The Impact of Ad-hoc Disaster Programs on the Use of Conservation Practices

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Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2012 AAEA Annual Meeting, Seattle, Washington, August 12-14, 2012

Abstract

The paper estimates the impacts of risk reducing government programs on the use of conservation practices in agriculture. Specifically, conservation tillage or no-till agriculture can be used to reduce risk from weather shocks while subsidized crop insurance and disaster payments also reduce risk from weather shocks through financial assistance. The paper examines the extent to which conservation practices (i.e., private insurance) and government programs (i.e., public insurance) are substitutes for each other. The paper uses data on conservation practices from the Conservation Tillage Information Center. Results are estimated using instrumental variables and spatial panel data techniques. The economic model shows that government support programs and self management of risk through improved production practices are substitutes. The empirical analysis shows that producers with riskier climate conditions are more likely to use conservation tillage practices but that recent receipts of ad-hoc disaster payments and insurance indemnity payments reduce those probabilities.

1 Introduction

In this paper, we examine the various incentives in place for an agricultural producer to adopt conservation tillage practices. Conservation tillage is a method of production that leaves more residue on the field after harvest. This has several benefits, both public and private. The public benefits of conservation tillage include reduced runoff and improved water quality, and these public benefits have been used to justify a variety of federal, state, and local programs that provide funding to assist producers in adopting conservation tillage. In addition to the public benefits, there are also private benefits to an individual producer for adopting conservation tillage. These private benefits include improved soil moisture conditions and reduced topsoil runoff. While reduced topsoil runoff is a medium to long-run benefit to an individual landowner, improving soil moisture is a benefit in the short run.

2 Literature Review

There has been a limited analysis of the determinant of agricultural disaster payments. Some of the previous literature has examined the political influence of elected officials on disaster payments (Garrett, Marsh &

Marshall 2006). Despite a stated desire to move away from disaster payments and rely more on subsidized crop insurance, Congress has continued to fund ad-hoc disaster payments on a regular basis (Glauber & Collins 2002, Chite 2006). Other research has examined the connection between crop insurance enrollment and disaster payments (Goodwin & Vado 2007, Goodwin & Rejesus 2008), finding evidence that producers substitute away from crop insurance coverage with high levels of disaster payments. However, existing research has not examined the link between those payments and a producer's choice of production practice. The literature on crop insurance is more developed, and studies have examined enrollment decisions, trying to determine if either moral hazard or adverse selection exists in crop insurance enrollment and production practice choice. In previous work, Ding et al (2009) find evidence that high rates of enrollment in crop insurance reduce the use of conservation tillage practices. However, the paper does not include disaster payments or actual indemnity payments.

The goal of this paper is to estimate the impact of federal risk management programs on the adoption of risk reducing production methods. To do this, we first develop an economic model that examines the tradeoffs facing a producer. The model highlights how expected payments from government programs affect a producers' decision to self-protect against crop failures. The empirical estimation is motivated by the economic model and by existing literature. We first develop a consistent estimator of ad-hoc disaster payments and insurance indemnity payments. In doing so we use a variety of weather and climate data that provide better indicators of crop failure than the data used in previous studies. Using the predicted values for disaster payments and climate data, we use simultaneous equation estimation to measure the impact of those payments on tillage practices. The results shed light on how government payments and production practices are expected to respond to climate change and increasing incidence of extreme weather events if such programs are not changed.

3 Government Programs

Before developing the economic model of producer investment in risk-reducing practices, we describe some of the government programs that are included in our economic model.

3.1 Disaster Payments

Ad-hoc disaster payments are frequently used to reimburse farmers after natural disasters occur. Drought is the most cited reason for ad-hoc disaster payments, although floods are also a common cause (Garrett et al. 2006). For example, P.L. 108-7 of 2003 provided 3.1 billion dollars to crop and livestock producers in counties affected by drought during the 2001 and 2002 seasons, and P.L. 103-75 of 1993 provided 2.5 billion dollars to Midwest producers impacted by flood (Chite 2006). These ad-hoc disaster payments have continued in recent years, despite changes to the federal crop insurance program designed to increase the level of enrollment and reduce the need for disaster payments (Glauber & Collins 2002).

3.2 Crop Insurance

Since 1980, the Federal Crop Insurance Program has become the primary form of crop loss protection for agricultural producers in the United States. To encourage participation, the insurance premiums are highly subsidized. According to the 2007 report of the Risk Management Agency (RMA), approximately 60 percent of total premiums were paid by the federal government. The high level of subsidies has raised concerns about the potential distorting effects of the crop insurance program on farmers' production decisions. Previous research suggests that crop insurance plays a role in determining input use, planted acres, and cropping patterns (Smith & Goodwin 1996, Babcock & Hennessy 1996, Wu 1999, Goodwin, Vandeveer & Deal n.d.). Williams (1988) and Wu and Babcock (1998) have analyzed the effect of crop insurance on tillage practices, but their results were inconclusive as to whether crop insurance programs promote or delay the adoption of conservation tillage. In a previous paper we found that the percentage of producers enrolled in crop insurance coverage is negatively correlated with the proportion of land in no-till and conservation till (Ding, Schoengold & Tadesse 2009). While the primary focus of the current paper is on the role of disaster payments it is clear that crop insurance indemnity payments may also affect the use of risk-reducing practices.

4 Economic Model

Let wealth or income be the sum of direct profits from production and government payments. We let x denote the level of residue left on the field from conservation tillage, so a high level of x corresponds to no-till production and a low level of x corresponds to conventional tillage. The weather condition is a stochastic variable and is denoted by θ with mean $\bar{\theta}$ and variance σ^2. A low value of θ represents weather that is more conducive to high production levels. A producer also has the option to purchase crop insurance, and the chosen level of coverage is k, where a higher level of k denotes more insurance coverage. The total profit is $W(x, k, \theta)$, which includes net revenue from farm production and from government payments.

4.1 Net production profit

To put more structure on the problem, we represent stochastic production levels by a Just-Pope production function, which assumes that the output function can be separated into two components - a deterministic portion that is a function of input variables and a stochastic portion that is a function of inputs and the stochastic variable.

$$y(x, \theta) = f(x) + g(x)\theta \tag{1}$$

Conservation tillage practices can reduce the risk associated with stochastic rainfall, irrigation availability, and temperature. Since higher levels of θ denote poor weather conditions, we assume that $g(x) < 0$ with $g'(x) > 0$ and $g''(x) < 0$.

There is a cost of adopting conservation tillage, and that cost is denoted by $c(x)$, where $c'(x) > 0$ and $c''(x) > 0$. These costs include things like the time needed to learn about new production methods and the costs for additional inputs such as fertilizer and insecticides that are required with reduced tillage. Combining these gives the function for net production profit, which is $\pi(x, \theta) = f(x) + g(x)\theta - c(x)$. This reflects the real profit net of any government programs.

4.2 Government programs

In this work, we are primarily interested in the impact of government programs that are designed to affect risk and the adoption of conservation practices. Specifically, we focus on two types of programs: ad-hoc disaster payments and insurance indemnity. Disaster payments are voted on by Congress after some type of event such as a flood, drought, or tornado. Disaster payments are expected to increase with poor weather, which is denoted by a high value of θ and to increase with high levels of political influence. These payments are denoted by $D(z, \theta)$ with $D_\theta(z, \theta) > 0$ and $D_z(z, \theta) > 0$ where z denotes the level of political influence that state representatives have on funding decisions. As these payments are supposed to be provided for serious disasters, we assume that $D_{\theta\theta}(z, \theta) > 0$. Also, for the same weather conditions, those areas with better representation are expected to receive higher payments, and thus $D_{z\theta}(z, \theta) > 0$. The influence z is due to committee membership on important Congressional committees or other state level political factors. Thus, this parameter measures the relative political influence for a particular location relative to a baseline level of political support for agriculture.

The second relevant government program is insurance indemnity payments. The amount of the indemnity paid to a farmer is denoted by $I(k, \theta)$ where an individual producer chooses a level of coverage denoted by k and payment is based on the level of coverage and the weather outcome. In a private and competitive insurance market, the premium rate for coverage level k, denoted by $M(k)$, should equal the expected value of the indemnity payments, or $M(k) = \int_\theta I(k, \tau) f(\tau) d\tau]$. However, crop insurance is subsidized by the federal government, with the subsidy level denoted by $\gamma(k)$ where $\gamma(k)$ is between 0 and 1 and $\gamma_k < 0$. This reflects the reality that the federal government offers large subsidies on relatively basic levels of coverage while the subsidized proportion is reduced at higher levels of coverage. Thus, the actual premium paid by the producer is $(1 - \gamma(k))M(k)$.

Thus, there are two choice variables for the producer (k and x), two policy decisions ($\gamma(k)$ and $D(z, \theta)$), and one random variable (θ). For now we consider the level of political influence z as exogenous to an individual producer. The national policy variables will be affected by general support for agricultural producers. Empirically, we will examine differences by county, so both national level policies and differences in implementation by county are important in identifying the impact of various policies on overall conservation.

4.3 Producer profit

Combining the profit from production and government payments gives us the following expression for total producer wealth, conditional on the policy variables and the realization of the weather variable:

$$\begin{aligned} W(x,k|\theta,z,\gamma(k)) &= f(x)+g(x)\theta-c(x)+D(z,\theta) \\ &\quad +I(k,\theta)-(1-\gamma(k))M(k) \end{aligned} \tag{2}$$

We denote the expected value of disaster payments as $\bar{D}(z,f(\theta)) = \int_\theta D(z,\tau)f(\tau)d\tau$ and the expected value of net insurance indemnity payments after premiums are paid as $\bar{I}(k,f(\theta)) = \gamma(k)\int_\theta I(k,\tau)f(\tau)d\tau$.

The expected value and variance of wealth are the following:

$$\begin{aligned} E[W(x,k|\theta,z,\delta,\gamma(k))] &= f(x)+g(x)\bar{\theta}-c(x)+\bar{D}(z,f(\theta)) \\ &\quad +\bar{I}(k,f(\theta)) \end{aligned} \tag{3}$$

$$\begin{aligned} \mathrm{Var}(W(x,k|\theta,z,\gamma(k))) &= [g(x)+D_\theta(z,\bar{\theta})+I_\theta(k,\bar{\theta})]^2\sigma^2 \\ &= V^2\sigma^2 \end{aligned} \tag{4}$$

We use V to denote the marginal change in wealth due to an increase in mean value of θ. We note that $V_x = g'(x) > 0$ and $V_{xx} = g''(x) < 0$. Also, $V_k = I_{\theta k}(k,\bar{\theta}) > 0$ and $V_{kk} = I_{\theta kk}(k,\bar{\theta})$. Since insurance indemnity payments increase in a linear manner with respect to coverage level, we assume that $V_{kk} = 0$. We also note that $V_{kz} = V_{kx} = V_{xz} = 0$. The sign of V depends on the relative size of the different components. The first component, $g(x) < 0$ and represents the yield risk reduction due to conservation tillage. The second and third components are the marginal increase in disaster payments and insurance indemnities respectively, and these are both positive. The net effect is unclear and we cannot determine if $V > 0$ or $V < 0$. If the payments from government programs more than offset expected losses in yield, $V > 0$ and expected returns increase with worse weather. If the lost returns from yield losses are higher than the compensation from government programs, $V < 0$ and expected returns decrease with worse weather. The effect of this on a producer's decisions about tillage and insurance coverage are determined by the relative value of V and by an individual's level of risk aversion r.

4.4 Expected utility

There are a variety of expressions that we could use to model the welfare or utility of a producer. One form that is frequently used is the exponential utility function, or $U(W) = 1 - e^{-rW}$. This utility function implies that producers have constant absolute risk aversion of level r. This means that expected utility is a function of the mean and variance of W, or that $EU(W) = 1 - e^{-r(\mu_W - 0.5r\sigma_W^2)}$. Maximizing expected utility function gives the following optimization problem:

$$\max_{x,k} EU = E[W(x,k|\theta,z,\gamma(k))] - 0.5rV^2\sigma^2 \tag{5}$$

We substitute Equations 3 and 4 into the maximization problem to determine a producer's optimal level of tillage and insurance coverage. Most of the literature considers the choice of tillage practice as a discrete choice, and in our empirical section we do define discrete categories (e.g., no-till). However, tillage practices span a wide range, and modeling it as a continuous variable allows us to better understand the economic intuition without changing the fundamental results.

Solving Equation 5, we find the following first order conditions:

$$\frac{\partial EU}{\partial x} = f_x() + g_x()\bar{\theta} - c_x() - rV\frac{\partial V}{\partial x}\sigma^2 = 0 \tag{6}$$

$$\frac{\partial EU}{\partial k} = \bar{I}_k() - rV\frac{\partial V}{\partial k}\sigma^2 = 0 \tag{7}$$

Equations 6 and 7 vary from the standard first order conditions for profit maximization due to the risk aversion parameter. Under risk neutrality, a producer will choose the level of tillage and insurance coverage to equate the marginal benefits and marginal costs of those decisions. These decisions are modified based on the risk aversion levels

Assuming an interior solution, we find the second order conditions which we denote by SOC_x and SOC_k.

$$\begin{aligned} \frac{\partial^2 EU}{\partial x^2} &= f_{xx}() + g_{xx}()\bar{\theta} - c_{xx}() \\ &\quad -r\sigma^2(VV_{xx} + V_x^2) < 0 \end{aligned} \tag{8}$$

$$\frac{\partial^2 EU}{\partial k^2} = \bar{I}_{kk}() - r\sigma^2 V_k^2 < 0 \tag{9}$$

In order to solve the comparative statics we create a new variable $\bar{\gamma}$ which represents the average subsidy level for $\gamma(k)$ over all possible values of k. Thus, the comparative statics results measure the effect of a change of equal proportion across all subsidy levels. We totally differentiate the first order conditions with respect to the endogenous variables (x and k) and those variables that are exogenous to a single producer $(z, \bar{\gamma}, \bar{\theta}, \sigma^2)$.

$$\begin{bmatrix} SOC_x & -r\sigma^2 V_x V_k \\ -r\sigma^2 V_x V_k & SOC_k \end{bmatrix} \begin{pmatrix} dx \\ dk \end{pmatrix}$$

Denoting the matrix as [**A**], we can solve for changes in the choice variables based on changes in the exogenous policy variables based on the following:

$$[\mathbf{A}] \begin{pmatrix} dx \\ dk \end{pmatrix}$$

$=$

$$\begin{bmatrix} r\sigma^2 V_x V_z & 0 & rVV_x & -V_x(1 - r\sigma^2 V_{\bar{\theta}}) \\ r\sigma^2 V_k V_z & -\int_\theta I(k,\tau) f(\tau) d\tau & rVV_k & -(\bar{I}_{k\bar{\theta}}() - r\sigma^2 (V_k V_{\bar{\theta}})) \end{bmatrix} \begin{pmatrix} dz \\ d\bar{\gamma} \\ d\sigma^2 \\ d\bar{\theta} \end{pmatrix}$$

Since we know that the second order conditions are negative and that their product is larger than the cross terms, we can show that the determinant of the matrix **A** is positive.

We use Cramer's Rule to calculate the impact of the exogenous variables of interest on a producer's choices. We first present the impact of each of the four variables of interest (political representation, average insurance subsidy rate, variance of weather outcomes and average weather outcomes) on tillage choice.

4.5 Impacts of Exogenous Variables on Tillage Levels

$$\frac{dx}{dz} = \frac{r\sigma^2 V_x V_z (SOC_k - r\sigma^2 V_k^2)}{|A|} < 0 \qquad (10)$$

Equation 10 shows that an increase in the level of government representation on key committees reduces an individual's incentive to use conservation tillage to reduce yield risk.

$$\frac{dx}{d\bar{\gamma}} = -\int_\theta I(k,\tau) f(\tau) d\tau \frac{r\sigma^2 V_x V_k}{|A|} < 0 \qquad (11)$$

Equation 11 shows that an increase in the average subsidy level for insurance reduces the level of conservation tillage. This is equivalent to showing that managing risk through changes in production practices and managing risk through insurance are substitutes for each other.

$$\frac{dx}{d\sigma^2} = -\frac{r^2 V V_x V_k \sigma^2 (V_k - V_x)}{|A|} \tag{12}$$

The sign of Equation 12 depends on the sign of V and on the relative magnitudes of V_k and V_x. For producers who rely entirely on production practices for risk management and do not use government programs, it is clear that $\frac{dx}{d\sigma^2} > 0$ and an increase in weather risk increases the level of tillage. When government programs compensate for those losses the sign is unclear.

$$\frac{dx}{d\bar{\theta}} = -\frac{\bar{I}_{kk}()V_x(1 - r\sigma^2 V_{\bar{\theta}})}{|A|} \tag{13}$$

The sign of Equation 13 is also unclear and depends on whether $r\sigma^2 V_{\bar{\theta}} > 1$.

The next section shows the derived impacts of the exogenous variables on a producer's choice for insurance coverage. As with the decision about tillage practices, most of the results are intuitive and depend on the relative importance of insurance protection and production choices in managing risk.

4.6 Impacts of Exogenous Variables on Insurance Coverage

The following comparative statics show how a producer's decision about the level of insurance coverage is influenced by political and weather variables.

$$\frac{dk}{dz} = r\frac{\sigma^2 V_k V_z (SOC_x + r\sigma^2 V_x V_{xx})}{|A|} < 0 \tag{14}$$

Equation 14 shows that a producer is less likely to enroll in high levels of crop insurance coverage when he or she has a high level of political representation due to the expected impact on disaster payments

$$\frac{dk}{d\bar{\gamma}} = -\int_{\theta} I(k,\tau) f(\tau) d\tau \frac{SOC_x}{|A|} > 0 \tag{15}$$

Equation 15 shows that an increase in the average subsidy level for insurance coverage will increase demand for insurance. This is intuitive and can be observed in historical patterns of insurance coverage and subsidy rates in the United State. While not the sole reason for changes in the number of producers who enroll in crop insurance, higher subsidies during the past thirty years are correlated with increased levels of crop insurance participation.

$$\frac{dk}{d\sigma^2} = rVV_k\frac{(SOC_x + r\sigma^2V_x^2)}{|A|} \tag{16}$$

The sign of Equation 16 depends on the sign of V. If $V > 0$, then we expect that $\frac{dk}{d\sigma^2} < 0$. The intuition for this result is that if the expected payment increases with deteriorating weather conditions, an increase in the variance of the weather variable actually leads a producer to demand lower levels of crop insurance.

$$\frac{dk}{d\bar{\theta}} = -\frac{SOC_x(\bar{I}_{k\theta}() - r\sigma^2V_kV_{th\bar{e}ta}) - V_x^2r\sigma^2V_k(1 - r\sigma^2V_{\bar{\theta}})}{|A|} \tag{17}$$

The sign of Equation 17 is unclear and depends on the magnitudes of several effects. Under risk neutrality ($r = 0$), it is clear that $\frac{dk}{d\bar{\theta}} > 0$ and that when average weather conditions are worse producers will respond by purchasing a higher level of insurance. In most cases we expect that result to hold under risk aversion as well. However, in cases where government program payments are expected to be high even without insurance (i.e., through ad-hoc disaster payments), this result may not hold.

5 Empirical Estimation Strategy

The empirical strategy allows us to measure the effect of government payments on the use of conservation practices by comparing differences in adoption levels across counties, and relating those differences to heterogeneity in government funding. For example, the total level of ad-hoc disaster payments that were paid to producers in Adair and Cass counties in Iowa from 1990 until 2008 was \$2,216,339 and \$2,687,147, respectively, while the total payments to Adams county, which is adjacent to Adair and Cass counties, was \$7,376,018 (FSA payment data).

We are concerned that the data on disaster payments and insurance indemnities may be endogenous to the estimation of tillage practice. Since producers choose both their crop insurance coverage level and tillage practices, there may be underlying characteristics that affect both of these choices.

For example, a producer with more education may be both better informed about government programs and about the benefits and practice of conservation tillage. With disaster payments, there may be underlying characteristics of the county that affect both the level of disaster payment and the choice of tillage practice. For example, counties that are more rural may have less access to extension and other educational materials about production practices and those same counties may be more likely to vote for representatives who support large disaster payments. Therefore we need to find instruments that are correlated with the level of government programs but uncorrelated with tillage practices. As shown in Garrett et al. (2006), any estimation of disaster payments should include insurance indemnities. However, Garrett et al.(2006) also show that insurance indemnity payments are endogenous to disaster payments and therefore we estimate the level of government program payments in two steps. First, we estimate the level of indemnity payments in a particular year and then use the predicted values of indemnity payments in the Tobit estimation of disaster payments. Predicted values for both programs are then used to estimate tillage production practices.

5.1 Government Programs

The data on disaster payments were obtained through a request with the USDA Farm Service Agency (FSA). The original data has transaction level data on all government program payments that are managed through FSA, including disaster payments, commodity programs, the Conservation Reserve Program, as well as may others. There are a variety of different program codes that are used for disaster payments. The original data includes a short program code, however, that code was not very useful in determining the target of a program. Thus, we determined which program codes to used by comparing a sample of the counties and state totals to the payments listed in the Environmental Working Group's data. The aggregate totals are for crop production disaster payments, as livestock related payments would not directly affect crop production practices.

The crop insurance indemnity payments are from the USDA Risk Management Agency (RMA). The original data files include the total payment by year, crop, and type of coverage to a particular county. For our initial results we aggregate the total payment for all crops and insurance plans to get an annual county-level total indemnity payment. Total payments for all programs are in constant 2006 dollars.

5.2 Estimation of Government Payments

The first step of the analysis is to obtain estimates of government payments, as we need instruments for these payments to measure their effect on production practices. To do so, we jointly estimate disaster payments and crop insurance indemnities. We estimate these for the 1990-2006 period. One decision that we need to make is whether to use the program year or the calendar year for the disaster payment estimation. The program year refers to the year that the appropriation is made for an ad-hoc disaster payment. Thus, if knowledge of future payments impacts production practices, this is the appropriate measure to use for estimating the impact on behavior. However, if there is uncertainty about those payments, the calendar year may be the appropriate measure, as it provides the actual amount of money transferred in a particular year. In most cases, the calendar year payment is in the year following the program year. We use the program year for the analysis since it is more straightforward to connect weather conditions with payments. An analysis using the calendar year shows that the primary results are unchanged.

In estimating these payments, one concern is the censoring of the payment data. In many years there are no disaster payments to a county, and thus we need an estimation method that accounts for the large number of zeros in the data. Of a total of 1,992 unique year/county observations, 1,249 have no disaster payment. If the analysis was done at an individual producer level this would also be a concern for crop insurance indemnity payments since producers do not receive insurance payments every year. However, when we aggregate to a county level the insurance indemnity total is always positive.

Letting y_1 denote crop insurance indemnity payments, x_1 denote instruments for the crop insurance indemnity estimation, y_2 denote the actual (censored) value of disaster payments and x_2 the instruments for disaster payments, we estimate the following equations to get predicted values for government program payments.

$$y_1 = \alpha_1 x_1 + \epsilon_1 \tag{18}$$

$$\begin{aligned} y_2^* &= \alpha_2 x_2 + \alpha_3 \hat{y}_1 + \epsilon_2 \\ \text{Where} \quad & y_2 = 0 \text{ if } y_2^* \leq 0 \\ & y_2 = y_2^* \text{ if } y_2^* > 0 \end{aligned} \tag{19}$$

Table 1: Frequency of Indemnity Payments by Type and Month, 1990-2008

Month	Drought	Percent	Freeze	Percent	Flood	Percent	Excess Precip.	Percent	Heat	Percent
January	969	1.7%	84	2.1%	63	0.5%	625	0.7%	109	1.0%
February	343	0.6%	51	1.2%	22	0.2%	220	0.3%	27	0.3%
March	526	0.9%	152	3.7%	42	0.4%	1,156	1.3%	23	0.2%
April	1,363	2.4%	361	8.8%	202	1.7%	6,444	7.5%	67	0.6%
May	5,217	9.1%	728	17.8%	2,737	23.1%	26,671	31.0%	551	5.1%
June	8,904	15.6%	281	6.9%	4,684	39.5%	24,506	28.5%	1,471	13.6%
July	13,175	23.1%	268	6.5%	1,944	16.4%	10,348	12.0%	3,329	30.9%
August	10,938	19.2%	241	5.9%	658	5.5%	4,190	4.9%	2,611	24.2%
September	4,669	8.2%	1,227	30.0%	482	4.1%	3,012	3.5%	796	7.4%
October	4,366	7.7%	403	9.8%	486	4.1%	3,596	4.2%	862	8.0%
November	3,727	6.5%	175	4.3%	354	3.0%	2,995	3.5%	532	4.9%
December	2,837	5.0%	125	3.1%	196	1.7%	2,248	2.6%	400	3.7%
Total	57034		4096		11870		86011		10778	

The predicted values from Equations 18 and 19 will be used in the multinomial logit estimation of production practices.

5.3 Crop Insurance Indemnities

Crop insurance indemnities are expected in conditions when there are crop failures. In addition to the measures for drought and flood, indicators of temperature extremes during the growing season are expected to contribute to higher levels of indemnity payments. Table 1 shows the frequency of payments for some of the most common reasons for indemnity payments by month. If flood and excess precipitation are combined, it is clear that either too much or too little precipitation (drought) are the most frequent causes of indemnity payments.

5.3.1 Instruments for Crop Insurance Indemnities and Disaster Payments

We use several sources of weather and climate information in the estimation. Two of the most common reasons for disaster payments are flood and drought. The Palmer Drought Severity Index (PDSI) is the standard measure of drought in the meteorological literature. The PDSI measures drought conditions in a particular location relative to average conditions, which allows the measure to be comparable across locations. It uses measures of precipitation and soil moisture, which provides a better indicator of drought conditions than solely using precipitation measures. Flood conditions can also be measured using the PDSI, although in many cases the standard precipitation index (SPI) is a better measure.

As opposed to simply using a maximum temperature or an average temperature, which do not provide good information about the range and distribution of temperatures over the growing season, we use degree days. Previous research (Schlenker and Roberts, 2009) has shown that the number of degree days over 30 is a good measure of yield loss. We include the number of degree days over 30 as a measure of crop loss due to high temperatures. In addition to the degree days we also use the number of acres planted, the April SPI, total growing season precipitation, and the August PDSI value.

The important criteria for choosing an instrument is that the instrument is correlated with the endogenous variable (i.e., crop insurance indemnities) but is not correlated with the dependent variable in the primary estimation (i.e., tillage practice choice). Since tillage practices are chosen prior to the growing season, weather variables that affect output in the current season will be uncorrelated with those choices. However, as shown by Table 1, current season weather variables are strong predictors of insurance payments.

The choice of instruments for disaster payments needs to include at least one variable that is uncorrelated with either crop insurance indemnity payments or with tillage practices. As shown in Garrett et al. (2006), political representation in the Agricultural or Appropriations Committees in the Senate or House of Representatives is a determinant of disaster payments. In addition, political support for the agricultural industry at the local level is also predicted to be correlated with disaster payments. Disaster payments are also determined by the level of a disaster, and thus we also include county-level variables that indicate weather conditions during the growing season. We use the Smith-Blundell procedure to test for the exogeneity of crop insurance indemnity payments in the disaster payment estimation. We are unable to accept the hypothesis that they are exogenous and thus we use the predicted values as instruments in the disaster payment estimation.

5.3.2 Estimation Results

We first estimate total insurance indemnity payments (measured in 2006 dollars) as function of several factors using an OLS regression. The results of the estimation are shown in Table 5.3.2.

The predicted values from Equation 18 are used as instruments in the estimation of Equation 19.

Most of the instruments used in the estimation have the expected signs and are of standard significance levels. The results of the disaster payment

Instrument	Coefficient	Standard Error	T-Statistic	P-value
Degree days above 30	41,901	2662	15.7	0.000
Growing season precipitation	3755	4299	0.870	0.382
August PDSI	138,318	31,509	4.39	0.000
April SPI	-13,500	46,303	-0.29	0.771
Acres Planted	5.91	0.378	15.6	0.000
Constant	-1,042,463	227,527	-4.58	0.000

Instrument	Coefficient	Standard Error	T-Statistic	P-value
Republican Governor	206,223	90,009	2.29	0.022
August PDSI	-217,404	31,452	-6.91	0.000
Ag. Committee Reps	458,761	84,990	5.40	0.000
App. Committee Reps	-262,322	74,068	-3.54	0.000
Flood Precipitation	-1205	7622	-0.16	0.874
Predicted Insurance Indemnity	.00182	.0493	0.04	0.970
Constant	-1,355,616	160,804	-8.43	0.000

estimation are shown in Table 5.3.2. Predicted values for the government payment variables are used in the estimation of land use.

5.4 Land Use

The data on tillage practices is collected by the Crop Residue Management (CRM) Survey, conducted by the Conservation Technology Information Center (CTIC). These data are collected annually from 1990-1998, and biennially from 1998 until 2006. Conservation tillage generally refers to any practice that leaves at least 30 percent of the residue on the field. We use two categories of conservation tillage - no-till, or zero tillage and other conservation tillage. Other conservation tillage refers to ridge till and mulch till practices. Reduced tillage refers to practices where 15 to 30 percent of the residue is left on the field, and conventional refers to practices where less than 15 percent of the residue is left on the field. In our analysis we use conventional tillage as our base category and compare the use of conventional tillage with zero tillage, conservation tillage, and reduced tillage practices.

5.5 Weather and Climate Variables

In addition to information on government program payments we expect that other characteristics of a county will affect the proportion of producers that use conservation or no tillage practices. Previous work has found that recent drought or flood conditions may lead to higher adoption of conservation tillage practices (Ding et al. 2009). In addition, we expect that production practices are determined in part by long-term conditions in a county. Thus, we include long-term average levels for spring temperature and precipitation. We expect that counties that have historically had drier conditions are more likely to have greater levels of adoption of conservation tillage. In addition, research has shown that conservation tillage has greater benefits on highly erodible land. Thus, we include the proportion of land in a county that is considered highly erodible.

6 Econometric Estimation and Results

The econometric estimation combines Zellner's Seemingly Unrelated Regression (SUR) with panel data. We use conventional as the base category for tillage and all coefficient estimates show the relative importance of the variable in the use of a particular tillage practice relative to conventional. We estimate the share equations for three practices: zero tillage, conservation tillage, and reduced tillage. Letting m denote the tillage system, i the county, and t the year, we estimate a system of three equations. We use the predicted values for the previous two years for crop insurance indemnity payments ($\hat{y}_1$) and ad-hoc disaster payments ($\hat{y}_2$). Since we are interested in the effect of unexpected program benefits we do not want to use the current year's level of payments. We tested using both the previous year and the previous two years and the results are similar. However, we expect that the previous two years does a better job of estimating the trend in those payments, and it is that trend that we expect will have the primary influence on behavior.

$$log(s_{it}^m/s_{it}^0) = X_{it}^m\beta_m + \hat{y}_1\beta_1 + \hat{y}_2\beta_2 + \mu_i^m + \nu_{it}^m \tag{20}$$

The estimation allows for spatial autocorrelation in the error structure where,

$$\nu_t^m = (I_N - \lambda^m W)^{-1}\upsilon_t^m \tag{21}$$

where W is the spatial weight matrix. The matrix W is a symmetric contiguous matrix, where each element (w_{ij}) equals 1 if county i is adjacent to county j, and 0 otherwise.

6.1 Results

Table 2 shows the results of the estimation with and without using the instrumented values of government program payments.

Since the coefficients in the estimation of the system of share equations do not show the marginal effects we also compute the marginal effects of the explanatory variables on all tillage practices with and without the instrumental variables. Table 3 shows the marginal effects of each of the explanatory variables on the share of each tillage practice.

7 Discussion and Conclusion

The results from the estimation show several important things about how farmers choose to manage climate risk based on the combination of practice choices and government payments. They also provide evidence that using instruments for government program payments is important, as those variables are endogenous. The signs of the coefficients in the system estimation shown in Table 2 are generally as we expect. For example, the amount of highly erodible land in a county is a strong predictor of the share of land under zero tillage and conservation tillage relative to conventional tillage. In previous research we found that recent drought and flood conditions are significant predictors of the use of zero tillage and conservation tillage (Ding et al. 2009). We still find that recent droughts and floods have a significant impact on practice choice but the magnitude of the result is lower in the current results. This provides evidence that the impact of recent climate extremes on practice choice is tempered when government payments reduce the financial impact.

Using instruments for government payments does not have a major effect on most of the coefficients in the results. Both the estimate coefficients and significance levels are similar in the two estimation results. However, using instruments for government payments does have a strong impact on the magnitude and the significance of the impact of disaster payments on production practices. It is not surprising that ad-hoc disaster payments have

Table 2: Results from a Random Effects SUR Model with Spatial Autocorrelation

	No Till	Conservation Till	Reduced Till	No Till	Conservation Till	Reduced Till
Variable	No Instruments			Payments Instrumented		
Constant	-5.41 ***	-0.862	1.49	-5.10 ***	-0.509	1.61 **
	-5.20	-0.83	1.85	-4.87	-0.486	1.98
Recent drought	0.046	0.104	-0.006	0.082	0.112 *	-0.001
	0.697	1.58	-0.119	1.24	1.70	-0.023
Recent flood	0.056	0.134 **	-0.0045	0.012	0.065	-0.048
	0.853	2.03	-0.087	0.184	0.97	-0.9
April SPI	-0.734 ***	-0.412 **	-0.244	-0.54 ***	-0.29	-0.16
	-3.72	-2.08	-1.58	-2.68	-1.4	-0.99
Average Precipitation	0.037 ***	0.016	-0.006	0.032 **	0.004	-0.0088
	3.07	1.34	-0.62	2.44	0.329	-0.886
Average Temperature	-0.02 *	0.005	-0.01	-0.022 *	0.011	-0.008
	-1.67	0.406	-1.05	-1.719	0.901	-0.852
Highly Erodible Land	3.2 ***	0.49 *	0.401 *	3.26 ***	0.51 *	0.43 **
	11.6	1.81	1.89	11.8	1.87	2.04
Fuel Price	0.043	-0.016	-0.078	0.003	-0.051	-0.10 **
	0.717	-0.272	-1.66	0.053	-0.852	-2.15
Time trend	0.652 ***	0.106	0.011	0.51 ***	0.035	-0.023
	7.06	1.15	0.148	5.2	0.357	-0.297
Time trend Squared	-0.025 ***	-0.0006	0.0033	-0.015 ***	0.003	0.005
	-5.02	-0.115	0.85	-2.97	0.627	1.23
Disaster program Payments	-0.046	-0.083 *	-0.054	-0.3 ***	-0.215 ***	-0.122 **
	-1.07	-1.92	-1.58	-4.267	-3.03	-2.21
Insurance indemnity Payments	0.048 ***	-0.043 ***	-0.025 **	0.061 *	-0.062 *	-0.014
	3.11	-2.77	-2.12	1.78	-1.82	-0.55

Asymptotic t-statistics are shown below the coefficients. Significance at the 0.01, 0.05, and 0.1 levels denoted by ***, **, and * respectively.

Table 3: Marginal Effects of Explanatory Variables on Tillage Practice Shares

	No till	Conservation	Reduced	Conventional	No till	Conservation	Reduced	Conventional
Variable	No Instruments				Payments Instrumented			
Drought	0.00091	0.0205	-0.0129	-0.00849	0.00578	0.0195	-0.0145	-0.0107
Flood	0.00055	0.0263	-0.0158	-0.0110	0.00033	0.0178	-0.0159	-0.0022
SPI	-0.0765	-0.0218	0.0275	0.0709	-0.0592	-0.0140	0.0233	0.0499
Precipitation	0.00514	0.00157	-0.00448	-0.00222	0.00526	-0.00034	-0.0038	-0.00108
Temperature	-0.00301	0.00326	-0.00130	0.00105	-0.00373	0.0046	-0.0015	0.000591
HEL	0.453	-0.132	-0.136	-0.185	0.459	-0.134	-0.134	-0.191
Fuel price	0.0120	0.000587	-0.0163	0.00372	0.0092	-0.00254	-0.0157	0.0090
Disaster Payments	0.000009	-0.000106	-0.000008	0.000105	-0.0271	-0.0171	0.0109	0.0333
Insurance Indemnities	0.000116	-0.000101	-0.000038	0.000023	0.0143	-0.01614	-0.000643	0.0025

a larger effect than crop insurance indemnity payments, as crop insurance payments can be predicted by a producer. However, ad-hoc disaster payments are generally unexpected and can vary significantly between counties. The coefficients for zero, conservation, and reduced tillage are all negative and significant with the instrumental variable estimation.

The estimate coefficients provide a comparison of the effect of the explanatory variables on the predicted shares of each tillage practice relative to conventional tillage but it is not straightforward to interpret the coefficients. Thus, we also estimate the marginal effects of each variable of interest on the share of all four tillage practices. Since the share equation estimates are non-linear, the sign of the coefficient is not always the same as the sign of the marginal effect. Table 3 shows the estimated marginal effects of each variable. For comparison we include the estimated effects with and without instrumental variables. As with the estimated coefficients, we find that it is important to use instrumental variables for the government payments. When we ignore the endogeneity of those payments we have find a small marginal effect. However, when we properly account for the endogeneity of the payments we find that while the marginal effects are still small, they are both the expected sign and of a size that may be important. For example, we find that an increase in recent disaster payments (measure in millions of 2006 dollars) decreases the share of land in zero and conservation tillage by 2.7 and 1.7 percent respective, while increasing the percentage of and in conventional tillage by 3.3 percent. While these coefficients are not large, when spread over a large area or with high levels of payments this could have sizeable effect on land use choices, soil erosion, water pollution, and other environmental indicators.

While previous research has examined the role of insurance indemnity payments and insurance enrollment on production practices, this paper is the first to extend those results to consider the impact of ad-hoc disaster payments. While disaster payments are supposed to be rare and unexpected, the reality is that the level of payments is sizeable, amounting to approximately 23 percent of crop insurance indemnity payments during the years in our sample. Given the magnitude of these payments it is not surprising that they may affect producer choices on practices. The economic model in the paper provides a clear description of how a risk averse producer may view government programs as a substitute for production choices that are costly but reduce risk. The empirical results show that there is evidence that counties that have had high rates of disaster and crop insurance indemnity payments are more likely to use conventional tillage practices, a choice that can reduce costs but can increase the risk of weather related disasters.

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