{\pm4.7E\text{-}5}$
	TGLFA	$\mathbf{1.2613_{\pm8.1E\text{-}4}}$	$\mathbf{1.1986_{\pm1.0E\text{-}3}}$	$\mathbf{1.1566_{\pm8.3E\text{-}4}}$	$\mathbf{1.1223_{\pm1.3E\text{-}3}}$	$\mathbf{0.5266_{\pm4.5E\text{-}4}}$	$\mathbf{0.4650_{\pm7.3E\text{-}4}}$	$\mathbf{0.4352_{\pm5.3E\text{-}4}}$	$\mathbf{0.4176_{\pm7.0E\text{-}4}}$
MAE	TGLFA-Single-A	$0.5041_{\pm1.1E\text{-}3}$	$0.4647_{\pm3.2E\text{-}4}$	$0.4512_{\pm8.2E\text{-}4}$	$0.4217_{\pm4.8E\text{-}4}$	$0.2292_{\pm2.4E\text{-}2}$	$0.1637_{\pm3.3E\text{-}4}$	$0.1555_{\pm9.1E\text{-}4}$	$0.1482_{\pm2.0E\text{-}3}$
	TGLFA-Single-H	$0.6689_{\pm2.0E\text{-}3}$	$0.6509_{\pm2.9E\text{-}3}$	$0.6521_{\pm2.5E\text{-}3}$	$0.6470_{\pm1.0E\text{-}3}$	$0.2887_{\pm2.8E\text{-}3}$	$0.2830_{\pm2.3E\text{-}3}$	$0.2826_{\pm7.6E\text{-}4}$	$0.2824_{\pm3.9E\text{-}4}$
	TGLFA	$\mathbf{0.4992_{\pm1.3E\text{-}3}}$	$\mathbf{0.4581_{\pm1.5E\text{-}3}}$	$\mathbf{0.4378_{\pm1.4E\text{-}3}}$	$\mathbf{0.4214_{\pm1.6E\text{-}3}}$	$\mathbf{0.1879_{\pm6.0E\text{-}4}}$	$\mathbf{0.1636_{\pm4.6E\text{-}4}}$	$\mathbf{0.1510_{\pm4.1E\text{-}4}}$	$\mathbf{0.1441_{\pm5.2E\text{-}4}}$

Single indicates that a specified module only outputs the node features in the last layer; A denotes the attribute characteristics extraction module (Module (a)); and H denotes the high-order connectivity information extraction module (Module (b)).

TABLE S4
SUGGESTED HYPER PARAMETER SETTINGS OF TGLFA.

Learning Rate	L_2 Regularization Coefficient	Batch Size	K	L	ω	F
5e-3	0.1	512	3	12	0.2	128

TABLE S5
THE RMSE, WIN/LOSS COUNTS, AND FRIEDMAN TEST RESULTS OF M1-15 ON ALL TESTING CASES.

No.	D1.1	D1.2	D1.3	D1.4	D2.1	D2.2	D2.3	D2.4	Win/Loss	F-Rank*
M1	$1.6989_{\pm2.6\text{E-}3}$	$1.4632_{\pm6.5\text{E-}3}$	$1.3069_{\pm1.1\text{E-}2}$	$1.2077_{\pm2.2\text{E-}3}$	$0.6365_{\pm1.3\text{E-}3}$	$0.5238_{\pm1.4\text{E-}3}$	$0.4743_{\pm1.5\text{E-}4}$	$0.4531_{\pm2.4\text{E-}4}$	8/0	8.38
M2	$1.4527_{\pm7.6\text{E-}4}$	$1.2945_{\pm2.7\text{E-}3}$	$1.2294_{\pm4.5\text{E-}4}$	$1.1943_{\pm2.6\text{E-}3}$	$0.6985_{\pm1.1\text{E-}3}$	$0.5413_{\pm2.6\text{E-}3}$	$0.4884_{\pm5.7\text{E-}4}$	$0.4698_{\pm8.2\text{E-}4}$	8/0	7.38
M3	$1.7249_{\pm5.9\text{E-}3}$	$1.6751_{\pm4.0\text{E-}3}$	$1.6428_{\pm3.9\text{E-}3}$	$1.6127_{\pm3.8\text{E-}3}$	$0.8324_{\pm2.1\text{E-}3}$	$0.7844_{\pm1.1\text{E-}3}$	$0.7532_{\pm1.6\text{E-}3}$	$0.7273_{\pm3.8\text{E-}3}$	8/0	13.63
M4	$1.2922_{\pm2.5\text{E-}3}$	$1.2176_{\pm1.3\text{E-}3}$	$1.1712_{\pm5.1\text{E-}3}$	$1.1314_{\pm1.4\text{E-}3}$	$0.5364_{\pm1.9\text{E-}3}$	$0.4879_{\pm1.2\text{E-}3}$	$0.4449_{\pm1.6\text{E-}3}$	$0.4219_{\pm9.7\text{E-}4}$	8/0	2.56
M5	$1.5593_{\pm5.7\text{E-}3}$	$1.2906_{\pm4.2\text{E-}3}$	$1.1952_{\pm3.0\text{E-}3}$	$1.1400_{\pm1.4\text{E-}3}$	$0.7818_{\pm5.3\text{E-}3}$	$0.5561_{\pm1.6\text{E-}2}$	$0.4773_{\pm6.6\text{E-}3}$	$0.4394_{\pm2.8\text{E-}3}$	8/0	6.75
M6	$1.2842_{\pm8.2\text{E-}3}$	$1.2146_{\pm1.7\text{E-}3}$	$1.1725_{\pm2.7\text{E-}3}$	$1.1275_{\pm1.1\text{E-}3}$	$0.5738_{\pm3.3\text{E-}3}$	$0.4850_{\pm1.2\text{E-}3}$	$0.4498_{\pm1.1\text{E-}3}$	$0.4298_{\pm5.2\text{E-}4}$	8/0	3.00
M7	$1.5513_{\pm2.2\text{E-}3}$	$1.4316_{\pm3.2\text{E-}3}$	$1.2670_{\pm2.5\text{E-}3}$	$1.1607_{\pm1.2\text{E-}3}$	$0.6686_{\pm1.6\text{E-}3}$	$0.4930_{\pm6.7\text{E-}4}$	$0.4482_{\pm5.7\text{E-}4}$	$0.4220_{\pm5.2\text{E-}4}$	8/0	6.38
M8	$1.6376_{\pm4.1\text{E-}3}$	$1.4952_{\pm3.5\text{E-}3}$	$1.4264_{\pm3.3\text{E-}3}$	$1.3505_{\pm6.6\text{E-}3}$	$0.9373_{\pm2.5\text{E-}3}$	$0.7019_{\pm3.1\text{E-}3}$	$0.5563_{\pm6.0\text{E-}3}$	$0.4900_{\pm2.8\text{E-}3}$	8/0	12.75
M9	$1.5728_{\pm6.9\text{E-}4}$	$1.4740_{\pm2.9\text{E-}3}$	$1.3619_{\pm2.8\text{E-}3}$	$1.2397_{\pm9.4\text{E-}3}$	$0.9029_{\pm3.2\text{E-}3}$	$0.6509_{\pm5.5\text{E-}3}$	$0.5283_{\pm2.3\text{E-}3}$	$0.4785_{\pm1.5\text{E-}3}$	8/0	11.00
M10	$1.8186_{\pm4.3\text{E-}4}$	$1.7981_{\pm1.4\text{E-}3}$	$1.7871_{\pm1.9\text{E-}3}$	$1.7712_{\pm2.5\text{E-}3}$	$1.0096_{\pm2.2\text{E-}4}$	$0.9880_{\pm1.9\text{E-}4}$	$0.9680_{\pm2.3\text{E-}3}$	$0.9467_{\pm6.6\text{E-}3}$	8/0	15.00
M11	$1.4873_{\pm6.8\text{E-}3}$	$1.3014_{\pm4.7\text{E-}3}$	$1.2179_{\pm2.6\text{E-}3}$	$1.1601_{\pm1.4\text{E-}3}$	$0.6718_{\pm1.6\text{E-}3}$	$0.5210_{\pm2.6\text{E-}3}$	$0.4684_{\pm9.9\text{E-}4}$	$0.4438_{\pm6.9\text{E-}4}$	8/0	6.13
M12	$1.5495_{\pm9.5\text{E-}5}$	$1.4286_{\pm2.0\text{E-}3}$	$1.2643_{\pm2.3\text{E-}3}$	$1.1610_{\pm8.3\text{E-}4}$	$0.6634_{\pm2.0\text{E-}3}$	$0.4913_{\pm4.5\text{E-}4}$	$0.4476_{\pm3.6\text{E-}4}$	$0.4219_{\pm3.6\text{E-}4}$	8/0	5.56
M13	$1.5975_{\pm1.1\text{E-}3}$	$1.4939_{\pm7.2\text{E-}4}$	$1.4182_{\pm2.7\text{E-}3}$	$1.3296_{\pm1.2\text{E-}3}$	$0.8938_{\pm2.5\text{E-}3}$	$0.6308_{\pm1.7\text{E-}3}$	$0.5268_{\pm9.9\text{E-}4}$	$0.4892_{\pm1.1\text{E-}3}$	8/0	11.25
M14	$1.4224_{\pm1.8\text{E-}3}$	$1.3744_{\pm8.6\text{E-}3}$	$1.3447_{\pm3.6\text{E-}3}$	$1.3289_{\pm3.2\text{E-}3}$	$0.6535_{\pm4.3\text{E-}3}$	$0.6453_{\pm2.3\text{E-}4}$	$0.6430_{\pm3.1\text{E-}4}$	$0.6409_{\pm3.4\text{E-}4}$	8/0	9.25
M15	$\mathbf{1.2535_{\pm9.0\text{E-}4}}$	$\mathbf{1.1869_{\pm1.1\text{E-}3}}$	$\mathbf{1.1462_{\pm5.7\text{E-}4}}$	$\mathbf{1.1158_{\pm9.0\text{E-}4}}$	$\mathbf{0.5250_{\pm7.9\text{E-}4}}$	$\mathbf{0.4661_{\pm8.2\text{E-}4}}$	$\mathbf{0.4348_{\pm8.4\text{E-}4}}$	$\mathbf{0.4170_{\pm5.8\text{E-}4}}$	—	**1.00**

High F-rank denotes low RMSE.

TABLE S6
THE MAE, WIN/LOSS COUNTS, AND FRIEDMAN TEST RESULTS OF M1-15 ON ALL TESTING CASES.

No.	D1.1	D1.2	D1.3	D1.4	D2.1	D2.2	D2.3	D2.4	Win/Loss	F-Rank*
M1	$0.7037_{\pm6.9\text{E-}4}$	$0.5815_{\pm2.6\text{E-}3}$	$0.5186_{\pm3.9\text{E-}3}$	$0.4805_{\pm9.5\text{E-}4}$	$0.2324_{\pm7.0\text{E-}4}$	$0.1932_{\pm6.4\text{E-}4}$	$0.1755_{\pm9.9\text{E-}5}$	$0.1675_{\pm1.5\text{E-}3}$	8/0	8.00
M2	$0.5606_{\pm7.5\text{E-}4}$	$0.4852_{\pm3.8\text{E-}4}$	$0.4621_{\pm5.2\text{E-}4}$	$0.4468_{\pm6.0\text{E-}4}$	$0.2891_{\pm4.6\text{E-}4}$	$0.1947_{\pm1.0\text{E-}3}$	$0.1775_{\pm8.0\text{E-}4}$	$0.1700_{\pm6.0\text{E-}4}$	8/0	6.13
M3	$0.8066_{\pm6.4\text{E-}4}$	$0.7777_{\pm5.0\text{E-}3}$	$0.7688_{\pm6.4\text{E-}3}$	$0.6991_{\pm1.7\text{E-}2}$	$0.3818_{\pm4.8\text{E-}3}$	$0.3550_{\pm3.2\text{E-}3}$	$0.3350_{\pm2.6\text{E-}3}$	$0.3249_{\pm2.1\text{E-}3}$	8/0	14.25
M4	$0.5067_{\pm2.4\text{E-}3}$	$0.4635_{\pm3.1\text{E-}3}$	$0.4456_{\pm1.5\text{E-}3}$	$0.4289_{\pm1.4\text{E-}3}$	$0.1993_{\pm7.8\text{E-}4}$	$0.1761_{\pm1.1\text{E-}3}$	$0.1596_{\pm5.1\text{E-}4}$	$0.1509_{\pm2.5\text{E-}4}$	8/0	2.69
M5	$0.6081_{\pm5.2\text{E-}3}$	$0.5116_{\pm2.4\text{E-}3}$	$0.4724_{\pm2.9\text{E-}3}$	$0.4474_{\pm3.2\text{E-}3}$	$0.2830_{\pm1.5\text{E-}3}$	$0.2157_{\pm7.5\text{E-}3}$	$0.1891_{\pm9.3\text{E-}4}$	$0.1767_{\pm7.3\text{E-}4}$	8/0	7.38
M6	$0.5687_{\pm6.7\text{E-}3}$	$0.5112_{\pm2.3\text{E-}3}$	$0.4850_{\pm1.3\text{E-}3}$	$0.4607_{\pm2.6\text{E-}3}$	$0.2357_{\pm1.5\text{E-}3}$	$0.1878_{\pm1.0\text{E-}3}$	$0.1700_{\pm1.1\text{E-}3}$	$0.1618_{\pm9.1\text{E-}4}$	8/0	5.38
M7	$0.6423_{\pm4.9\text{E-}4}$	$0.5620_{\pm1.9\text{E-}3}$	$0.4892_{\pm6.3\text{E-}4}$	$0.4458_{\pm3.9\text{E-}4}$	$0.2375_{\pm1.0\text{E-}3}$	$0.1747_{\pm2.4\text{E-}4}$	$0.1589_{\pm2.9\text{E-}4}$	$0.1485_{\pm4.6\text{E-}4}$	8/0	4.69
M8	$0.6992_{\pm3.3\text{E-}3}$	$0.6273_{\pm3.0\text{E-}3}$	$0.5990_{\pm1.9\text{E-}3}$	$0.5522_{\pm2.6\text{E-}3}$	$0.3872_{\pm1.4\text{E-}3}$	$0.2725_{\pm1.3\text{E-}3}$	$0.2080_{\pm1.5\text{E-}3}$	$0.1819_{\pm4.3\text{E-}4}$	8/0	12.38
M9	$0.6634_{\pm1.6\text{E-}3}$	$0.6064_{\pm1.6\text{E-}3}$	$0.5488_{\pm1.5\text{E-}3}$	$0.4930_{\pm7.3\text{E-}3}$	$0.3469_{\pm1.4\text{E-}3}$	$0.2380_{\pm1.9\text{E-}3}$	$0.1940_{\pm6.6\text{E-}4}$	$0.1769_{\pm5.1\text{E-}4}$	8/0	10.25
M10	$0.7539_{\pm5.7\text{E-}5}$	$0.7532_{\pm7.5\text{E-}5}$	$0.7530_{\pm8.2\text{E-}5}$	$0.7530_{\pm1.1\text{E-}4}$	$0.4164_{\pm6.3\text{E-}5}$	$0.4162_{\pm9.2\text{E-}5}$	$0.4162_{\pm3.4\text{E-}5}$	$0.4160_{\pm3.4\text{E-}5}$	8/0	14.63
M11	$0.5674_{\pm5.9\text{E-}3}$	$0.4967_{\pm2.0\text{E-}3}$	$0.4712_{\pm9.6\text{E-}4}$	$0.4467_{\pm1.6\text{E-}3}$	$0.2555_{\pm1.2\text{E-}3}$	$0.1899_{\pm1.5\text{E-}3}$	$0.1714_{\pm8.1\text{E-}4}$	$0.1635_{\pm5.4\text{E-}4}$	8/0	5.25
M12	$0.6417_{\pm8.5\text{E-}4}$	$0.5654_{\pm1.8\text{E-}3}$	$0.4909_{\pm7.7\text{E-}4}$	$0.4464_{\pm9.1\text{E-}4}$	$0.2372_{\pm8.9\text{E-}4}$	$0.1747_{\pm1.5\text{E-}4}$	$0.1596_{\pm1.8\text{E-}4}$	$0.1495_{\pm2.0\text{E-}4}$	8/0	5.13
M13	$0.6862_{\pm1.2\text{E-}3}$	$0.6360_{\pm1.0\text{E-}3}$	$0.5988_{\pm2.1\text{E-}3}$	$0.5491_{\pm2.2\text{E-}3}$	$0.3628_{\pm1.8\text{E-}4}$	$0.2394_{\pm5.6\text{E-}4}$	$0.1990_{\pm3.6\text{E-}4}$	$0.1847_{\pm3.5\text{E-}4}$	8/0	11.75
M14	$0.6474_{\pm3.4\text{E-}4}$	$0.5968_{\pm1.7\text{E-}2}$	$0.5627_{\pm8.5\text{E-}4}$	$0.5485_{\pm1.4\text{E-}3}$	$0.2868_{\pm6.6\text{E-}4}$	$0.2816_{\pm4.1\text{E-}4}$	$0.2787_{\pm1.1\text{E-}3}$	$0.2781_{\pm1.6\text{E-}4}$	8/0	11.13
M15	$\mathbf{0.4948_{\pm4.2\text{E-}4}}$	$\mathbf{0.4551_{\pm1.2\text{E-}3}}$	$\mathbf{0.4334_{\pm1.7\text{E-}3}}$	$\mathbf{0.4199_{\pm2.0\text{E-}3}}$	$\mathbf{0.1873_{\pm5.1\text{E-}4}}$	$\mathbf{0.1628_{\pm4.0\text{E-}4}}$	$\mathbf{0.1500_{\pm5.3\text{E-}4}}$	$\mathbf{0.1436_{\pm2.8\text{E-}4}}$	—	**1.00**

High F-rank denotes low MAE.

TABLE S7
THE TRAINING TIME COST IN RMSE (SEC.), WIN/LOSS COUNTS, AND FRIEDMAN TEST RESULTS OF M1-15 ON ALL TESTING CASES.

No.	D1.1	D1.2	D1.3	D1.4	D2.1	D2.2	D2.3	D2.4	Win/Loss	F-Rank*
M1	$11954_{\pm4092.98}$	$12107_{\pm4769.09}$	$11156_{\pm5460.32}$	$8583_{\pm2421.37}$	$17267_{\pm2272.97}$	$13982_{\pm2368.04}$	$8882_{\pm2224.26}$	$5175_{\pm1532.91}$	8/0	10.38
M2	$235_{\pm7.12}$	$325_{\pm17.97}$	$299_{\pm17.51}$	$327_{\pm22.12}$	$\mathbf{184_{\pm7.78}}$	$433_{\pm18.45}$	$\mathbf{368_{\pm22.09}}$	$\mathbf{379_{\pm26.10}}$	5/3	1.63
M3	$1070_{\pm24.43}$	$1002_{\pm116.82}$	$1032_{\pm21.07}$	$1246_{\pm19.00}$	$1336_{\pm98.60}$	$1615_{\pm122.60}$	$1624_{\pm125.01}$	$1834_{\pm220.93}$	8/0	3.25
M4	$881_{\pm87.55}$	$1015_{\pm53.73}$	$2194_{\pm121.24}$	$2419_{\pm251.35}$	$14625_{\pm2342.49}$	$2647_{\pm314.09}$	$3643_{\pm833.96}$	$4446_{\pm763.50}$	8/0	6.25
M5	$2416_{\pm115.26}$	$2402_{\pm55.87}$	$2591_{\pm90.47}$	$2823_{\pm80.26}$	$2462_{\pm36.55}$	$2252_{\pm55.95}$	$2499_{\pm168.56}$	$2743_{\pm72.51}$	8/0	6.50
M6	$1537_{\pm52.96}$	$1833_{\pm93.52}$	$2277_{\pm129.40}$	$2650_{\pm95.35}$	$2328_{\pm767.43}$	$1748_{\pm50.33}$	$1853_{\pm118.35}$	$2171_{\pm107.51}$	8/0	5.00
M7	$3242_{\pm136.54}$	$9331_{\pm193.59}$	$12299_{\pm234.04}$	$14211_{\pm302.65}$	$4964_{\pm106.70}$	$8086_{\pm144.00}$	$10019_{\pm283.43}$	$11812_{\pm156.58}$	8/0	8.88
M8	$5122_{\pm448.81}$	$11377_{\pm662.84}$	$17593_{\pm316.03}$	$24323_{\pm1609.49}$	$3382_{\pm375.85}$	$9568_{\pm730.37}$	$17055_{\pm1170.95}$	$23215_{\pm2260.42}$	8/0	10.75
M9	$5679_{\pm178.29}$	$11356_{\pm658.53}$	$18836_{\pm888.19}$	$24886_{\pm193.27}$	$3823_{\pm153.40}$	$7954_{\pm216.53}$	$10724_{\pm386.23}$	$12689_{\pm434.26}$	8/0	10.38
M10	$2151_{\pm403.94}$	$1977_{\pm260.81}$	$1327_{\pm219.04}$	$1288_{\pm141.65}$	$1682_{\pm492.23}$	$1381_{\pm488.28}$	$2085_{\pm655.38}$	$2306_{\pm1044.22}$	8/0	4.63
M11	$36992_{\pm1391.36}$	$33108_{\pm1317.36}$	$35478_{\pm702.79}$	$37621_{\pm760.63}$	$21164_{\pm492.46}$	$26404_{\pm409.56}$	$25938_{\pm766.47}$	$29208_{\pm644.28}$	8/0	14.38
M12	$3272_{\pm204.54}$	$9714_{\pm83.95}$	$12415_{\pm121.75}$	$14405_{\pm119.67}$	$5249_{\pm103.26}$	$8445_{\pm155.70}$	$10353_{\pm149.50}$	$12006_{\pm276.26}$	8/0	9.88
M13	$6611_{\pm483.08}$	$12931_{\pm310.82}$	$20614_{\pm541.37}$	$28265_{\pm511.37}$	$4572_{\pm162.75}$	$13219_{\pm585.96}$	$19211_{\pm436.56}$	$22050_{\pm828.51}$	8/0	12.13
M14	$22562_{\pm3206.86}$	$29119_{\pm4938.11}$	$33585_{\pm6431.56}$	$42091_{\pm11482.16}$	$22139_{\pm3590.56}$	$28474_{\pm3703.66}$	$36034_{\pm1900.76}$	$40132_{\pm6234.69}$	8/0	14.63
M15	$\mathbf{109_{\pm13.87}}$	$\mathbf{253_{\pm48.28}}$	$\mathbf{266_{\pm17.92}}$	$\mathbf{297_{\pm11.55}}$	$441_{\pm74.81}$	$\mathbf{411_{\pm31.99}}$	$445_{\pm42.42}$	$447_{\pm30.80}$	—	**1.38**

High F-rank denotes low time cost to converge in RMSE.

TABLE S8
THE TRAINING TIME COST IN MAE (SEC.), WIN/LOSS COUNTS, AND FRIEDMAN TEST RESULTS OF M1-15 ON ALL TESTING CASES.

No.	D1.1	D1.2	D1.3	D1.4	D2.1	D2.2	D2.3	D2.4	Win/Loss	F-Rank*
M1	$10556_{\pm4357.46}$	$12148_{\pm4143.32}$	$10872_{\pm5402.71}$	$8185_{\pm1562.90}$	$17170_{\pm2273.43}$	$14120_{\pm2646.15}$	$8130_{\pm2213.19}$	$4619_{\pm1212.11}$	8/0	9.75
M2	$293_{\pm33.87}$	$356_{\pm30.67}$	$351_{\pm11.37}$	$356_{\pm28.45}$	$257_{\pm21.59}$	$492_{\pm27.73}$	$434_{\pm40.41}$	$441_{\pm44.99}$	7/1	1.88
M3	$1180_{\pm229.11}$	$1058_{\pm306.69}$	$1224_{\pm97.29}$	$23764_{\pm11859.43}$	$2054_{\pm219.49}$	$1868_{\pm112.63}$	$1920_{\pm181.61}$	$2125_{\pm311.95}$	8/0	4.75
M4	$990_{\pm111.53}$	$1290_{\pm275.14}$	$2338_{\pm185.49}$	$3311_{\pm974.27}$	$14513_{\pm2480.57}$	$3243_{\pm660.04}$	$5220_{\pm1312.60}$	$5666_{\pm699.69}$	8/0	6.75
M5	$1949_{\pm98.10}$	$1928_{\pm47.91}$	$2014_{\pm110.80}$	$2084_{\pm83.22}$	$2463_{\pm39.64}$	$2124_{\pm49.26}$	$2206_{\pm80.28}$	$2423_{\pm73.80}$	8/0	5.50
M6	$1680_{\pm168.65}$	$1832_{\pm113.62}$	$2055_{\pm111.77}$	$2219_{\pm200.02}$	$2342_{\pm829.11}$	$1701_{\pm50.05}$	$1732_{\pm172.04}$	$1642_{\pm78.67}$	8/0	4.63
M7	$8249_{\pm201.41}$	$11615_{\pm141.02}$	$12947_{\pm149.46}$	$13713_{\pm141.48}$	$6626_{\pm100.16}$	$8107_{\pm162.61}$	$9309_{\pm162.23}$	$10492_{\pm64.46}$	8/0	8.63
M8	$6830_{\pm574.10}$	$13351_{\pm1072.35}$	$20042_{\pm1105.05}$	$28866_{\pm773.37}$	$4363_{\pm173.32}$	$11372_{\pm442.11}$	$17796_{\pm617.42}$	$21347_{\pm778.06}$	8/0	10.50
M9	$8943_{\pm227.51}$	$15719_{\pm495.71}$	$21659_{\pm730.30}$	$25554_{\pm395.15}$	$5037_{\pm110.10}$	$8236_{\pm209.58}$	$9837_{\pm157.11}$	$11222_{\pm250.25}$	8/0	10.75
M10	$4813_{\pm191.31}$	$2344_{\pm89.84}$	$1426_{\pm60.30}$	$1079_{\pm18.84}$	$2475_{\pm186.80}$	$1211_{\pm58.33}$	$737_{\pm31.32}$	$556_{\pm25.01}$	8/0	4.50
M11	$39764_{\pm1490.50}$	$32747_{\pm1230.10}$	$33187_{\pm429.97}$	$34077_{\pm483.32}$	$25385_{\pm612.62}$	$24920_{\pm581.60}$	$23243_{\pm484.09}$	$24361_{\pm324.07}$	8/0	14.50
M12	$8518_{\pm182.16}$	$11926_{\pm97.50}$	$13210_{\pm107.78}$	$13968_{\pm72.74}$	$6768_{\pm150.34}$	$8223_{\pm179.02}$	$9509_{\pm138.70}$	$10772_{\pm267.13}$	8/0	9.63
M13	$9250_{\pm203.44}$	$16228_{\pm640.70}$	$24379_{\pm335.21}$	$31689_{\pm470.50}$	$7372_{\pm173.82}$	$14798_{\pm289.76}$	$19726_{\pm747.49}$	$22922_{\pm955.79}$	8/0	12.75
M14	$23004_{\pm3830.51}$	$30423_{\pm5773.42}$	$33634_{\pm6202.17}$	$31525_{\pm2403.30}$	$21042_{\pm3438.79}$	$26048_{\pm4605.46}$	$27398_{\pm5724.56}$	$36247_{\pm3486.86}$	8/0	14.38
M15	$196_{\pm33.27}$	$228_{\pm41.61}$	$221_{\pm12.83}$	$208_{\pm10.76}$	$451_{\pm63.60}$	$331_{\pm39.80}$	$343_{\pm34.54}$	$328_{\pm64.10}$	—	1.13

*High F-rank denotes low time cost to converge in MAE.

TABLE S9
WILCOXON SIGNED-RANKS TEST RESULTS IN RMSE AND MAE CORRESPONDING TO TABLES S3 AND S4.

Comparison	R+*	R−	p-value**
M15 vs M1	136	0	**2.41E-4**
M15 vs M2	136	0	**2.41E-4**
M15 vs M3	136	0	**2.41E-4**
M15 vs M4	136	0	**2.41E-4**
M15 vs M5	136	0	**2.41E-4**
M15 vs M6	136	0	**2.41E-4**
M15 vs M7	136	0	**2.41E-4**
M15 vs M8	136	0	**2.41E-4**
M15 vs M9	136	0	**2.41E-4**
M15 vs M10	136	0	**2.41E-4**
M15 vs M11	136	0	**2.41E-4**
M15 vs M12	136	0	**2.41E-4**
M15 vs M13	136	0	**2.41E-4**
M15 vs M14	136	0	**2.41E-4**

*For M15, a higher R+ value indicates a higher estimation accuracy; **With the significance level of 0.1, the accepted hypotheses are highlighted.

TABLE S10
WILCOXON SIGNED-RANKS TEST RESULTS ON CONVERGING TIME COST IN RMSE AND MAE CORRESPONDING TO TABLES S5 AND S6.

Comparison	R+*	R−	p-value**
M15 vs M1	136	0	**2.41E-4**
M15 vs M2	95	41	**8.53E-2**
M15 vs M3	136	0	**2.41E-4**
M15 vs M4	136	0	**2.41E-4**
M15 vs M5	136	0	**2.41E-4**
M15 vs M6	136	0	**2.41E-4**
M15 vs M7	136	0	**2.41E-4**
M15 vs M8	136	0	**2.41E-4**
M15 vs M9	136	0	**2.41E-4**
M15 vs M10	136	0	**2.41E-4**
M15 vs M11	136	0	**2.41E-4**
M15 vs M12	136	0	**2.41E-4**
M15 vs M13	136	0	**2.41E-4**
M15 vs M14	136	0	**2.41E-4**

*For M15, a higher R+ value indicates a higher computational efficiency; **With the significance level of 0.1, the accepted hypotheses are highlighted.
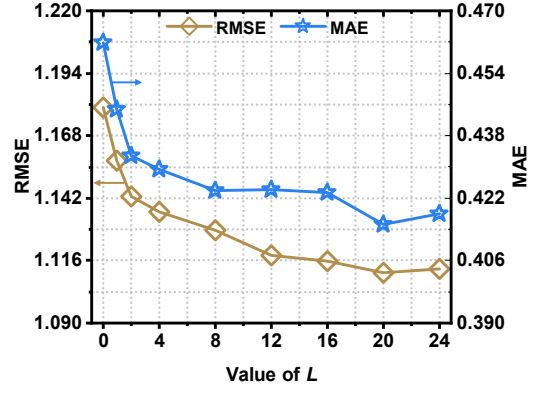
2. SUPPLEMENTARY FIGURES
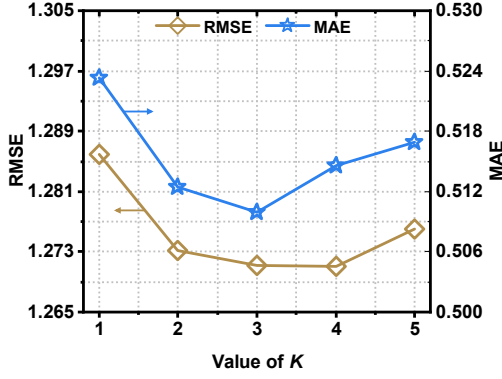
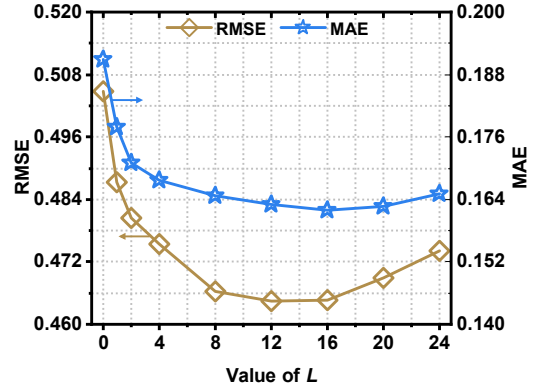

(a) Errors on D1.1
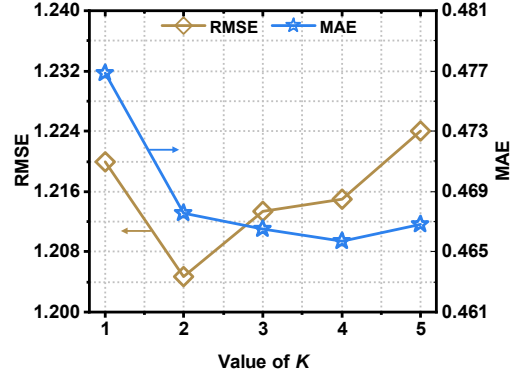
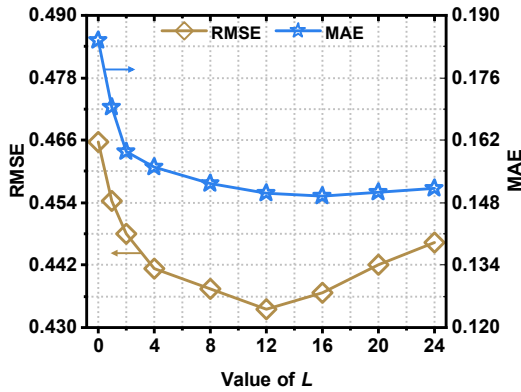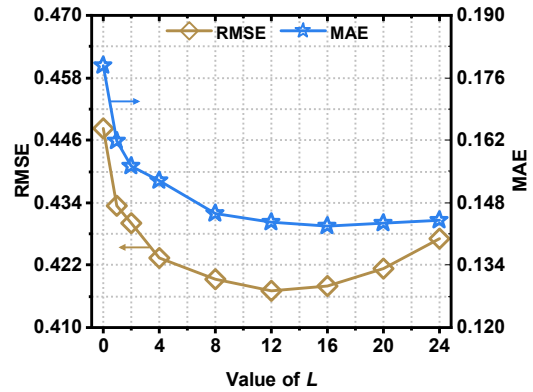(b) Errors on D1.2
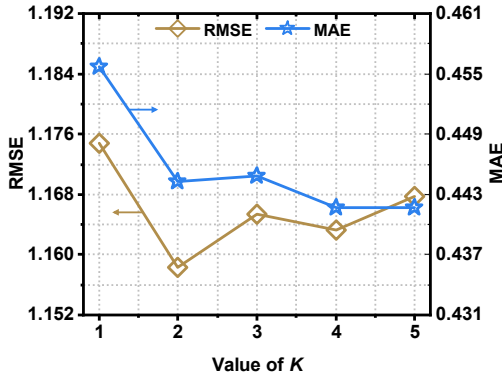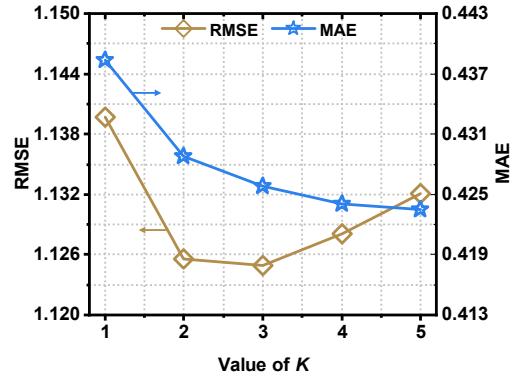
(c) Errors on D1.3
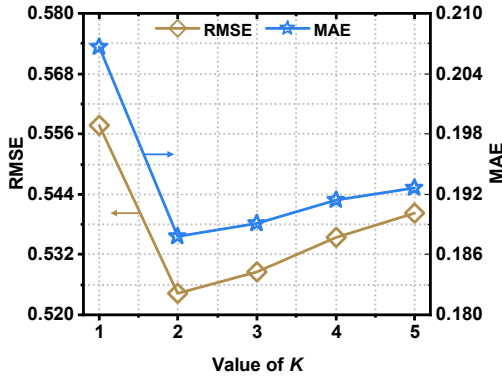
(d) Errors on D1.4
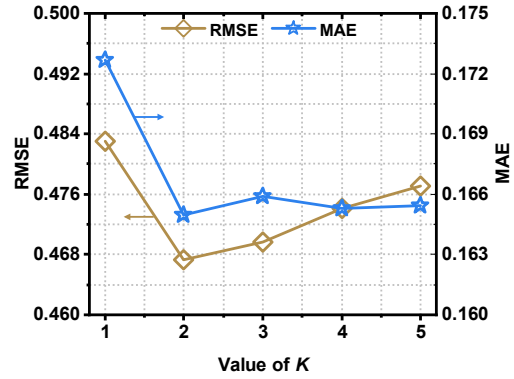
(e) Errors on D2.1
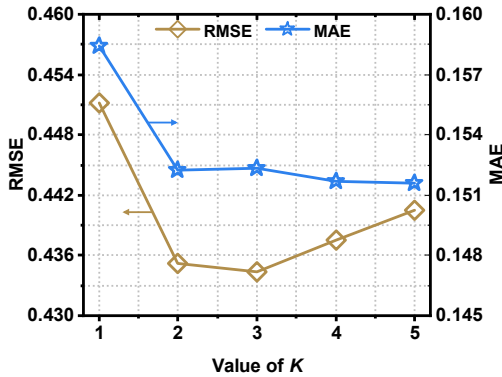
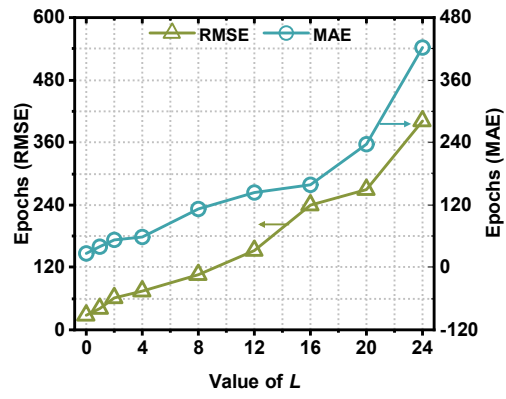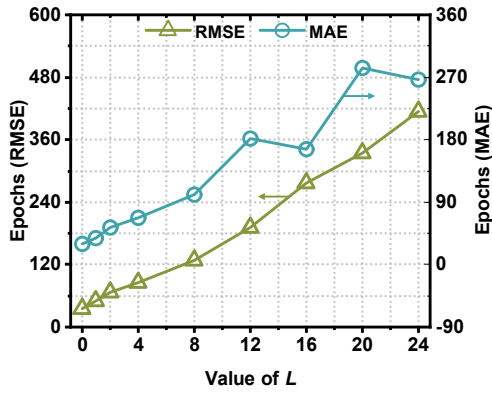(f) Errors on D2.2
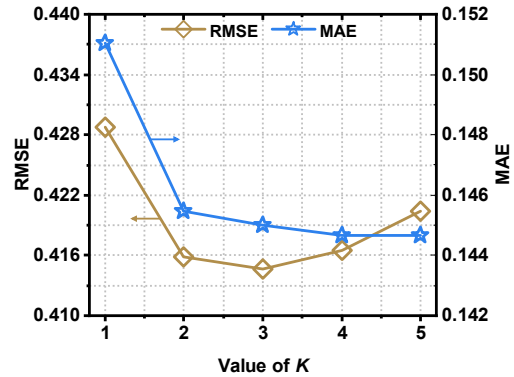
(g) Errors on D2.3

(h) Errors on D2.4

Fig. S1. Errors of TGLFA with different numbers of hidden layers in the attribute characteristics extraction module on all testing cases.
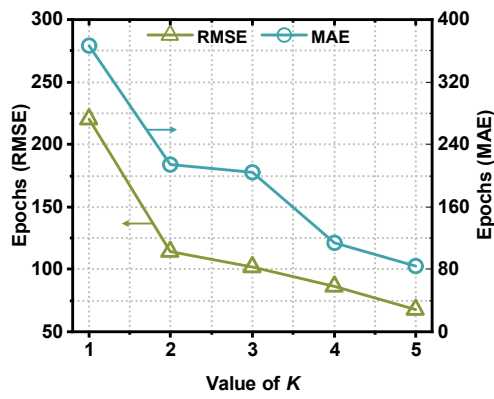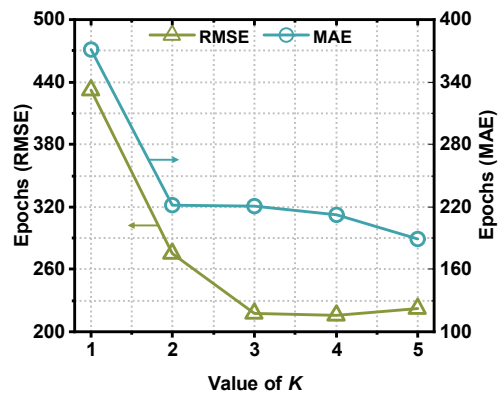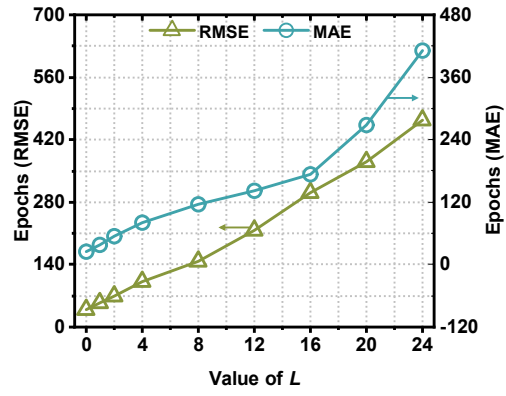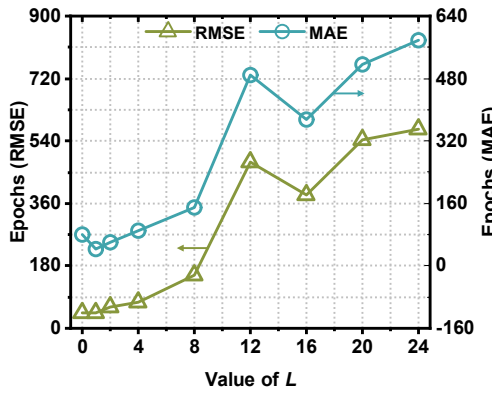
(a) Epochs on D1.1
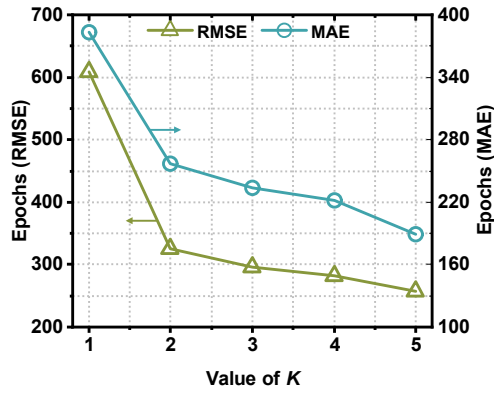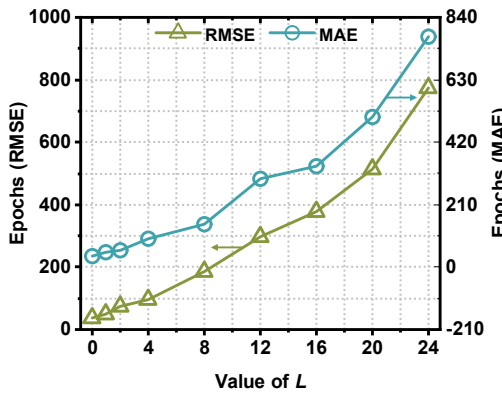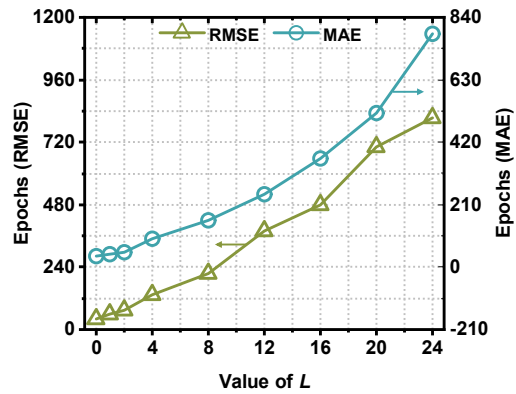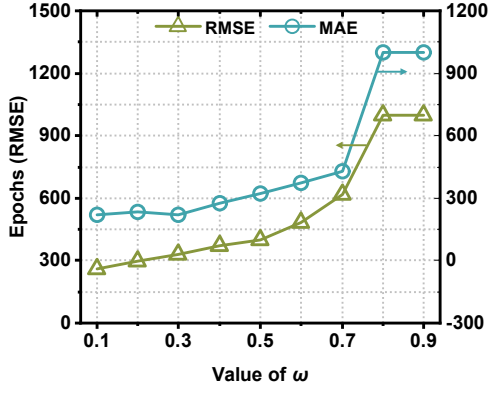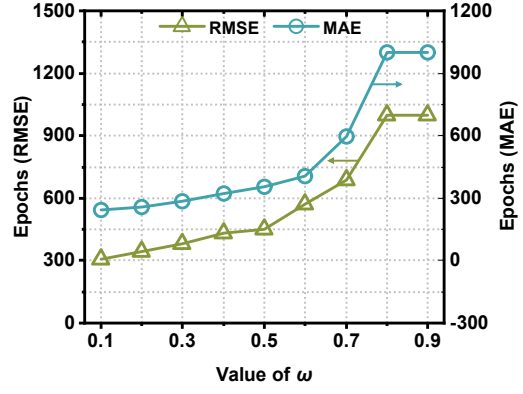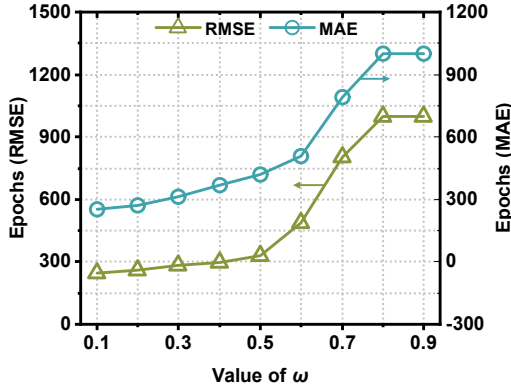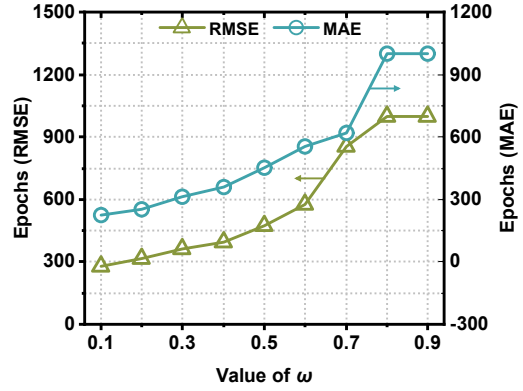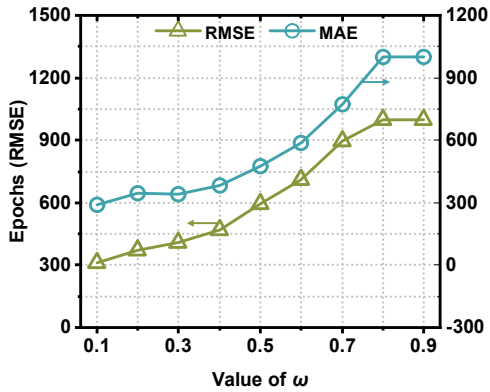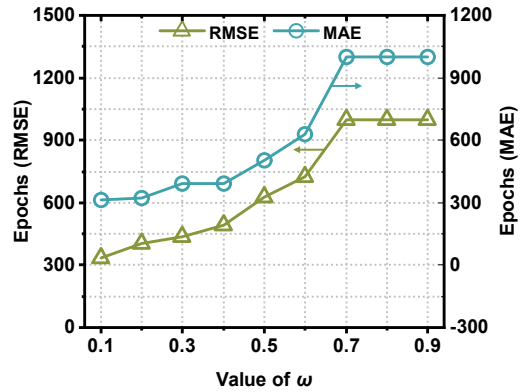
(b) Epochs on D1.2
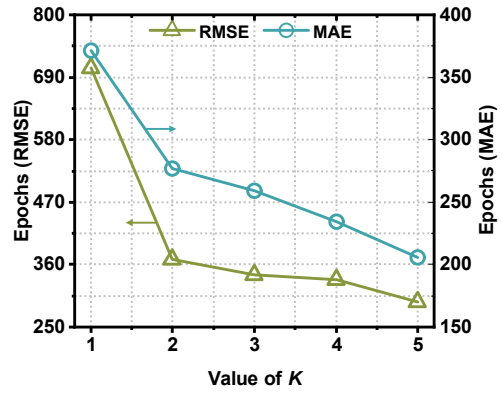
(c) Epochs on D1.3
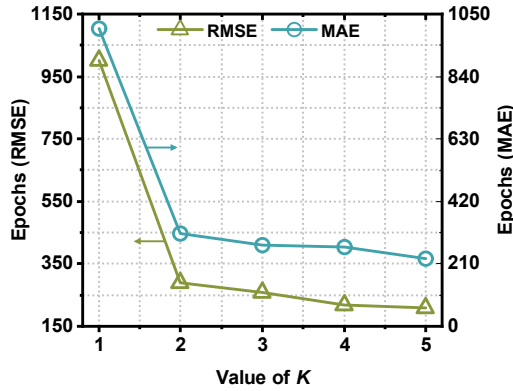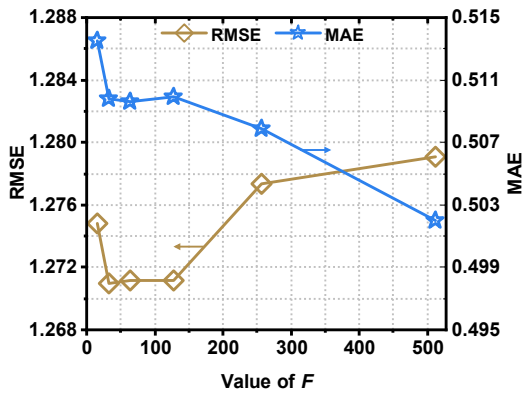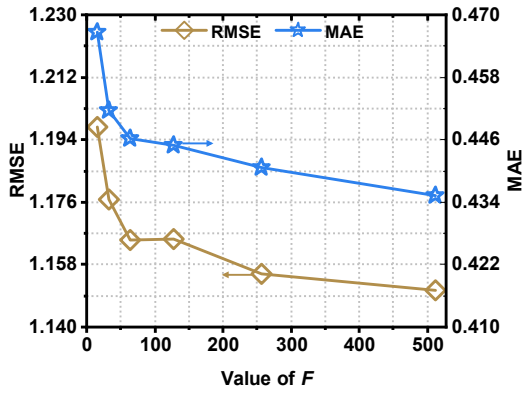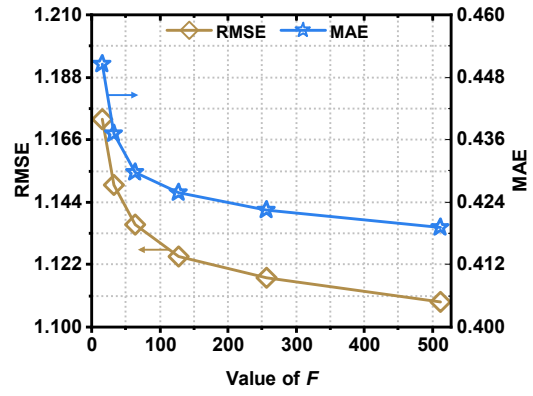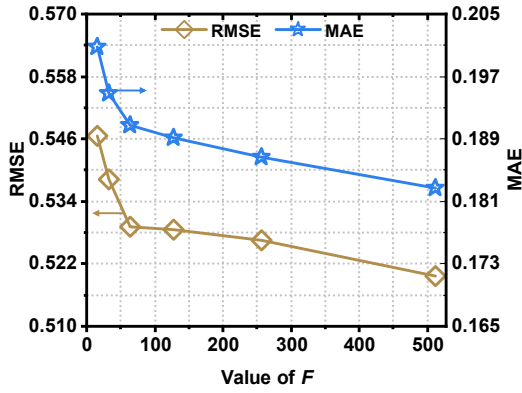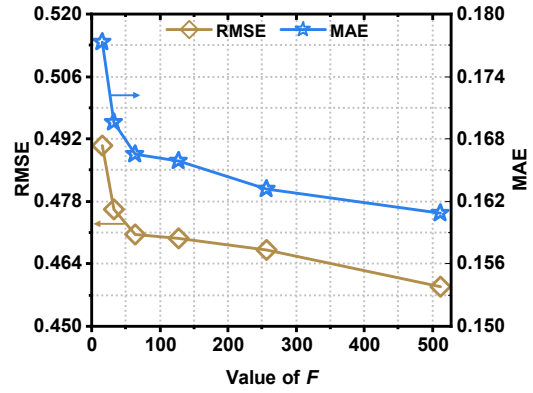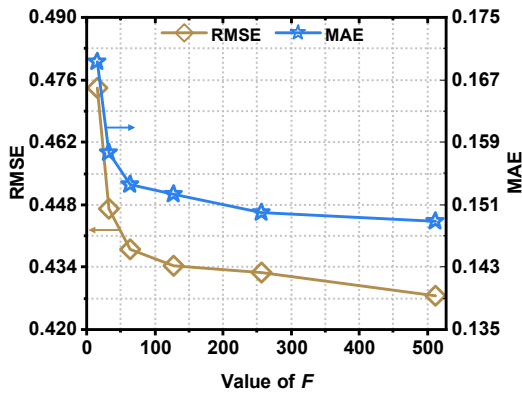
(d) Epochs on D1.4
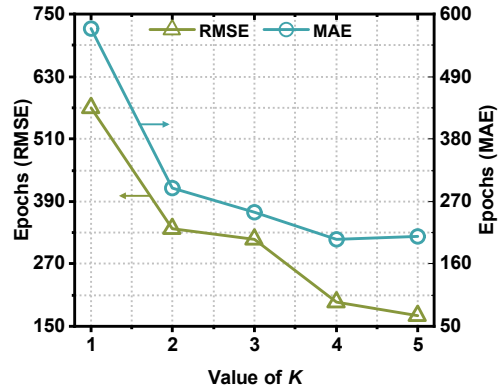
(e) Epochs on D2.1
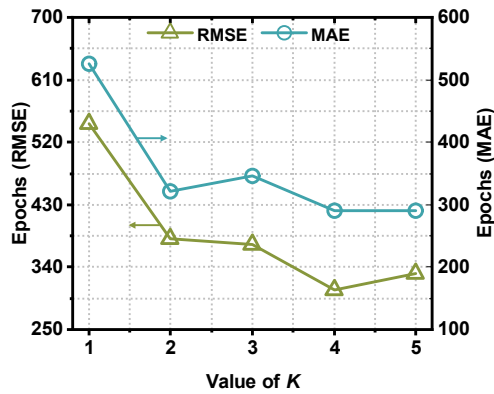
(f) Epochs on D2.2
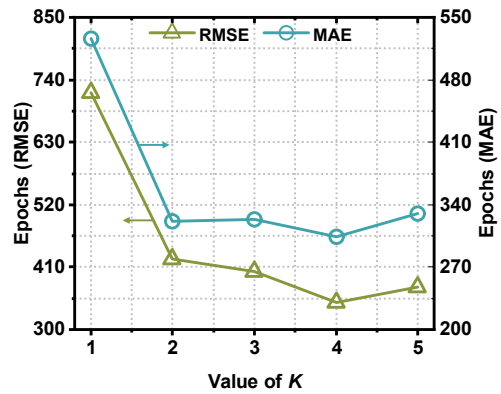
(g) Epochs on D2.3

(h) Epochs on D2.4

Fig. S2. Converging epochs of TGLFA with different numbers of hidden layers in the attribute characteristics extraction module on all testing cases.
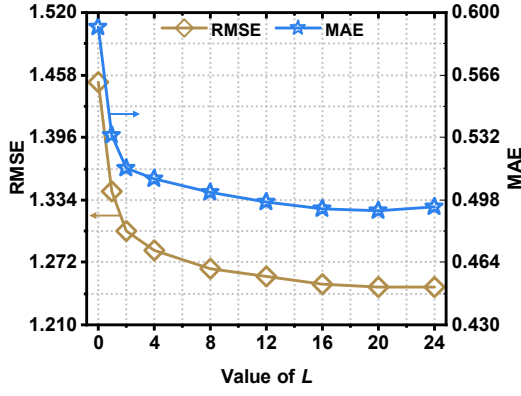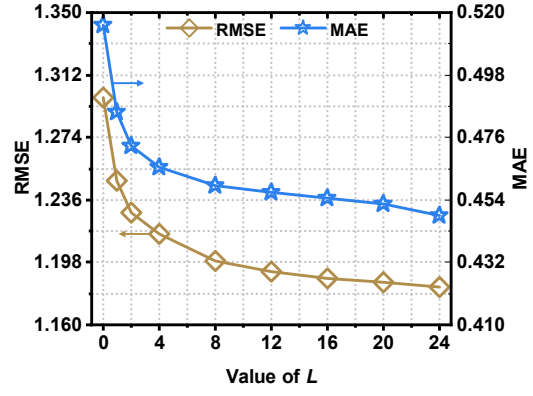
(a) Errors on D1.1
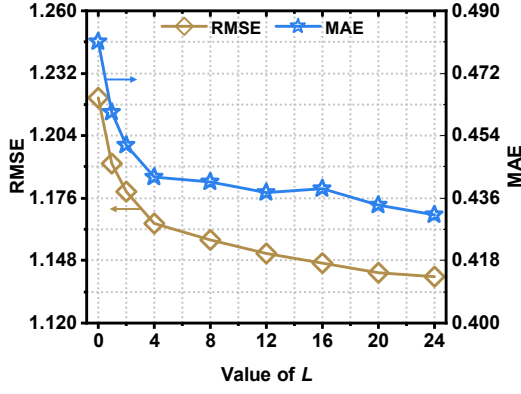
(b) Errors on D1.2

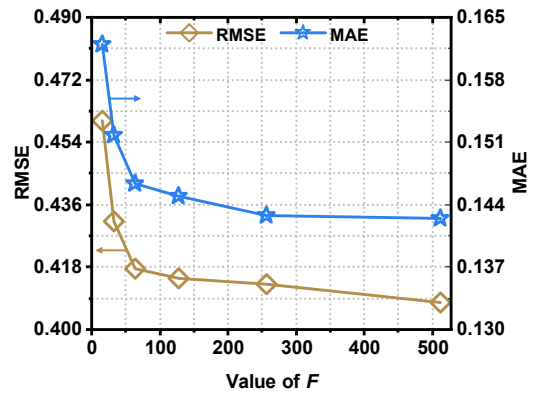(c) Errors on D1.3
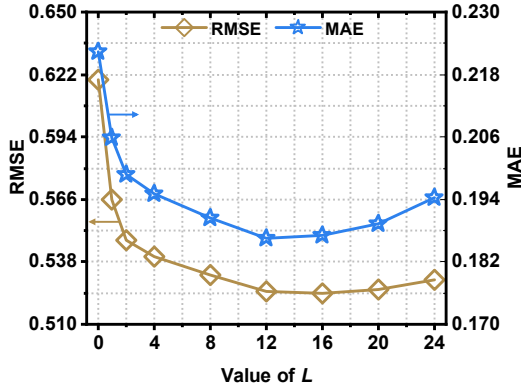
(d) Errors on D1.4

(e) Errors on D2.1

(f) Errors on D2.2

(g) Errors on D2.3

(h) Errors on D2.4

Fig. S3. Errors of TGLFA with different numbers of light graph convolutional layers on all testing cases.
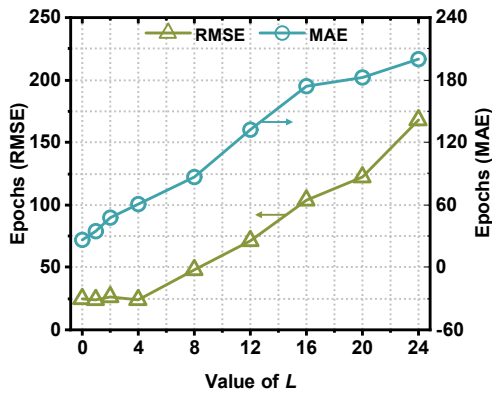
(a) Epochs on D1.1

(b) Epochs on D1.2

(c) Epochs on D1.3

(d) Epochs on D1.4
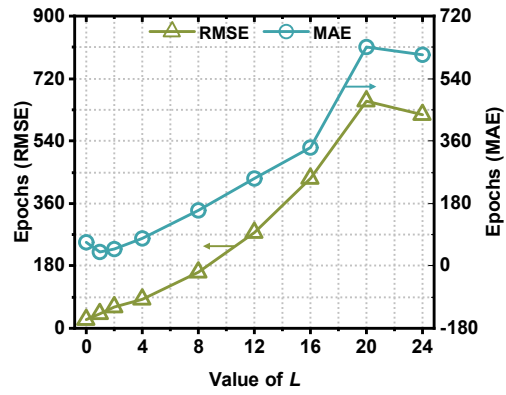
(e) Epochs on D2.1

(f) Epochs on D2.2

(g) Epochs on D2.3

(h) Epochs on D2.4

Fig. S4. Converging epochs of TGLFA with different numbers of light graph convolutional layers on all testing cases.

(a) Errors on D1.1

(b) Errors on D1.2

(c) Errors on D1.3

(d) Errors on D1.4

(e) Errors on D2.1

(f) Errors on D2.2
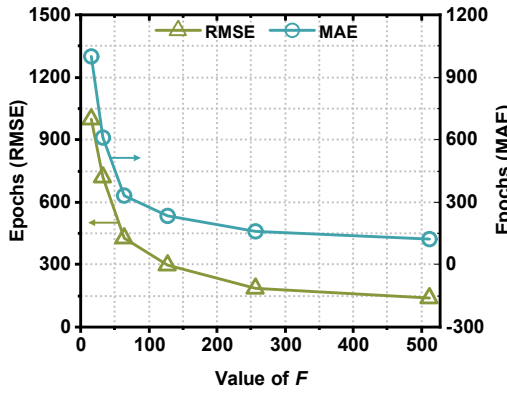
(g) Errors on D2.3
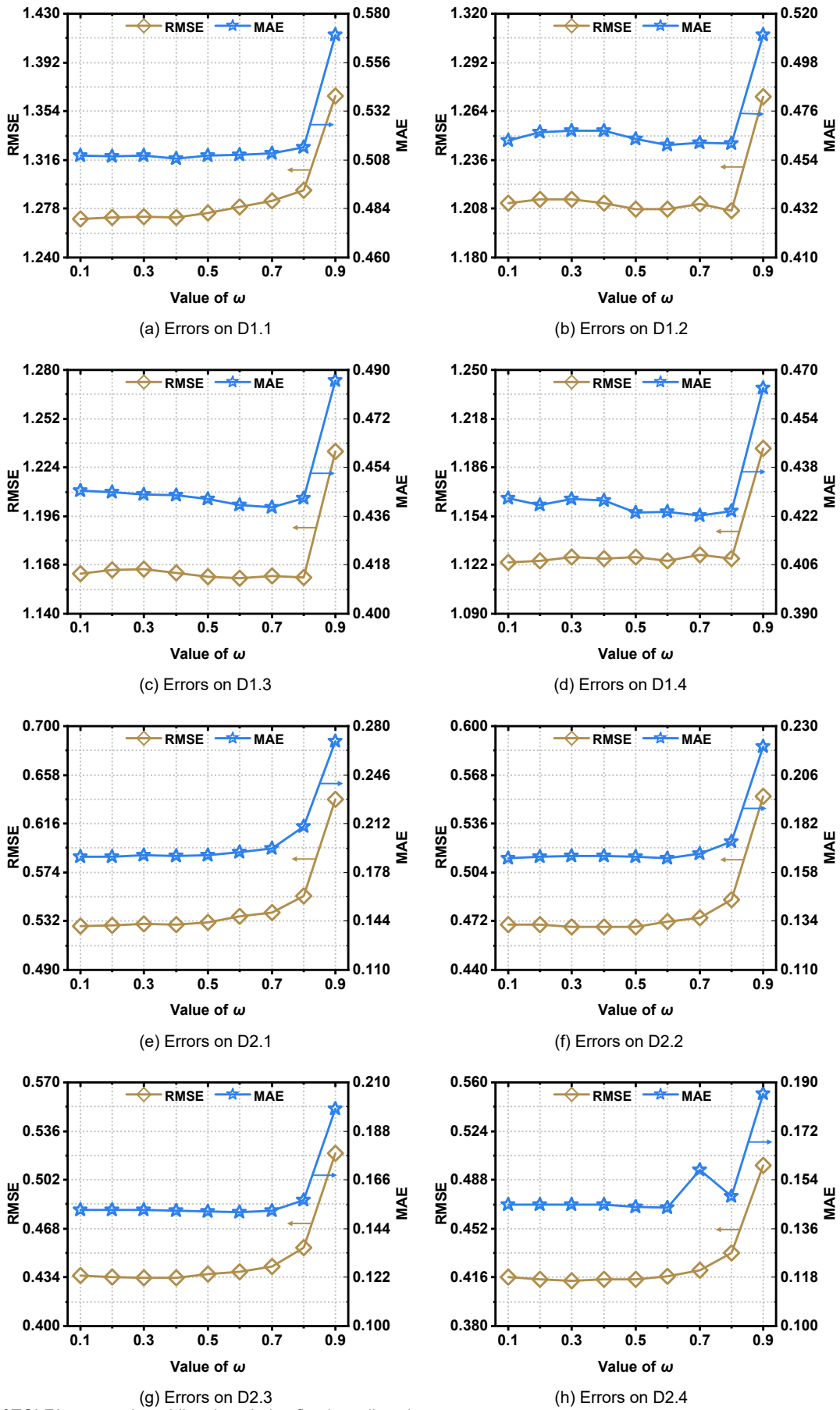
(h) Errors on D2.4

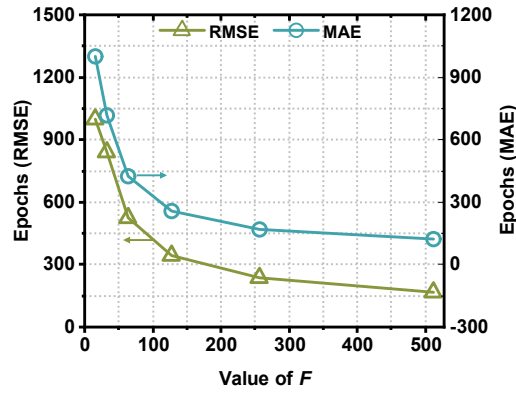Fig. S5. Errors of TGLFA as ω varies while others being fixed on all testing cases.
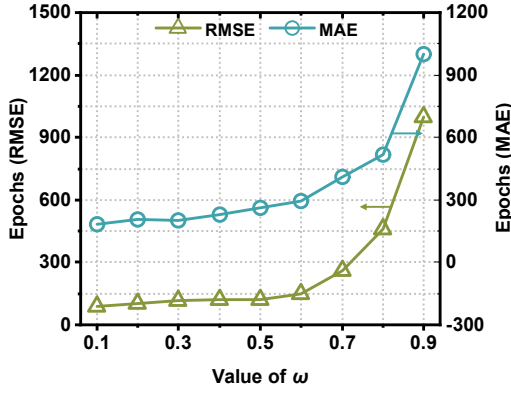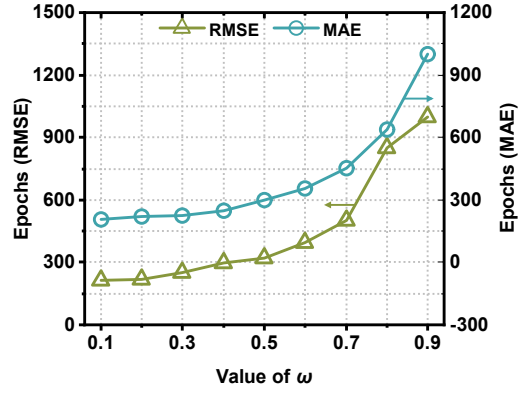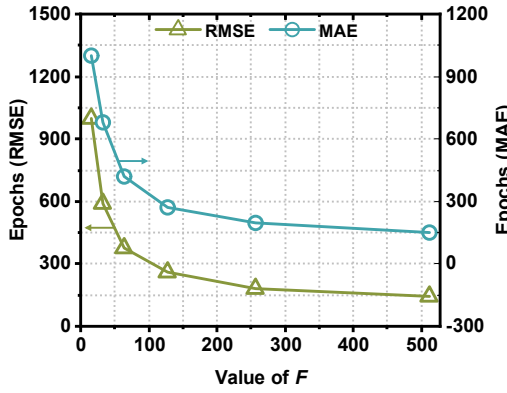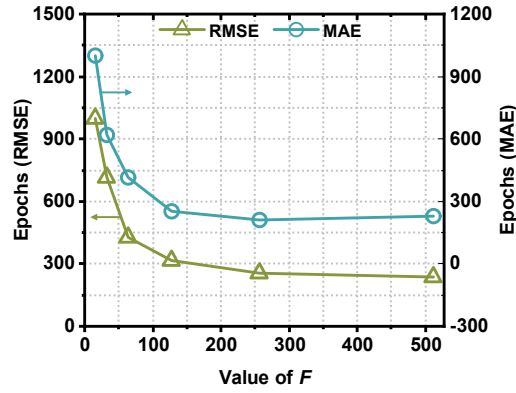
(a) Epochs on D1.1

(b) Epochs on D1.2

(c) Epochs on D1.3

(d) Epochs on D1.4

(e) Epochs on D2.1

(f) Epochs on D2.2

(g) Epochs on D2.3

(h) Epochs on D2.4

Fig. S6. Converging epochs of TGLFA as ω varies while others being fixed on all testing cases.
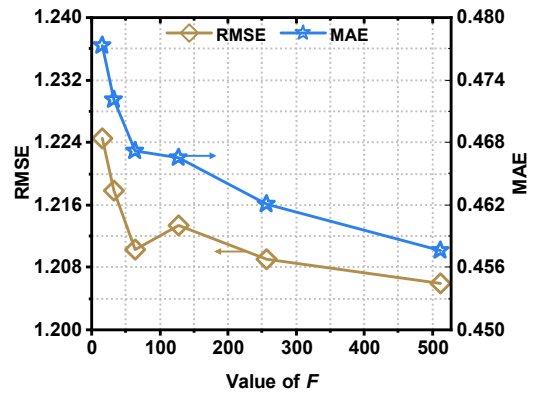
(a) Errors on D1.1

(b) Errors on D1.2

(c) Errors on D1.3

(d) Errors on D1.4

(e) Errors on D2.1

(f) Errors on D2.2

(g) Errors on D2.3

(h) Errors on D2.4

Fig. S7. Errors of TGLFA as F varies while others being fixed on all testing cases.
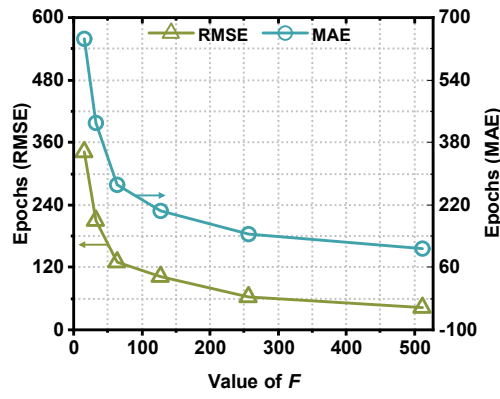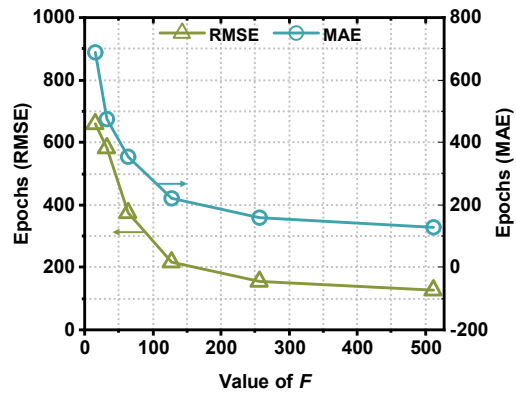
(a) Epochs on D1.1
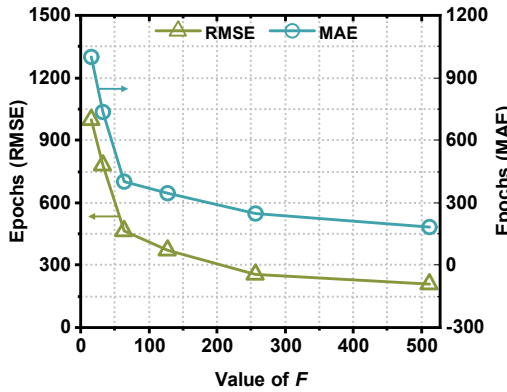
(b) Epochs on D1.2

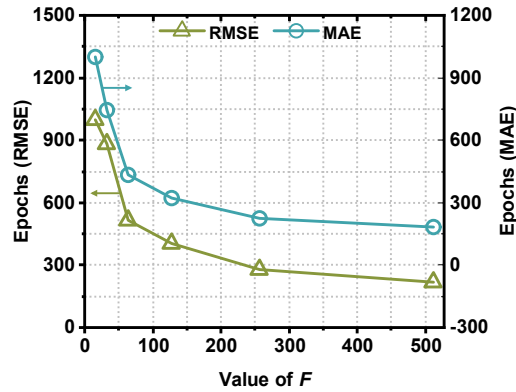(c) Epochs on D1.3

(d) Epochs on D1.4

(e) Epochs on D2.1

(f) Epochs on D2.2

(g) Epochs on D2.3

(h) Epochs on D2.4

Fig. S8. Converging epochs of TGLFA as F varies while others being fixed on all testing cases.

11