Studying Conservation Practices and Fertilizer Use with Multilevel and Structural Equation Models

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Introduction

- Agriculture is a significant source of water impairment due to soil and nutrient run-off (EPA 2014)
- Conservation practices are intended to reduce agricultural impacts (Robertson and Vitousek 2009)
  - Out of field practices intercept soil and nutrients
  - In-field practices retain and contribute to soil and nutrients
- Expectation that in-field conservation practices reduce amount of fertilizer needed (Odum 1984; Robertson and Harwood 2013; Robertson and Vitousek 2009)
  - Incentive to adopt practice
  - Off-sets costs of practice adoption
- Do farmers actually reduce fertilizer use when using conservation practices?
- Do they do so enough to actually make a difference in environmental quality at a larger scale?

Research Question

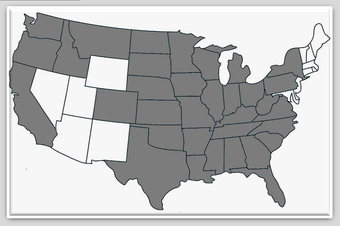
- Does the use of in-field conservation practices reduce the amount of fertilizer applied per acre?

Conclusions

- Cover crops → increases fertilizer use
- Conservation tillage → decreases fertilizer use
- No-till → decreases fertilizer use
- Higher value land → increases fertilizer use
- Rented land→ decreases fertilizer use
- Still lots of room for model improvement
- There is significant variation in fertilizer use between states so it is important to use a multilevel model
- In future use multilevel structural equation modeling (MSEM) to account for counties nested in states as well as indirect effects

Data and Sample

- 2012 Census of Agriculture
- County level data for 34 states
  - With data for 25+ counties per state
  - N = 2,293



Analytic Methods

- Multilevel regression using HLM 7 with counties nested in states (2 level model)
  - Doesn't assume independence of observations
  - Can control for and explain variation at multiple levels
  - More accurate standard errors when there is significant grouping of observations
  - Random effects (error terms) are included in intercept and can be included for slopes
- Structural equation modeling (SEM) using LISREL 9.1
  - An advanced form of path analysis that calculates all path equations at once
  - Allows modeling of direct, indirect and total effects
  - Allows modeling of reciprocal effects and feedback loops
  - Can include both observed and latent variables

Variables

All are at county level:

- **Fertilizer per Acre**—dollars spent on fertilizer per acre fertilized in the county (logged)
- **Cover Crops—**ratio of acres in cover crops to acres of cropland (logged)
- **Conservation Tillage**—ratio of acres in conservation tillage to acres of cropland (logged)
- **No-Till**—ratio of acres in no-till to acres of cropland (logged)
- **Land Value**—average estimated market value of land and buildings per acre in dollars (logged)
- **Rented Land**—ratio of rented acres to acres of farmland (logged)

Multilevel Models

- 1-way ANOVA (null model)—Not shown
  - Only includes the dependent variable and random effects at both levels
  - **44.8%** of the variance in county level fertilizer use per acre is between states (is significant)
- Random Coefficient Regression Model (RCRM)—Table
  - A random slope model with level-1 predictors and random effects at level-2 in intercept and slope

Descriptive Statistics (not logged)

	Mean	Std. Dev.	Min	Max
Fertilizer per Acre	149.364	101.688	15.802	1916.667
Cover Crops	0.035	0.042	0.000	0.511
Conservation Tillage	0.147	0.123	0.000	0.558
No-Till	0.212	0.185	0.000	0.923
Land Value	3647.565	2896.992	405.000	86616.000
Rented Acres	0.387	0.146	0.013	0.922
N = 2293				

Next steps

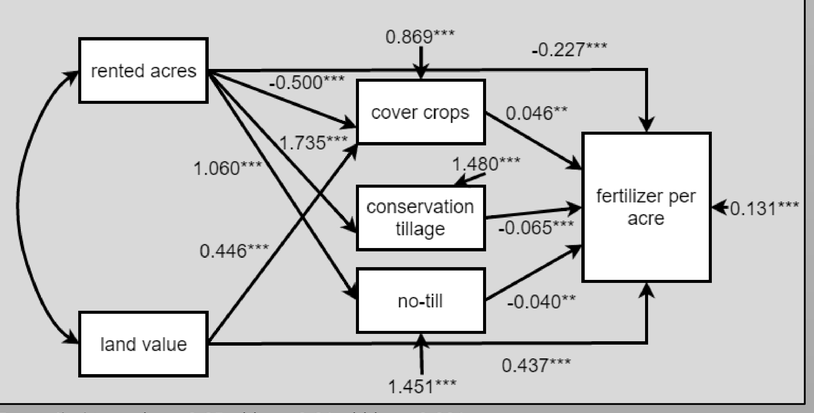
- Adding additional variables to model
  - Ecological variables
  - Demographic variables
  - Economic variables
  - Agricultural variables
- Sub-models of conservation practice use
- Looking forward to getting 2017 Ag Census data!

Multilevel RCRM for Fertilizer per Acre (logged)

	Model 1		Model 2	
	Fixed Effects	Random Effects	Fixed Effects	Random Effects
Cover Crops (logged)	**0.069** (0.019)**	0.010***	**0.043** (0.015)**	0.005***
Conservation Tillage (logged)	-0.016 (0.022)	0.013***	-0.017 (0.016)	0.006***
No-Till (logged)	**-0.057** (0.014)***	0.004***	**-0.051** (0.014)***	0.004***
Land Value (logged)			**0.282** (0.034)***	0.029***
Intercept	4.898 (0.059)***	0.120***	4.898 (0.059)***	0.120***
County Level Random Effect		0.102***		0.084

Two-tailed test * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

SEM Model for Fertilizer per Acre (logged)



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References

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