Natural Hedge Effects on Revenue Stability and Crop Insurance Decisions

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What is the natural hedge?

- Shocks to yields can have a large impact on producers' revenues.
- But often, such shocks are geographically wide enough that the supply curve shifts and prices rise.
- This price rise potentially mitigates the impact of the yield shock on revenue.
- This inverse relation between prices and yields is called the *natural hedge*.

Does the natural hedge actually matter?

- While intuition suggests that the natural hedge has a stabilizing effect on revenue, little empirical evidence of such an effect exists.
  - We test the effect of the natural hedge on long-run revenue variability.
- The role of the natural hedge in explaining crop insurance participation also remains under-examined.
  - Intuitively, producers for whom the natural hedge is largest will demand less crop insurance, *ceteris paribus*, thanks to the revenue stabilizing benefits conferred by the natural hedge.
  - We test the effect of the natural hedge on different measures of crop insurance participation.

Towards a more “natural” natural hedge

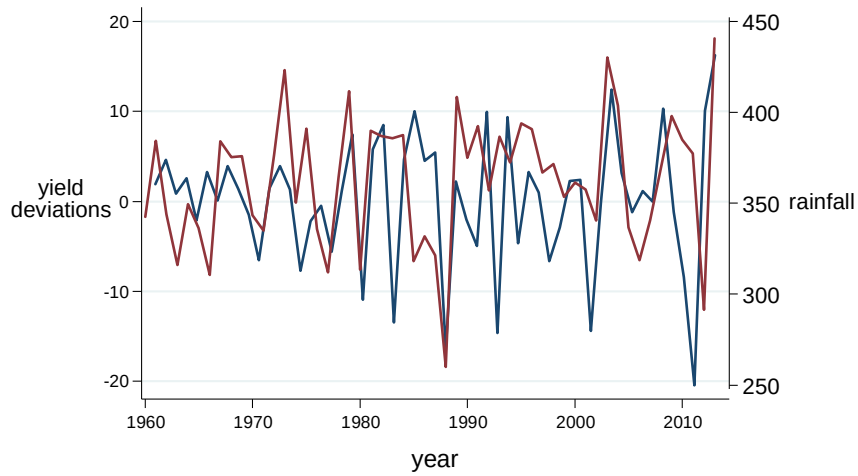
- The traditional measure of the natural hedge ignores the potential endogeneity of yields and prices.
  - For example, prices can affect planting on marginal acres with the effects felt on average yields.
  - Prices can also affect producers’ decisions to apply inputs, which can also change yields.
- We propose a new, more “natural” natural hedge, which relies on an exogenous determinant of yields, namely planting season rainfall.

Data and methodology (I)

- We collect annual, county-level data on yields and prices from the National Agricultural Statistical Service (NASS) for the period 1960-2014
  - Corn, soybeans, wheat, rice, and cotton
  - Prices are deflated using the Bureau of Labor Statistics Producer Price Index for Farm Products for each crop.
  - Yields over time are straight line detrended.
- We collect planting season rainfall data from the PRISM data base (1960-2014) at Oregon State University and funded by the USDA's Risk Management Agency.
- We collect county-level insurance data from the Risk Management Agency for year 2014.
- We calculate county-specific correlations between (1) prices and yields and (2) prices and rainfall.
  - These variables represent the two natural hedge measures we aim to test in our formal model.

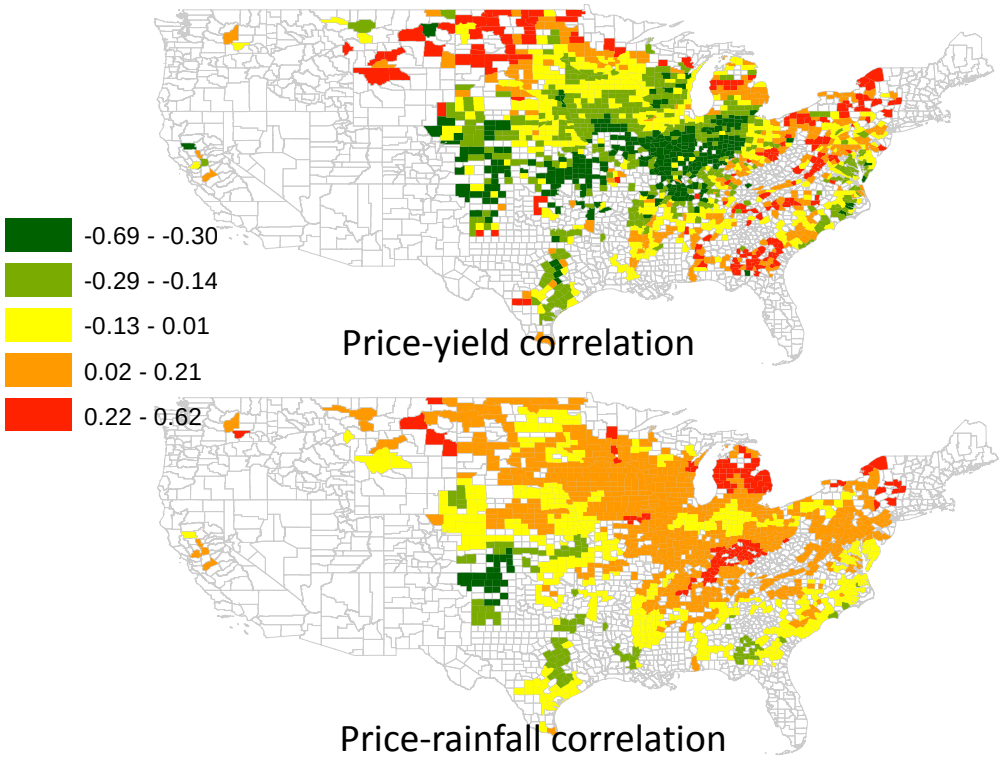
Data and methodology (II)

- To calculate the traditional natural hedge:
  - We detrend county-specific annual yields from 1960-2013 to reveal the deviations from the average.
  - We deflate national crop prices using the Bureau of Labor Statistic's sector and crop-specific Producer Price Index.
  - For each county, we calculate the correlation of yields and prices, generating the traditional measure of the natural hedge.
- To calculate the alternative, more "natural," natural hedge:
  - We rely on the same county yields as above.
  - We observe county-specific total rainfall in April, May, June, and July for each year over the period 1960-2013.
  - For each county, we calculate the correlation of yields with rainfall, generating the alternative measure of the natural hedge.



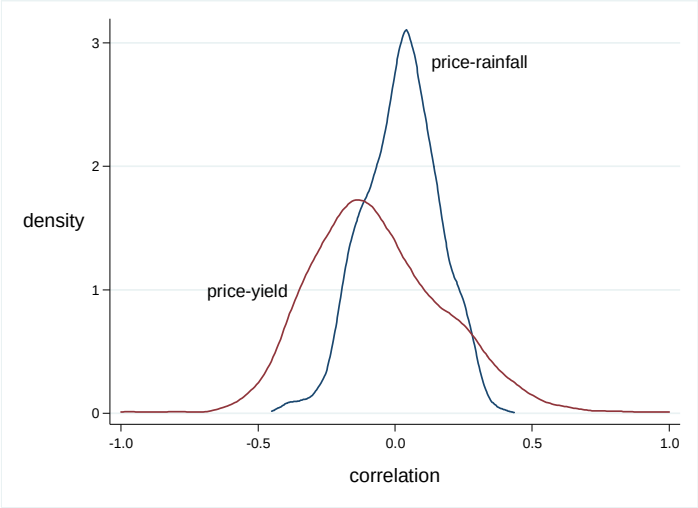
County-level yield (detrended) and rainfall in the United States, 1960-2014

Comparing the two measures of natural hedge: the case of corn

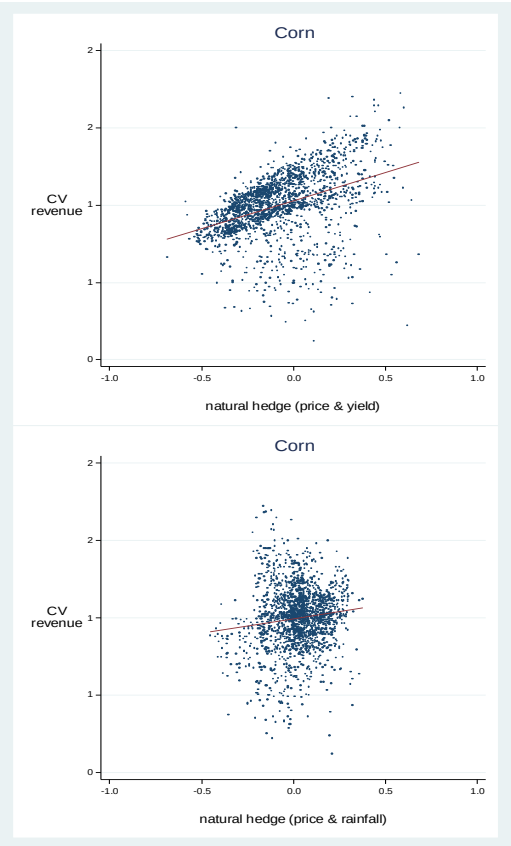


Dark green represents large negative correlations. Dark red represents large positive correlations. Counties depicted in white reflect (1) zero production in 2014 or (2) lack of county-level data, due to NASS aggregations.

- The price-yield natural hedge shows strong inverse correlations, particularly in the Corn Belt.
- But the price-rainfall measure shows a much less pronounced correlation.
- A comparison of the distribution of county-level correlations confirms that the spread of correlations is much greater under the traditional measure.



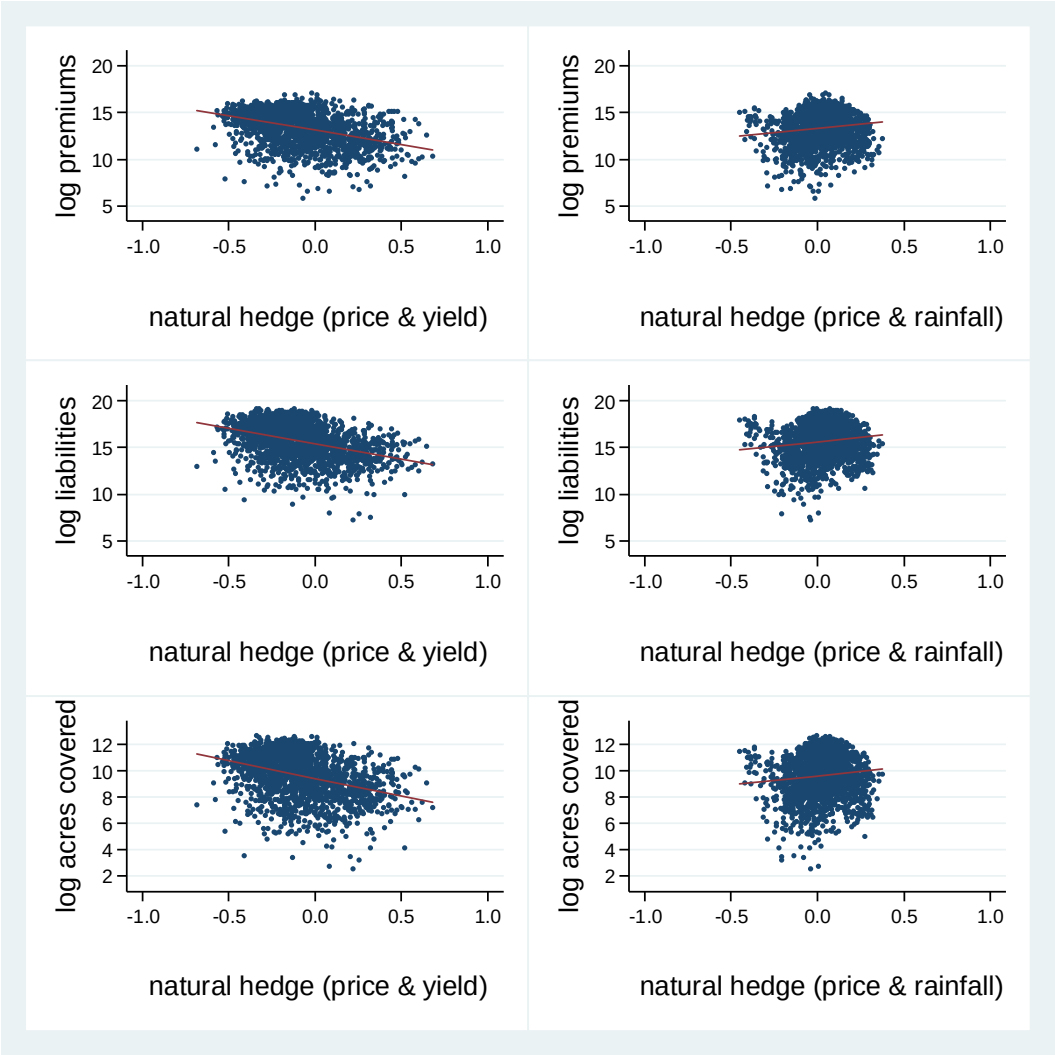
Correlations of natural hedge with revenue volatility: the case of corn



- Given the difference between each of the measures, we observe the effect of each measure on revenue volatility, measured as the coefficient of variation of revenue over the period 1960-2014.
- In both measures of the natural hedge, revenue volatility is reduced as the correlation becomes more negative.
- But the more “natural” price-rainfall measure appears weaker than the traditional price-yield measure.

Correlations of the natural hedge with insurance uptake: the case of corn.

- But does a location's long-run natural hedge potentially affect producers' present-day insurance decisions?
- Intuitively, locations with the highest natural hedge (i.e. where the correlation is most negative) will demand less insurance, ceteris paribus.
- We use several measures of insurance participation: (1) total acres under coverage (2) total premiums and (3) and total acres covered.
- The correlations depicted on the right reveal that only the price-rainfall measure of the natural hedge operates according to intuition, i.e. the greater the natural hedge, the lower the demand for insurance.



Estimating a simple model: the case of corn

- We formally estimate the effect of each measure of the natural hedge on revenue variability and insurance uptake.
- 7 out of 8 estimated signs match the correlations depicted in the graphs above.
- Statistical significance however is spotty across all specifications, suggesting that the natural hedge, in whichever form we specify it, appears not to exert a detectable effect on certain outcomes.
- Additional explicit controls are necessary, including known correlates with rainfall (e.g. temperature), as well as controls for spatially correlated unobservables.

	CV revenue		log premiums		log liabilities		log corn acres covered	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Natural Hedge (price-yield)	**0.307*** **		**-0.372** **		**-0.164* **		**-0.112**	
	(0.053)		(0.148)		(0.09)		(0.0686)	
Natural Hedge (price-rainfall)		**0.083**		**0.696** **		**-0.358**		**0.153**
		(0.06)		(0.335)		(0.246)		(0.101)
Log corn acres			0.951***	0.980***	1.145***	1.147***	1.019***	1.027***
			(0.0246)	(0.0273)	(0.0107)	(0.0106)	(0.0117)	(0.0135)
Constant			3.848***	3.617***	4.276***	4.248***	-0.446***	-0.510***
			(0.208)	(0.228)	(0.0906)	(0.0896)	(0.0987)	(0.114)
State effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
n	1,860	1,860	1,424	1,424	1,424	1,424	1,424	1,424
R-square	0.57	0.5	0.94	0.94	0.976	0.976	0.982	0.982

Conclusions

- This research attempts to quantify the effect of the natural hedge on two important farm outcomes: revenue stability and insurance participation.
- We consider an alternative measure of the natural hedge that relies strictly on rainfall, not yield, as a correlate of prices, to make the natural hedge more "natural."
- Results suggest that both measures of natural hedge exert a dampening effect on long-run revenue volatility.
- However, the effects of each measure on insurance outcomes have opposite signs, suggesting that only the more "natural" measure has the predicted effect on premiums, liabilities, and covered acreage.
  - The statistical significance of the estimates, however, leave room to doubt whether these effects aren't appearing by chance.