Table S1. Penalty value of IFTSC model in the second stage under different hydrological scenarios ($\times 10^4$ t).

Number	Region	Section	Business	Five hydrological scenarios P(H) ($\times 10^4$ t)				
				Extreme Abundance	Abundance	Normal Flow	Dryness	Extreme Dryness
1	Liancheng County	Industry	Paper	[7.36, 321.65]	[6.95, 321.65]	[7.05, 321.65]	[6.93, 321.65]	[6.63, 321.65]
			Steel	[12.77, 1822.32]	[12.42, 1822.32]	[12.70, 1822.32]	[12.55, 1822.32]	[13.02, 1822.32]
			Cement	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
			Thermal power	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
		Municipal	Town	[0.00, 650.43]	[0.00, 656.03]	[0.00, 648.09]	[0.00, 649.21]	[0.00, 647.81]
			Resident	[623.05, 2929.58]	[618.42, 2929.58]	[625.81, 2929.58]	[625.09, 2929.58]	[626.25, 2929.58]
		Agriculture	Breeding	[0.82, 2.13]	[0.84, 2.13]	[0.83, 2.13]	[0.84, 2.13]	[0.83, 2.13]
			Planting	[2.37, 8.24]	[2.15, 8.24]	[2.33, 8.24]	[2.18, 8.24]	[2.27, 8.24]
		Ecology	Ecology	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
2	Shanghang County	Industry	Paper	[7.08, 226.17]	[6.13, 266.17]	[6.96, 226.17]	[6.29, 226.17]	[6.65, 226.17]
			Steel	[39.05, 1366.30]	[43.99, 1366.30]	[43.72, 1366.30]	[43.76, 1366.30]	[44.05, 1366.30]
			Cement	[0.00, 2.97]	[0.00, 4.69]	[0.00, 3.93]	[0.00, 5.01]	[0.00, 4.60]
			Thermal power	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
		Municipal	Town	[0.00, 706.55]	[0.00, 722.60]	[0.00, 689.68]	[0.00, 708.77]	[0.00, 698.63]
			Resident	[687.01, 3108.98]	[665.66, 3108.98]	[698.42, 3108.98]	[679.08, 3108.98]	[688.86, 3108.98]
		Agriculture	Breeding	[0.55, 1.38]	[0.55, 1.38]	[0.55, 1.38]	[0.55, 1.38]	[0.55, 1.38]
			Planting	[2.52, 9.72]	[2.21, 9.72]	[2.51, 9.72]	[2.35, 9.72]	[2.44, 9.72]
		Ecology	Ecology	[0.00, 0.88]	[0.00 0.77]	[0.00 0.86]	[0.00, 0.81]	[0.00, 0.84]
3	Wuping County	Industry	Paper	[7.86, 616.05]	[9.46, 616.05]	[8.69, 616.05]	[9.14, 616.05]	[9.46, 616.05]
			Steel	[84.71, 978.34]	[80.80, 978.34]	[83.41, 978.34]	[81.58, 978.34]	[82.29, 978.34]
			Cement	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
			Thermal power	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
		Municipal	Town	[0.00, 111.22]	[0.00, 108.01]	[0.00, 110.32]	[0.00, 108.83]	[0.00, 109.32]
			Resident	[1228.58, 5151.47]	[1234.46, 5151.47]	[1230.01, 5151.47]	[1233.13, 5151.47]	[1231.50, 5151.47]
		Agriculture	Breeding	[0.68, 1.72]	[0.69, 1.72]	[0.68, 1.72]	[0.69, 1.72]	[0.68, 1.72]
			Planting	[2.56, 9.60]	[2.19, 9.60]	[2.50, 9.60]	[2.25, 9.60]	[2.36, 9.60]
		Ecology	Ecology	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
4	Xinluo District	Industry	Paper	[0.00, 701.21]	[0.00, 701.21]	[0.00, 701.21]	[0.00, 701.21]	[0.00, 701.21]
			Steel	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
			Cement	[0.00, 437.93]	[0.00, 437.93]	[0.00, 437.93]	[0.00, 437.93]	[0.00, 437.93]
			Thermal power	[0.00, 460.86]	[0.00, 460.86]	[0.00, 460.86]	[0.00, 460.86]	[0.00, 460.86]
		Municipal	Town	[561.96, 1226.63]	[415.57, 1222.45]	[562.07, 1229.01]	[441.62, 1240.78]	[396.26, 1244.06]
			Resident	[29.75, 515.08]	[176.13, 519.26]	[29.64, 512.70]	[150.09, 500.93]	[195.45, 497.65]
		Agriculture	Breeding	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
			Planting	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
		Ecology	Ecology	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
5	Yongding District	Industry	Paper	[10.04, 529.15]	[7.30, 529.15]	[8.97, 529.15]	[7.90, 529.15]	[10.46, 529.15]
			Steel	[10.51, 1064.80]	[15.53, 1064.80]	[16.09, 1064.80]	[15.40, 1064.80]	[7.14, 1064.80]
			Cement	[0.00, 5.82]	[0.00, 2.88]	[0.00, 2.87]	[0.00, 3.13]	[0.00, 1.64]
			Thermal power	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
		Municipal	Town	[0.00, 538.02]	[0.00, 512.47]	[0.00, 577.24]	[0.00, 526.07]	[0.00, 542.48]
			Resident	[741.58, 2619.29]	[769.67, 2619.29]	[701.16, 2619.29]	[755.04, 2619.29]	[744.85, 2619.29]
		Agriculture	Breeding	[0.84, 2.68]	[0.69, 2.68]	[0.77, 2.68]	[0.70, 2.68]	[0.74, 2.68]
			Planting	[4.57, 22.68]	[2.84, 22.68]	[4.29, 22.68]	[3.15, 22.68]	[4.08, 22.68]
		Ecology	Ecology	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
6	Pinghe County	Industry	Paper	[8.82, 400.17]	[11.95, 356.16]	[9.16, 382.82]	[11.36, 361.82]	[10.46, 370.76]
			Steel	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
			Cement	[37.02, 935.92]	[36.29, 1100.97]	[41.11, 999.26]	[37.34, 1073.32]	[38.94, 1042.71]
			Thermal power	[2.10, 256.40]	[2.94, 135.35]	[1.98, 210.41]	[2.72, 157.34]	[2.22, 179.02]
		Municipal	Town	[549.54, 597.12]	[348.05, 560.01]	[505.78, 521.52]	[375.67, 534.45]	[431.97, 519.18]
			Resident	[706.47, 1803.49]	[692.67, 2052.55]	[729.91, 1894.82]	[717.84, 2024.94]	[732.83, 1968.64]
		Agriculture	Breeding	[0.00, 0.96]	[0.00, 0.91]	[0.00, 0.96]	[0.00, 0.93]	[0.00, 0.95]
			Planting	[0.00, 4.86]	[0.00, 4.99]	[0.00, 5.13]	[0.00, 5.15]	[0.00, 5.19]
		Ecology	Ecology	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
7	Changting County	Industry	Paper	[112.61, 308.09]	[111.31, 296.85]	[112.97, 304.86]	[111.55, 299.32]	[112.01, 302.06]
			Steel	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
			Cement	[61.12, 930.14]	[56.44, 1057.90]	[61.43, 969.93]	[58.33, 1034.71]	[60.11, 1006.97]
			Thermal power	[1.81, 317.96]	[1.88, 201.44]	[1.31, 281.41]	[1.57, 222.16]	[1.40, 247.16]
		Municipal	Town	[1.72, 230.06]	[1.56, 183.11]	[1.18, 216.72]	[1.52, 193.77]	[1.44, 205.16]
			Resident	[1.56, 609.73]	[7.47, 656.68]	[1.89, 623.07]	[5.75, 646.02]	[3.79, 634.63]

		Agriculture	Breeding	[0.00, 1.44]	[0.00, 1.49]	[0.00, 1.45]	[0.00, 1.47]	[0.00, 1.46]
			Planting	[0.00, 2.56]	[0.00, 2.67]	[0.00, 2.59]	[0.00, 2.64]	[0.00, 2.61]
		Ecology	Ecology	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
8	Zijin County	Industry	Paper	[5.96, 255.24]	[6.88, 255.24]	[6.53, 255.24]	[7.15, 255.24]	[6.95, 255.24]
			Steel	[12.24, 1928.81]	[11.03, 1928.81]	[11.83, 1928.81]	[10.91, 1928.81]	[11.23, 1928.81]
			Cement	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
			Thermal power	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
		Municipal	Town	[0.00, 290.22]	[0.00, 291.07]	[0.00, 292.50]	[0.00, 299.08]	[0.00, 296.88]
			Resident	[347.56, 3717.65]	[347.03, 3717.65]	[345.10, 3717.65]	[338.85, 3717.65]	[340.90, 3717.65]
		Agriculture	Breeding	[0.88, 2.88]	[0.96, 2.88]	[0.87, 2.88]	[0.91, 2.88]	[0.88, 2.88]
			Planting	[3.40, 12.19]	[3.28, 12.19]	[3.43, 12.19]	[3.35, 12.19]	[3.42, 12.19]
		Ecology	Ecology	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
9	Dapu County	Industry	Paper	[6.02, 220.66]	[6.37, 220.66]	[6.09, 220.66]	[6.64, 220.66]	[6.40, 220.66]
			Steel	[9.26, 1589.45]	[5.40, 1651.21]	[7.92, 1611.16]	[5.45, 1662.81]	[6.56, 1632.62]
			Cement	[1.41, 262.72]	[4.35, 200.97]	[2.57, 241.02]	[4.23, 189.36]	[3.49, 219.56]
			Thermal power	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
		Municipal	Town	[281.55, 662.72]	[281.44, 672.19]	[281.04, 669.89]	[280.86, 682.91]	[281.00, 672.88]
			Resident	[285.63, 1399.46]	[286.39, 1389.99]	[286.25, 1392.30]	[286.75, 1379.27]	[286.45, 1389.30]
		Agriculture	Breeding	[0.00, 0.61]	[0.00, 0.66]	[0.00, 0.60]	[0.00, 0.63]	[0.00, 0.61]
			Planting	[0.00, 3.27]	[0.00, 3.15]	[0.00, 3.28]	[0.00, 3.20]	[0.00, 3.25]
		Ecology	Ecology	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
10	Fengshun County	Industry	Paper	[5.99, 209.29]	[6.24, 209.29]	[5.95, 209.29]	[6.52, 209.29]	[6.28, 209.29]
			Steel	[10.04, 9.27]	[9.27, 1866.31]	[10.01, 1866.31]	[9.16, 1866.31]	[9.54, 1866.31]
			Cement	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
			Thermal power	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
		Municipal	Town	[0.00, 283.76]	[0.00, 260.08]	[0.00, 280.18]	[0.00, 266.34]	[0.00, 274.45]
			Resident	[355.29, 3945.01]	[379.50, 3945.01]	[358.93, 3945.01]	[373.09, 3945.01]	[364.80, 3945.01]
		Agriculture	Breeding	[0.74, 2.33]	[0.81, 2.33]	[0.73, 2.33]	[0.76, 23.33]	[0.73, 2.33]
			Planting	[3.69, 14.24]	[3.62, 14.24]	[3.72, 14.24]	[3.66, 14.24]	[3.71, 14.24]
		Ecology	Ecology	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
11	Meixian District	Industry	Paper	[8.39, 419.66]	[8.40, 419.66]	[9.03, 419.66]	[9.03, 419.66]	[9.37, 419.66]
			Steel	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
			Cement	[59.42, 1383.88]	[63.41, 1383.88]	[61.32, 1383.88]	[62.54, 1383.88]	[61.48, 1383.88]
			Thermal power	[11.92, 249.18]	[9.40, 249.18]	[12.70, 249.18]	[10.65, 249.18]	[12.17, 249.18]
		Municipal	Town	[279.74, 387.44]	[235.27, 396.93]	[280.32, 385.81]	[240.05, 389.31]	[262.61, 384.70]
			Resident	[277.28, 1659.53]	[320.59, 1650.04]	[273.40, 1661.16]	[314.71, 1657.66]	[291.22, 1662.27]
		Agriculture	Breeding	[0.00, 0.92]	[0.00, 0.91]	[0.00, 0.88]	[0.00, 0.89]	[0.00, 0.88]
			Planting	[0.00, 3.23]	[0.00, 2.91]	[0.00, 3.25]	[0.00, 3.03]	[0.00, 3.16]
		Ecology	Ecology	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
12	Wuhua County	Industry	Paper	[6.21, 314.71]	[7.71, 314.71]	[7.20, 314.71]	[7.91, 314.71]	[7.72, 314.71]
			Steel	[11.95, 200.44]	[12.06, 200.44]	[12.68, 200.44]	[12.68, 200.44]	[13.02, 200.44]
			Cement	[13.81, 1549.32]	[11.24, 1549.32]	[12.11, 1549.32]	[11.46, 1549.32]	[11.18, 1549.32]
			Thermal power	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
		Municipal	Town	[101.49, 276.26]	[98.48, 220.33]	[101.04, 263.20]	[99.53, 226.72]	[100.61, 245.35]
			Resident	[285.24, 1953.58]	[342.84, 1956.59]	[298.33, 1954.03]	[335.14, 1955.55]	[316.39, 1954.46]
		Agriculture	Breeding	[0.00, 1.15]	[0.00, 1.21]	[0.00, 1.12]	[0.00, 1.15]	[0.00, 1.12]
			Planting	[0.00, 10.41]	[0.00, 9.66]	[0.00, 10.41]	[0.00, 9.97]	[0.00, 10.27]
		Ecology	Ecology	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
13	Xingning County	Industry	Paper	[7.86, 463.06]	[8.83, 463.06]	[8.78, 463.06]	[9.35, 463.06]	[9.47, 463.06]
			Steel	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
			Cement	[58.78, 1497.91]	[62.12, 1498.44]	[60.35, 1502.05]	[61.64, 1482.78]	[59.76, 1505.49]
			Thermal power	[12.69, 98.99]	[10.15, 98.47]	[13.60, 94.85]	[11.39, 114.12]	[13.15, 91.41]
		Municipal	Town	[299.89, 826.90]	[326.16, 1015.63]	[300.47, 838.78]	[322.71, 1056.13]	[315.49, 835.31]
			Resident	[284.99, 1249.54]	[257.49, 1060.81]	[280.97, 1237.66]	[259.49, 1020.31]	[266.43, 1241.12]
		Agriculture	Breeding	[0.00, 0.80]	[0.00, 0.84]	[0.00, 0.79]	[0.00, 0.81]	[0.00, 0.79]
			Planting	[0.00, 5.98]	[0.00, 5.38]	[0.00, 6.04]	[0.00, 5.60]	[0.00, 5.89]
		Ecology	Ecology	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
14	Chenghai District	Industry	Paper	[6.91, 211.66]	[6.12, 211.66]	[6.56, 211.66]	[6.39, 211.66]	[6.27, 211.66]
			Steel	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]
			Cement	[14.21, 214.85]	[9.69, 214.85]	[14.62, 214.85]	[10.69, 214.85]	[12.20, 214.85]
			Thermal power	[105.44, 1639.52]	[110.68, 1639.52]	[110.16, 1639.52]	[110.90, 1639.52]	[113.20, 1639.52]
		Municipal	Town	[298.24, 476.48]	[308.05, 492.73]	[298.35, 482.73]	[304.31, 491.54]	[300.01, 487.83]
			Resident	[286.39, 1597.65]	[277.00, 1581.40]	[281.44, 1591.39]	[279.18, 1582.58]	[279.66, 1586.29]
		Agriculture	Breeding	[0.00, 1.06]	[0.00, 1.10]	[0.00, 1.06]	[0.00, 1.05]	[0.00, 1.03]
			Planting	[0.00, 2.48]	[0.00, 2.09]	[0.00, 2.54]	[0.00, 2.21]	[0.00, 2.36]
		Ecology	Ecology	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.00]

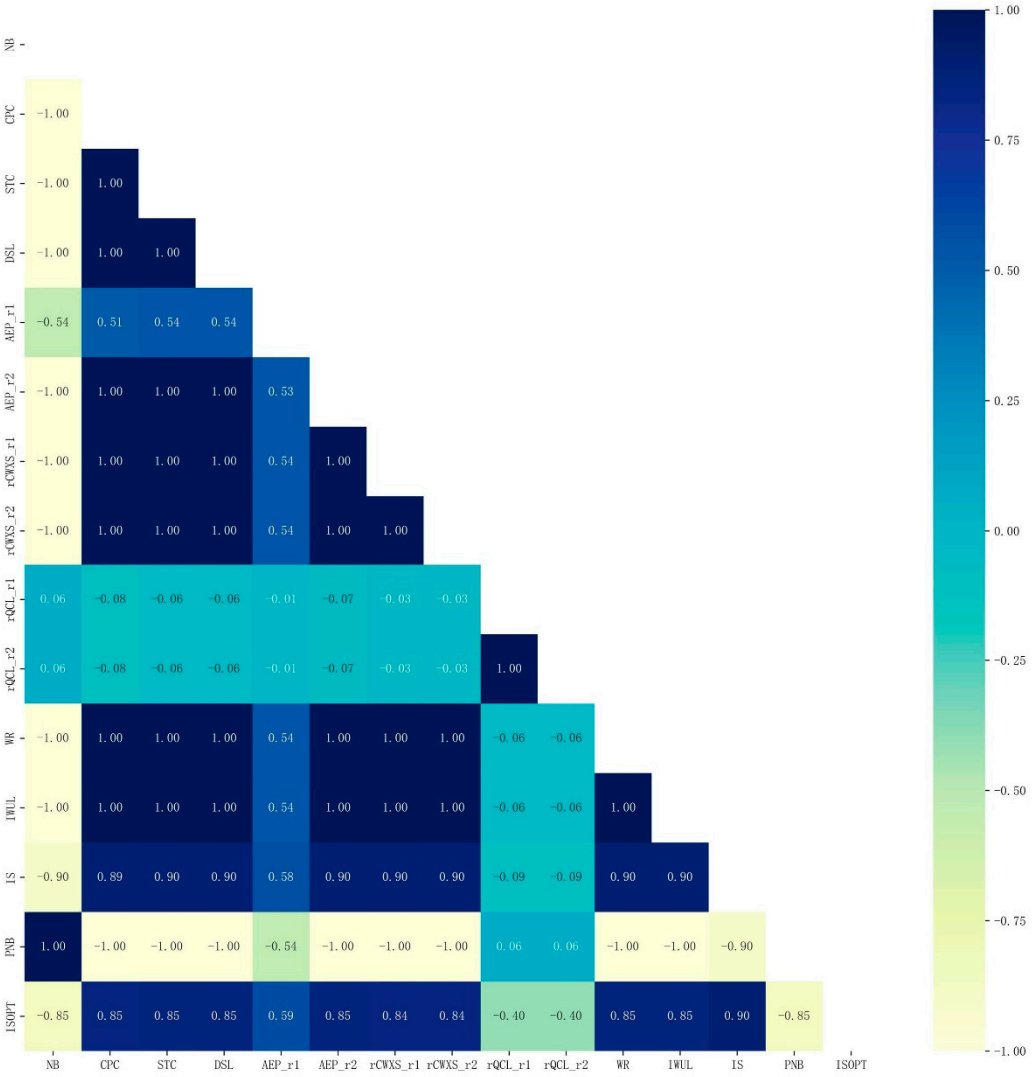


Figure S1. Correlation of variables in the IFTSC model for the municipal sector.

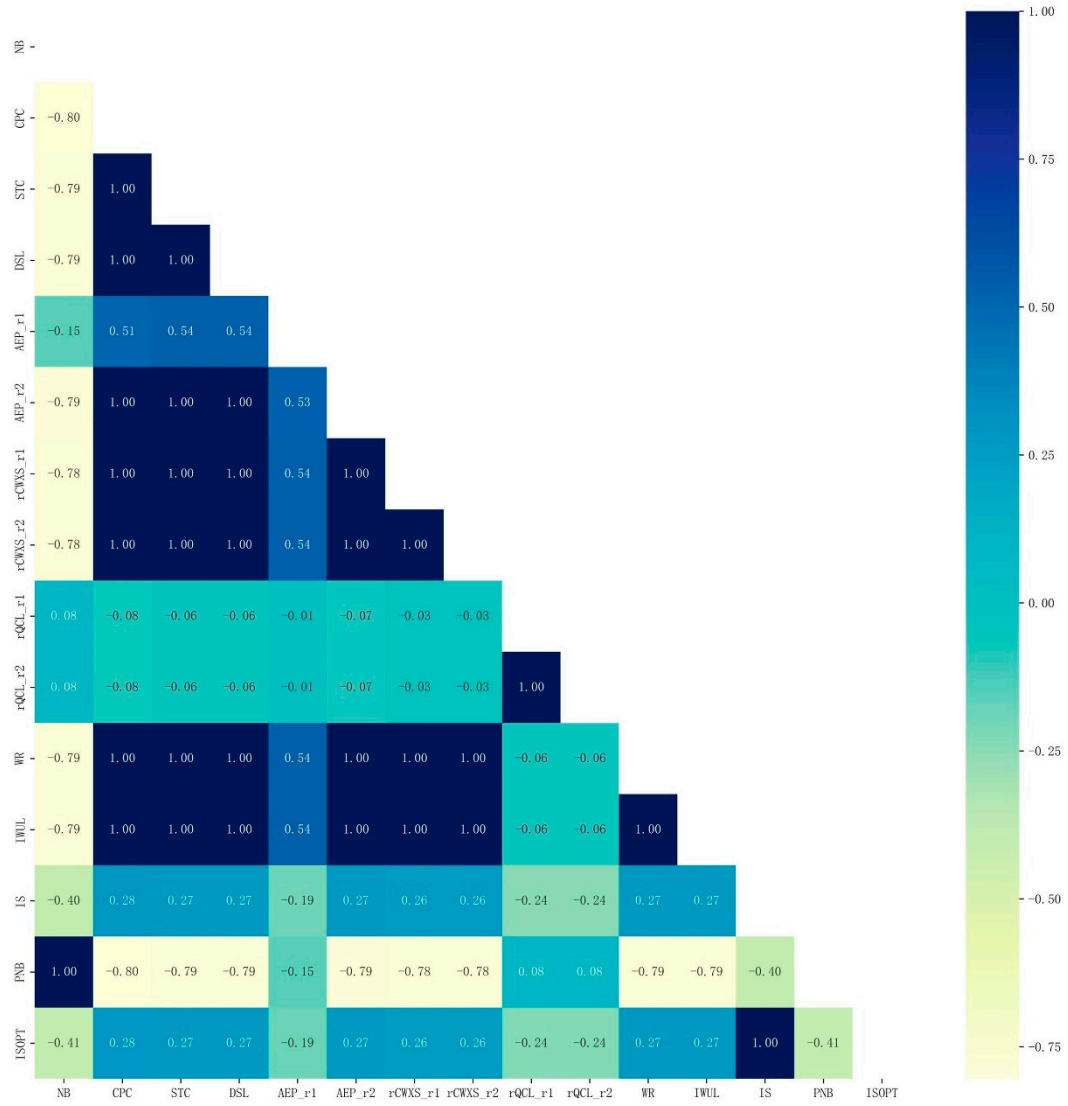


Figure S2. Correlation of variables in the IFTSC model for the agricultural sector.

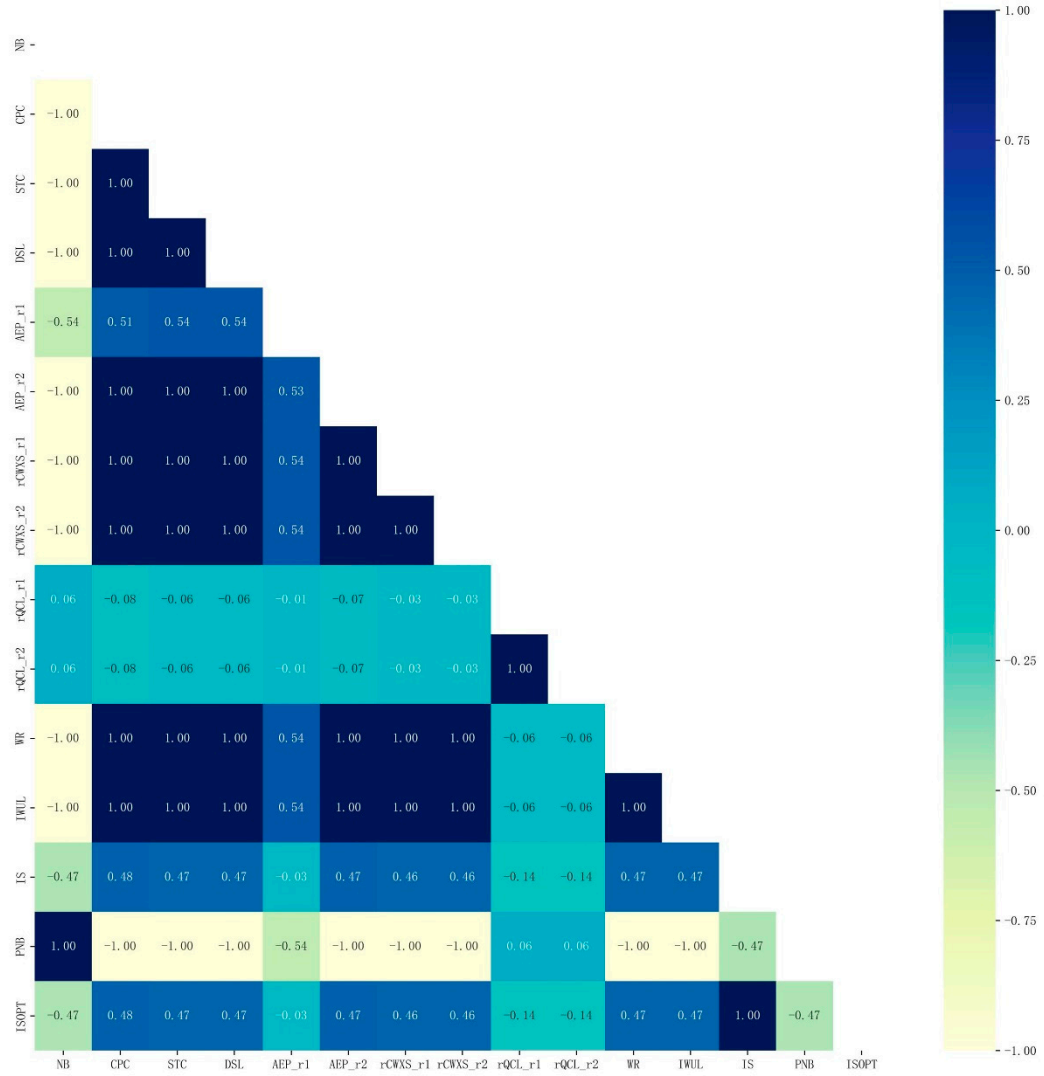


Figure S3. Correlation of variables in the IFTSC model for the ecological sector.

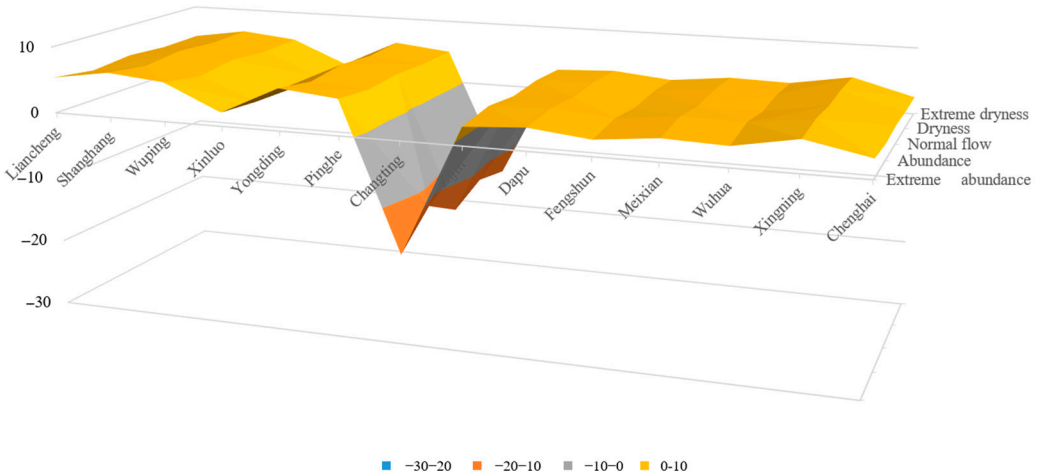


Figure S4. Difference between the upper limit of economic efficiency of each administrative unit in IFTSC and IFTS models.