10. Historical Impacts of Precipitation and Temperature On Farm Production in Kansas

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Abstract/Summary

Using a continuous set of Kansas Farm Management Association farms, we quantify weather effects on crop and livestock output and farm incomes. The effects of weather are largely asymmetric, with temperature and precipitation values below average affecting output and income differently than observations lying above a farm's long-term average. Precipitation effects depend on timing during the production year. The number of days exceeding 90^{o} F (i.e., the "hot" years) negatively impact production and income, though the impact reverses (i.e., is positive) for crop output in the cooler years. The results indicate the importance of including weather in predicting output and net farm income and designing and adopting risk management instruments to mitigate weather trends and variability.

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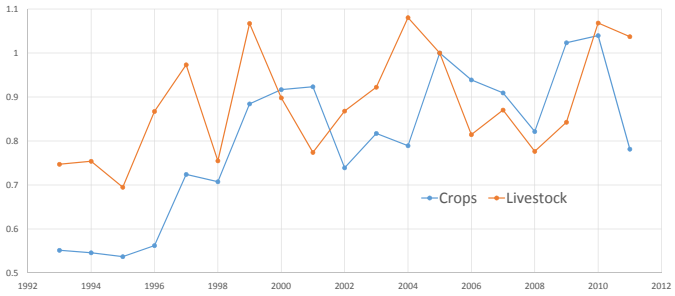
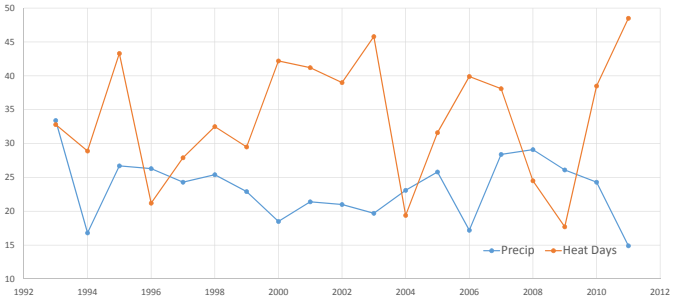
Overview of the talk:

- Using data from 331 KFMA members from 1993-2011
- Investigate the impacts of farm inputs on a combined measure of crop & livestock output
- Since there is so much variation in output and in weather variables over the years, investigate as well the impact of the number of heat days and precipitation (as well as farm inputs) on output
- Finally, can the weather observations be linked to the Value of Farm Production?

Crop & Livestock Output – 331 KFMA Farms



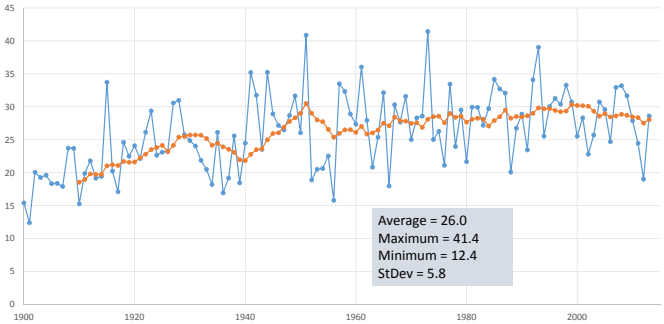
Farm Average Precipitation & Days over 90°



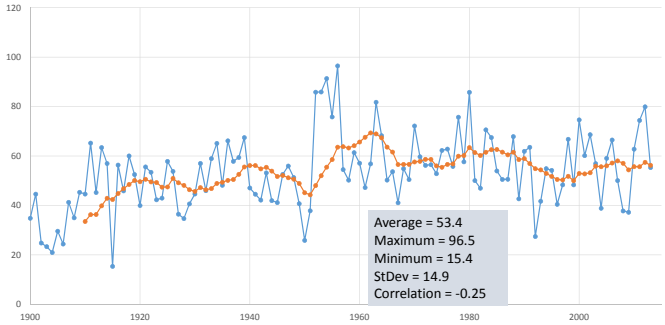
This is of more than casual interest…

- Average January-October precipitation: 23.4 inches
  - Highest value: 33.4 inches (1993)
  - Lowest value: 14.9 inches (2011)
- Average number of days over 90°: 33.8
  - Highest value: 48.5 (2011)
  - Lowest value: 17.7 (2009)
- Correlation between the two: -0.44

County Average Precipitation, 1900 - 2013



County Average Days over 90°, 1900 - 2013



Are there trends?

- Models were run to detect trends in
  - Total annual precipitation
  - Number of days each year over 90°
- Using the 10-year averages,
  - There was an upward trend between year and precipitation
  - No (statistically significant) trend was seen between year and number of days over 90°

Question:

Can the correlation between weather and farm production be measured?

From the KFMA data,

- Can compare farm output levels (both crops and livestock) to farm inputs:
  - Hired and unpaid labor
  - Fuel & energy (fuel, vehicle, irrigation energy, & utilities)
  - Other inputs (repairs, machine hire, farm insurance, property taxes, organization fees, conservation costs, interest, farm rents, opportunity cost of equity)
  - Crop and livestock inputs
    - (Crops: seed, fertilizer, chemicals, crop marketing and storage, crop insurance costs;
    - Livestock: dairy costs, purchased feed, veterinarian expenses, livestock marketing expenses, and breeding costs)

In addition,

- Include farm weather observations that might affect production:
  - <u>Precipitation</u>
    - January – April
    - May – July
    - August – October
  - <u>Days over 90°</u>
    - May - October

Weather average values:

	January to April Precipitation	May to July Precipitation	August to October Precipitation	Days Over 90°
State (n = 6289)	8.0	13.9	9.5	50.4
NC (n = 1064)	6.9	13.1	8.7	54.1
SC (n = 1159)	6.9	12.5	8.4	62.7
SW (n = 304)	4.9	8.9	6.2	60.9
NE (n = 1064)	8.1	14.5	10.5	39.2
NW (n = 228)	3.9	8.9	6.0	56.5
SE (n = 2470)	9.7	15.7	10.7	45.7

Model:

- We use 19 years of observations on farm output (crops and livestock combined) for 331 KFMA farms
- Output is a function of:
  - Farm inputs
  - Weather variables
- Variables are all expressed as percentage differences from the farm average
  - i.e., if output is equal to the average, its value is zero. If output is 10% above the 19 year average for that farm, its value is 0.10, etc.

Dependent variable:
Crop & Livestock Output deviation from farm average

Farm Inputs	Coefficient	T-ratio
Constant	0.0055	0.56
Time Trend	0.0088	11.87***
Labor	0.0908	6.86***
Fuel & Energy	0.1948	16.86***
Other Inputs	0.2276	16.63***
C & L Inputs	0.3544	38.55***
Significant at the: 90% level *; 95% level **; 99% level ***		

Dependent variable:
Crop & Livestock Output deviation from farm average

Farm Inputs	Coefficient	T-ratio
Dt1_pos	-0.1106	-5.95***
Dt1_neg	0.0536	3.21***
Tpct_JanApr	0.0900	9.86***
Tpct_MayJul_pos	-0.1882	-14.24***
Tpct_MayJul_neg	0.1728	9.81***
TpctAugOct_pos	-0.0609	-4.55***
TpctAugOct_neg	0.0884	4.98***

What do these results show?

- Farm inputs all have a positive effect on output
- Combined impact of farm inputs show DRTS: Sum = 0.87, with a t-ratio of 54.80
- There has been a 0.88% increase in farm output each year for these 331 farms
- Weather effects are mostly asymmetric:
  Too much is not a good thing

Number of days over 90°
When above farm average, more days have a negative effect on output, but a few more warm days when the number of hot days are lower than average is good

Precipitation

Jan-Apr
– more precipitation increases output (0.09%)

May-Jul
– When low, each 1% increase in precipitation increases output by 0.17%
- When above average, each 1% increase reduces output by 0.19%

Aug-Sep
– When low, each 1% increase increases output by 0.09%.
- When above average, each 1% increase reduces output by 0.06%

Ignoring farm inputs, is there a relationship between output and the value of farm production (VFP)?

Correlation Coefficients:

Output	Real VFP	Real NFI	
1	0.93	0.67	Output

Dependent variable:
Value of Farm Production (Deviation from farm average)

Weather	Coefficient	T-ratio
Dt1_pos	0.0682	2.34**
Dt1_neg	-0.2840	-10.78***
Tpct_JanApr_pos	-0.0592	-2.28**
Tpct_JanApr_neg	-0.1355	-4.67***
Tpct_MayJul_pos	-0.1165	-5.58***
Tpct_MayJul_neg	0.1689	6.00***
Tpct_AugOct_pos	-0.0151	-0.71
Tpct_AugOct_neg	0.0941	3.31***

Good news / Bad news

- Weather appears to affect VFP and NFI
- Coefficient of determination (r^2) for VFP model is very low
  - Only 2% of the variance in VFP is explained by the model
  - Increases to 53% if include farm inputs (e.g., labor, fuel)

What about 2012 and 2013?

Predicted Values – all counties (i.e., not farms!)

	2012	2013
	Value of Farm Production	Value of Farm Production
1 – NC	-0.09	-0.01
2 – SC	-0.10	0.00
3 – SW	-0.11	0.01
4 – NE	-0.06	0.01
5 – NW	-0.11	-0.03
6 – SE	-0.09	-0.01

But remember,

the model did not predict well!

Changing management (e.g., increasing input levels) can offset the effects of the models using just the weather events.

In conclusion,

- The model was fit to 331 KFMA members for whom continuous records were available from 1993-2011
- There was considerable variation in crop and livestock production
- There was considerable variation in extreme heat days and precipitation

Production and weather were related!

Days above 90°

If the number of days were above average, additional days had a negative effect on crop & livestock output.

If the number was below average, additional days had a positive effect.

Precipitation – January to April

Additional precipitation had a positive effect

Precipitation – May to October

If precipitation was above average, additional precipitation had a negative effect

If precipitation was below average, additional precipitation had a positive effect

On a positive note,

- Both output levels and VFP are affected by weather, but management decisions (such as input use) have a greater impact.

Participant suggestions for future work

- Separate data into those years with "good" weather and those years with "Bad" weather
  - Early models – just splitting observations based on number of years above and below average number of days over 90° had a minor effect on outcomes: Fuel and energy use impacts increased in the "hot" years, maybe consistent with greater use of irrigation and other energy costs to offset more days over 90°
- Estimate models for each of the 6 KFMA regions to capture differences in topography and "normal" weather
- Include a measure of evapotranspiration to capture combined effects of heat, precipitation and humidity. Some researchers have used the "Temperature-humidity index" – the model can expanded to include either this index or crop evapotranspiration

Participant suggestions for future work

- Timeliness of temperature and precipitation is important – can the weather variables be further disaggregated to include, say, "normal" precipitation during a period, but crops still suffer because they went too long without any precipitation (and not captured by the aggregate weather variables used)?
- And PLEASE, if you have any other ideas please give me a call or send me an email and I'll include them:

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