

Supplemental Materials

Spatial Panel Models of Crop Yield Response to Weather: Econometric Specification Strategies and Prediction Performance

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These supplemental materials contain the full estimation results with all variables from the regressions reported in Table 3 and Table 4 in the text. The original data used in this manuscript are publicly available through the corresponding author's GitHub repository: <https://github.com/ysd2004/spatialcrophyieldJAAE>. All underlying data processed to create model variables come from peer-reviewed and publicly accessible sources.

Table S1. Moran's I Statistic of the Yearly Average Temperature, Growing Season Degree Days (GDD) (Mar. to Aug.), Total Precipitation (Mar. to Aug.), and Corn Yields (bu/ac), 1981–2012.

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Table S1. Moran's I Statistic of the Yearly Average Temperature, Growing Season Degree Days (GDD) (Mar. to Aug.), Total Precipitation (Mar. to Aug.), and Corn Yield (bu/ac), 1981–2012.

Year	Mean Temperature			GDD			Total Precipitation			Yield
	Grid	County	State	Grid	County	State	Grid	County	State	County
1981	0.9861	0.9778	0.7233	0.6838	0.6511	0.0075	0.9420	0.6532	0.1729	0.8201
1982	0.9875	0.9827	0.7581	0.7298	0.7974	0.1763	0.9396	0.6922	0.2831	0.7943
1983	0.9860	0.9761	0.7192	0.7162	0.7683	0.0719	0.9393	0.6684	0.3582	0.7801
1984	0.9876	0.9802	0.7337	0.7258	0.7828	0.0753	0.9455	0.7750	0.1996	0.7575
1985	0.9881	0.9830	0.7517	0.7004	0.7666	0.1085	0.9491	0.6934	0.2869	0.7719
1986	0.9870	0.9808	0.7530	0.6699	0.6063	0.0522	0.9391	0.6009	0.2094	0.8710
1987	0.9860	0.9744	0.7334	0.6467	0.6544	0.0206	0.9361	0.6150	0.1180	0.8628
1988	0.9861	0.9765	0.7164	0.6717	0.7657	0.0470	0.9344	0.6741	0.1626	0.7023
1989	0.9869	0.9809	0.7317	0.7161	0.7391	0.1756	0.9583	0.7628	0.1744	0.7519
1990	0.9870	0.9796	0.7468	0.6785	0.7027	0.1161	0.9529	0.6430	0.2065	0.8472
1991	0.9871	0.9792	0.7350	0.7266	0.7812	0.0375	0.9452	0.7935	0.3496	0.7321
1992	0.9862	0.9783	0.7313	0.7081	0.7628	0.2801	0.9449	0.7523	0.1544	0.8456
1993	0.9879	0.9814	0.7440	0.6974	0.6010	0.0767	0.9493	0.6393	0.1791	0.8391
1994	0.9864	0.9797	0.7381	0.6960	0.7822	0.2854	0.9616	0.7822	0.2767	0.8216
1995	0.9868	0.9794	0.7345	0.7203	0.7615	0.0717	0.9402	0.6389	0.2762	0.6778
1996	0.9876	0.9818	0.7394	0.7087	0.7500	0.2704	0.9514	0.7670	0.1901	0.7748
1997	0.9864	0.9784	0.7215	0.7201	0.7892	0.2390	0.9490	0.7059	0.1820	0.7881
1998	0.9871	0.9786	0.7530	0.6719	0.7383	0.2720	0.9486	0.7934	0.3074	0.8524
1999	0.9872	0.9791	0.7367	0.6901	0.6975	0.0656	0.9407	0.6385	0.2648	0.8244
2000	0.9871	0.9803	0.7420	0.6757	0.7229	0.1504	0.9500	0.7112	0.1720	0.7135
2001	0.9869	0.9781	0.7314	0.6963	0.7971	0.2792	0.9530	0.7004	0.3177	0.6921
2002	0.9871	0.9793	0.7295	0.7245	0.7997	0.2004	0.9596	0.7220	0.3470	0.8625
2003	0.9862	0.9798	0.7366	0.7118	0.8327	0.1438	0.9569	0.8447	0.2785	0.7576
2004	0.9868	0.9803	0.7376	0.7080	0.7437	0.2167	0.9552	0.7449	0.1518	0.7645
2005	0.9871	0.9797	0.7386	0.6767	0.7467	0.0953	0.9431	0.7667	0.2904	0.7400
2006	0.9873	0.9788	0.7258	0.6581	0.6999	0.0755	0.9416	0.6927	0.2615	0.7353
2007	0.9870	0.9808	0.7485	0.6678	0.7270	0.1039	0.9584	0.5954	0.0821	0.7879
2008	0.9879	0.9823	0.7328	0.7164	0.7859	0.1687	0.9633	0.7171	0.1904	0.8069
2009	0.9878	0.9827	0.7362	0.7094	0.7651	0.3062	0.9579	0.7618	0.2920	0.8101
2010	0.9877	0.9787	0.7381	0.6764	0.6820	0.1040	0.9418	0.6394	0.1842	0.8400
2011	0.9884	0.9829	0.7452	0.7119	0.7358	0.3715	0.9556	0.7551	0.2183	0.7916
2012	0.9872	0.9788	0.7309	0.6706	0.7607	0.3090	0.9461	0.6802	0.2998	0.7793

Table S2. In-Sample Estimation Results, 1981-2012

	Pooled	FE	RE	SEM	KKP	SLX	SAR
	Eq. (3)	Eq. (4)	Eq. (5)	Eq. (7)	Eq. (8)	Eq. (9)	Eq. (10)
h_{it}	0.0432*** (0.0017)	0.0024* (0.0015)	0.0353*** (0.0007)	0.0051 (0.0038)	0.0450*** (0.0012)	0.0202* (0.0120)	-0.0006 0.0009
h_{it}^2	-0.0001*** (0.0000)	0.0000* (0.0000)	-0.0001*** (0.0000)	0.0000 (0.0000)	-0.0001*** (0.0000)	-0.0001 (0.0000)	0.0000* 0.0000
$\sqrt{h_{it}^e}$	-0.1136*** (0.0013)	-0.1413*** (0.0020)	-0.1359*** (0.0019)	-0.1090*** (0.0046)	-0.1062*** (0.0043)	-0.0905*** (0.0121)	-0.0276*** 0.0013
P_{it}	0.0016*** (0.0001)	0.0014*** (0.0000)	0.0017*** (0.0000)	0.0012*** (0.0001)	0.0012*** (0.0001)	0.0011*** (0.0001)	0.0005*** 0.0000
P_{it}^2	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** 0.0000
whc			0.0152*** (0.0010)		0.0048*** (0.0010)		
k-factor			0.5521*** (0.0684)		0.0163 (0.0730)		
om			0.0001*** (0.0000)		0.0000 (0.0000)		
spH			0.1119*** (0.0059)		0.0817*** (0.0097)		
$w_i h_{it}$						-0.0185 (0.0121)	
$w_i h_{it}^2$						0.0001 (0.0000)	
$w_i \sqrt{h_{it}^e}$						-0.0552*** (0.0123)	
$w_i P_{it}$						0.0005*** (0.0001)	
$w_i P_{it}^2$						-0.0000*** (0.0000)	
t	0.0085*** (0.0007)	0.0084*** (0.0005)	0.0063*** (0.0005)	0.0085*** (0.0016)	0.0062*** (0.0017)	0.0082*** (0.0005)	0.0014*** 0.0003
t^2	0.0001*** (0.0000)	0.0001*** (0.0000)	0.0002*** (0.0000)	0.0001*** (0.0000)	0.0002*** (0.0000)	0.0002*** (0.0000)	0.0000*** 0.0000
Intercept	0.9685*** (0.1257)						
r, γ or ρ				0.8148*** (0.0035)	0.8216*** (0.0033)		0.8003*** (0.0037)
County FE	No	Yes	No	Yes	No	Yes	Yes
# of Obs.	33,344	33,344	33,344	33,344	33,344	33,344	33,344
SSE	2,390.9	1,223.1	2,024.7	1,252.2	2,088.5	1,215.1	485.3
RMSE	0.2678	0.1915	0.2464	0.1938	0.2503	0.1909	0.1206
APC	0.0717	0.0391	0.0608	0.0376	0.0627	0.0388	0.0146
RMPE	0.1920	0.1535	0.1864	0.1533	0.1758	NA	NA

Notes: * p < 10%, ** p < 5%, and *** p < 1%; Standard errors are reported in parentheses; County FE: county fixed effects; SSE: sum of squared errors; RMSE: root mean squared errors; APC: Amemiya's prediction criterion; RMPE: root mean squared prediction errors for 2013-2018 out-of-sample period.

Table S3. Estimation Results with nonlinear GDD bins

	Pooled	FE	RE	SEM	KKP	SLX	SAR
	Eq. (3')	Eq. (4')	Eq. (5')	Eq. (7')	Eq. (8')	Eq. (9')	Eq. (10')
$x_{it,1}$	-3.1901*** (0.1633)	-2.2592*** (0.1261)	-3.9148*** (0.1139)	-1.7717*** (0.2102)	-3.6220*** (0.1944)	-1.6979*** (0.4668)	-0.3389*** (0.0796)
$x_{it,2}$	-0.7273*** (0.1055)	-0.9634*** (0.0877)	-2.7893*** (0.0661)	-1.3082*** (0.1656)	-4.0299*** (0.1147)	-2.1969*** (0.4023)	-0.1717*** (0.0553)
$x_{it,3}$	-2.2303*** (0.1500)	-0.4085*** (0.1174)	-2.0775*** (0.1057)	-0.4649** (0.1882)	-2.2502*** (0.1772)	-0.7582** (0.3748)	-0.0038 (0.0739)
$x_{it,4}$	0.4866*** (0.1067)	1.2807*** (0.0882)	-0.3026*** (0.0736)	0.4571*** (0.1598)	-1.7855*** (0.1325)	-0.2541 (0.3327)	0.2573*** (0.0557)
$x_{it,5}$	-0.9410*** (0.1278)	0.7123*** (0.1001)	-0.4679*** (0.0936)	0.4197*** (0.1586)	-0.9030*** (0.1530)	-0.2917 (0.3053)	0.2103*** (0.0631)
$x_{it,6}$	-0.1558 (0.1072)	1.1936*** (0.0865)	0.1094 (0.0803)	0.1416 (0.1466)	-1.3323*** (0.1376)	-0.8280*** (0.2832)	0.2206*** (0.0545)
$x_{it,7}$	-1.6723*** (0.0904)	-0.5435*** (0.0710)	-1.0827*** (0.0694)	-0.3151*** (0.1155)	-0.9049*** (0.1156)	-0.1974 (0.2193)	-0.0916*** (0.0447)
$x_{it,8}$	-0.7398*** (0.0943)	-0.3007*** (0.0739)	-0.8609*** (0.0722)	-0.4841*** (0.1185)	-1.1635*** (0.1179)	-0.4551** (0.2220)	-0.1022*** (0.0465)
P_{it}	0.0015*** (0.0001)	0.0013*** (0.0000)	0.0016*** (0.0000)	0.0012*** (0.0001)	0.0014*** (0.0001)	0.0011*** (0.0001)	0.0005*** (0.0000)
P_{it}^2	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)
whc			0.0150*** (0.0012)		0.0045*** (0.0011)		
k-factor			0.9094*** (0.0827)		0.3528*** (0.0789)		
om			0.0001*** (0.0000)		0.0000 (0.0000)		
spH			0.2114*** (0.0059)		0.2113*** (0.0085)		
$w_i x_{it,1}$						-0.5344 (0.5039)	
$w_i x_{it,2}$						1.3729*** (0.4215)	
$w_i x_{it,3}$						0.4655 (0.4130)	
$w_i x_{it,4}$						1.7374*** (0.3536)	
$w_i x_{it,5}$						1.1152*** (0.3371)	
$w_i x_{it,6}$						2.2673*** (0.3050)	
$w_i x_{it,7}$						-0.3461 (0.2391)	
$w_i x_{it,8}$						0.1989 (0.2423)	
$w_i P_{it}$						0.0003*** (0.0001)	
$w_i P_{it}^2$						-0.0000*** (0.0000)	
t	0.0126***	0.0098***	0.0112***	0.0107***	0.0148***	0.0094***	0.0017***

	(0.0007)	(0.0005)	(0.0005)	(0.0016)	(0.0017)	(0.0005)	(0.0003)
t^2	0.0000***	0.0001***	0.0001	0.0001*	-0.0001***	0.0001***	0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Intercept	3.2321***						
	(0.0523)						
r, γ or ρ				0.8130***	0.8212***		0.7950***
				(0.0036)	(0.0033)		(0.0037)
County FE	No	Yes	No	Yes	No	Yes	Yes
# of Obs.	33,344	33,344	33,344	33,344	33,344	33,344	33,344
SSE	2,316.9	1,186.4	2,420.6	1,234.7	2,234.3	1,171.5	485.2
RMSE	0.2636	0.1886	0.2694	0.1924	0.2589	0.1874	0.1206
APC	0.0695	0.0379	0.0727	0.0371	0.0671	0.0375	0.0146
RMPE	0.2004	0.1517	0.2286	0.1533	0.2380	NA	NA

Notes: * $p < 10\%$, ** $p < 5\%$, and *** $p < 1\%$; Standard errors are reported in parentheses; County FE: county fixed effects; SSE: sum of squared errors; RMSE: root mean squared errors; APC: Amemiya's prediction criterion; RMPE: root mean squared prediction errors for 2013-2018 out-of-sample period.

Table S4. Robustness Check for Data Selection: Counties in 1981-2012

	Balanced Panel Data			Full Data (Unbalanced Panel)		
	Pooled Eq. (3)	FE Eq. (4)	RE Eq. (5)	Pooled	FE	RE
h_{it}	0.0432*** (0.0017)	0.0024* (0.0015)	0.0353*** (0.0007)	0.0550*** (0.0020)	0.0014*** (0.0017)	0.0341*** (0.0007)
h_{it}^2	-0.0001*** (0.0000)	0.0000* (0.0000)	-0.0001*** (0.0000)	-0.0002*** (0.0000)	0.0000*** (0.0000)	-0.0001*** (0.0000)
$\sqrt{h_{it}^e}$	-0.1136*** (0.0013)	-0.1413*** (0.0020)	-0.1359*** (0.0019)	-0.0985*** (0.0013)	-0.1407*** (0.0026)	-0.1265*** (0.0022)
P_{it}	0.0016*** (0.0001)	0.0014*** (0.0000)	0.0017*** (0.0000)	0.0012*** (0.0001)	0.0012*** (0.0000)	0.0013*** (0.0000)
P_{it}^2	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)
whc			0.0152*** (0.0010)			0.0153*** (0.0010)
k-factor			0.5521*** (0.0684)			0.5795*** (0.0621)
om			0.0001*** (0.0000)			0.0001*** (0.0000)
spH			0.1119*** (0.0059)			0.1324*** (0.0060)
t	0.0085*** (0.0007)	0.0084*** (0.0005)	0.0063*** (0.0005)	0.0081*** (0.0008)	0.0015** (0.0006)	0.0013** (0.0006)
t^2	0.0001*** (0.0000)	0.0001*** (0.0000)	0.0002*** (0.0000)	0.0002*** (0.0000)	0.0003*** (0.0000)	0.0003*** (0.0000)
Intercept	0.9685*** (0.1257)			0.2113 (0.1415)		
County FE	No	Yes	No	No	Yes	No
# of Obs.	33,344	33,344	33,344	58,468	58,468	58,468
UniqueN	1,042	1,042	1,042	2,246	2,246	2,246
SSE	2,390.9	1,223.1	2,024.7	10,098.3	5,584.1	5,969.2
RMSE	0.2678	0.1915	0.2464	0.4156	0.3090	0.3195
APC	0.0717	0.0391	0.0608	0.1728	0.0990	0.1021

Notes: * $p < 10\%$, ** $p < 5\%$, and *** $p < 1\%$; Standard errors are reported in parentheses; County FE: county fixed effects; SSE: sum of squared errors; RMSE: root mean squared errors; APC: Amemiya's prediction criterion; UniqueN: # of unique counties for 1981 - 2012.

Table S5. Robustness Check for Time Fixed Effects (Two-way model): Counties in 1981-2012

	FE	SEM	SLX	SAR
	Eq. (4)	Eq. (7)	Eq. (9)	Eq. (10)
h_{it}	0.0042*** (0.0019)	0.0011 (0.0045)	0.0258** (0.0114)	-0.0015 (0.0012)
h_{it}^2	0.0000*** (0.0000)	0.0000 (0.0000)	-0.0001* (0.0000)	0.0000** (0.0000)
$\sqrt{h_{it}^e}$	-0.1468*** (0.0029)	-0.1092*** (0.0056)	-0.0858*** (0.0115)	-0.0366*** (0.0020)
P_{it}	0.0014*** (0.0000)	0.0012*** (0.0001)	0.0012*** (0.0001)	0.0005*** (0.0000)
P_{it}^2	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)
whc				
k-factor				
om				
spH				
$w_i h_{it}$			-0.0320*** (0.0117)	
$w_i h_{it}^2$			0.0001*** (0.0000)	
$w_i \sqrt{h_{it}^e}$			-0.0694*** (0.0121)	
$w_i P_{it}$			0.0003** (0.0001)	
$w_i P_{it}^2$			-0.0000*** (0.0000)	
r, γ or ρ		0.7946*** (0.0038)		0.7800*** (0.0039)
County FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
# of Obs.	33,344	33,344	33,344	33,344
SSE	1,093.1	1,108.8	1,087.3	1,215.1

Notes: * p < 10%, ** p < 5%, and *** p < 1%; Standard errors are reported in parentheses; County FE: county fixed effects; Year FE: year fixed effects, SSE: sum of squared errors; Two-way fixed effects (both county and year fixed effects) models are not available for RE and KKP-RE models.