Modeling No-Tillage Adoption by Corn and Soybean Producers: A Binary Panel Approach

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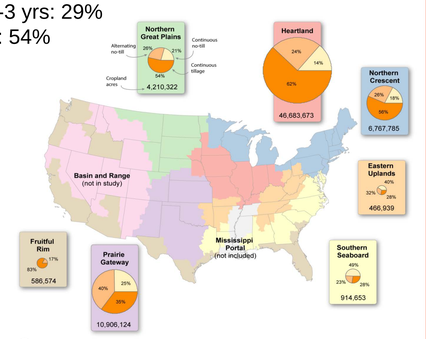
Introduction

- No-till acreage has increased in recent years but many farmers use the practice intermittently
  - Off-farm benefits: cleaner water, cleaner air, and improved carbon sequestration.
  - On-farm benefits: soil moisture conservation, reduced erosion, increase soil organic matter, improved soil aggregate size and stability, etc.
- Many of these benefits are fully realized only when no-till is used continuously over a period of years (Johnson et al., 2005).
- Cross-sectional data ignores important elements of adoption (Cameron, 1999; Doss, 2006).
- Panel data are needed to better understand the factors that influence adoption.

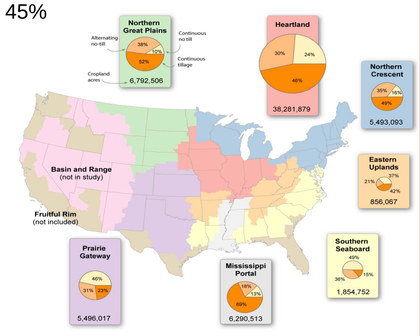
❑ Objective: Identify and estimate the factors that influence field-level tillage decisions both between fields and within a given field over time.

No-Till Use by Farm Resource Regions

2010 Corn Survey
- No-Till for 4 yrs: 17%
- No-Till for 1-3 yrs: 29%
- Till for 4 yrs: 54%



2012 Soybean Survey
- No-Till for 4 yrs: 25%
- No-Till for 1-3 yrs: 29%
- Till for 4 yrs: 45%



Recent Research

- Economic studies examine the adoption of conservation technology and specific practices but these are static:
  - Knowler & Bradshaw *FP* (2007)
  - Prokopy et al. *JSWC* (2008)
  - Meta analysis: Baumgart-Getz et al. *JEM* (2012)
- Few economic studies examine no-till over time but these use aggregated data:
  - Ding, Schoengold, & Tadesse *JARE* (2009)
  - Schoengold, Ding, & Headlee *AJAE* (2015)
- Other studies:
  - Wilman *JARE* (2011): uses a theoretical model of adoption over time.
  - Llewellyn et al. *Field Crop Research* (2012): asks farmers future tillage plans.
  - Wade & Claassen *JAAE* (2017): use an ordered logit model to estimate factors affecting choices among continuous no-till, alternating no-till and tillage, and continuous tillage adoption.

❑ This is the first national study that uses field-level panel data to investigate adopters' attributes.

Data

The Agricultural Resource Management Survey (ARMS) provides a 4 year snapshot of field-level no-till decisions. Data are constructed from machine codes (in the survey year) and operator recollection of previous no-till use. We use the subset of fields that planted either corn or soybeans in each year.

- Corn—2010*, 2009, 2008, 2007
- Soybeans—2012*, 2011, 2010, 2009 *Survey year

Model

The random effects logit model allows estimation of static variables such as highly erodible land and drainage, in addition to time-varying factors such as weather and fuel costs.

$$NT_{it} = \gamma_{t_1} + \delta X_{it} + \sigma Z_i + \varepsilon_{it}$$
$$\varepsilon_{it} = \alpha_i + \upsilon_{it}$$

- i = 1,…,1993 fields
- t = 1,…,4
- NT_{it} is 1 if no-till used; 0 if other tillage used
- γ_{t_1} captures differences between the corn and soy surveys
- X_{it} is a vector of variables that change over time
- Z_i is a vector of static variables

Results: Odds Ratio

ᵀ Soybean was prior crop	0.498***
ᵀ Wages ($/hr)	1.190
ᵀ Diesel prices ($/Gal)	1.212***
ᵀ Precipitation (5-yr weather; mm)	0.990
ᵀ Precipitation sq (5-yr weather; mm²)	1.000**
ᵀ Precipitation month before planting (total)	0.998**
ᵀ Temperature prior year (weather; ºC)	0.973
ᵀ Temperature in month prior to planting (ºC)	1.077***
Precipitation (climate; mm)	1.297***
Precipitation sq (climate; mm²)	0.999**
Temperature (climate; ºC)	1.214
Highly erodible land	44.863***
Moderately to excessively well-drained soil	5.159***
LCC: moderate or slightly limited	0.422***
2012 Survey	5.270***
Survey year	0.320***
Rho	0.888***
Percent correct predictions	68

ᵀVariables that change over time. Bootstrap standard errors are not shown. The full set of controls include ERS regions, irrigated land, and farm size. ***p<0.01, **p<0.05, *p<0.1.

Note: The Hausman test indicates that random effects (RE) and fixed effects (FE) estimates are significantly different from each other. *Nonetheless, for variables that change over time, the RE and FE models show consistent results.*

The Effect of Dynamic Variables

Precipitation: A one millimeter increase in precipitation in the month prior to planting significantly decreases the odds of no-till use by 0.2%. No-till works best under dry conditions (Soule et al. 2000; Ogle et al. 2012).

Temperature: A one degree increase in temperature during the month prior to planting significantly increases the odds of no-till use by 7.7%. No-till works best on warm soils (Soule et al. 2000; Ogle et al. 2012).

Diesel: An additional dollar increase in fuel prices increases the odds of no-till use by 21.2%. No-till requires fewer machine runs and therefore uses less fuel. Higher diesel prices may make no-till more attractive.

Previous year's crop: When soybeans were planted in the prior year the odds of no-till use decrease by 50.2%. About 80% of fields are in a corn-soybean rotation. If the previous crop is soybeans it is likely that corn is the current crop. No-till is more likely to be used on soybeans than on corn fields (Wade et al., 2015).

Conclusion

Increasing no-till acreage requires a better understanding of the economic drivers of sustained use.

- Temporal factors influence tillage decisions and tillage use literature fails to account for the dynamic nature of adoption decisions.
- The 4-year panel provides a richer understanding of attributes affecting no-till use.
  - Static variables such as climate, highly erodible land, land capability class, and drainage play an important role in no-till use.
  - Dynamic variables such as diesel prices, immediate weather also play a significant role in yearly tillage choices.
- *Preliminary* findings for increasing no-till acres:
  - Programs that encourage sustained adoption could consider factoring in the changes in input prices that farmers observe into multi-year contracts.

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