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

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***Selected Paper prepared for presentation at the 2017 Agricultural & Applied Economics Association  
Annual Meeting, Chicago, Illinois, July 30-August 1***

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# Modeling No-Tillage Adoption by Corn and Soybean Producers: A Binary-Panel Regression 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.

## 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.

## Results: Odds Ratio

<sup>T</sup> Soybean was prior crop	0.498***
<sup>T</sup> Wages (\$/hr)	1.190
<sup>T</sup> Diesel prices (\$/Gal)	1.212***
<sup>T</sup> Precipitation (5-yr weather; mm)	0.990
<sup>T</sup> Precipitation sq (5-yr weather; mm <sup>2</sup> )	1.000**
<sup>T</sup> Precipitation month before planting (total)	0.998**
<sup>T</sup> Temperature prior year (weather; °C)	0.973
<sup>T</sup> Temperature in month prior to planting (°C)	1.077***
Precipitation (climate; mm)	1.297***
Precipitation sq (climate; mm <sup>2</sup> )	0.999**
Temperature (climate; °C)	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

<sup>T</sup>Variables 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.*

*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

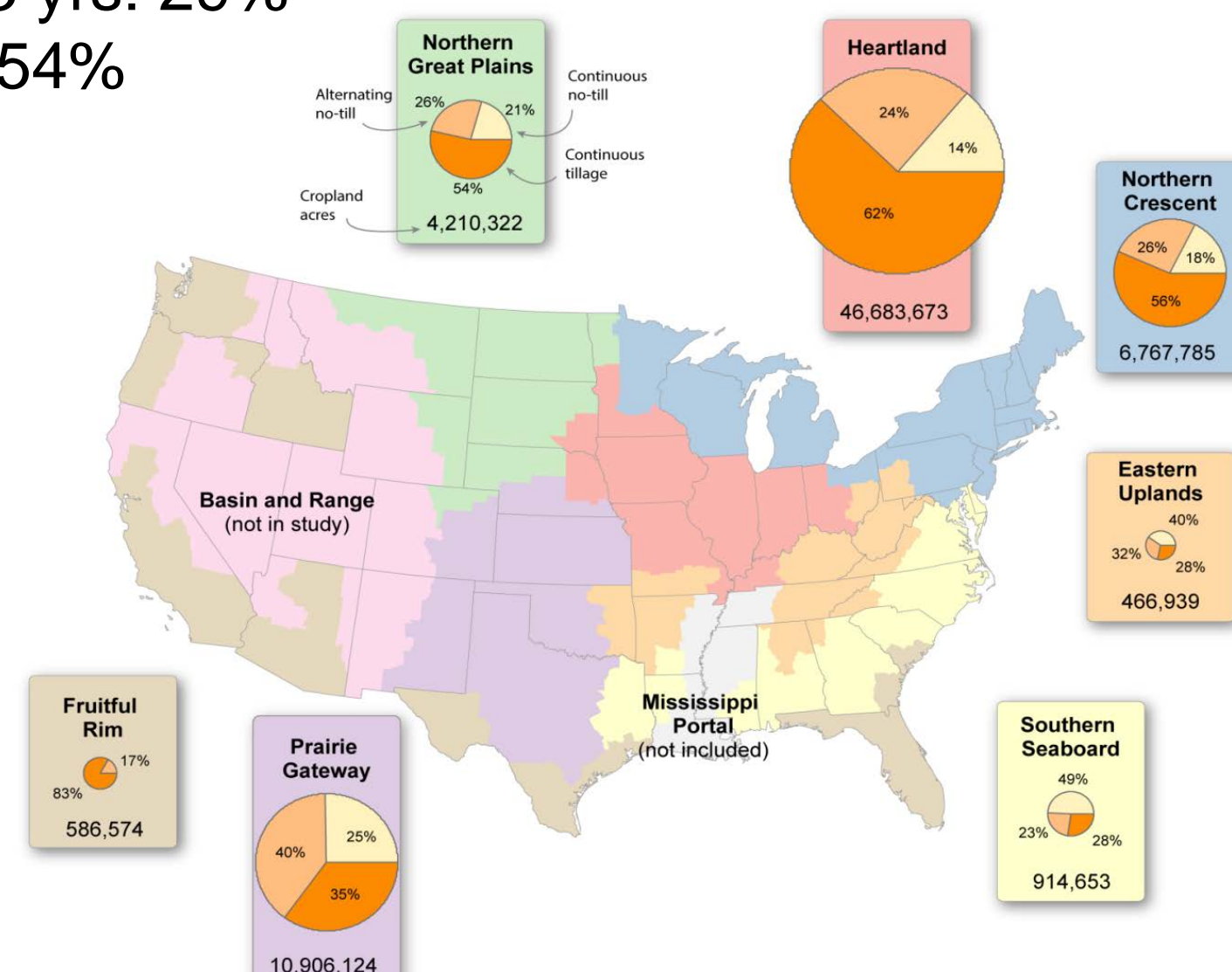
Increasing no-till acreage requires a better understanding of the economic drivers of sustained use.

- 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.

## No-Till Use by Farm Resource Regions

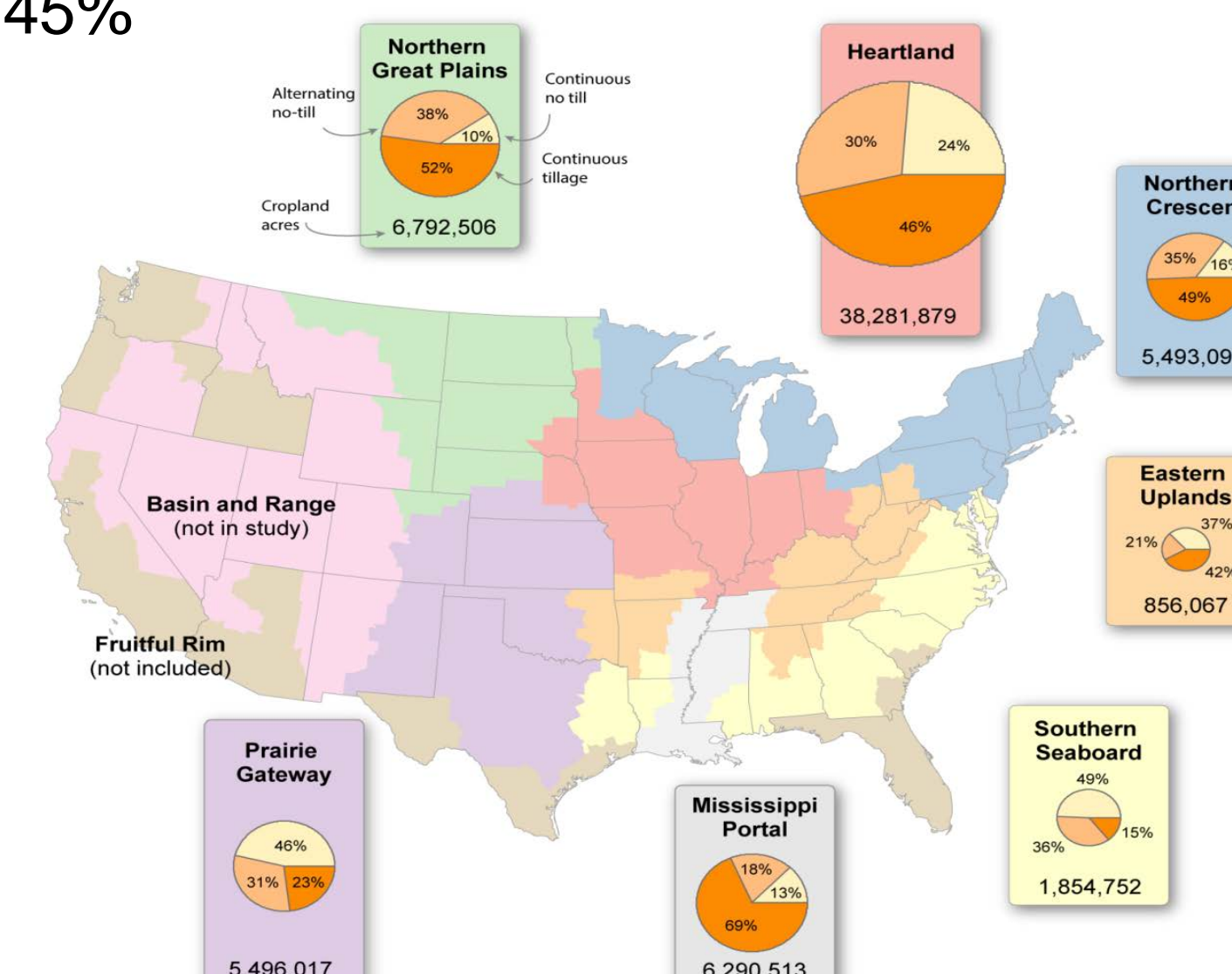
### 2010 Corn Survey

- 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%



## 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.

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

$$\varepsilon_{it} = \alpha_i + v_{it}$$

- $i = 1, \dots, 1993$  fields
- $t = 1, \dots, 4$
- $NT_{it}$  is 1 if no-till used; 0 if other tillage used
- $\gamma_{t_1}$  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

## 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.

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## Acknowledgments

This research was partially funded by the USDA National Institute of Food and Agriculture, award No. 2016-67024-24755. The funding source has no involvement in the study design, data collection and analysis, or any other aspects of the research or paper publication. The views expressed are those of the authors and do not necessarily reflect the views or policies of the USDA or the USDA, Economic Research Service.