Challenging Belief in the Law of Small Numbers

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The Risk Management Context

- Has risk changed?
- Have the tools changed   Yes!
  - Crop Insurance + ARC + SCO + AMP
    - Layers of instruments
    - Price versus revenue
    - FSA versus crop insurance
    - Choice of opting out
    - Choice of coverage level

A Teachable Moment?

- The more complex the problem the more likely we will be asked for guidance.
- What approach should one take when asked for risk management recommendations?
  - Hippocrates “ first do no harm”
  - “If they want it bad they will get it bad.”
- Our premise in this paper
  - We can improve producer risk management
    - if the right approaches are taken
    - caution is merited

Progress in Risk Modeling

- Risk research has moved forward
  - analytical tools
  - Financial tool design
  - risk behavior and perceptions.
- Spreadsheet on laptops versus main frame computers 25 years ago.
  - optimization and simulation packages
- Data Availability
  - NASS area-level production, acreage and prices
  - weather data are available from NOAA
  - futures prices are widely available from private sources

What has not changed

- weather and related risks still drive crop yield risk
  - farm-level time-series yield data tend to be scarce and relatively short
  - Technological change implies changing distributions
- Price level and risk may have changed
  - Pre – Post RFS
- How many observations are enough observation to accurately portrait the decision faced by the producer?
  - 5
  - 25
  - 50
  - More?

Tversky and Kahneman: The Law of Small Numbers

- People believe samples to be very similar to one another and to the population from which they are drawn
- People believe sampling to be a self-correcting process.
  - Both result in variability of expectations is less than the true variability of small samples.

Tversky and Kahneman: The Law of Small Numbers

- The law of large numbers implies large samples will be representative of the population from which they are drawn.
  - People's intuition about random sampling appear to satisfy the law of small numbers, which asserts that the law of large numbers applies to small samples as well.

The Law of Small Numbers and Agricultural Risk

- In the case of yield and revenue associated with crop agriculture we get essentially one observation per year.
- At that rate of stochastic revelation, small samples grow quite slowly into large samples.
- The TK results would seem broadly applicable to those working with agricultural risk decision making
  - Our search of the SCOPUS abstracting database finds that their paper is cited 445 times in refereed literature, but not once by an agricultural economics journal.

The Law of Small Numbers and Agricultural Risk

- Producer behavior if they believe in the law of small numbers
  - too much weight on an evaluation based on very small samples.
    - “show us what the policy would have done if in place for the last five years.”
  - Discounting weather events that are known to have occurred with some frequency but not recently
    - The idea that ‘bad weather and good weather must average each other out. ”

The Law of Small Numbers and Agricultural Risk

- Do systemic biases and heuristics being used in in statistically small samples has the potential to affect farm policy evaluations
  - the demand for crop insurance and why subsidies have appeared necessary to attract participation in crop insurance.
  - Evaluation of a five year farm bill

The Law of Small Numbers and Agricultural Risk

- TK's paper was not addressing errors made by laymen.
  - TK pointedly described errors made by scientists in doing their research!
  - The fundamental error was misjudging the sample size necessary to make a statistically valid inference.
- This is a problem that has persistently plagued agricultural policy and insurance research.
- In much of the risk management literature optimization and simulation techniques are used and hypothesis tests omitted.
  - Without these tests, there may be a lack of restraint on conclusions drawn from sample samples.

Empirical Analysis

- Investigate the implications of sample size on the evaluation of two simple crop insurance purchase decisions
  - individual coverage revenue insurance
  - area revenue triggered SCO
- We evaluate how well a particular estimation or statistical procedure performs given hypothetical, but known distributions.
  - We do know the true distribution of crop revenue for any particular crop/location
  - we generate data from a known distribution to investigate the implications of sample size on the modeling.

Data

	Corn Farm Revenue	Corn County Revenue	Soybean Farm Revenue	Soybean County Revenue
Mean	783.4	783.4	577.2	607.7
Standard Deviation	195.7	136.0	116.4	64.9
C.V.	0.25	0.17	0.20	0.11
	Cotton Farm Revenue	Cotton County Revenue	Wheat Farm Revenue	Wheat County Revenue
Mean	589.0	544.3	96.6	95.6
Standard Deviation	334.8	145.2	54.9	34.5
C.V.	0.57	0.27	0.57	0.36

Effect of Sample Size

	McLean Co Ill. Corn		McLean Co Ill. Soybeans	
	(1)	(2)	(3)	(4)
	75% coverage CRC	SCO 90% to 75%	75% coverage CRC	SCO 90% to 75%
Mean Premium/Ac.	23.13	28.33	10.94	11.13
	Sample size 10			
Std Dev	18.46	14.18	10.03	7.39
C.V.	0.80	0.50	0.92	0.66
	Sample size 20			
Std Dev	13.15	10.07	7.04	5.19
C.V.	0.57	0.36	0.64	0.47
	Sample size 30			
Std Dev	10.76	8.24	5.72	4.22
C.V.	0.47	0.29	0.52	0.38

Shallow loss rates are more stable than deep loss rates

	McLean Co Ill. Corn		McLean Co Ill. Corn	
	(1)	(2)	(3)	
	75% coverage CRC	SCO 90% to 75%	65% coverage CRC	SCO 90% to 65%
Mean Premium/Ac.	23.13	28.33	9.96	33.56
	Sample size 10			
Std Dev	18.46	14.18	11.16	18.21
C.V.	0.80	0.50	1.12	0.54
	Sample size 20			
Std Dev	13.15	10.07	7.93	12.96
C.V.	0.57	0.36	0.80	0.39
	Sample size 30			
Std Dev	10.76	8.24	6.48	10.60
C.V.	0.47	0.29	0.65	0.32

Changing Coverage

	McLean Co Ill. Corn		McLean Co Ill. Corn	
	(1)	(2)	(3)	
	75% coverage CRC	SCO 90% to 75%	65% coverage CRC	SCO 90% to 65%
Mean Premium/Ac.	23.13	28.33	9.96	33.56
	Sample size 10			
Std Dev	18.4[illegible]	14.18	11.16	18.21
C.V.	0.80	0.50	1.12	0.54
	Sample size 20			
Std Dev	13.15	10.07	7.93	12.96
C.V.	0.57	0.36	0.80	0.39
	Sample size 30			
Std Dev	10.76	8.24	6.48	10.60
C.V.	0.47	0.29	0.65	0.32

Riskier Regions have more stable rates

SCO 90& to 75%	Ill Corn	MS Cotton	TX Cotton	KS Wheat
Mean Premium/AC	28.33	33.66	31.49	$5.55
	Sample Size 10			
Std Dev	11.63	12.37	11.20	2.18
C.V.	0.41	0.37	0.36	0.39
	Sample Size 20			
Std Dev	10.07	8.68	7.96	1.53
C.V.	0.36	0.26	0.25	0.28
	Sample Size 30			
Std Dev	8.24	7.06	6.53	1.25
C.V.	0.29	0.21	0.21	0.23

Suggestions

- We need to be ever vigilant of falling into the fallacy of the law of small numbers
  - this takes intellectual discipline
  - we should hold one another accountable for avoiding these errors when evaluating risk management analysis.
  - given the paucity of citations to TK’s work in our literature are we attuned to the issue

Suggestions

- when using simulation or optimization packages to evaluate insurance and farm programs, we need to clearly acknowledge that often we are positing alternative estimators.
  - For example, if you evaluate the expected indemnity of a75 percent coverage RP insurance policy and compare the results to the rates offered by USDA/RMA, then your estimate and that of RMA are competing estimators of the same risk.
  - should not assume one estimator is correct and deviation is error on the part of another estimator.
  - Out-of-sample competition

Suggestions

- In terms of our analysis that may be constrained by small samples, we see two primary means to mitigate the issue.
  - augmenting short time series with longer aggregate series of related data
  - Weather weighting
- Training producers to be more sophisticated risk assessors and managers
  - Our tendency in outreach and extension programs is to focus on tools and results not the intellectual process used by the producer
  - Can we teach producers to avoid certain behavioral errors in judgment?