Supplementary Material

# Supplementary Figures



Figure 1. Parallel trend test.



Figure 2. Time placebo test.



Figure 3. Spatial placebo test.



Figure 4. Mixed placebo test.

# Supplementary Tables

Table 1. Evaluation index system of AGTFP.

|  |  |  |  |
| --- | --- | --- | --- |
| **Type** | **Indicator** | **Definition** | **Unit** |
| Input indicators | Land | Total sown area of crops | 1000 hectares |
| Labor force | Number of employees in agricultural industry | 10,000 persons |
| Agricultural machinery | Total power of agricultural machinery | 10,000 kilowatts |
| Chemical fertilizer | Pure amount of agricultural chemical fertilizer application | 10,000 tons |
| Water | Effective irrigation area | 1000 hectares |
| Output indicators | Desired outputs | Agricultural economic value | 100 million CNY |
| Agricultural ecological value | 100 million CNY |
| Undesired outputs | Agricultural carbon emissions | 10,000 tons |
| Agricultural non-point source pollution | 100 million cubic meters |

Table 2. Descriptive statistics of variables.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variables** | **Obs** | **Mean** | **Std.Dev.** | **Min** | **Max** |
| AGTFP | 3718 | 1.6462 | 0.6125 | 0.2124 | 6.8208 |
| DE | 3718 | 0.2598 | 0.4386 | 0.0000 | 1.0000 |
| GTI | 3718 | 4.6893 | 1.7418 | 0.0000 | 10.0116 |
| ER | 3718 | 0.9904 | 0.2785 | 0.3331 | 3.0866 |
| FD | 3718 | 0.2078 | 0.0550 | 0.0924 | 0.5648 |
| IND | 3718 | 0.4301 | 0.1155 | 0.1139 | 0.9771 |
| AFE | 3718 | 0.1220 | 0.0464 | 0.0125 | 0.3828 |
| FDI | 3718 | 1.4442 | 1.5726 | 0.0008 | 12.0992 |
| HCS | 3718 | 4.7754 | 0.9717 | 0.5666 | 7.1328 |
| PI | 3718 | 0.4153 | 0.2042 | 0.0125 | 1.9884 |
| LI | 3718 | 1.1242 | 0.5332 | 0.0615 | 2.8293 |

Table 3. Results of baseline model.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Variables** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
| DE | 0.1070\*\*(0.0417) | 0.1075\*\*\*(0.0392) | 0.1058\*\*\*(0.0393) | 0.1074\*\*\*(0.0393) | 0.1061\*\*\*(0.0387) | 0.1043\*\*\*(0.0389) |
| IND |  | 0.2181(0.2316) | 0.2113(0.2339) | 0.2181(0.2315) | 0.2084(0.2290) | 0.2007(0.2314) |
| AFE |  | -0.7328(0.5493) | -0.7165(0.5483) | -0.7360(0.5378) | -0.7290(0.5457) | -0.7114(0.5329) |
| FDI |  | 0.0333\*\*\*(0.0076) | 0.0333\*\*\*(0.0076) | 0.0333\*\*\*(0.0077) | 0.0348\*\*\*(0.0076) | 0.0347\*\*\*(0.0077) |
| HCS |  | 0.0653(0.0454) | 0.0657(0.0454) | 0.0652(0.0455) | 0.0676(0.0458) | 0.0680(0.0458) |
| PI |  | 0.2450(0.1676) | 0.2433(0.1674) | 0.2430(0.1710) | 0.2470(0.1683) | 0.2448(0.1715) |
| LI |  | -0.2549\*\*\*(0.0908) | -0.2549\*\*\*(0.0911) | -0.2550\*\*\*(0.0908) | -0.2496\*\*\*(0.0898) | -0.2496\*\*\*(0.0901) |
| SmartCity |  |  | 0.0256(0.0319) |  |  | 0.0285(0.0318) |
| NBDCEZs |  |  |  | -0.0035(0.0537) |  | -0.0006(0.0535) |
| NASTPs |  |  |  |  | -0.0696\*(0.0360) | -0.0703\*(0.0360) |
| Constant | 1.0000\*\*\*(0.0179) | 0.7763\*\*\*(0.2648) | 0.7771\*\*\*(0.2650) | 0.7780\*\*\*(0.2638) | 0.7746\*\*\*(0.2645) | 0.7758\*\*\*(0.2634) |
| City FE | YES | YES | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES | YES | YES |
| N | 3718 | 3718 | 3718 | 3718 | 3718 | 3718 |
| R2 | 0.7319 | 0.7395 | 0.7396 | 0.7395 | 0.7406 | 0.7407 |

Notes: The robust standard errors of clustering at the city level are reported in parentheses; \*, \*\*, and \*\*\* represent significance at the 10%, 5%, and 1% levels, respectively.

Table 4. Results of Goodman-Beacon decomposition.

|  |  |  |
| --- | --- | --- |
| **DD Comparison** | **Avg DD Est** | **Weight** |
| Earlier Treatment vs. Later Comparison | 0.077 | 0.022 |
| Later Treatment vs. Earlier Comparison | -0.050 | 0.057 |
| Treatment vs. Never Treated | 0.118 | 0.920 |

Table 5. Results of instrumental variable test.

|  |  |  |
| --- | --- | --- |
| **Variables** | **（1）** | **(2)** |
| **DE** | **AGTFP** |
| DE |  | 0.6444\*\*(0.2596) |
| IV | 0.0026\*\*\*(0.0005) |  |
| Constant | -0.0946(0.2137) | 0.5271\*(0.2870) |
| Control Variables | YES | YES |
| City FE | YES | YES |
| Year FE | YES | YES |
| Kleibergen-Paap rk LM statistic | 17.83\*\*\*(0.0000) |  |
| Cragg-Donald Wald F statistic | 137.85 |  |
| Kleibergen-Paap rk Wald F statistic | 22.50 |  |
| N | 3718 | 3718 |
| R2 | 0.3707 | 0.6873 |

Notes: \*, \*\*, and \*\*\* represent significance at the 10%, 5%, and 1% levels, respectively.

Table 6. Results of PSM-DID.

|  |  |  |  |
| --- | --- | --- | --- |
| **Variables** | **(1)** | **(2)** | **(3)** |
| **Nearest Neighbor Match** | **Radius Match** | **Kernel Match** |
| DE | 0.1038\*\*\*(0.0387) | 0.1075\*\*\*(0.0392) | 0.1068\*\*\*(0.0392) |
| Constant | 0.9858\*\*\*(0.3182) | 0.7763\*\*\*(0.2648) | 0.7486\*\*\*(0.2698) |
| Control Variables | YES | YES | YES |
| City FE | YES | YES | YES |
| Year FE | YES | YES | YES |
| N | 2880 | 3718 | 3704 |
| R2 | 0.7464 | 0.7395 | 0.7389 |

Notes: The robust standard errors of clustering at the city level are reported in parentheses; \*\*\* represent significance at the 1% levels.

Table 7. Results of other robustness tests.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variables** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** |
| **Intensity DID** | **Lag Treatment of Independent Variable** | **Exclude Certain City Samples** | **1% Bilateral Winsorization** | **Controlling for Province-Year Fixed Effect** |
| DE | 0.4534\*\*\*(0.1458) |  | 0.0793\*(0.0436) | 0.1005\*\*\*(0.036) | 0.1311\*\*\*(0.0341) |
| L2.DE |  | 0.1078\*\*(0.0430) |  |  |  |
| Constant | 0.7293\*\*\*(0.2645) | 0.7478\*\*(0.3075) | 0.7127\*\*\*(0.2735) | 0.6791\*\*(0.3074) | 0.4645(0.3026) |
| Control Variables | YES | YES | YES | YES | YES |
| City FE | YES | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES | YES |
| Province\*Year FE | NO | NO | NO | NO | YES |
| N | 3718 | 3146 | 3263 | 3718 | 3718 |
| R2 | 0.7411 | 0.7039 | 0.7336 | 0.7796 | 0.8170 |

Notes: The robust standard errors of clustering at the city level are reported in parentheses; \*\* and \*\*\* represent significance at the 5% and 1% levels, respectively.

Table 8. Results of mechanism test.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Variables** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** |
| **AGTFP** | **GTI** | **AGTFP** | **ER** | **AGTFP** | **FD** | **AGTFP** |
| DE | 0.1075\*\*\*(0.0392) | 0.1422\*\*\*(0.0524) | 0.0989\*\*(0.0393) | 0.0568\*\*(0.0221) | 0.1038\*\*\*(0.0393) | 0.0746\*\*\*(0.0030) | 0.0516(0.0557) |
| GTI |  |  | 0.0600\*\*\*(0.0214) |  |  |  |  |
| ER |  |  |  |  | 0.0636\*\*(0.0281) |  |  |
| FD |  |  |  |  |  |  | 0.7491\*(0.4269) |
| Constant | 0.7763\*\*\*(0.2648) | 2.4793\*\*\*(0.4025) | 0.6275\*\*(0.2696) | 0.6446\*\*\*(0.1415) | 0.7353\*\*\*(0.2669) | 0.2652\*\*\*(0.0193) | 0.5776\*(0.3076) |
| Control Variables | YES | YES | YES | YES | YES | YES | YES |
| City FE | YES | YES | YES | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES | YES | YES | YES |
| Sobel Test |  | 0.009\*\*\*(0.002) | 0.004\*\*(0.002) | 0.056\*\*\*(0.018) |
| Bootstrap Test |  | (0.0030, 0.0141) | (0.0003, 0.0070) | (0.0136, 0.0981) |
| N | 3718 | 3718 | 3718 | 3718 | 3718 | 3718 | 3718 |
| R2 | 0.7395 | 0.8222 | 0.7412 | 0.0832 | 0.7402 | 0.6819 | 0.7403 |

Notes: The robust standard errors of clustering at the city level are reported in parentheses; \*\* and \*\*\* represent significance at the 5% and 1% levels, respectively; Bootstrap Test reports the confidence interval at the 95% level.

Table 9. Results of heterogeneity test for natural geographical factors.

|  |  |  |  |
| --- | --- | --- | --- |
| **Variables** | **Natural Geographical Locations** | **Precipitation Distributions** | **Terrain Relief Degrees** |
| **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** |
| **Eastern** | **Central** | **Western** | **Humid Areas** | **Non-Humid Areas** | **High** | **Low** |
| DE | 0.1544\*\*(0.0606) | 0.0915\*(0.0543) | 0.0583(0.0833) | 0.0836(0.0510) | 0.1383\*\*(0.0570) | 0.1026\*(0.0572) | 0.1118\*\*(0.0533) |
| Constant | 0.6207(0.5570) | 1.465\*\*\*(0.4013) | 0.7013\*\*(0.3505) | 0.8966\*\*(0.4201) | 0.6153\*\*(0.3094) | 0.9589\*\*\*(0.2919) | 0.7216(0.5886) |
| Control Variables | YES | YES | YES | YES | YES | YES | YES |
| City FE | YES | YES | YES | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES | YES | YES | YES |
| N | 1313 | 1287 | 1118 | 2340 | 1378 | 1859 | 1859 |
| R2 | 0.8016 | 0.6910 | 0.7667 | 0.7194 | 0.7966 | 0.7625 | 0.7249 |

Notes: The robust standard errors of clustering at the city level are reported in parentheses; \*, \*\*, and \*\*\* represent significance at the 10%, 5%, and 1% levels, respectively.

Table 10. Results of heterogeneity test for socio-economic factors.

|  |  |  |  |
| --- | --- | --- | --- |
| **Variables** | **Agricultural Functional Zones** | **Digitalization Levels** | **Financial Literacy Levels** |
| **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
| **Main Grain-Producing Areas** | **Non-Main Grain-Producing Areas** | **High** | **Low** | **High** | **Low** |
| DE | 0.0882\*\*(0.0393) | 0.1995\*\*\*(0.0740) | 0.0870\*(0.0482) | 0.0837(0.0695) | 0.1403\*\*\*(0.0465) | 0.0479(0.0646) |
| Constant | 1.1861\*\*\*(0.3232) | 0.4384(0.3867) | 0.8400\*\*(0.4039) | 0.5780(0.3594) | 0.5201(0.7660) | 0.5934\*(0.3331) |
| Control Variables | YES | YES | YES | YES | YES | YES |
| City FE | YES | YES | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES | YES | YES |
| N | 2210 | 1508 | 1859 | 1859 | 1859 | 1859 |
| R2 | 0.7286 | 0.7941 | 0.8035 | 0.6837 | 0.7921 | 0.6821 |

Notes: The robust standard errors of clustering at the city level are reported in parentheses; \* and \*\* represent significance at the 10% and 5% levels, respectively.

Table 11. Results of spatial autocorrelation test.

|  |  |  |
| --- | --- | --- |
| **Year** | ***W*1** | ***W*2** |
| 2012 | 0.1008\*\*\* | 0.1608\*\*\* |
| 2013 | 0.1398\*\*\* | 0.1705\*\*\* |
| 2014 | 0.1508\*\*\* | 0.1734\*\*\* |
| 2015 | 0.1310\*\*\* | 0.1552\*\*\* |
| 2016 | 0.0827\*\*\* | 0.1138\*\*\* |
| 2017 | 0.0420\*\*\* | 0.0597\* |
| 2018 | 0.1135\*\*\* | 0.1558\*\*\* |
| 2019 | 0.1209\*\*\* | 0.1688\*\*\* |
| 2020 | 0.1271\*\*\* | 0.1654\*\*\* |
| 2021 | 0.1125\*\*\* | 0.1634\*\*\* |
| 2022 | 0.1482\*\*\* | 0.1476\*\*\* |
| 2023 | 0.1458\*\*\* | 0.1477\*\*\* |

Notes: \* and \*\*\* represent significance at the 10% and 1% levels, respectively.

Table 12. Results of adaptability test for spatial econometrics model.

|  |  |  |
| --- | --- | --- |
| **Test** | ***W*1** | ***W*2** |
| LM\_Lag | 2411.266\*\*\* | 6880.890\*\*\* |
| Robust LM\_Lag | 887.985\*\*\* | 1340.878\*\*\* |
| LM\_Error | 160.337\*\*\* | 5779.219\*\*\* |
| Robust LM\_Error | 117.056\*\*\* | 239.207\*\*\* |
| Hausman | 27.62\*\*\* | 31.33\*\*\* |
| Wald\_Lag | 18.15\*\*\* | 23.83\*\*\* |
| Wald\_Error | 17.43\*\*\* | 19.23\*\*\* |
| LR\_Lag | 12.23\* | 25.35\*\*\* |
| LR\_Error | 17.84\*\* | 22.94\*\*\* |
| LR\_SDM\_Ind | 44.38\*\*\* | 379.52\*\*\* |
| LR\_SDM\_Time | 2652.94\*\*\* | 2607.75\*\*\* |

Notes: \*, \*\*, and \*\*\* represent significance at the 10%, 5%, and 1% levels, respectively.

Table 13. Results of SDID model.

|  |  |  |
| --- | --- | --- |
| **Variables** | ***W*1** | ***W*2** |
| DE | 0.1110\*\*\*(0.0364) | 0.0957\*\*(0.0375) |
| W\*DE | 0.0602\*(0.0325) | 0.0448\*(0.0242) |
| Rho | 0.6414\*\*\*(0.0637) | 0.2670\*\*\*(0.0411) |
| Direct Effect | 0.1075\*\*\*(0.0396) | 0.1005\*\*\*(0.0384) |
| Indirect Effect | 0.0988\*(0.0594) | 0.0886\*\*(0.0444) |
| Total Effect | 0.2063\*(0.1191) | 0.1891\*(0.1029) |
| Proportion of Indirect Effect | 0.4789 | 0.4688 |
| Control Variables | YES | YES |
| City FE | YES | YES |
| Year FE | YES | YES |
| N | 3718 | 3718 |
| R2 | 0.3906 | 0.2499 |

Notes: The robust standard errors of clustering at the city level are reported in parentheses; \*, \*\*, and \*\*\* represent significance at the 10%, 5%, and 1% levels, respectively.

Table 14. Results of robustness tests for SDID model.

|  |  |  |  |
| --- | --- | --- | --- |
| **Variables** | **Exclude Certain City Samples** | **1% Bilateral Winsorization** | **Replace the Spatial Weight Matrix** |
| **(1)** | **(2)** | **(3)** | **(4)** | **(5)** |
| ***W*1** | ***W*2** | ***W*1** | ***W*2** | ***W*3** |
| DE | 0.0877\*\*(0.0418) | 0.0702\*(0.0418) | 0.1034\*\*\*(0.0331) | 0.0879\*\*(0.0344) | 0.1163\*\*\*(0.0367) |
| W\*DE | 0.0478\*(0.0284) | 0.0353\*\*(0.0179) | 0.0577\*\*(0.0285) | 0.0373\*(0.0203) | 0.0341\*(0.0192) |
| Rho | 0.6032\*\*\*(0.0720) | 0.2711\*\*\*(0.0464) | 0.6811\*\*\*(0.0612) | 0.2866\*\*\*(0.0457) | 0.3208\*\*\*(0.0613) |
| Direct Effect | 0.0794\*(0.0450) | 0.0770\*(0.0433) | 0.1012\*\*\*(0.0364) | 0.0924\*\*\*(0.0354) | 0.1154\*\*\*(0.0396) |
| Indirect Effect | 0.0519\*\*(0.0226) | 0.0436\*\*(0.0222) | 0.0934\*(0.0502) | 0.0805\*(0.0444) | 0.0848\*(0.0497) |
| Total Effect | 0.1312\*\*(0.0619) | 0.1205\*(0.0722) | 0.1946\*(0.1131) | 0.1729\*(0.0998) | 0.1992\*\*(0.0994) |
| Proportion of Indirect Effect | 0.3953 | 0.3616 | 0.4800 | 0.4655 | 0.4258 |
| Control Variables | YES | YES | YES | YES | YES |
| City FE | YES | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES | YES |
| N | 3263 | 3263 | 3718 | 3718 | 3718 |
| R2 | 0.3874 | 0.0949 | 0.0809 | 0.3910 | 0.3854 |

Notes: The robust standard errors of clustering at the city level are reported in parentheses; \*, \*\*, and \*\*\* represent significance at the 10%, 5%, and 1% levels, respectively.