*Journal of Agricultural and Resource Economics* 41(2):247–265 ISSN 1068-5502

# The Effects of Crop Insurance Subsidies and Sodsaver on Land-Use Change

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It is well known that insurance market information asymmetry can cause socially excessive cropping of yield-risky land. We show that crop insurance subsidies can cause the same problem absent information failures. Using field-level yield data, we find an inversed U-shaped relationship between crop prices and crop insurance subsidies' land-use impacts. For seventeen counties in the U.S. Prairie Pothole Region, simulations show that 0.05% to 3.3% (about 2,600 to 157,900 acres) of land under crop insurance would not have been converted from grassland had premium subsidies not existed. Land-use impacts of Sodsaver in the 2014 Farm Act are also quantified.

*Key words*: copula, crop insurance, grassland, land use, Sodsaver, subsidy chasing

## Introduction

The U.S. government influences farmers' land-use behavior via various commodity, conservation, and risk management programs. The subsidized crop insurance program in particular has attracted much attention because of its magnitude and potential land-use effects. In 2014 aggregate crop insurance premiums amounted to $10 billion, of which the federal government paid $6.2 billion in the form of premium subsidies (Risk Management Agency, 2015a). Studies have shown that areas with high production risk tend to receive larger crop insurance payments (e.g., Glauber, 2004; Coble and Barnett, 2013). A more recent study by the U.S. Government Accountability Office (2015) shows that between 1994 and 2013 higher risk areas (including the Dakotas) received more than $1.50 of net insurance payments per dollar of premium paid by farmers, whereas lower risk counties received much less. This is mainly because higher risk areas have higher premiums and subsidies are provided as a percentage of premiums.

Intuition would suggest that subsidizing production activities on risky land will bring more acres of such land into production. Therefore there have long been concerns that crop insurance subsidies would have significant impacts on land-use decisions, with implications for soil degradation, wildlife habitat, biodiversity, as well as water and air quality. To address concerns that crop insurance may cause grassland conversion, the Food, Conservation, and Energy Act of 2008 (hereafter the 2008 Farm Act) incorporated a Sodsaver provision that applies to the Prairie Pothole Region (PPR) in five states (Iowa, Minnesota, South Dakota, North Dakota, and Montana), but only if the governors of those states requests an implementation. However, no governor made such a request.

The Sodsaver provision was re-authorized in the Agricultural Act of 2014 (hereafter the 2014 Farm Act) with some major modifications. One is that the implementation of Sodsaver became

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This study was partially supported by Ducks Unlimited. We thank Larry Makus and two anonymous referees for their insightful and helpful comments. Any remaining errors are ours.

Review coordinated by Larry Makus.

effective upon the enactment of the 2014 Farm Act and is no longer conditional on a governor's request. Another is that Sodsaver in the 2014 Farm Act covers all counties in six states (Iowa, Minnesota, South Dakota, North Dakota, Nebraska, and Montana) instead of just the PPR area of the aforementioned five states. Furthermore, the Sodsaver provision in the 2014 Farm Act will reduce the crop insurance (excluding Catastrophic Risk Protection coverage) premium subsidy rate by fifty percentage points in the first four years of agricultural production on land converted from grassland.

The purpose of this study is to analyze and quantify the land-use effects of crop insurance subsidies and Sodsaver at the extensive margin. We do so by using data and approaches significantly different from those in previous research.[1] Many studies have examined the impacts of federal crop insurance programs on land-use decisions (e.g., Young, Vandeveer, and Schnepf, 2001; Goodwin, Vandeveer, and Deal, 2004; Lubowski et al., 2006). Goodwin, Vandeveer, and Deal (2004) represent the consensus that crop insurance subsidies do incentivize cropping, but that the effect is not large. To our best knowledge, only two studies have taken a high-resolution look at the effects of farm risk management programs on land-use decisions at the extensive margin in North and South Dakota based on recent data. By fitting a mixed logit model, Claassen et al. (2011) estimated the land-use consequences of crop insurance and disaster payments in seventy-seven selected counties of the Dakotas. Focusing on seven selected counties in the Dakotas, Claassen, Cooper, and Carriazo (2011) constructed representative farms in the PPR and then simulated Sodsaver's land-use effects under the 2008 Farm Act. However, these two studies were based on county-level yield data and used inflated county-level yield standard deviations to represent farm-level yield risk.

We discern large gaps in the literature on crop insurance's land use effects. The focus has been generally at the county level of analysis. It has not mainly focused on the region most likely to be impacted (i.e., land at the cropping fringe in the arid Western Great Plains).[2] Additionally, the policy context has changed markedly since the more analytic, earlier studies, culminating in Goodwin, Vandeveer, and Deal (2004), who considered data over the period 1985–1993. Insurance subsidies increased significantly under the Federal Crop Insurance Reform Act of 1994 and Agriculture Risk Protection Act of 2000. Biofuels policies and increasing global demand for food and feed have led to dramatic increases in corn, soybean, and wheat prices and an expansion of land under crops during the period 2006–2012.

This article aims to fill the gaps outlined above. Our empirical analysis is based on field-level yield data for major crops over 1987–2006 in Central and North Central South Dakota. First, field-level yield data, when compared with county-level data, allow us to more accurately quantify yield risk and hence to simulate the effects of crop insurance on land-use decisions. Second, we focus on Central and North Central South Dakota because grassland conversion due to agricultural production in this area has marked adverse environmental impacts, especially on waterfowl abundance (Wong, van Kooten, and Clarke, 2012; Wright and Wimberly, 2013; Lark, Salmon, and Gibbs, 2015). Third, we analyze the land-use effects under a variety of market price scenarios over 2005–2008 to examine how commodity prices affect premium subsidies' effects on land use. Finally, our assessment of the land-use effects of Sodsaver in the 2014 Farm Act can provide timely insights to inform policy discussions.

We examine crop insurance subsidies' land-use impacts from an *ex post* perspective, given that our field-level yield data, obtained from the RMA of the U.S. Department of Agriculture (USDA), cover land that has already been in crop production. That is, our simulation addresses how much insured cropland would not have been converted from grassland absent crop insurance subsidies. By contrast, Claassen et al. (2011) and Claassen, Cooper, and Carriazo (2011) studied land-use impacts from an *ex ante* perspective by addressing how much grassland conversion would be reduced

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[1] In the 2014 Farm Act, Sodbuster and Swampbuster were amended to incorporate crop insurance subsidies as program benefits that could be lost were a producer to violate the provisions (see Stubbs, 2014a,b, for details). Although we focus on insurance subsidies and Sodsaver, our methodology can be utilized to study land-use consequences due to Sodbuster and Swampbuster.

[2] An exception is Goodwin, Vandeveer, and Deal (2004), which includes the North Great Plains.

were crop insurance to be eliminated. When studying the land-use effects of the 2014 Farm Act's Sodsaver provision, we utilize a portion of the least-productive insured cropland as an approximation of grassland in terms of productivity. Therefore, the results of Sodsaver's land-use effects in our study address the percentage of total grassland that will be saved from conversion to cropland due to the implementation of Sodsaver in the 2014 Farm Act from an *ex ante* perspective.

We first set up a theoretical model to understand a farmer's optimal land use decision in the presence of subsidized crop insurance. The issue here is one of comparing returns from different land uses: crop production versus other land uses. We then calibrate the decision model and simulate land use effects of crop insurance subsidies and Sodsaver. Simulation results are discussed and concluding remarks are provided at the end of this paper.

## Crop Insurance and Distorted Planting Decisions: Theoretical Framework

We consider how the extent of yield risk can affect planting decisions in the presence of a crop insurance subsidy. The analysis pertains to many tracts, each with a single owner. All acres in a tract are the same, whereas yield risk may differ across tracts. We assume that planting choice (respectively, insurance choice) is discrete in that either all acres in a tract are planted (respectively, insured) or none are. Let $U(\cdot)$ denote a land owner's utility function of profit, which is increasing and concave (i.e., $U'(\cdot) > 0 > U''(\cdot)$). We assume that the yield of one tract is $y = \mu + \delta\varepsilon$, where $\mu > 0$ is mean yield; $\delta \in [0,1]$ is a deterministic parameter that reflects risk magnitude; and $\varepsilon$ is a random variable with support $[-\mu,\mu]$, mean 0, and cumulative distribution function $G(\varepsilon)$. We assume that $G(\varepsilon)$ is continuous and differentiable. Our interest is in yield variability only, so $\mu$ is held to be a constant while $\delta$ is heterogeneous across tracts with cumulative distribution function $F(\delta)$.

The alternative to cropping is to leave the land in some noncropping activities, which could include pastoral farming, use as a hunting preserve, or enrolling in a conservation program. We assume that return from noncropping activities is nonstochastic and equal to $r$ per tract, so that it generates utility $U^{nc} = U(r)$. In short, three choices exist for the owner of a tract with risk level $\delta$:

A. Do not crop (label as *nc*) and receive a certain utility, $U^{nc} = U(r)$;

B. Grow a crop but do not insure (label as *gni*) and face a yet-to-be-computed expected utility $U^{gni}(\delta)$; or

C. Grow a crop and do insure (label as *gi*) with the premium subsidized at rate $s \in [0,1]$ and yet-to-be-calculated expected utility, $U^{gi}(\delta;s)$.

Thus the overall problem is to identify

$$V(\delta;s) = \max[U^{nc}, U^{gni}(\delta), U^{gi}(\delta;s)]. \tag{1}$$

Choice B is in itself uninteresting since risk aversion together with a subsidy means that choice C second-order stochastically dominates choice B for actuarially fair premiums. However, a comparison of A and B will help facilitate discussions on the comparison between A and C. Thus, we analyze both comparisons.

### *Comparing Choices A and B*

To establish expected utility when the land is planted we need to build up the payoffs. With output price $p > 0$ and total cost $c > 0$, under choice B (i.e., grow but do not insure) the profit is $\pi^{gni}(\delta) = p(\mu + \delta\varepsilon) - c$. Therefore, we have $U^{gni}(\delta) = \int_{-\mu}^{\mu} U(\pi^{gni}(\delta))dG(\varepsilon)$. It is readily checked that $U_{\delta}^{gni}(\delta) < 0$ and $U_{\delta\delta}^{gni}(\delta) < 0$ given $U'(\cdot) > 0 > U''(\cdot)$, which indicates that growers' utility under choice B is decreasing at an increasing rate in yield risk. Let the difference between expected utilities from choices B and A be $\Delta^{gni}(\delta) \equiv U^{gni}(\delta) - U^{nc}$.

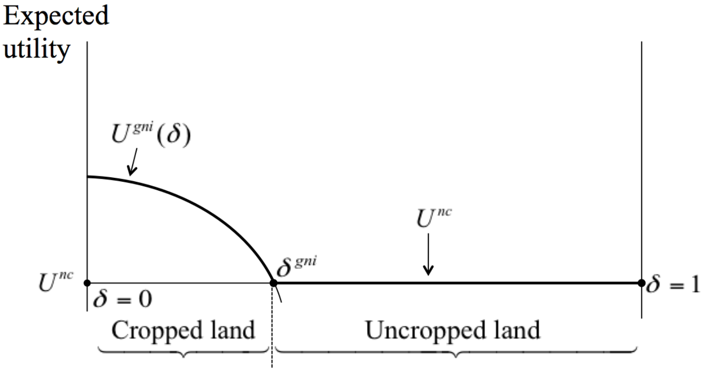

**Figure 1. Maximum of Uninsured Expected Utility and Noncropping Expected Utility as Risk Changes**

*Notes:* Thick black line is $\max[U^{gni}(\delta;s),\ U^{nc}]$.

We seek to identify and understand the levels of $\delta \in [0,1]$ such that $\Delta^{gni}(\delta) = 0$. To make the comparison meaningful we assume that under choice B the least-risky land generates higher utility from cropping than from noncropping and the opposite is true for the riskiest land. That is, we assume that $U^{gni}(0) > U^{nc} > U^{gni}(1)$. Therefore, there is a unique $\delta^{gni} \in [0,1]$ that solves $\Delta^{gni}(\delta) = 0$. As $U^{gni}(\delta)$ is decreasing in $\delta$, it follows that tracts with $\delta \in [0, \delta^{gni}]$ will be planted, and so the fraction of land that will be planted is $F(\delta^{gni})$ (see figure 1). For future reference, we formalize this obvious inference.

**Remark 1**: *Absent insurance, only tracts with $\delta \in [0, \delta^{gni}]$ are planted. That is, only tracts with low yield risk are planted.*

### *Comparing Choices A and C*

Now we introduce crop insurance to the model. For ease of exposition we only consider yield-based insurance in the theoretical analysis. In the simulation section we relax this constraint and consider revenue-based insurance. Let $\phi$ denote coverage level; insured yield is $\phi\mu$ and the indemnity payout on each tract is $p\max[\phi\mu - (\mu + \delta\varepsilon), 0]$. Obviously, insurance will only be taken up by tract owners having yield risk that satisfies $\phi\mu - (\mu - \delta\mu) > 0$ (i.e., $\delta > 1 - \phi$). The expected indemnity, and so the unsubsidized actuarially fair premium absent any administrative costs, is

$$v(\delta) = \int_{-\mu}^{\mu} p\max[\phi\mu - (\mu + \delta\varepsilon), 0]\, dG(\varepsilon). \tag{2}$$

In the presence of premium subsidy rate $s \in [0,1]$, the grower-paid premium is $(1-s)v(\delta)$ while the subsidy is $sv(\delta)$. Remark 2, which states that the subsidy is more extensive for riskier land, is key to understanding incentives in what follows:

**Remark 2**: *Subsidy $sv(\delta)$ increases in yield risk (i.e., $\partial[sv(\delta)]/\partial\delta > 0$).*

Remark 2 is consistent with empirical data as indicated in table 1. Only the premium and subsidy for corn are shown in the table, but the numbers for soybean show a similar pattern. Cropland in South Dakota is overall less productive and more risky than cropland in Iowa. Thus, the average premium is higher in South Dakota than in Iowa. Since subsidy is proportional to premium, South Dakota also has higher subsidy per acre.[3]

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[3] Other factors such as selection of coverage levels and insurance unit types may also affect the magnitude of premiums and subsidies. However, since premiums and subsidies in South Dakota are about twice as large as those in Iowa for both Yield Protection and Revenue Protection (see table 1), we believe that the selection of coverage levels and unit types can only explain part of the difference in premiums and subsidies between South Dakota and Iowa.

**Table 1. Comparison of Per Acre Premium and Subsidy in South Dakota and Iowa for Corn under Yield Protection and Revenue Protection**

| | Premium ($/acre) | | | | Subsidy ($/acre) | | | |
|---|---|---|---|---|---|---|---|---|
| | South Dakota | | Iowa | | South Dakota | | Iowa | |
| Year | Yield Protection | Revenue Protection | Yield Protection | Revenue Protection | Yield Protection | Revenue Protection | Yield Protection | Revenue Protection |
| 2014 | 34.6 | 69.9 | 15.1 | 39.4 | 23.7 | 48.2 | 8.1 | 20.6 |
| 2013 | 39.4 | 76.7 | 19.8 | 50.1 | 26.9 | 51.9 | 10.7 | 26.9 |
| 2012 | 33.8 | 68.6 | 20.4 | 50.3 | 22.9 | 47.3 | 11.4 | 29.3 |
| 2011 | 34.9 | 72.0 | 19.9 | 58.1 | 23.1 | 48.5 | 11.4 | 33.7 |
| 2010 | 26.2 | 48.6 | 12.7 | 34.0 | 16.9 | 32.7 | 7.1 | 20.1 |
| 2009 | 26.6 | 53.8 | 13.9 | 42.8 | 17.0 | 36.1 | 7.8 | 25.0 |
| 2008 | 28.8 | 71.3 | 16.7 | 53.4 | 17.8 | 41.2 | 9.2 | 29.2 |
| 2007 | 21.9 | 51.2 | 11.4 | 37.6 | 13.4 | 29.4 | 6.6 | 20.4 |
| 2006 | 12.6 | 30.4 | 6.1 | 20.9 | 7.7 | 17.5 | 3.7 | 11.4 |
| 2005 | 13.8 | 25.3 | 7.5 | 18.8 | 8.4 | 14.5 | 4.4 | 10.2 |

*Source:* Calculated by the authors based on data from RMA's Summary of Business Reports and Data, National Summary by Crop/State. Data are available at http://www.rma.usda.gov/data/sob.html (accessed May 21, 2015). For the columns of Revenue Protection, calculations over 2009–2010 are based on data for Crop Revenue Coverage (CRC), whereas calculations over 2005–2008 are based on data for Revenue Assurance (RA). For the columns of Yield Protection, calculations over 2005–2010 are based on data for APH total.

If the land owner chooses C (i.e., grow and insure) then profit becomes

$$\pi^{gi}(\delta;s) = p(\mu+\delta\varepsilon) + p\max[\phi\mu-(\mu+\delta\varepsilon),0] - c - (1-s)v(\delta), \tag{3}$$

and the expected utility is simply $U^{gi}(\delta;s) = \int_{-\mu}^{\mu} U(\pi^{gi}(\delta;s))dG(\varepsilon)$. To focus on how crop insurance subsidies affect land with different levels of risk, we analyze utility as a function of $\delta$ for a given coverage level $\phi$. It is readily shown that $\partial U^{gi}(\delta;s)/\partial s > 0$, which implies that an increase in subsidy rate, $s$, enhances the utility obtained from choosing C. That is, for a given tract, an increase in $s$ may switch the relationship between $U^{gi}(\delta;s)$ and $U^{nc}(\delta)$ from $U^{gi}(\delta;s) < U^{nc}$ to $U^{gi}(\delta;s) \geq U^{nc}$. Therefore, we can conclude:

**Remark 3**: *An increase in crop insurance subsidy rate, s, expands, at least weakly, the set of tracts cropped.*

We define the difference between expected utility of choices C and A as

$$\Delta^{gi}(\delta;s) \equiv U^{gi}(\delta;s) - U^{nc}. \tag{4}$$

Break-even risk levels, labeled as $\delta^{gi}$, solve $\Delta^{gi}(\delta;s) = 0$. Since we cannot be sure of the sign of $\partial U^{gi}(\delta;s)/\partial\delta$ without further qualification, we cannot be sure that any solution to $\Delta^{gi}(\delta;s) = 0$ is unique. For example, if $s = 1$ and $\phi = 0$, then $\partial U^{gi}(\delta;s)/\partial\delta < 0$; but if $s = \phi = 1$ then $\partial U^{gi}(\delta;s)/\partial\delta > 0$. However, when there is no subsidy ($s = 0$), it can be shown that $\partial U^{gi}(\delta;s=0)/\partial\delta < 0$.[4] So, whenever there is a solution $\delta^{gi}|_{s=0} \in [0,1]$ to $\Delta^{gi}(\delta;s)|_{s=0} = 0$, then the solution is unique. Figure 2 depicts land use in the presence of unsubsidized crop insurance when $\delta^{gni} > 1-\phi$. Note that in figure 2, $\delta^{gi}|_{s=0} > \delta^{gni}$ because $U^{gi}(\delta;s=0) > U^{gni}(\delta)$ whenever $\delta > 1-\phi$. To summarize, we have

**Proposition 1**: *Relative to no crop insurance, the introduction of unsubsidized crop insurance expands the set of land farmed from $F(\delta^{gni})$ to $F(\delta^{gi}|_{s=0})$ whenever $\delta^{gni} > 1-\phi$. It remains the case that only tracts with low yield risk are cropped.*

This result, though unsurprising, should be viewed as a reference point because the presence of an insurance subsidy may reverse the relationship between land risk type and the decision to crop.

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[4] Proof is available from the authors upon request.

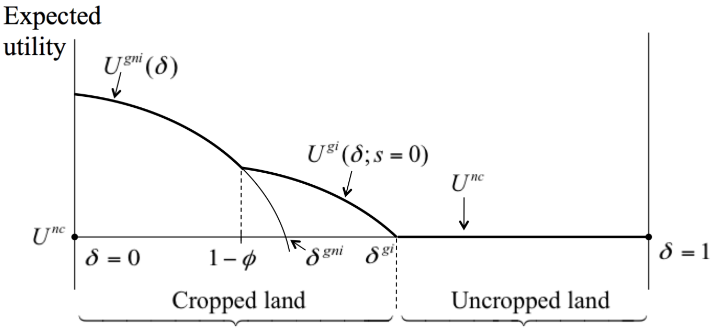

**Figure 2. Land Use in the Presence of Unsubsidized Crop Insurance when $\delta^{gni} > 1 - \phi$**
*Notes:* Thick black line is $V(\delta; s)$.

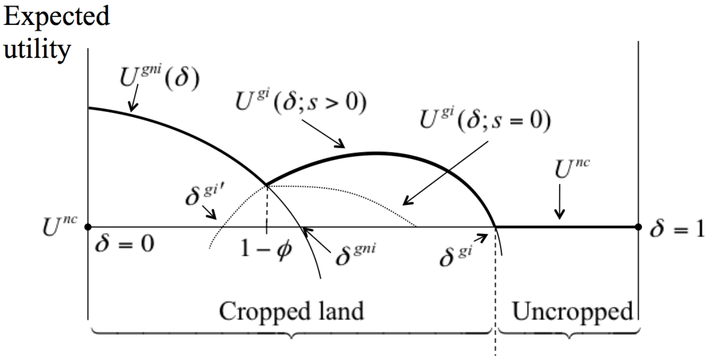

**Figure 3. Subsidized Crop Insurance that Does Not Distort Planting Decisions**
*Notes:* Thick black line is $V(\delta; s)$.

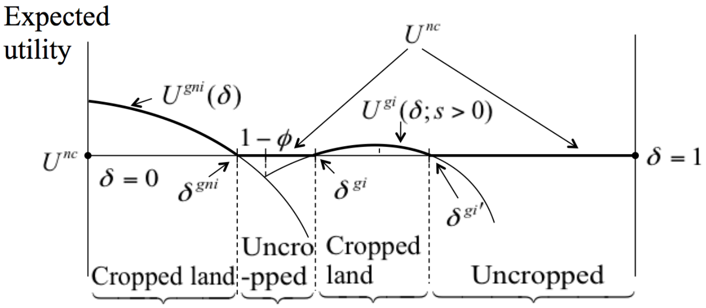

**Figure 4. Subsidized Crop Insurance that Distorts Planting Decisions**
*Notes:* Thick black line is $V(\delta; s)$.

### *Distorted Planting Decisions in the Presence of Crop Insurance Subsidy*

The presence of crop insurance subsidies may distort the decision to crop. Depending on the sign of $\partial U^{gi}(\delta; s)/\partial \delta$ and the curvature of $U^{gi}(\delta)$, $V(\delta; s)$ in equation (1) can have many possible shapes. Figures 3 and 4 depict just two possible shapes and so leave much unstated. In figure 3, it is still the case that tracts with low yield risk are cropped. Specifically, tracts with $\delta \in [0, 1-\phi]$ are cropped but not insured, tracts with $\delta \in (1-\phi, \delta^{gi})$ are cropped and insured, and tracts with $\delta \in [\delta^{gi}, 1]$ are not cropped.

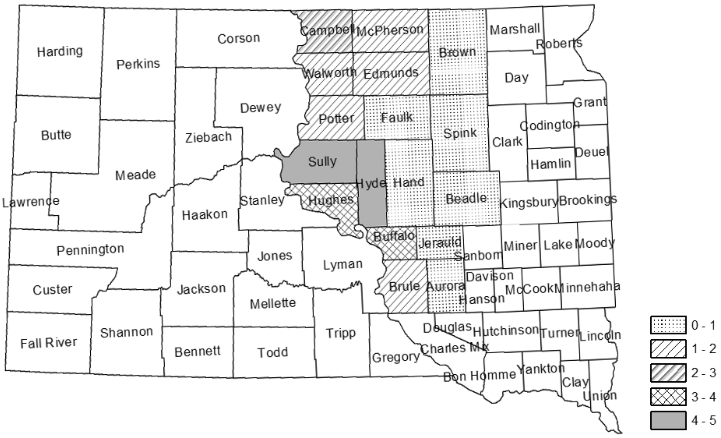

**Figure 5. Insurance Subsidies' Average Land Use Consequences over Four Price Scenarios in the 17 South Dakota Counties (%)**

It is also possible that the subsidized crop insurance can bring tracts with high yield risk under cropping but leave tracts with relatively low yield risk uncropped. Figure 4 shows an example. In figure 4, tracts with $\delta \in [0, \delta^{gni}]$ are cropped but not insured, tracts with $\delta \in [\delta^{gi}, \delta^{gi'}]$ are cropped and insured, and tracts with $\delta \in (\delta^{gni}, \delta^{gi}) \cup (\delta^{gi'}, 1]$ are uncropped. Near $\delta = 1$, the risk incurred is still too high to support cropping even though premium subsidies are high.

From the perspective of policy, figures 3 and 4 capture some widely held concerns about the land-use implications of crop insurance in some parts of the United States. Bear in mind that our analysis is not about adverse selection or moral hazard market failures as a result of asymmetric information. Information asymmetry is not necessary in order for riskier land to be cropped. While information asymmetries may indeed be part of the story, the simplest and most direct story is that a subsidy is most valuable on the riskiest land. As pointed out in Remark 2, insurance subsidies are largest for land with the highest production risk. Figure 4 illustrates a case in which the subsidy is strong enough to reverse the intuitive ordering on how land should enter production (i.e., where demand is highest for the least risky land as a factor in production). We refer to behavior in which high-yield-risk tracts enter cropping with the specific intent of obtaining subsidies as "subsidy chasing." Subsidy chasing requires expected utility to increase in yield risk (i.e., $\partial U^{gi}(\delta; s)/\partial \delta > 0$), which can be formally shown when coverage level and subsidy rate are sufficiently large.[5] We summarize the above discussions in the following proposition:

**Proposition 2**: *Without any information failures, subsidized crop insurance can bring high-risk land into cropping while leaving low-risk land uncropped because the subsidy is increasing in yield risk.*

Both Propositions 1 and 2 indicate that cropland expands in response to insurance subsidies. Our empirical investigation will examine the magnitude of any expansion. For ease of exposition in the theoretical analysis, we focused on yield insurance. In our empirical investigation we incorporate revenue insurance because it covers the majority of insured acres.

## Simulation Approach and Data

We focus on seventeen counties in Central and North Central South Dakota (see figure 5) and on three major crops in this area (i.e., corn, soybean, and wheat). We start by specifying the payoffs from revenue insurance and Sodsaver provision. The grower is assumed to have a constant absolute

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[5] The proof as well as an example with constant absolute risk aversion utility function and with a two-point yield distribution are available from the authors upon request.

risk aversion (CARA) utility function of form $-e^{-\vartheta\pi}$, where $\vartheta > 0$ is the absolute risk aversion (ARA) parameter.[6]

*Revenue Insurance and Effects of Crop Insurance Subsidies*

In the simulation we consider revenue protection (RP) crop insurance, the most popular revenue-based insurance policy in South Dakota. About 82% of total enrolled acres in South Dakota were covered under RP in 2014 (Risk Management Agency, 2015a). Whenever realized revenue from one crop is lower than a revenue guarantee, then an indemnity is paid to the grower. The revenue guarantee is based on the higher value of projected price and harvest price. Specifically, the indemnity per acre for crop $i \in X \equiv \{\text{corn, soybean, wheat}\}$ under a RP policy can be written as

$$(5) \qquad I_i = \max[\phi_i y_i^{APH} \max[p_i^{proj}, p_i^{harv}] - p_i^{harv} y_i, 0],$$

where $\phi_i$ is the coverage level chosen by the grower for crop $i$, $y_i^{APH}$ is the grower's actual production history (APH) yield, $p_i^{proj}$ and $p_i^{harv}$ are projected price and harvest price established by the Risk Management Agency (2011), and $y_i$ is the grower's realized yield for crop $i$. Since crop insurance premiums are subsidized by the federal government, the net indemnity can be written as

$$(6) \qquad NI_i = I_i - (1-s)E(I_i),$$

where $E(\cdot)$ is the expectation operator. Therefore, the farmer's profit from growing and insuring is

$$(7) \qquad \pi^{gi} = \sum_{i \in X} a_i(p_i^c y_i + NI_i + L_i - \tau_i) + PP,$$

where $a_i$ is payment acres for crop $i \in X$, $p_i^c$ is the county-level cash price for crop $i$, $L_i$ is per acre loan deficiency payments (LDPs), $\tau_i$ is production cost per acre for crop $i$, and $PP$ is program payments and includes farm-level direct payments (DPs) and farm-level counter-cyclical payments (CCPs).[7]

Once profit is identified, we can calculate and compare the utilities for alternative land-use and insurance scenarios. By construction we know that $E(U(\pi^{gi}|_{s>0})) \geq E(U(\pi^{gi}|_{s=0}))$. Therefore, eliminating crop insurance subsidies will induce the producer to switch land use from cropping to noncropping if and only if $E(U(\pi^{gi}|_{s>0})) \geq U^{nc} > E(U(\pi^{gi}|_{s=0}))$. For a certain area (e.g., a county), let $A$ denote the total acreage of cropland whose owner has $E(U(\pi^{gi}|_{s>0})) \geq U^{nc} > E(U(\pi^{gi}|_{s=0}))$ and let $\Omega$ denote the total cropland acreage in the area. Then the land-use effects of crop insurance subsidies in this area can be measured as $100(A/\Omega)\%$.

*Sodsaver Provision and Its Land-Use Effects*

Under the Sodsaver provision in the 2014 Farm Act, crop production on new breakings will still be eligible for crop insurance and insurance premium subsidies, but the premium subsidy rate during the first four years will be reduced by 50 percentage points. Moreover, during the first four years the APH yield will be fixed at 65% of county-level transitional yield (T-yield), and no yield substitution will be allowed. Starting from the fifth year, production will become eligible for the normal subsidy

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[6] We select the CARA utility function for its simplicity and calibrate the CARA utility function following the approach developed by Babcock, Choi, and Feinerman (1993). To confirm robustness we also conduct the simulation based on a calibrated decreasing absolute risk aversion (DARA) utility function. We find that these two classes of utility functions generate results with negligible differences. Simulation results based on the DARA utility function are available from the authors upon request.

[7] Vedenov and Power (2008) describe the calculations of LDPs, DPs, and CCPs. We include CCPs instead of Average Crop Revenue Election (ACRE) payment because ACRE enrollment was much smaller than CCP enrollment in South Dakota (24% versus 76% of total base acres, according to Farm Service Agency, 2013).

rate and the calculation of APH yield will assume the normal procedure discussed in Edwards (2014).[8] Specifically, under the Sodsaver provision, crop $i$'s APH yield for a tract of broken land in county $j$ and year $t$ can be written as

$$y_{ijt}^{APH\_Sod} = \begin{cases} 0.65 y_{ijt}^{T} & \text{if } 1 \leq t \leq 4, \\ \frac{1}{t-1} \sum_{n=1}^{t-1} \max[y_{ijn}, 0.6 y_{ijt}^{T}] & \text{if } 5 \leq t \leq 10, \\ \frac{1}{10} \sum_{n=t-10}^{t-1} \max[y_{ijn}, 0.6 y_{ijt}^{T}] & \text{if } t > 10, \end{cases} \tag{8}$$

where $y_{ijt}^{T}$ is the T-yield for crop $i$ in county $j$ in year $t$; $y_{ijn}$ is the broken land's actual yield in year $n$.

By assuming an RP policy, the indemnity, $I_{ijt}^{Sod}$, and net indemnity, $NI_{ijt}^{Sod}$, in year $t \geq 1$ under Sodsaver can be written as

$$I_{ijt}^{Sod} = \max\left[\phi y_{ijt}^{APH\_Sod} \max[p_{it}^{proj}, p_{it}^{harv}] - p_{it}^{harv} y_{ijt}, 0\right], \tag{9}$$

$$NI_{it}^{Sod} = \begin{cases} I_{it}^{Sod} - [1 - \max(0, s_{it} - 0.5)] E(I_{it}^{Sod}) & \text{if } 1 \leq t \leq 4, \\ I_{it}^{Sod} - (1 - s_{it}) E(I_{it}^{Sod}) & \text{if } t > 4 \end{cases} \tag{10}$$

where 0.5 stands for the 50 percentage points of premium subsidy rate to be reduced under the Sodsaver provision. Therefore the grower's profit with Sodsaver in year $t$ is

$$\pi_t^{Sod} = PP_t + \sum_{i \in X} a_{it}(p_{it}^{c} y_{it} + NI_{it}^{Sod} + L_{it} - \tau_{it}), \tag{11}$$

where $PP_t$ stands for agriculture risk coverage (ARC) and price loss coverage (PLC) payments established in the commodity title of the 2014 Farm Act. Coppess and Paulson (2014) document the calculations for ARC and PLC payments.[9] Without the Sodsaver provision, the calculation of APH follows the standard approach described in Edwards (2014). The net indemnity payments and profits from cropping without Sodsaver can be readily calculated similar to the approach described in equations (5), (6), and (11).

Let $U^{Sod}$ and $U^{NSod}$ denote the grower's expected utility obtained from farming the newly broken land with and without Sodsaver, respectively, and $M$ denote the tenure of new breakings under cropping. This gives us $U^{Sod} = \sum_{t=1}^{M} \beta^{t-1} E[U(\pi_t^{Sod})]$ and $U^{NSod} = \sum_{t=1}^{M} \beta^{t-1} E[U(\pi_t^{NSod})]$, where $\beta \in [0,1]$ is a discount factor and $\pi_t^{NSod}$ is cropping profit in year $t$ without Sodsaver. By construction we know that $U^{NSod} \geq U^{Sod}$. The implementation of Sodsaver will induce the grower to switch from breaking to not breaking the grassland if and only if $U^{NSod} \geq U^{nc} > U^{Sod}$. For an area (e.g., a county), let $A^{Sod}$ denote the total acreage of grassland whose owners have $U^{NSod} \geq U^{nc} > U^{Sod}$ and let $\Omega^{Sod}$ denote the total grassland acreage in this area. Then Sodsaver's land-use effects in this area can be measured as $100(A^{Sod}/\Omega^{Sod})\%$.

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[8] The first year's production is generally ineligible for crop insurance because at least one year's APH is required to purchase crop insurance. However, a grower can petition for insurance for the first year's production. We assume that a grower will file such a petition and insure the first year's production.

[9] Under the 2014 Farm Act, farmers can select either ARC or PLC (but not both) for one covered commodity. In the seventeen counties included in this study, corn and soybean ARC payments are generally expected to be larger than PLC payments, while the opposite is true for wheat (Farm Service Agency, 2015b). Therefore, we assume that farmers select ARC for corn and soybeans and PLC for wheat. Moreover, we do not consider Supplemental Coverage Option (SCO) in this study, since farmers who select ARC are not eligible for SCO and the take-up rate for SCO in South Dakota as of May 2015 was quite low (only 120 SCO policies were sold according to Risk Management Agency, 2015b).

### *Obtaining Yield-Price Joint Distributions*

The simulation is based on field-level yield data. A key step in the simulation is to identify field-level yield-price joint distributions for the purpose of calculating crop insurance premiums and hence premium subsidies for each field. Because of the flexibility provided, copula approaches are becoming increasingly popular for modeling joint distributions (Yan, 2007; Du and Hennessy, 2012; Goodwin and Hungerford, 2015). We utilize the Multivariate Gaussian Copula (MGC) because the RMA has applied it to determine crop insurance premium rates (Goodwin and Hungerford, 2015) and it is one of the most commonly used copulas in risk management (Zhu, Ghosh, and Goodwin, 2008).[10] Based on the MGC, an $m$-dimensional joint distribution, $F(x_1, \ldots, x_m)$ can be expressed by

$$F(x_1, \ldots, x_m) = \Phi_m(\Phi^{-1}(F_1(x_1)), \ldots, \Phi^{-1}(F_m(x_m)); \rho), \tag{12}$$

where $\Phi_m(\cdot)$ is the $m$-dimensional multivariate standard normal distribution with mean zero and correlation matrix as $\rho$, $\Phi^{-1}(\cdot)$ is the inverse distribution function of the standard one-dimensional normal distribution, and $F_k(x_k)$, $k \in \{1, \ldots, m\}$ is the marginal distribution of random variable $X_k$.

A common method used to estimate the marginals and the correlation matrix is the Inference Function for Margins (IFM) method proposed by Joe (2005). Du and Hennessy (2012) provide an example of using the IFM method to estimate a yield-price joint distribution. We also apply the IFM method, but we use the kernel density estimation method to estimate the marginals (see Ker and Goodwin, 2000, for an application of the kernel method). In doing so we do not need to identify specific parametric distributions for the marginals. Once we obtain draws from the m-dimensional joint distribution of yield and price, we can calculate a) the actuarially fair premium for revenue insurance under various coverage levels and b) expected utility from growing each crop with insurance.

### *Data*

Data utilized in our simulation include county-level yields, field-level yields, projected prices, harvest futures prices, harvest cash prices, production cost, and pastureland cash rent. Our analysis uses both county-level yields and insurance unit-level yields. County-level yields and harvested acreage data for corn, soybeans, and wheat from 1960–2009 (1960–2008 for wheat) are obtained from the National Agricultural Statistics Service (NASS) of the USDA. An insured unit can be a single field or several fields, depending on the farm's physical characteristics and the grower's preferences. Actual yield history records for each insured corn, soybean, and wheat unit under the federal crop insurance program in policy year 2007 are obtained from the RMA. The yield history has up to ten years yield records for each insured unit, but these ten years are not necessarily continuous. For example, a unit's first actual yield observation in the record may be in 1990 but the second may be in 1995. In the unit-level yield dataset, the latest year in the yield history records is 2006, while the earliest year is 1970. However, only about 0.9% of units have yield history earlier than 1987. Therefore, to gain efficiency in unit-specific productivity estimation when detrending yields, we limit our analysis to units with yield history records between 1987 and 2006. Also, in order to have the largest possible number of observations and to gain confidence in estimating yield marginal distributions, a unit is included only if it has ten years of actual yield observations.[11]

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[10] Woodard et al. (2011) find that MGC, Multivariate Student's $t$ copula, and kernel copula perform equally well in modeling crop yield risk. However, "Clayton copula often generated [premium] rates that are unacceptably low in some cases" (Woodard et al., 2011, p. 110). We understand that the MGC might be problematic due to tail correlation issues, although not much is known about the issue because, unlike financial data, farm-level yield observation time series tend to be very short. Other approaches, including the canonical vine copula approach used in Goodwin and Hungerford (2015), might be more appropriate. We leave investigations along this line for future research.

[11] We recognize that by requiring exactly ten years of actual yield observations, we are selecting relatively high-quality land and leaving lower-quality land outside of the simulation. This may underestimate the land-use effect of crop insurance.

Irrigated units are excluded because they only account for a small portion of total units (3.4% for corn, 2.7% for soybean, and 0.05% for wheat). No information regarding crop rotation or organic production is available in the data.

Yield observations for each unit are detrended by following the approach in Claassen and Just (2011) that accounts for the county-level yield trend. Moreover, since our RMA yield datasets for corn, soybean, and wheat are distinct and the location information within a county has not been released by the RMA, we cannot link these three datasets by units. Therefore, in order to establish a link across datasets, we match units having high corn yield with units having high soybean yield and units having high wheat yield based on the assumption that high-quality land tends to have high yields for corn, soybean, and wheat.

Three types of crop prices are utilized in the simulation: projected prices, harvest futures prices, and harvest cash prices. Projected prices and harvest futures prices are utilized to a) determine crop insurance indemnity (see equations 5 and 9) and b) estimate joint yield-price distributions. The projected prices and harvest futures prices for the three crops in South Dakota are determined according to Risk Management Agency (2011) rules based on futures prices, which are obtained from Barchart.com. Cash prices are utilized in calculating growers' profit from cropping (see equations 7 and 11). Cash price draws are obtained by adding county-level basis to harvest futures prices drawn from the estimated yield-price joint distribution. For a given year, county-level basis is obtained by subtracting the historically observed harvest futures price from the simple average of posted county prices (PCP) in the harvest month obtained from the Farm Service Agency (2015a). We assume October to be the harvest month for corn and soybeans and August to be the harvest month for spring wheat.

Janssen and Hamda (2009) report spring crop budgets for Central and North Central South Dakota in 2008. Excluding crop insurance premium and land charge, their per acre production costs for corn, soybean, and wheat are \$205, \$145, and \$180, respectively, which we term basic production costs. We assume that each farm in the area has the same basic production costs in a given year. The crop insurance premium and land rent (i.e., the opportunity cost of farming the land, which we assume to be pastureland cash rent) may differ across farms. Since we do not have production cost information for Central and North Central South Dakota in years earlier than 2008, we use a ratio to scale the 2008 basic production costs to obtain production costs in earlier years. The ratio is defined as production costs in this earlier year in South Central North Dakota divided by costs in 2008 in the same area.[12] For example, we use the ratios of 2005 costs over 2008 costs from South Central North Dakota budgets to scale up or down the aforementioned amounts of \$205, \$145, and \$180 to obtain 2005 production costs in Central and North Central South Dakota. Unlike crop prices, production costs are treated as deterministic variables.

Pastureland cash rent is the assumed return for noncropping activities. County-level pastureland cash rents in 2008 for the seventeen counties are obtained from NASS. The NASS pastureland cash rent data do not differentiate between high-quality and low-quality pastureland, but it is reasonable to assume that higher-quality fields should have higher pastureland cash rent. Therefore, we use the ratio of RMA unit average yield over county average yield to multiply the county-level pastureland cash rent when estimating unit-level cash rent. Since county-level pastureland cash rents for years earlier than 2008 are not available, we use the state-level increase in the pastureland cash rent between an earlier year and 2008 in South Dakota to derive the cash rents in this earlier year. For example, at the state-level the pastureland cash rent increased by 15% from 2007 to 2008 in South Dakota. Therefore, a county's pastureland cash rent in 2007 is calculated by using the county's pastureland cash rent in 2008 divided by 1.15. Data on annual changes in pastureland cash rents are calculated using state-level cash rent data from the USDA's Agricultural Statistics Board (2008). Pastureland cash rent is treated as a deterministic variable as well.

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[12] This area is selected because it is contiguous to Central and North Central South Dakota. Production costs for this area over 2005–2008 are obtained from the North Dakota State University Extension Service (2005–2008).

**Table 2. Projected Prices in Planting Season of Corn, Soybean, and Wheat over 2005–2008 ($/bushel)**

| | **2005** | **2006** | **2007** | **2008** |
|---|---|---|---|---|
| Corn | 2.32 | 2.59 | 4.06 | 5.40 |
| Soybean | 5.53 | 6.18 | 8.09 | 13.36 |
| Wheat | 3.35 | 4.22 | 5.23 | 11.11 |

*Source:* Calculated by the authors based on the Risk Management Agency (2011) rule and data from Barchart.com.

## Simulation Results

We simulate the land-use consequences of crop insurance subsidies and of Sodsaver under four scenarios, represented by the market environments of the four years from 2005 to 2008.[13] These four years are chosen because crop prices increased dramatically over this period. Table 2 shows these projected prices, from which we can see that 2008 prices increased by approximately 150% compared to 2005 prices. The large differences between crop prices over this period provide an opportunity to assess the impacts of crop prices on insurance subsidies' land-use effects.

### *Land-Use Consequences of Crop Insurance Subsidies*

Table 3 presents the simulation results for crop insurance subsidies' land-use consequences. To generate the results in table 3, the coverage level for each unit is determined endogenously and the level that generates the highest expected utility is chosen. Given that government subsidy rate is determined by coverage level, the subsidy payment for each unit is also determined endogenously. Bearing in mind that the data pertain to land that is already cropped and insured, the results are the percentages of land covered under crop insurance that would have not been converted from grassland had there been no crop insurance subsidies. Since the units included in our data have already been enrolled in the federal crop insurance program, the expected utility from cropping and insuring should be greater than the reservation utility (i.e., $U^{gi} > U^{nc}$ for every unit). In our simulation results, $U^{gi} > U^{nc}$ holds for all but a small percentage of units.[14] There are several possible reasons for units to have $U^{gi} < U^{nc}$. First, because we have limited information regarding land owners' heterogeneity, we assume that they have the same utility functions and basic production costs. Second, economies of scope in production may exist; that is, some units might have been converted because they are near land that is profitable to crop, so the marginal costs of planting on these units are low.

The results show that if projected crop prices had been those in 2006 and if there had not been crop insurance subsidies, about 3.3% of acres covered under crop insurance in the seventeen counties would have provided more economic surplus to the owner under grassland than under cropland. According to the Risk Management Agency (2015b), 4,764,046 acres were covered by crop insurance in the seventeen counties in 2006. Hence, the 3.3% land use change means that 157,875 acres of grassland would have not been converted absent crop insurance subsidies. If projected crop prices had been as high as those in 2008, and without subsidies, however, then about 0.05% of the seventeen-county acreage (i.e., 2,591 acres) covered by crop insurance would not have been converted. This is intuitive: when crop prices are very high, planting crops can become so profitable that growers prefer planting even without insurance subsidies.

When crop prices are relatively low, then the availability of crop insurance subsidies may become a critical factor influencing growers' land-use decisions. Therefore, we see that under 2005 and 2006 price scenarios the land-use consequences of subsidies are large but under 2008 prices the land-use

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[13] Simulation procedures and computer codes are available from the authors upon request.

[14] In our simulation, when crop insurance is subsidized at current rates (see Shields, 2015, table 1), then the total percentage of units that have $U^{gi} < U^{nc}$ under price scenarios from 2005 to 2008 for the seventeen counties are 5.5%, 6.2%, 1.6%, and 0.1%, respectively.

**Table 3. Percentage of Land under Federal Crop Insurance That Would Not Have Been Converted from Grassland Had There Been No Crop Insurance Subsidies (%)**

| County | Under 2005 Prices | Under 2006 Prices | Under 2007 Prices | Under 2008 Prices |
|---|---|---|---|---|
| Aurora | 0.4 | 1.7 | 0.5 | 0.0 |
| Beadle | 0.6 | 0.2 | 0.0 | 0.0 |
| Brown | 0.1 | 0.2 | 0.0 | 0.0 |
| Brule | 1.4 | 2.3 | 0.8 | 0.0 |
| Buffalo | 2.6 | 6.1 | 5.9 | 0.4 |
| Campbell | 4.0 | 5.0 | 2.6 | 0.0 |
| Edmunds | 1.3 | 3.0 | 0.3 | 0.5 |
| Faulk | 1.1 | 1.6 | 0.1 | 0.0 |
| Hand | 0.9 | 1.7 | 0.5 | 0.0 |
| Hughes | 2.9 | 8.5 | 1.5 | 0.0 |
| Hyde | 3.4 | 10.4 | 5.5 | 0.0 |
| Jerauld | 0.0 | 1.3 | 1.2 | 0.0 |
| McPherson | 3.2 | 2.3 | 0.0 | 0.0 |
| Potter | 3.4 | 3.0 | 0.9 | 0.0 |
| Spink | 0.5 | 0.3 | 0.0 | 0.0 |
| Sully | 9.2 | 5.7 | 2.9 | 0.0 |
| Walworth | 2.6 | 3.0 | 0.0 | 0.0 |
| Average | 2.22 | 3.31 | 1.33 | 0.05 |
| Acres | 105,640 | 157,875 | 63,417 | 2,591 |

*Notes:* The last row, "Acres," is calculated by using the average percentage times total acreage covered under crop insurance in 2006 within the seventeen counties (i.e., 4,764,046 acres according to RMA's Summary of Business Reports and Data, http://www.rma.usda.gov/data/sob/scc/index.html, accessed May 15, 2015).

consequences are small. The average of crop insurance subsidies' land-use effects over the four price scenarios is 1.7%. If results from 2008 are excluded, the average effect is 2.3%.

The relationship between the magnitude of insurance subsidies' land-use consequences and projected crop prices is not necessarily monotonically decreasing. From table 3 we see that the land-use consequences of subsidies reach the highest levels under the 2006 price scenario and decrease over the 2007–2008 price scenarios for twelve out seventeen counties. For the remaining five counties (i.e., Beadle, McPherson, Potter, Spink, and Sully), the land-use consequences are highest under the 2005 price scenario and decrease as projected prices increase. That is, it appears that the magnitude of subsidies' land-use consequences and projected crop prices generally have an inverse U-shaped relationship, which can be explained as follows. Were crop prices continuously extremely low, then—irrespective of crop insurance subsidies, indemnity payments, and other government payments—landowners would prefer to keep their land uncropped (i.e., no landowners would switch their land uses due to the change in subsidy availability. Therefore, the land-use effects of subsidies would simply be zero. Similarly, were crop prices extremely high, then all landowners with positive yield on their land would prefer to put land under cropping, even if crop insurance subsidies were eliminated. The subsidies' land-use effects would again be zero. Therefore, crop insurance subsidies have the largest impact when crop prices are such that conversion from grassland is marginally profitable.

The results also show that subsidies' land-use consequences in counties close to the Missouri River are generally larger than consequences in the other counties in our simulation (figure 5). One explanation is that counties near the Missouri River have higher yield risks than do the other counties. As we have shown in Remark 3 and Proposition 2, subsidized crop insurance brings risky land into cropping, which implies that owners of risky land are more sensitive to crop insurance subsidies.

Based on data between 1998 and 2007, Claassen et al. (2011) found that the average effect of crop insurance (including subsidies) was to shift about 0.9% of rangeland to cropland over the

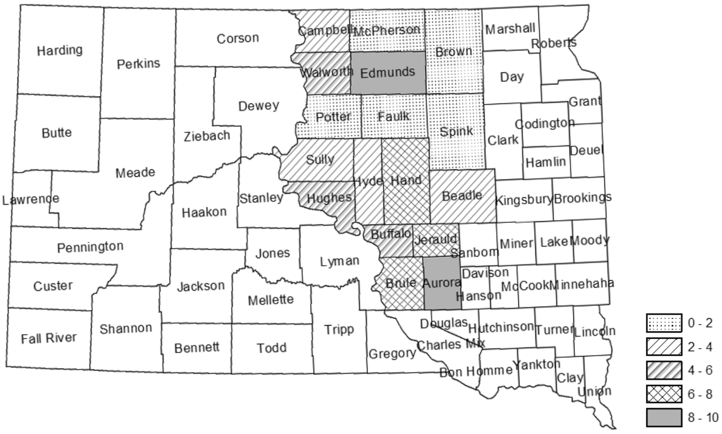

**Figure 6. Sodsaver's Average Land Use Consequences over Four Price Scenarios in the 17 South Dakota Counties (%)**

studied period. Although we do not directly simulate the land-use effect of eliminating both subsidies and crop insurance, Proposition 1 suggests that this effect will be larger than the effect of only eliminating subsidies. However, since our study employs different methodologies and data than those in Claassen et al. (2011), the results of the two studies are not comparable. Specifically, the percentage in the Claassen et al. (2011) results stands for the percentage of grassland. In our study, however, the land-use change percentage is the percentage of cropland covered under crop insurance.

### *Land-Use Consequences of Sodsaver*

Since we do not have crop productivity information for grassland, we utilize the 15% least productive insured units in each county as an approximation of crop productivity on grassland in that county when simulating the land-use effects of the Sodsaver provision.[15] We then identify units that would not have been converted had Sodsaver been implemented and calculate the percentage of such units among the 15% least productive units for each county. In the simulation we assume tenure under cropping to be fifty years. Assuming tenure longer than fifty years will not affect the simulation results much because returns in fifty years have low net present value (NPV). For simplicity, we follow through on one year's projected prices across the entire tenure of cropland under each price scenario.[16] Moreover, we follow Claassen, Cooper, and Carriazo (2011) in assuming that farmers choose RP policy with 70% coverage level for corn, soybeans, and wheat because this coverage level is popular among growers (Claassen, Cooper, and Carriazo, 2011; Du, Feng, and Hennessy, 2016).[17]

Table 4 provides simulation results for Sodsaver's land-use effects. The pattern of effects is similar to that of insurance subsidies' land-use effects. That is, a) the effects are significantly affected by projected crop prices, b) the relationship between the magnitude of Sodsaver's land-use effects and projected crop prices is also inverse U-shaped, and c) the effects tend to be larger in western counties of the studied area (figure 6). On average, Sodsaver's land-use effects reach the highest

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[15] This is one reason why we observe negative market profit in the simulation results for some counties, especially under 2005–2006 price scenarios (see table 4).

[16] However, harvest prices across the tenure may differ because harvest prices are correlated with yields and the yields are randomly drawn in the simulation. We understand that a stochastic dynamic programming approach may be more appropriate to capture how growers view the evolution of crop prices, but that is beyond the scope of the present work.

[17] To confirm the robustness, we also simulated the Sodsaver's land-use effect when crop insurance coverage level is set to 85% and premium subsidy rate to 38%. We find that switching the coverage level from 70% to 85% does not affect the results significantly.

**Table 4. Sodsaver's Land-Use Effects, Expected Four-Year Decrease in Net Indemnities ($/acre) Caused by Sodsaver, and Four-Year Market Profit of Land ($/acre) under Crop Prices over 2005–2008**

| County | Land-Use Effects (%) | Decrease in Net Indemnity | Profit with Sodsaver | Profit without Sodsaver | Land-Use Effects (%) | Decrease in Net Indemnity | Profit with Sodsaver | Profit without Sodsaver |
|---|---|---|---|---|---|---|---|---|
| | **Under Crop Prices in 2005** | | | | **Under Crop Prices in 2006** | | | |
| Aurora | 12.6 | 58 | 35 | 93 | 15.8 | 66 | 56 | 122 |
| Beadle | 4.9 | 43 | 116 | 159 | 3.0 | 48 | 166 | 213 |
| Brown | 0.0 | 31 | 290 | 321 | 0.0 | 34 | 301 | 336 |
| Brule | 10.8 | 55 | 4 | 59 | 14.7 | 63 | 30 | 93 |
| Buffalo | 2.8 | 41 | −26 | 15 | 1.2 | 48 | −43 | 5 |
| Campbell | 1.0 | 42 | −56 | −13 | 0.1 | 51 | −94 | −44 |
| Edmunds | 11.8 | 51 | 84 | 136 | 17.9 | 59 | 66 | 126 |
| Faulk | 0.6 | 39 | 143 | 182 | 2.3 | 45 | 143 | 188 |
| Hand | 6.3 | 48 | 27 | 76 | 12.7 | 57 | 37 | 94 |
| Hughes | 9.3 | 49 | 60 | 110 | 9.1 | 60 | 79 | 139 |
| Hyde | 1.7 | 28 | −15 | 13 | 0.3 | 34 | −44 | −10 |
| Jerauld | 11.7 | 45 | 29 | 74 | 12.5 | 52 | 41 | 93 |
| McPherson | 0.0 | 59 | −181 | −122 | 0.0 | 71 | −229 | −158 |
| Potter | 1.4 | 24 | 128 | 151 | 3.8 | 28 | 104 | 132 |
| Spink | 2.5 | 38 | 157 | 195 | 2.6 | 43 | 182 | 225 |
| Sully | 0.6 | 32 | 32 | 65 | 9.8 | 46 | 26 | 72 |
| Walworth | 6.3 | 40 | 52 | 92 | 11.7 | 47 | 32 | 79 |
| Average | 5.0 | 43 | 52 | 94 | 6.9 | 50 | 50 | 100 |
| | **Under Crop Prices in 2007** | | | | **Under Crop Prices in 2008** | | | |
| Aurora | 7.3 | 98 | 152 | 249 | 0.0 | 146 | 641 | 787 |
| Beadle | 0.4 | 69 | 361 | 430 | 0.0 | 97 | 958 | 1,055 |
| Brown | 0.0 | 50 | 488 | 538 | 0.0 | 74 | 1,014 | 1,088 |
| Brule | 1.1 | 91 | 185 | 276 | 0.0 | 143 | 816 | 959 |
| Buffalo | 16.2 | 74 | 34 | 107 | 0.0 | 106 | 389 | 495 |
| Campbell | 5.4 | 81 | −61 | 20 | 6.4 | 122 | 216 | 338 |
| Edmunds | 10.0 | 87 | 150 | 237 | 0.0 | 132 | 574 | 707 |
| Faulk | 0.0 | 63 | 255 | 318 | 0.0 | 96 | 849 | 946 |
| Hand | 6.2 | 82 | 147 | 229 | 0.0 | 130 | 686 | 816 |
| Hughes | 0.8 | 80 | 215 | 294 | 0.0 | 147 | 919 | 1,066 |
| Hyde | 7.3 | 50 | 6 | 56 | 0.2 | 81 | 406 | 487 |
| Jerauld | 5.6 | 76 | 157 | 233 | 0.0 | 117 | 636 | 754 |
| McPherson | 0.0 | 114 | −273 | −159 | 0.5 | 170 | −127 | 43 |
| Potter | 0.8 | 39 | 208 | 247 | 0.0 | 63 | 754 | 817 |
| Spink | 1.1 | 62 | 335 | 397 | 0.0 | 91 | 891 | 982 |
| Sully | 4.4 | 59 | 133 | 192 | 0.0 | 109 | 789 | 898 |
| Walworth | 2.7 | 67 | 114 | 181 | 0.0 | 108 | 574 | 682 |
| Average | 4.1 | 73 | 153 | 226 | 0.4 | 114 | 646 | 760 |

value, 6.9%, under the 2006 price scenario. If the projected crop prices in each year were the same as those in 2006 over fifty years and if the Sodsaver provision had been implemented, then about 6.9% of acres among the 15% of least productive insured cropland would not have been converted from grassland. Since we use the 15% least productive insured cropland to mimic grassland, this 6.9% can also be interpreted as asserting that 6.9% of grassland will be saved from conversion by Sodsaver provision. Under the 2008 (respectively, 2005) price scenario Sodsaver's average land-use effects are 0.4% (respectively, 5%), which is smaller than that under the 2006 price scenario. The same reason for the relationship between the magnitude of insurance subsidies' land-use consequences and projected crop prices applies here. The average of Sodsaver's land-use effects over the four price scenarios is 4%.

Sodsaver's land-use effects are driven by the Sodsaver provision's reduction in net indemnity of crop production on new breakings during the first four years. Table 4 also presents a) NPVs of reduction in net indemnity caused by the Sodsaver program and b) profits from land under crop production during the first four years with and without Sodsaver. Comparing the four price scenarios, we find that the NPVs of four-year net indemnity reduction (respectively, profits without Sodsaver) increases from \$43/acre (respectively, \$94/acre) under the 2005 price scenario to \$114/acre (respectively, \$760/acre) under the 2008 price scenario. The ratio of net indemnity reduction over cropping profits without Sodsaver provision is the highest, 50%, under the 2006 price scenario, which may explain why Sodsaver's land-use effect is the largest under the 2006 price scenario.

This study and Claassen, Cooper, and Carriazo (2011) have six counties in common: Beadle, Edmunds, Faulk, Hand, Hyde, and Sully. Claassen, Cooper, and Carriazo (2011) is based on analysis of representative farms. By calculating the 2008 Farm Act Sodsaver's effects on the farms' net returns and using conversion elasticities from the existing literature, they conclude that Sodsaver's land-use effects in the six counties range from 1% to 9%, depending on the conversion elasticities used. Although the results in Claassen, Cooper, and Carriazo (2011) and this study appear close, they are not directly comparable because of differences in methodology, data, and Sodsaver provisions under the 2008 Farm Act and the 2014 Farm Act. Since Claassen, Cooper, and Carriazo (2011) use a five-year time horizon, the impacts of Sodsaver under the 2008 Farm Act are enlarged because the loss of insurance benefits is only imposed in the first five years, after which the newly converted land will be treated the same as other cropland. By contrast, we assume that, once converted, a unit will be farmed for a long period (fifty years in this study). Once their results are adjusted by considering a longer time horizon, their estimates of Sodsaver's land-use impacts would be significantly smaller. If the interest rate is 0.07 (as used in Claassen, Cooper, and Carriazo, 2011), then a constant annual payment's five-year NPV is about 29.7% of its fifty-year NPV. Therefore, were the fifty-year horizon considered, the 9% land-use change in Claassen, Cooper, and Carriazo (2011) should be scaled down to 2.7% by multiplying by 0.297.

## Concluding Remarks

To understand how the availability of federal crop insurance subsidies influences land-use decisions, we first develop a conceptual model of optimal land allocation in the presence of crop insurance subsidies. Our model shows that crop insurance subsidies can induce land with higher yield risk into crop production, while land with identical mean productivity but lower yield risk is left uncropped. This is because the subsidy is greatest for the most production-risky land, which usually includes newly converted grassland.

Using farm-level data, we follow the conceptual results through to establish implications of subsidies for land use. We simulate the expected utility to be derived from putting land of a given production capability into crop production. Our simulation results show that riskier land is more sensitive to the changes in crop insurance subsidy rates. Sodsaver's impacts on land use are also simulated. Our results indicate that the magnitudes of crop insurance subsidies and Sodsaver's land-use effects are significantly determined by crop prices. When crop prices are very high (e.g., 2008 prices) or very low (e.g., 2005 prices), then the estimated land-use effects of insurance subsidies and Sodsaver are small. When crop prices are modest, however, then the estimated land-use effects are large. This indicates that when crop prices are very high or very low, reducing crop insurance's land-use effects by decreasing the premium subsidy rate may not be effective. However, when crop prices look to be settled indefinitely at moderate levels, decreasing the premium subsidy rate may be an effective way to reduce crop insurance's land-use effects. We use RP in the simulations because it is the most popular insurance policy in the area studied. RP provides more subsidy dollars than other types of insurance policies. Were other types of insurance policies to be used in the analysis, the results would be smaller than those under RP. Therefore, our analysis provides an upper bound on subsidies' land-use effects.

Our findings should be placed in context as there are other channels through which crop insurance could conceivably affect land-use choices. Our model is static while dynamic features of the conversion decision are likely to be economically significant. For example, land conversion costs are not insignificant. Barnhart and Duffy (2012) estimate that it would cost about $200/acre to establish a pasture from cropland in Iowa. For converting CRP land into cropping in North Dakota, Ransom et al. (2008) indicate a cost of about $55/acre, where costs might include the removal of heavy scrub and gopher mounds as well as chemical treatments. Converting native sod would be more expensive, especially if rocks need to be removed. A crop revenue safety net provides the owner with the assurance that subsequent conversion costs back to former uses are unlikely and so would increase the likelihood of conversion (Miao, Hennessy, and Feng, 2014).

Moreover, other conservation programs, such as the CRP, may influence the land-use consequences of crop insurance. Miao et al. (2016) show how inclusion of crop insurance payments into CRP enrollment criteria will affect enrollment patterns. But the CRP program might also stimulate cropping, where crop insurance subsidies serve as a catalyst. For example, the existence of CRP as an option to retire environmentally sensitive cropland with fixed payments for ten to fifteen years may entice producers to break a tract of less productive (and usually environmentally sensitive) grassland and collect benefits from crop insurance before enrolling in CRP. Recall that county-level T-yields are used to calculate the APH yield for the first four years' production. If the new breaking's productivity is far below county average, then an indemnity payment is almost surely guaranteed. However, such crop insurance benefits will disappear after a few years of production as actual production record is eventually used to calculate the APH yield. Once such crop insurance benefits disappear, the producer may choose to enroll the land into CRP to receive a riskless CRP payment, which is typically higher than pastureland cash rent. An unexplored issue in the formal literature is the extent to which the possibility of CRP enrollment could interact with crop insurance to affect producers' cropping decisions.

*[Received May 2013; final revision received January 2016.]*

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