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Farmers Decision on Nitrogen Application: the Role of Learning and Message

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1. Introduction

- Farmers depend on nitrogen(N) additions to cropland to support high yields.
- N losses from these systems have significant ecological consequences, including water pollution and greenhouse gas emissions.
- Conservation Agriculture (CA) practices and tools have been developed to reduce N application and loss, but their adoption rates remain strikingly low among farmers.
- Subsidies are introduced to encourage adoption of CA practices and tools.

2. Objectives

- Evaluate corn growers Willingness To Accept (WTA) payments to adopt CA practices.
- Test the presence of learning and message effects in decision making.
- Compare the results from preference space and WTA space.
- Predict participation rates of proposed CA combinations.

3. General Design and Treatments' Description

- Before the choice tasks, respondents received two information treatments.

Table 1: Treatments Description

	Message Treatment		Learning Treatment	
Treatment	Positive	Increasing nitrogen efficiency can save farmers' money, and protect the environment.	Delay	If the program is not implemented for now, the respondent can gain more information and decide one year later.
Control	Negative	Nitrogen lost from farming operations contributes to pollution of the environment.	No delay	There will be no chance to decide later if the program is not passed and implemented this year.

Table 2. Treatment Groups

	Positive Message	Delay Option Available
Treatment 1 (PD)	✓	✓
Treatment 2 (PN)	✓	×
Treatment 3 (ND)	×	✓
Treatment 4 (NN)	×	×

- Hypotheses tests built on the four treatments

Learning Effect

Hypothesis 1:
$$H0_1: WTA_{PD} - WTA_{PN} = 0$$
$$H1_1: WTA_{PD} - WTPA_{PN} \neq 0$$
Hypothesis 2:
$$H0_2: WTA_{ND} - WTA_{NN} = 0$$
$$H1_2: WTA_{ND} - WTA_{NN} \neq 0$$

Message Effect

Hypothesis 3:
$$H0_3: WTA_{PD} - WTA_{ND} = 0$$
$$H1_3: WTA_{PD} - WTA_{ND} \neq 0$$
Hypothesis 4:
$$H0_4: WTA_{PN} - WTA_{NN} = 0$$
$$H1_4: WTA_{PN} - WTA_{NN} \neq 0$$

4. Choice Experiment Model

- Individual *i 's* utility from choice alternative *j* in choice situation *t* in preference space estimation:

$$U_{ijt} = \alpha * Pay_{ijt} + \beta_1 * Winter_{ijt} + \beta_2 * Fall_{ijt} + \beta_3 * Side_{ijt} + \beta_4 * Nitrogen + \beta_5 * SQ_{ijt} + \varepsilon_{ijt} \quad (Preference)$$

- Utility in WTA space to check robustness of preference space estimation:

$$U_{ijt} = \alpha\left(Pay_{ijt} + \theta_1 * Winter_{ijt} + \theta_2 * Fall_{ijt} + \theta_3 * Side_{ijt} + \theta_4 * Nitrogen + \theta_5 * SQ_{ijt}\right) + \gamma_1 * \left(treatdelay * Winter_{ijt}\right) + \gamma_2 * \left(treatdelay * Fall_{ijt}\right) + \gamma_3 * \left(treatdelay * Side_{ijt}\right) + \gamma_4 * (treatdelay * Nitrogen) + \gamma_5 * (treatdelay * SQ_{ijt}) + \varepsilon_{ijt} \quad (WTA\_Learning)$$

$$U_{ijt} = \alpha\left(Pay_{ijt} + \theta_1 * Winter_{ijt} + \theta_2 * Fall_{ijt} + \theta_3 * Side_{ijt} + \theta_4 * Nitrogen + \theta_5 * SQ_{ijt}\right) + \delta_1 * (treatpositive * Winter_{ijt}) + \delta_2 * (treatpositive * Fall_{ijt}) + \delta_3 * (treatpositive * Side_{ijt}) + \delta_4 * (treatpositive * Nitrogen) + \delta_5 * (treatpositive * SQ_{ijt}) + \varepsilon_{ijt} \quad (WTA\_Message)$$

5. Survey and Data

- The target population: corn growers in Michigan, Iowa, and Indiana Figure 1.
- Mail survey Figure 2, sample drawn from Farm Service Agency (FSA) of USDA.
- Total usable sample: 1294. Sent out 4800 surveys with $2 incentives in Mar 2016 with a response rate of 31%. After removing incomplete returns, the response rate is 27%.
- D-efficiency design based on priors from pre-test data Table 3.

Figure 2. Choice Task Sample

Note: This program is not expected to reduce corn yield with appropriate application rates Expected N savings are based on average application rate of 170 lbs/acre with no practice adoption.
The program chosen by the majority of respondents will be implemented immediately. If the majority of respondents choose "not to participate," no program will be implemented.

	Program 1	Program 2	Do not participate
Fall application prohibited	No	Yes	I would not participate in these programs
Sidedress application required	Yes	No	
Winter cover crops required	Yes	No	
Expected Nitrogen savings	40%	10%	
Annual payment level	$180/acre	$180/acre	
I would choose ... (check only one)	☐	☐	☐

Figure 1. Research Area Map

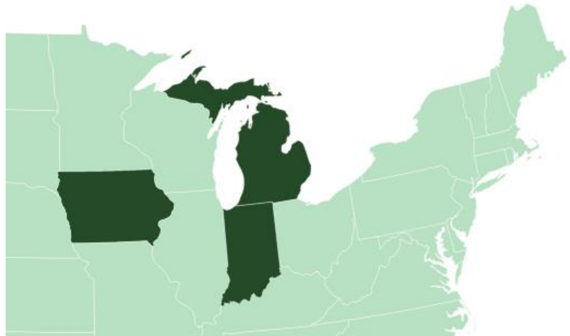


Table 3. Attributes and Levels in the Choice Design

Attributes	Levels
Winter Cover Crops Required	Yes, No
Fall Application Prohibited	Yes, No
Sidedress Application Required	Yes, No
Expected Nitrogen Savings %	0, 10, 25, 40, 50
Annual Payment $/Acre	0, 5, 20, 40, 100, 180

6. Estimation

- For preference space estimation: Random Parameter Logit (RPL) and Random Parameter Logit with error components (RPL-EC) models. Payment is assumed to be fixed and the four other attribute coefficients follow normal distributions.
- For WTA space estimation: RPL-EC. Payment is assumed to follow triangle distribution and the four other attribute coefficients follow normal distributions.
- Estimation was conducted in NLOGIT 5.
- Across samples comparison in preference space is conducted in R using combinatorial test suggested by Poe, Giraud, and Loomis (2005).

7. Selected Results

Table 4. Marginal WTA Values ($/acre) across Treatments

Hypotheses Tests	Winter	Fall	Sidedress	Nitrogen	Status Quo
$H0_1: WTA_{PD} - WTA_{PN} = 0$					
WTA_{PD}	162(0.000)[a]	15(0.185)	46(0.042)	-398(0.005)	-131(0.000)
WTA_{PN}	94(0.000)	14(0.141)	3(0.438)	-56(0.291)	-80(0.000)
p-value[b]	➤ **0.02065**	0.47713	➤ **0.09816**	➤ **0.02508**	➤ **0.09979**
$H0_2: WTA_{ND} - WTA_{NN} = 0$					
WTA_{ND}	112(0.000)	-2(0.462)	20(0.184)	-244(0.009)	-84(0.000)
WTA_{NN}	131(0.000)	-1(0.444)	53(0.005)	-334(0.000)	-135(0.000)
p-value	0.29163	0.48586	0.13941	0.28291	➤ **0.08153**
$H0_3: WTA_{PD} - WTA_{ND} = 0$					
WTA_{PD}	162(0.000)	15(0.185)	46(0.042)	-398(0.005)	-131(0.000)
WTA_{ND}	112(0.000)	-2(0.462)	20(0.184)	-244(0.009)	-84(0.000)
p-value	➤ **0.08596**	0.21459	0.23073	0.20004	0.1334
$H0_4: WTA_{PN} - WTA_{NN} = 0$					
WTA_{PN}	94(0.000)	14(0.141)	3(0.438)	-56(0.291)	-80(0.000)
WTA_{NN}	131(0.000)	-1(0.444)	53(0.005)	-334(0.000)	-135(0.000)
p-value	➤ **0.09706**	0.20023	➤ **0.03755**	➤ **0.02785**	➤ **0.04883**

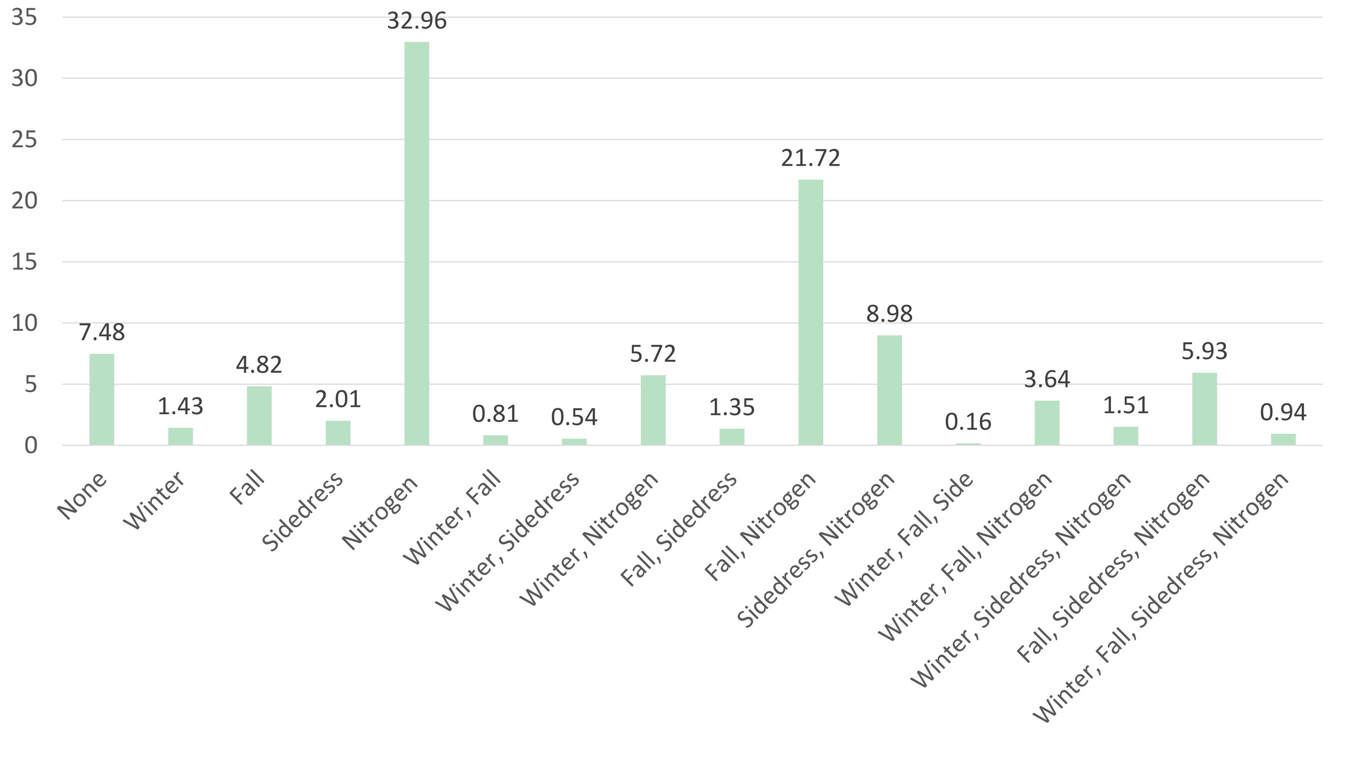
a P-value of the WTA estimation in the bracket.
b P-value estimated using combinational method of Poe (2005).

Table 5. Robustness Tests in WTA Spaces ($/acre)

Learning Effect	Winter* treatdelay	Fall* treatdelay	Sidedress* treatdelay	Nitrogen* treatdelay	SQ* treatdelay
$H0_1: WTA_{PD} - WTA_{PN} = 0$					
Coefficient	-0.88391[c]	-0.05409	-.27925	1.52099	0.09029
P-value	➤ **0.0288**	0.6658	➤ **0.0873**	➤ **0.0576**	0.6428
$H0_2: WTA_{ND} - WTA_{NN} = 0$					
Coefficient	-.35958	0.33937	-0.07973	4.41489	-0.05505
P-value	0.5835	0.4211	0.8991	0.1596	0.9368
Message Effect	Winter* treatpositive	Fall* treatpositive	Sidedress* treatpositive	Nitrogen* treatpositive	SQ* treatpositive
$H0_3: WTA_{PD} - WTA_{ND} = 0$					
Coefficient	-0.91217	-0.01507	-0.20922	1.61338	0.44582
P-value	➤ **0.0797**	0.9613	0.6748	0.5040	0.4285
$H0_4: WTA_{PN} - WTA_{NN} = 0$					
Coefficient	-0.61164	-0.19031	0.13432	-1.65572	0.08143
P-value	0.2627	0.5722	0.7810	0.4816	0.8807

c As the coefficient for each CA practice is negative, negative estimation here indicates higher WTA.

Figure 3. Predicted Participation Rate for Each Proposed CA Combo



8. Conclusions

- **Preference for status quo:** payment is needed to move farmers away from current practices.
- The WTA for **winter cover** crop ranks the highest, while the WTA for sidedress ranks the lowest among the three proposed CA practices.
- The most favored CA combinations are (1) **Saving Nitrogen**, (2) Saving Nitrogen, and Prohibiting Fall Application, (3) Saving Nitrogen, and Applying Sidedress. Adopting all three proposed CA practices is least favored.
- **Delay option raises WTA** under positive message, but not under negative message.
- **Positive message lowers WTA** under immediate decision (in preference space estimation), but not under delaying decision.
- Predictions from preference space and WTA space are generally consistent.