The Development of a Weather-based Crop Disaster Program

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Motivation

- Recent efforts to provide disaster programs have been implemented through FSA (LFP, LIP, ELAP, NAP).
- Past efforts to provide area products have been unpopular.
- Crop disaster program may still provide safety net at a substantially lower cost.
  - Insurance to guard against only systemic drought risk.
  - Monitoring and administrative cost reduction.
  - Indemnity payments made earlier to reduce timing inefficiencies.

Outline

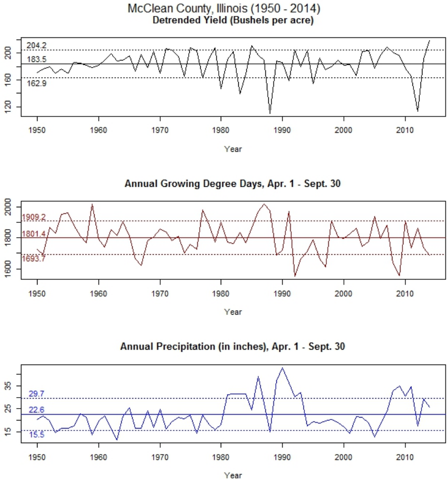
Past Studies

- Weather and yields fitted to examine impacts of predicted climate change (Deschenes and Greenstone, 2007; Schlenker, Hanemann, and Fisher, 2006; Schlenker and Roberts, 2009).
- Fitted relationship to examine the impact from drought on yields (Westcott and Jewison, 2013; Yu and Babcock, 2010).
- Use weather outcomes to inform yield distributions (Cai et al., 2014; Rejesus, et al., 2015).
- Comparison of "free area insurance" versus individual insurance policies (Paulson and Babcock, 2009).

Weather and Yield Data

- Weather station data collected through NOAA's Daily Global Historical Climatology Network (GHCN) dataset.
  - Data are aggregated to the county level.
  - For counties with less than 3 stations, nearest stations are used.
- County-level detrended yields.
- Top 5 corn production states: Illinois, Indiana, Iowa, Minnesota, and Nebraska.

Summary plots for weather and production variables for McClean County, Illinois, 1950-2014



Yield Regression

The following indices were computed for the county, agricultural district, and state:

$$
\begin{aligned}
IP_{Git} &= GDD_{Git} * (-PRCP_{Git}) \\
IS_{Git} &= GDD_{Git} - PRCP_{Git}
\end{aligned}
$$

where

$$
\begin{aligned}
GDD_{dit} &= max\left(\frac{T_{min} + T_{max}}{2} - 50, 0\right) \\
GDD_{Git} &= max\left[\frac{\left(\sum_{d=1}^{D} GDD_{dit}\right) - mean(GDD_{Gi})}{std(GDD_{Gi})}, 0\right] \\
PRCP_{Git} &= min\left[\frac{\left(\sum_{d=1}^{D} PRCP_{dit}\right) - mean(PRCP_{di})}{std(PRCP_{di})}, 0\right]
\end{aligned}
$$

for G =two-month time period, i =county, d =day, t =year.

Yield Regression

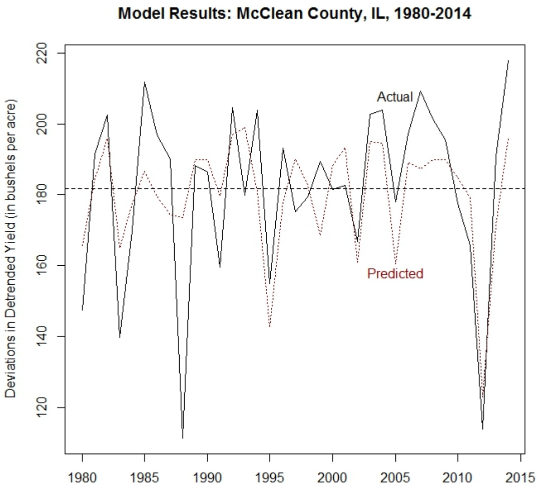
$$\begin{aligned} Y_{it} &= \beta_0 + \beta_1 IS_{Git} + \beta_2 IS^2_{Git} + \beta_3 IP_{Git} + \beta_4 IP_{it} + \beta_5 IP^2_{it} \\ &+ \beta_6 IP_{At} + \beta_7 IP^2_{At} + \beta_8 IP_{St} + \beta_9 IP^2_{St} + e_{it} \end{aligned}$$

- Y_{it} is the standardized yield deviations for county i in year t.
- Regressions run separately by state.
- i =county, A =Agricultural district, S =State.

Regression Results, by State, 1980-2015 (Dependent Variable: Stardized Yields)

	Illinois (n=79)				Indiana (n=66)				Iowa (n=99)			
	Parameter Estimate	Standard Error	T-stat		Parameter Estimate	Standard Error	T-stat		Parameter Estimate	Standard Error	T-stat	
Intercept	0.392	0.034	11.557	***	0.336	0.036	9.365	***	0.011	0.030	0.385	
IS_AM	1.237	0.105	11.807	***	1.633	0.114	14.314	***	0.873	0.092	9.468	***
IS_AM^2	-0.838	0.089	-9.413	***	-1.137	0.092	-12.344	***	-0.380	0.068	-5.605	***
IS_JJ	-0.955	0.092	-10.347	***	-0.633	0.054	-11.625	***				
IS_JJ^2	0.324	0.070	4.601	***					-0.104	0.046	-2.282	*
IS_AS	-0.579	0.085	-6.792	***	-0.527	0.056	-9.469	***				
IS_AS^2	0.105	0.047	2.214	*					-0.337	0.030	-11.108	***
IP_AM	1.490	0.227	6.554	***	1.888	0.251	7.520	***	0.341	0.197	1.731	.
IP_JJ	-1.326	0.184	-7.200	***	-0.725	0.124	-5.842	***	-1.349	0.216	-6.235	***
IP_AS					0.841	0.138	6.098	***	0.836	0.172	4.870	***
IP	0.774	0.150	5.156	***	0.356	0.096	3.713	***	0.963	0.196	4.924	***
IP^2	-0.240	0.055	-4.349	***					-0.267	0.064	-4.196	***
IPD	-2.097	0.286	-7.342	***	-2.851	0.379	-7.528	***	-3.028	0.436	-6.944	***
IPD^2	1.186	0.178	6.678	***	2.515	0.336	7.488	***	1.269	0.367	3.457	***
IPS	3.552	0.568	6.259	***	5.603	0.685	8.180	***	3.842	0.969	3.966	***
IPS^2	-9.574	0.923	-10.369	***	-13.921	1.244	-11.194	***	-3.602	1.186	-3.037	**
Adjusted R^2	0.439				0.400				0.188			

Plot of actual detrended versus predicted yields for McClean County, Illinois, 1980-2015



Model Fit Regression Summary Statistics, by State, 1980-2015

State	n	Adjusted R^2
Illinois	79	0.439
Indiana	66	0.400
Iowa	99	0.188
Minnesota	58	0.167
Nebraska	77	0.170
All States	379	0.202

Departures from Previous Efforts to Model Yields

Yu and Babcock (2010)

- $Y_{it} = \beta_0 + \alpha_i + \sum_{r=1}^{R} \gamma_r (CRD_r \times T) + \beta_1 DI_{it} + \beta_2 DIT_{it} + \beta_3 DI_{it}^2 + \beta_4 DIDIT_{it} + e_{it}$
- DI uses Cooling Degree Days
- Index constructed at county-level (similar results with ag. district model)

Westcott and Jewison (2013)

- $Y_t = \beta_0 + \beta_1 T + \beta_2 PlantProg_{midMay} + \beta_3 TEMP_{July} + \beta_4 PRCP_{July} + \beta_5 PRCP_{July}^2 + \beta_6 PRCP_{June} I(< .10) + e_t$
- Aggregates weighted by harvested corn acres.
- Data are used from 1988 - 2012.

Departures from Previous Efforts to Model Yields (cont.)

Schlenker and Roberts (2009)

- $y_{it} = \int_{low}^{high} g(h)\phi_{it}(h)dh + z_{it}\delta + c_i + e_i t$
- Includes weather between March to August for corn/soybeans.
- Finely scaled data from PRISM (2.5 mile squared).
- Weather data are aggregated to county-level to match yield data.

Deschenes and Greenstone (2007)

- $V_{it} = \alpha_i + \alpha_t + \beta_1 X_{it} + \sum_h \theta_h f_h(\bar{W}_{hi}) + \alpha_i + e_{it}$
- Farmland values (V) is the variable of interest.
- Use PRISM weather data and aggregate to county level.
- Soil quality data are included.
- h includes linear and quadratic terms for *PRCP* and *TEMP* in January, April, July, and October.

Farm-level Simulation Methodology

- Use a simulation model based on Cooper (2010) and Cooper and Delbecq (2014).
    - County based model generates representative producer yields and prices.
    - Each run consists of 10,000 draws of price and yield deviates.
    - Generate county yields and add variability to obtain representative producer yields based on crop insurance county base rates.

Farm-level Performance

- Each state utilizes its unique regression results with county covariates.
- Individual historic and actual yields are simulated using simulatoin procedure from Cooper (2010) and Cooper and Delbecq (2014).
- Indemnities are received when predicted county-level yields are below county-level trigger.
- Weather program is compared to Revenue Protection at 75% coverage level.

Preliminary Results

- Effective premium under disaster program is \$19.53, relative to \$34.64 for RP.

- Disaster program reduces revenue CV by 16.9%, relative to 29.7% for RP.

Future Endevours

- Deeper analysis of farm-level simulation results.
- Out-of-sample examination of model fit excluding counties and years.
- Extend analysis to include top producing states of soybeans, wheat, and cotton.
- Include estimated administrative cost of programs into analysis.

Thank you for your time.

Questions?

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