An Empirical Analysis of Acreage Effects of Participation in the Federal Crop Insurance Program

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The extent to which crop insurance programs have resulted in additional land being brought into production has been a topic of considerable debate. We consider multiequation structural models of acreage response, insurance participation, CRP enrollment, and input usage. Our analysis focuses on corn and soybean production in the Corn Belt and wheat and barley production in the Upper Great Plains. Our results confirm that increased participation in insurance programs provokes statistically significant acreage responses in some cases, though the response is very modest in every case. In the most extreme cases, 30% decreases in premiums as a result of increased subsidies provoke acreage increases ranging from 0.2% to 1.1%. A number of policy simulations involving increases in premium subsidies are considered.

Key words: acreage response, crop insurance.

U.S. crop insurance programs have undergone significant changes in recent years. The 1980 Federal Crop Insurance Act significantly expanded the program and provided large subsidies to encourage participation. The 1994 Crop Insurance Reform Act brought about a brief period of mandatory participation in the program, expanded premium subsidies, and instituted a "catastrophic" (CAT) level of protection that was intended to replace disaster relief payments at very low cost to producers. The 1994 Act also mandated development of "cost of production" insurance programs that, along with innovations by private insurers, led to the development of several different revenue insurance programs. Legislative actions in the late 1990s and in 2000 further expanded premium subsidies. Participation has grown substantially in response to these new programs and policy changes that have made crop insurance more attractive to producers.[1]

The U.S. crop insurance programs clearly provide positive net benefits to participating producers. Any provision that enables an economic agent to better withstand risk will provide incentives for agents to assume greater risk. Likewise, if participation in any program conveys positive net economic benefits to producers, the program may alter incentives and thus affect production patterns. Concern as to whether government risk management programs have affected planting decisions goes back at least to the 1970s, when observers speculated that disaster payments were encouraging production in high risk areas (Gardner and Kramer). To the extent that the benefits of risk management programs are not homogeneous across crops and across regions, regional crop production patterns may be influenced. Acreage effects brought about by participation in crop insurance programs could affect prices and input markets and thus have important policy implications.

Existing research on the production effects of insurance programs is limited. Recent results based on a single-equation, aggregate analysis by Keeton, Skees, and Long implied that expansions in risk management programs in the 1980s led to the introduction of about 50 million new acres of U.S. crop land into use (where use includes planted acres, idled acres, and land in conservation reserves). A large proportion of this increase,

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[1] For example, in 1995, total liability for corn insurance was \$6.7 billion. In 2001, total liability for corn had grown to nearly \$10.7 billion, with \$6.7 billion being accounted for by the CRC revenue insurance program (USDA-RMA 2003).

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approximately 35 million acres, was accounted for by land put into the Conservation Reserve Program (CRP). The large increases implied by this study stimulated considerable attention on the topic and concern on the part of policymakers. An alternative analysis using a national policy simulation model by Young, Vandeveer, and Schnepf suggested very modest aggregate U.S. acreage responses to the provision of insurance subsidies. Wu examined the effects of crop insurance on crop mix and input usage for a cross section of 235 farms in the Central Nebraska Basin in 1991 and found that farms that insured were more likely to produce soybeans, though no effect on corn was revealed because all farms in the sample were corn producers.

Though the existing research has provided important insights into the effects of the expansion of risk management programs on production patterns, a wide gap exists in the implications of existing studies. Some studies (Keeton, Skees, and Long) point to large effects while others (Young, Vandeveer, and Schnepf) show modest effects. An additional limitation associated with much of the existing research is its focus on *national* acreage and production response. In reality, production conditions and the parameters of risk management programs are heterogeneous across regions and crops, suggesting that a focus on aggregate effects may conceal crop- and region-specific effects.

The focus of our analysis is on a detailed empirical assessment of the effects of crop insurance program participation on acreage allocation decisions among competing crops in two relatively homogeneous growing regions—the Corn Belt and the Northern Great Plains. The central goal of our analysis is to test the hypothesis that crop insurance programs have had no discernable effect on agricultural land use. We utilize estimates of structural models reflecting the endogenous decisions of agricultural producers to simulate the possible effects of large premium changes. Our results generally imply very modest though statistically significant acreage effects of expanded insurance subsidies.

Modeling Framework and Data

Our empirical analysis consists of a six-equation structural model representing acreage, insurance, conservation program participation, and input usage decisions for two primary crops (corn and soybeans in the Corn Belt and wheat and barley in the Northern Great Plains). The specific equations used in our analysis, variable definitions, and summary statistics for our data are presented in table 1.

Theory of the demand for insurance generally considers the actions of a risk-averse agent facing a single source of risk for which a risk-neutral insurer offers some level of protection. Stylized models that attempt to capture the essential elements of crop insurance plans are typically rather simplified and thus often fail to capture actual characteristics of the operation of the crop insurance program. For example, most crop farms are multiproduct operations. Multiple crops face an array of risks from various sources. In addition, risks are often correlated across crops, so that yield outcomes (and thus loss events) for individual crops are correlated.

The insurance choice (i.e., the participation decision) is made jointly with other production decisions that must be made by producers. In our analysis, we focus on three decisions (choice variables) that are relevant to the insurance participation decision. At the time of planting, a producer must decide what to produce, how to produce it, and whether to participate in a myriad of government programs that may be available. We focus on two specific policies that were relevant to production decisions in the 1980s and 1990s—the federal crop insurance program and the CRP. Thus, for a producer facing the option of growing multiple crops, the decision involves the choice of a level of production (acreage for each crop and input usage), the level of insurance to purchase for each crop (which potentially could be zero), and whether or not to enroll land in the CRP program.

The focus of our analysis is empirical and thus we make no pretense as to the development of a detailed theoretical framework for jointly evaluating acreage response, insurance participation, input usage, and conservation program participation for multiple crops. Innes and Ardila provide a detailed evaluation of insurance participation and soil depletion in a single crop model. Our primary motivation involves a consideration of the extent to which federal crop insurance programs may have had effects on the acreage decisions of producers. As we have noted above, a range of results exist in the literature. Though the theory of the demand for insurance does not provide a prediction as to the sign and magnitude of this effect, we expect that the provision of economic benefits through insurance will result in expanded acreage and thus a positive relationship between acreage and participation.

Smith and Goodwin demonstrated that fertilizer and chemical usage for Kansas wheat producers tended to be negatively correlated with insurance purchases. That is, growers who purchased insurance tended to use less inputs than those growers that did not buy insurance. It should be acknowledged, however, that other research by Horowitz and Lichtenberg suggested that fertilizer and chemical inputs raise risk and thus were correlated with insurance purchases. In more recent work, Wu found that changes in the crop mix may make

Table 1. Model Specification, Variable Definitions, and Summary Statistics

Variable	Definition	Mean	Std. Dev.
	Model Specification		
Insurance Participation for Crop$_i$	$= f$ (Premium Rate$_i$, Loss-Ratio$_i$, Premium Rate$_i$ $*$ Loss-Ratio$_i$, Livestock Sales, Yield CV$_i$, Fertilizer, County Acres, Acres$_i$, Annual Dummies)		
Acres for Crop$_i$	$= f$ (Price$_i$, Acres$_j$, Insurance Participation$_i$, Acres$_{i,t-1}$, CRP Enrollment, Soil K-Factor, Soil T-Factor, Diverted Base, County Acres, Land Capability, Annual Dummies)		
CRP Enrollment	$= f$ (Rental Rate, Cost Share, Erosion Index, CRP$_{t-1}$, County Acres, Annual Dummies)		
Input Usage	$= f$ (Insurance Participation$_i$, Insurance Participation$_j$, Acres$_i$, Acres$_j$, Land Capability, Annual Dummies)		
	Heartland Corn and Soybeans (1986–1993)		
Insurance Participation (corn)	Liability/maximum possible liability (corn)	0.2303	0.1758
Input Usage	Fertilizer and chemical expenditures (real $thousand)/planted acre	0.0612	0.0180
Land Capability	Proportion of land in capability classes 1 and 2	0.3091	0.1422
Livestock Sales	Livestock revenues/total farm sales	0.4652	0.1901
Yield CV (corn)	CV of historical corn yields	22.3801	9.2657
Loss-Ratio (corn)	Historical mean loss ratio (corn)	1.7908	1.2449
Acres Planted (corn)	Acres planted of corn (10,000)	8.6205	5.7226
Insurance Participation (soybeans)	Liability/maximum possible liability (soybeans)	0.1943	0.1472
Yield CV (soybeans)	CV of historical soybean yields	16.4246	6.8982
Loss-Ratio (soybeans)	Historical mean loss ratio (soybeans)	1.6304	1.0001
Acres Planted (soybeans)	Acres planted of soybeans (10,000)	7.2133	4.5591
Price (corn)	Real corn price ($/bushel, basis adjusted price plus USDA projected deficiency payment)	3.9330	0.3546
CRP Enrollment	New enrollment in CRP program (10,000 acres)	0.1577	0.3619
Soil K-Factor	Universal K-factor	0.3245	0.0460
Soil T-Factor	T-factor representing tolerance to soil loss	4.4354	0.4788
Diverted Base (corn)	Adjusted base for corn (10,000)	6.9077	4.6865
Price (soybeans)	Real soybean price (cents/bushel), basis adjusted price	7.2636	0.8480
Rental Rate	Real CRP rental rate/acre	90.6399	16.9327
Cost Share	Real cost share payments for CRP/acre	59.1881	57.3752
Erosion Index	Soil erosion index	5.0777	3.3679
County Acres	County size (total land area in hundred thousand acres)	3.3678	1.1481
Premium Rate (corn)	Insurance premium rate (corn)	0.0456	0.0204
Premium Rate (soybeans)	Insurance premium rate (soybeans)	0.0448	0.0213
Revenue Liability (corn)	Revenue insurance liability/total liability (corn, 1997–1998)	0.0500	0.0210
Revenue Liability (soybeans)	Revenue insurance liability/total liability (soybeans, 1997–1998)	0.0579	0.0204
Revenue Premium Rate (corn)	Revenue insurance premium rate (corn)	0.2735	0.1773
Revenue Premium Rate (soybeans)	Revenue insurance premium rate (soybeans)	0.2688	0.1743

Table 1. Continued

Variable	Definition	Mean	Std. Dev.
	Great Plains Wheat and Barley (1986–1993)		
Insurance Participation (wheat)	Liability/maximum possible liability (wheat)	0.4699	0.2464
Input Usage	Fertilizer and chemical expenditures (real $thousand)/planted acre	0.0298	0.0171
Land Capability	Proportion of land in capability classes 1 and 2	0.2585	0.1271
Livestock Sales	Livestock revenues/total farm sales	0.4904	0.2597
Yield CV (wheat)	CV of historical wheat yields	32.8363	12.6502
Loss-Ratio (wheat)	Historical mean loss ratio (wheat)	2.1226	1.2725
Acres Planted (wheat)	Acres planted of wheat (10,000)	15.7722	10.9336
Insurance Participation (barley)	Liability/maximum possible liability (barley)	0.3598	0.2653
Yield CV (barley)	CV of historical soybean yields	37.5481	16.1103
Loss-Ratio (barley)	Historical mean loss ratio (barley)	2.0498	1.2965
Acres Planted (barley)	Acres planted of barley (10,000)	4.5503	4.3995
Price (wheat)	Real wheat price ($/bushel, basis adjusted price plus USDA projected deficiency payment)	5.9179	0.6494
CRP Enrollment	New enrollment in CRP program (10,000 acres)	0.6269	1.1245
Soil K-Factor	Universal K-factor	0.2895	0.0395
Soil T-Factor	T-factor representing tolerance to soil loss	4.3733	0.5441
Diverted Base (wheat)	Adjusted base for wheat (10,000)	10.7269	8.2175
Diverted Base (barley)	Adjusted base for barley (10,000)	3.6720	3.7166
Price (barley)	Real barley price ($/bushel, basis adjusted price plus USDA projected deficiency payment)	3.1707	0.4611
Rental Rate	Real CRP rental rate/acre	46.3033	8.9150
Cost Share	Real cost share payments for CRP/acre	36.5884	24.9507
Erosion Index	Soil erosion index	3.7853	1.7765
County Acres	County size (total land area in hundred thousand acres)	10.1749	6.0275
Premium Rate (wheat)	Insurance premium rate (wheat)	0.0671	0.0212
Premium Rate (barley)	Insurance premium rate (barley)	0.0883	0.0299

the overall relationship between insurance participation and fertilizer and chemical usage less clear. If insurance encourages shifting toward crops with more demanding input requirements, insurance participation may actually increase fertilizer usage. Thus, the expected relationship between insurance participation and input usage is unclear.

Our empirical analysis makes use of pooled cross-sectional, time-series data collected at the county level. We utilize a wide variety of sources to obtain county-level data. We focus our analysis on the years 1985–1993, though we also consider an extension to 1997 and 1998, a period characterized by a different mix of programs. It is important to recognize that there are two general sources of variability inherent in such longitudinal data—each of which may convey different types of changes. Most of the variability in our data are cross-sectional, being derived from a large sample of counties observed over a relatively small number of years. Farms in these counties are all subject to changes over time, which arise from variables that affect all farms in a homogeneous manner. Such factors include the effects of input prices and price uncertainty (assumed constant across all farms in a year) as well as general policy changes. We include fixed year effects to represent such variables.[2] Our models include a state-specific expected price comprised of the planting time price of a harvest time futures contract, a basis adjustment, and the U.S. Department of Agriculture (USDA) projected deficiency payment rate (for years prior to 1996).[3] To focus our

[2] Application of fixed and random effects modeling procedures is complicated by the large number of cross-sectional units relative to the short span of time. Consideration of these issues remains an important topic for future research.

[3] Basis adjustments are calculated from state average planting time prices as the difference in each state's price and a central market price (Illinois for corn and soybeans and Minnesota for wheat). State average barley prices are used because an appropriate futures

analysis on relatively homogeneous growing regions, we utilize the Farm Resource Regions of the USDA-ERS.[4] In particular, we evaluate corn and soybean insurance and production decisions in the "Heartland" region and wheat and barley insurance and production decisions in the "Northern Great Plains" region. The "Heartland" primarily represents the U.S. corn belt—a region that accounts for a large proportion of total liability in the U.S. crop insurance program. The "Northern Great Plains" is an area dominated by small grain production (wheat and barley).

The demand for insurance (i.e., insurance program participation) should be influenced by the expected return to insurance. We measure participation as the ratio of actual liability over a measure of total possible liability (discussed below).[5] Returns to insurance will be influenced by premium rates as well as the expected indemnity payments. Goodwin (1993) and Smith and Baquet found that adverse selection implied the potential for a differential response to premiums with respect to expected indemnities. Following the approach applied there, we include premium rates, the average loss ratio (for the preceding six years of experience in the county), and an interaction of the loss ratio and the premium rate.[6] We also include the coefficient of variation of county average yields. Though it may be difficult to precisely separate the two effects, average loss ratios should reflect expected indemnities (i.e., a subsidy effect) while the yield coefficient of variation should reflect the variability of yields. To the extent that producers respond to more yield variability by buying more insurance (holding expected returns constant), the significance of the yield coefficient of variation may reflect the extent to which producers are averse to risk. We also include a measure of farm diversification (the ratio of livestock sales to total sales) and a measure of the overall land area for a given county.

The typical approach to modeling acreage response in the literature (see, e.g., Morzuch, Weaver, and Helmberger) is to formulate a return variable that captures factors, including price, that influence the return to growing an individual crop. We follow a related approach here, though we include a number of variables intended to control for differences in soil type, land capability, and farm diversification. We allow for adjustment costs and partial adjustment by including lagged acreage in the acreage response functions. Such lagged effects may represent costly adjustment and may also reflect the importance of crop rotational patterns and acreage bases on observed acreage decisions. We include a measure of land quality (the proportion of land in capability classes one and two).[7] In addition, two additional measures of land quality, the K-factor (representing the inherent erodibility of land) and the T-factor (representing the ability of land to tolerate soil erosion without suffering yield losses) are included to capture any cross-sectional soil quality factors relevant to crop production.

It is important that our analysis adequately capture the effects of farm program constraints that were binding throughout the period of our analysis. Corn, wheat, and barley were eligible for deficiency payment program benefits during the period of our study. Of course, eligibility for such benefits depended upon having an acreage base. Three program parameters are relevant to acreage decisions for such crops during this period—the level of base acreage, the target price, and required acreage diversions under the acreage reduction program (ARP). We represent the effects of target price (deficiency payment) programs by adding the USDA's projected deficiency payment to the expected price for each crop in every year. We capture the effect of base and mandatory acreage diversion programs by including lagged acreage and a measure of diverted acreage as explanatory variables. This measure

market is lacking. It should be noted that annual fixed effects may confound identification of parameters for variables that have little variation in the cross-sections. This is discussed in greater detail in the following sections. The USDA announced a projected level of deficiency payments each year. This projection was used to define advanced deficiency payments. We use this projection as the market's best estimate of expected deficiency payments.

[4] For a discussion of the definitions of farm resource regions, see Heimlich.

[5] Note that participation does not refer to the proportion of producers buying insurance but rather is a county-level measure of the proportion of potential liability that is insured. Empirical studies of participation often consider the ratio of insured acres to total acres as a measure of participation. Such an approach overlooks the fact that varying price and yield coverage levels allow a producer to change their level of participation (liability) without changing the number of acres insured. Over the period of our study, yields could be insured at the 50%, 65%, and 75% levels, meaning that realized yields beneath this percentage of the expected yield would trigger indemnity payments. Our measure of participation captures such adjustments. See Goodwin (1993) for a detailed discussion of the operational aspects of federal crop insurance.

[6] The loss ratio is defined as the ratio of indemnities received over premiums paid. We adjust premiums to account for subsidies, which resulted in a substantial share of premiums being paid by the government.

[7] Land capability is a measure ranging from 1 (best) to 8 (worst) that represents the capability of an area to support a range of agricultural activities on a sustainable basis.

was constructed by adjusting the preceding year's base acreage for required diversions under the ARP program. In particular, mandatory diverted acreage was represented using the product of the previous year's base acreage and the required diversion rate. County-level base acreage was not available and thus we were forced to construct a proxy measure of the county-level base using state-level base acreage numbers. The measure of county-level base acreage was calculated by considering the state-level ratio of base acres to total planted acres. We used this ratio to adjust each county's planted acreage—thereby obtaining a county-level base that would aggregate to yield the observable state base totals.[8]

Our empirical analysis is complicated by the fact that the CRP program was introduced in 1986. CRP program participation is important to our analysis because it represents an important use of crop acreage. The CRP program essentially provided producers with a rental payment for removing land from production for conservation purposes. In 1985, participation in the CRP program was exogenously fixed at zero. In 1986 and subsequent years, CRP program participation was endogenously determined by farms in a joint evaluation with other production decisions, including acreage allocation and insurance program participation. To address this switching environment, we utilize a specification for CRP of the form $\text{CRP}_{it} = \lambda(X_{it}\beta) + e_{it}$ where CRP_{it} is an indicator of CRP enrollment (acres enrolled), X_{it} is a vector of relevant explanatory variables, and λ is 1 if the year is 1986 or greater and is zero otherwise, all for county i in year t. This is equivalent to endogenously modeling participation for 1986 and later and setting participation exogenously at zero in 1985.[9]

In addition to the fact that CRP enrollment was exogenously fixed at zero in 1985, concerns regarding the potential for censoring are relevant to our insurance and CRP participation equations. In the case of insurance, there is little likelihood that one would observe either complete participation or a zero level of participation at the county level and thus censoring is not a concern.[10] In the case of CRP enrollments, the issue of censoring is of more concern. In the case of Heartland corn and soybeans, of the 4,042 observations applying to years after 1985, only four county-level observations had no observed CRP enrollments. Thus, only 0.1% of the relevant observations are censored. In this case, censoring was ignored because any biases are likely to be negligible. In the case of Northern Great Plains wheat and barley, 25 of the 969 annual county observations for the relevant 1986–1993 period had no observed CRP enrollments. This suggests censoring in the order of 2.6% of the sample. To address this censoring, we utilize the modeling procedures of Shonkwiler and Yen. CRP rental rates and cost sharing for those counties with zero enrollment were measured using the average value of all surrounding counties in that particular year.

Consider a system of censored variables, y_{it}, related to a set of explanatory variables X_{it} through:

$$(1) \qquad y_{it} = f(X_{it}, \beta_i).$$

Shonkwiler and Yen propose a two-step estimation procedure, whereby the discrete variable indicating a noncensored observation of $y_{it}(d(y_{it} > 0))$ is evaluated using a probit model of the form:

$$(2) \qquad d_{it} = g(Z_{it}, \alpha_i)$$

where Z_{it} is a set of variables relevant to the discrete participation decision. These estimates are then used to construct correction terms of the form:

$$(3) \qquad y_{it} = \Phi(Z_{it}, \hat{\alpha}_i) f(X_{it}, \beta_i) + \delta_i \phi(Z_{it}, \hat{\alpha}_i) + \xi_{it}$$

where $\Phi(\cdot)$ represents the normal cumulative distribution function and $\phi(\cdot)$ represents the

[8] As is true with all proxy measures, the limitations associated with our measurement of county-level base acreage are obvious. We implicitly assume that each county's share of base acreage is the same as its share of overall acreage of the crop in the state. Note that the direct effects of base acreage are captured in lagged acreage.

[9] The only difference in our approach versus a two-step method where CRP participation is modeled separately for 1986 and later years arises from our use of joint estimation techniques. Parameter estimates are identical in the first step of each case, though corrections made for cross-equation correlation may result in differences in final estimates. This arises because our application of generalized method of moments (GMM) estimation techniques results in residuals that are zero in 1985 when CRP participation is exogenously set to zero. The implications of our analysis and the simulations that follow are entirely robust with respect to the manner of modeling CRP participation.

[10] Complete participation at the county level is simply never realized. In the regions targeted by our study, crop insurance has been in place for major crops for some time and thus it is unlikely that any individual county would have realized zero participation, although any such county would be omitted from our analysis in that we use participation data to construct insurance premium rates and participation figures.

normal probability density function. We utilize this approach to explicitly recognize the potential for censoring in the CRP enrollment equation. Note that the fact that participation is exogenously fixed at zero implies that $\Phi(\cdot)$ and $\phi(\cdot)$ are exogenously fixed at zero for 1985, a condition which is imposed in estimation.[11] Consistent estimation of the parameter covariance matrix in such two-stage estimation procedures can be complex. Further, Shonkwiler and Yen point out that the residual terms ξ_{it} will be heteroscedastic. To obtain consistent estimates of parameter covariances as well as standard errors for the policy simulations presented below, we utilized a nonparametric bootstrapping procedure where pseudosamples of size n (where n is the number of observations in the estimation sample) were drawn with replacement from the estimation data and the model was estimated a large number of times (2,500 replications). Standard error estimates were then obtained from the replicated parameter estimates. Such an approach provides consistent variance estimates that account for the estimation of parameters in the first-stage probit model and that are robust to heteroscedasticity.

Input usage is given by the ratio of total expenditures on fertilizer and chemicals to total planted acreage. We hypothesize that input usage, which is jointly determined with acreage and insurance participation decisions, will be influenced by the crops planted, by insurance participation, and by land quality characteristics. We include the measure of land capability to reflect county-specific soil quality characteristics that may be relevant to productivity and thus input usage patterns. In short, our analysis of acreage response and insurance participation implies a system of six equations—corn and soybean acreage allocation equations, corn and soybean insurance participation equations, an equation representing input usage, and an equation representing CRP enrollment. A nearly identical specification is used to model wheat and barley acreage response and insurance participation in the Northern Great Plains region.

Data were collected from a wide variety of sources. Insurance program data were taken from the RMA's unpublished county-level experience database. There is an important caveat associated with the use of such data. Experience data are available only for those farms that actually purchased insurance. Thus, to the extent that nonbuyers faced higher rates than buyers, our premium rates may understate the actual rates faced by the entire insurance pool. This criticism is relevant to most other empirical studies of insurance demand and participation as well. Unpublished NASS county-level yield and acreage statistics were collected. Input usage and farm sales statistics were taken from the U.S. Department of Commerce's Regional Economic Information System database. CRP enrollment statistics were taken from unpublished data obtained from the Economic Research Service. Soil characteristics were taken from the NRCS National Resource Inventory (NRI) database. Nominal economic variables were inflated to 2001 terms using the producer price index. Market prices used to define insurance liability were those quoted prior to planting time for post-harvest futures contracts. These were taken from the Bridge database. For barley, which lacks a futures market, state level, February cash prices were used. Projected deficiency payments for corn, wheat, and barley were collected from unpublished USDA sources.

Measuring the level of insurance participation is challenging because there is no direct measure of total eligible acres or potential liability in a county. We constructed a rough measure of total possible liability by taking the product of the futures market price, planted acres, and 75% of the county average yield for the preceding 10 years. Our measure of insurance participation is then given by the ratio of actual liability to total possible liability. As we have noted above, alternative measures of participation that are commonly used include the ratio of net insured acres to total planted acres. We argue that such a measure is likely to be inferior because it does not recognize the fact that the level of participation can be changed without canceling coverage merely by changing the price or yield coverage election. The analysis of corn and soybeans over the 1985–1993 period utilized 4,540 observations. The analysis of wheat and barley over the same period utilized 1,086 observations.[12] The analysis of corn and soybeans in the post-Food and Agricultural Improvement and Reform Act (FAIR) policy environment utilized 944 observations.

[11] Given the small extent of censoring present in CRP enrollments, this adjustment did not have an important effect on our results. Identical conclusions to those presented below were obtained when censoring was ignored.

[12] The difference in numbers of observations reflects the greater number of counties in the Heartland region.

Finally, it should be acknowledged that our sample, which is comprised of pooled county-level data over a number of years, may be subject to a number of issues related to residual correlation and heteroscedasticity. For the corn and soybean analysis, we considered a series of White-type tests for heteroscedasticity (presented below).[13] In every case, the results confirmed the presence of heteroscedasticity of an unspecified form. In addition, we suspected that correlation patterns may exist across years for individual counties. To address this issue, we ordered our data within each county by time and applied the nonparametric autocorrelation and heteroscedasticity consistent estimation procedures developed by Newey and West.[14] More complicated correlation patterns may exist in the two additional dimensions implied by spatial aspects of the counties' locations. An explicit correction for such spatial correlation is beyond the scope of our analysis, though it remains an important topic for future research. In light of the endogeneity of several key variables and the possibility of heteroscedasticity and correlation of unknown forms, our particular estimation approach involves the application of instrumental variables estimation techniques within the context of the GMM. Finally, we allow for the possibility that local (state-level) expected prices may be endogenous and include state and annual dummies in the instrument set.

Our models were estimated using a GMM, instrumental variables estimation approach. Each of the six equations was expressed in implicit form and used to define an error function:

$$(4) \qquad e_i(\theta) = y_i - f(x_i, z_i, \theta)$$

where y_i is the dependent variable, x_i represents exogenous variables, and z_i represents other endogenous variables. This error function is then used to define moment conditions of the form

$$(5) \qquad m_n^{\theta} = n^{-1} \sum_{i=1}^{n} [e_i(\theta) \otimes z_i]$$

where z_i represents a set of appropriately chosen instruments. The parameter set θ is estimated by minimizing

$$(6) \qquad S(\theta, V) = [nm_n(\theta)]' V^{-1} [nm_n(\theta)]$$

where V represents the covariance matrix of the moment conditions. We utilized a Newey–West-type kernel function with a single lag to estimate the covariance matrix in order to account for any correlation across years within a given county. Instrumental variables used in the estimation included all of the exogenous variables, state dummy variables, and land characteristics data taken from the NRI dataset.[15] Note that state and annual dummy variables are natural instruments for prices.[16]

Empirical Results

The empirical models were applied in two distinct applications. The first involves corn and soybean production and insurance purchases in the Corn Belt over the 1985–1993 period that included substantial expansions in the crop insurance program. This is the period that has been the subject of much debate regarding the extent to which expansions in insurance had acreage effects. The second considers Northern Great Plains wheat and barley production over the same period. We also consider an extension of the corn and soybean analysis to a more recent period that included the introduction of revenue insurance policies.

Heartland Corn and Soybeans

Table 2 contains GMM parameter estimates and summary statistics for the analysis of Heartland corn and soybean production. Hausman specification test results provide support for the joint determination of the choice variables and thus for our instrumental variables estimation approach. Likewise, White-type tests of heteroscedasticity in three-stage least squares estimates provide strong evidence of heteroscedasticity, suggesting the importance of the corrections implicit in our GMM estimation techniques.

As expected, the insurance demand equations reflect a negative relationship between premium rates and the level of participation. At the data means, the corn results imply an elasticity of demand of about −0.28. Likewise,

[13] Methods for calculation of valid test statistics for the bootstrapped estimates are not obvious, though an application of standard systems estimation procedures (i.e., ignoring the two-step aspects of estimation) yielded identical conclusions regarding model specification.

[14] Of course, this involves allowing for correlation across different years and different cross-sectional units for those observations corresponding to the last and first years in the data. Such an allowance is benign in light of the fact that no parametric correction is imposed by the Newey-West procedures.

[15] Variables representing land characteristics included the proportions of cropland in grass and pastures.

[16] For an extensive discussion of GMM estimation, including alternatives for estimation of the covariance matrix, see Gallant.

Table 2. GMM Estimates of Heartland Corn/Soybean Model (1986–1993)

Variable	Estimate	Standard Error	t-Ratio
Corn Insurance Participation			
Intercept	0.3071	0.0169	18.18*
Premium Rate	−1.9566	0.1935	−10.11*
Premium Rate ∗ Loss Ratio	0.2913	0.0757	3.85*
Fertilizer	−5.7683	0.1652	−34.92*
Livestock Sales	0.2483	0.0118	21.04*
Yield CV	0.0029	0.0003	10.44*
Loss Ratio	0.0344	0.0035	9.82*
Corn Acres	0.0059	0.0005	11.88*
County Acres	−0.0103	0.0022	−4.72*
D86	0.0303	0.0057	5.36*
D87	0.0596	0.0074	8.06*
D88	0.0048	0.0068	0.71
D89	0.1168	0.0089	13.07*
D90	0.1194	0.0076	15.63*
D91	0.0768	0.0073	10.54*
D92	0.1078	0.0072	15.01*
D93	0.1641	0.0082	20.13*
Soybean Insurance Participation			
Intercept	0.3331	0.0149	22.39*
Premium Rate	−2.0980	0.1548	−13.55*
Premium Rate ∗ Loss Ratio	0.3950	0.0800	4.94*
Fertilizer	−4.8275	0.1387	−34.81*
Livestock Sales	0.2466	0.0108	22.83*
Yield CV	0.0011	0.0003	3.78*
Loss Ratio	0.0083	0.0042	2.00*
Soybean Acres	0.0042	0.0005	8.48*
County Acres	0.0017	0.0017	1.02
D86	−0.0129	0.0050	−2.58*
D87	0.0034	0.0067	0.51
D88	−0.0463	0.0061	−7.58*
D89	0.0715	0.0077	9.33*
D90	0.0639	0.0072	8.83*
D91	0.0233	0.0063	3.71*
D92	0.0636	0.0064	9.94*
D93	0.0938	0.0068	13.73*
Corn Acreage Response			
Intercept	−0.9041	0.6362	−1.42
Corn Price	0.0886	0.1412	0.63
Corn Acres$_{t-1}$	0.9564	0.0054	175.97*
Soybeans Acres	0.0309	0.0040	7.79*
Participation Corn	0.3908	0.1035	3.78*
CRP Enrollment	−0.3283	0.0842	−3.90*
Soil K-Factor	0.3208	0.2862	1.12
Soil T-Factor	0.1783	0.0297	6.00*
Diverted Corn Base	−0.0352	0.0347	−1.01
County Acres	0.0348	0.0163	2.14*
D86	−1.1656	0.0453	−25.74*
D87	−1.2903	0.0883	−14.61*
D88	0.0988	0.0567	1.74*
D89	0.1638	0.0628	2.61*
D90	−0.1906	0.0480	−3.97*
D91	−0.1749	0.0908	−1.93*
D92	0.0178	0.0991	0.18
D93	−1.0744	0.0965	−11.13*
Land Capability	0.0547	0.0741	0.74

Table 2. Continued

Variable	Estimate	Standard Error	t-Ratio
	Soybean Acreage Response		
Intercept	−2.0877	0.7894	−2.64*
Soybean Price	0.1711	0.0930	1.84*
Soybean Acres$_{t-1}$	0.9706	0.0030	325.71*
Corn Acres	0.0168	0.0047	3.54*
Participation Soybeans	0.0933	0.1047	0.89
CRP Enrollment	−0.1907	0.0638	−2.99*
Soil K-Factor	0.5861	0.2049	2.86*
Soil T-Factor	0.1010	0.0250	4.05*
Diverted Corn Base	0.0367	0.0275	1.33
County Acres	0.0014	0.0106	0.13
D86	0.2720	0.1057	2.57*
D87	0.3512	0.1496	2.35*
D88	0.0113	0.0600	0.19
D89	0.2596	0.0901	2.88*
D90	0.0734	0.1111	0.66
D91	0.7257	0.1016	7.14*
D92	0.3198	0.1231	2.60*
D93	0.5259	0.1319	3.99*
Land Capability	−0.1759	0.0556	−3.16*
	CRP Enrollment		
Rental Rate	−0.0002	0.0002	−1.22
Cost Share	−0.0002	0.0000	−3.44*
Erosion Index	0.0144	0.0014	10.14*
D86	−0.0402	0.0191	−2.10*
D87	0.4008	0.0320	12.54*
D88	−0.0732	0.0206	−3.55*
D89	0.0059	0.0191	0.31
D90	−0.0387	0.0193	−2.01*
D91	−0.0942	0.0185	−5.09*
D92	−0.0263	0.0194	−1.36
D93	−0.0372	0.0198	−1.88*
County Acres	0.0157	0.0030	5.26*
CRP Acres $_{t-1}$	0.3192	0.0180	17.70*
	Input Usage		
Intercept	0.0795	0.0008	95.39*
Participation Corn	0.0255	0.0033	7.71*
Participation Soybeans	−0.0755	0.0043	−17.55*
Corn Acres	0.0007	0.0001	14.15*
Soybean Acres	−0.0014	0.0001	−17.52*
Land Capability	−0.0177	0.0014	−12.93*
D86	−0.0019	0.0006	−3.00*
D87	0.0004	0.0008	0.49
D88	−0.0065	0.0008	−8.09*
D89	−0.0030	0.0008	−3.65*
D90	−0.0009	0.0008	−1.04
D91	−0.0020	0.0008	−2.45*
D92	0.0033	0.0008	4.04*
D93	0.0090	0.0009	10.15*
Hausman Test: OLS vs. 2SLS	861.2*	White's Test: Corn Insurance	4175*
White's Test: Soybean Insurance	4189*	White's Test: Corn Acreage	1951*
White's Test: Soybean Acreage	1133*	White's Test: CRP	1520*
White's Test: Input Usage	196.3*		

An asterisk indicates statistical significance at the $\alpha = 0.10$ or smaller level.

for soybeans, the estimates imply an elasticity of −0.33. In both cases, a higher average loss ratio appears to significantly decrease the responsiveness of agents to premium changes. This is consistent with results presented elsewhere in the literature (see, e.g., Goodwin 1993) suggesting that agents with higher expected returns to insurance are less responsive to premium changes.[17] The relatively inelastic nature of these demand functions will play a critical role in simulations of the effects of premium subsidy changes on insurance participation presented below. Fertilizer and chemical expenditures exhibit the expected negative effect for both corn and soybeans, suggesting that insurance participation is lower for those farms that use more fertilizer and chemicals. This effect, representing actions that sometimes are interpreted as moral hazard, has been identified in other studies (see, e.g., Smith and Goodwin). Again, in this context of joint products, it may be difficult to separate the effects of increased production of a crop and insurance purchases on input usage because the input usage variable applies to all crops and not just to the individual crop under consideration.

The ratio of livestock sales to total farm sales is significantly positive in both cases, suggesting that farms (counties) with greater relative sales from livestock commodities are more likely to purchase insurance. Intuitively, one could anticipate two possible effects of greater relative livestock sales. On the one hand, a higher proportion of livestock sales may imply greater diversification on the part of crop producers, thus lowering overall financial risk. On the other hand, farmers may specialize in livestock because of comparative advantage patterns reflecting a higher degree of crop production risk or lower expected returns from crops. As expected, a higher yield coefficient of variation (CV) appears to be correlated with greater demand for insurance in both the corn and soybean insurance demand equations. Such a positive relationship is expected because insurance programs are considered by many to be important instruments for managing yield risk.

An interesting though not surprising finding is that higher average loss ratios, which correspond to higher expected relative indemnities, are significantly correlated with greater demand for insurance. The fact that both higher loss ratios and higher yield CVs are positively correlated with insurance demand may suggest that there are benefits to producers both from the income subsidy effects of insurance as well as from the risk reduction brought about by crop insurance. As we have noted, however, identifying the effects separately may be difficult. Increases in acreage of either of the two crops is correlated with more insurance purchases for each crop. This finding is in agreement with the results of other research (Goodwin 1993, Black and Dorfman) implying that insurance purchases are likely to be greater for larger farms or larger areas in that incentives for selling on the part of agents working on commission are likely to be greater in such cases.

The heart of our analysis lies in the corn and soybean acreage response equations. The price coefficients are both positive though quite close to zero, implying relatively inelastic acreage response functions. It is essential to recognize, however, that the annual fixed effects capture much of the relevant price movement. When these fixed effects are omitted from the analysis, acreage response price elasticities of 0.17 and 0.07 are implied. Lagged acreage, representing partial adjustment (along with the base acreage for corn) are highly significant in both the corn and soybean equations. The diverted corn base variable is not statistically significant in either of the acreage equations. This likely reflects correlation with the previous year's acreage, since it is calculated from the preceding year's base acreage. We included total acreage in the county as an indicator of the scale of a county's total size, though scale is also represented by lagged acreage.

As expected, the acreage response equations reveal a negative effect from CRP enrollment, though the effect is statistically significant only in the corn equation. Greater enrollment in CRP results in less acreage being devoted to the crops. We generally do not find evidence of shifting among the alternative crops. On the contrary, increases in soybean acreage appear to be correlated with more corn acreage, though corn acreage does not have a significant effect on soybean acreage. Of course, this may reflect intrinsic patterns of comparative advantage—counties that are well suited to produce soybeans are also likely to be suitable for corn production.[18]

[17] Identification of this adverse selection effect may be confounded by the inclusion of loss ratios as a regressor. This arises because of the manner in which insurance premiums are determined. In particular, the adjusted 20-year loss experience in each county is used to define rates. Details regarding methods for premium rate determination can be found in Goodwin (1994).

[18] An alternative specification that included total crop acres rather than county size as a measure of scale suggested evidence

Key to our analysis is the effect of increases in corn and soybean insurance participation on acreage of each respective crop. The equation for corn acreage reveals a significant positive effect on planted acreage from increases in corn insurance participation. Soybean insurance participation appears to have a small, though statistically insignificant, positive effect on soybean acreage. This would seem to support other research that has concluded that the increases in participation that occurred in response to expansions in crop insurance programs brought about statistically significant acreage responses for insured crops, at least for corn. However, when these coefficients are translated into elasticities, the implied effects, even when statistically significant, are quite small. For corn, the elasticity of acreage response to increases in participation is 0.0104. For soybeans, the corresponding elasticity is essentially zero (0.0025). Thus, small positive and statistically significant increases in corn acreage appear to occur as participation in the corn insurance program increases, though the magnitudes of these increases are very small. The effect is very close to zero for soybeans. In short, although overall conclusions regarding the effect of insurance on acreage requires model simulation, these results would seem to suggest that corn insurance has a statistically significant though small effect on acreage whereas almost no such effect exists for soybeans.

Finally, the input usage estimates reveal many of the expected effects. More corn acreage increases input usage, as does increased purchases of corn insurance.[19] In contrast, more soybean acreage and greater participation in the soybean insurance program lowers input usage. These effects are as expected because corn has much greater fertilizer requirements than soybeans. Land in higher capability classes appears to have lower input requirements, as would be expected if inputs are useful in overcoming shortcomings in the productive capacity of farmland. Insurance participation in the case of corn actually appears to be correlated with more input usage, though this effect could certainly reflect acreage shifts in favor of corn which, again, has greater input requirements. In contrast, higher participation in the soybean insurance program is strongly associated with less input usage.

An extension to the corn and soybean model was considered for a more recent period—1997 and 1998.[20] As we have noted, significant changes occurred in the U.S. crop insurance program during this period. In particular, the introduction of revenue insurance products substantially increased liability levels and participation. This model explicitly recognized the important role of revenue insurance in that equations representing the relative share of revenue insurance products were included in the model. In the later period, premium rates were actually positively correlated with participation. This is not altogether surprising and probably reflects the higher RMA-determined rates associated with revenue insurance products, which were being selectively introduced in individual counties during this period. An interesting result is that higher levels of insurance participation are associated with the share of participation accounted for by revenue insurance products. That is, areas having more revenue insurance (as a proportion of overall insurance) tended to have significantly higher overall levels of participation. This suggests that the introduction of revenue insurance products stimulated participation in the overall crop insurance program. Simulated effects of premium changes for the later period are presented below. However, a simple evaluation of the parameter estimates suggests that crop insurance participation has a small positive direct effect on corn acreage and no effect on soybean acreage.

Northern Plains Wheat and Barley

Table 3 contains bootstrapped parameter estimates and summary statistics for the analysis of Northern Great Plains wheat and barley production for the 1985–1993 period.[21] The insurance demand equations reveal a statistically significant negative relationship between

of shifting among crops, such that increases in one crop tended to bring about decreases in the other. We prefer the use of total county acres in that total crop acreage would be expected to be endogenous to corn and soybean acreage. As pointed out by a reviewer, we do not have adding up conditions that result in our modeling all crops and thus there may be substitutions with other crops or other land uses (e.g., pasture) that are not directly captured by our model. Likewise, explicitly modeling crop rotation patterns with county-level data is not feasible.

[19] Again, it may be difficult to separate these effects.

[20] In the interest of conserving space, parameter estimates for this segment of the analysis are not presented here but are available on request.

[21] As noted above, proper specification testing in the bootstrapping context is not straightforward. However, application of the specification tests discussed above to estimates that ignored censoring implied identical results in terms of the presence of heteroscedasticity and the need for instrumental variables estimation techniques.

Table 3. GMM Estimates of Wheat/Barley Model

Variable	Estimate	Standard Error	t-Ratio
Wheat Insurance Participation			
Intercept	0.5088	0.0650	7.83*
Premium Rate	−2.5371	0.5427	−4.67*
Premium Rate ∗ Loss Ratio	0.7919	0.2407	3.29*
Fertilizer	−4.1086	0.7992	−5.14*
Livestock Sales	−0.1293	0.0346	−3.74*
Yield CV	0.0005	0.0010	0.48
Loss Ratio	0.0522	0.0173	3.03*
Wheat Acres	0.0034	0.0007	4.59*
County Acres	0.0049	0.0011	4.31*
D86	0.0219	0.0288	0.76
D87	−0.0555	0.0292	−1.90*
D88	−0.0035	0.0277	−0.13
D89	−0.0771	0.0265	−2.91*
D90	0.0391	0.0274	1.42
D91	0.0569	0.0290	1.96*
D92	−0.1494	0.0269	−5.55*
D93	−0.0717	0.0268	−2.67*
Barley Insurance Participation			
Intercept	0.1835	0.0592	3.10*
Premium Rate	0.0801	0.3751	0.21
Premium Rate ∗ Loss Ratio	0.0215	0.2260	0.10
Fertilizer	−3.1194	0.9070	−3.44*
Livestock Sales	−0.2467	0.0408	−6.05*
Yield CV	0.0033	0.0008	4.40*
Loss Ratio	0.0818	0.0191	4.29*
Barley Acres	0.0133	0.0021	6.44*
County Acres	0.0013	0.0011	1.20
D86	−0.0731	0.0276	−2.65*
D87	−0.0364	0.0287	−1.27
D88	0.0870	0.0313	2.78*
D89	−0.0534	0.0333	−1.61
D90	0.0693	0.0351	1.97*
D91	0.1594	0.0381	4.18*
D92	0.0433	0.0350	1.24
D93	−0.0340	0.0339	−1.00
Wheat Acreage Response			
Intercept	11.0113	8.7488	1.26
Wheat Price	−1.7733	1.4419	−1.23
Wheat Acres$_{t-1}$	0.9796	0.0310	31.63*
Barley Acres	0.1087	0.0417	2.61*
Participation Wheat	0.1513	1.0770	0.14
CRP Enrollment	0.5258	0.4747	1.11
Soil K-Factor	4.2604	4.9397	0.86
Soil T-Factor	0.2339	0.1600	1.46
Diverted Wheat Base	−0.0446	0.0740	−0.60
County Acres	0.0060	0.0144	0.41
D86	−1.9236	0.5213	−3.69*
D87	−3.0209	0.8965	−3.37*
D88	−3.1039	1.3716	−2.26*
D89	−1.1456	1.7822	−0.64
D90	−3.6976	2.0119	−1.84*
D91	−6.6717	2.6856	−2.48*
D92	−1.1284	2.1319	−0.53
D93	−4.2861	2.5060	−1.71*
Land Capability	−0.4969	0.9027	−0.55

Table 3. Continued

Variable	Estimate	Standard Error	t-Ratio
	Barley Acreage Response		
Intercept	2.2537	0.6483	3.48*
Barley Price	−0.1861	0.1498	−1.24
Barley Acres$_{t-1}$	0.9569	0.0317	30.23*
Wheat Acres	0.0083	0.0068	1.21
Participation Barley	0.6025	0.2468	2.44*
CRP Enrollment	−0.0891	0.0924	−0.96
Soil K-Factor	−2.3485	0.9257	−2.54*
Soil T-Factor	−0.0097	0.0493	−0.20
Diverted Barley Base	−0.1031	0.1908	−0.54
County Acres	−0.0051	0.0055	−0.91
D86	−0.3084	0.1385	−2.23*
D87	−1.1842	0.1599	−7.41*
D88	−1.0458	0.1873	−5.58*
D89	−0.9163	0.1372	−6.68*
D90	−1.1852	0.1588	−7.46*
D91	−0.6797	0.1569	−4.33*
D92	−1.6140	0.1637	−9.86*
D93	−0.8568	0.1428	−6.00*
Land Capability	−0.5489	0.2817	−1.95*
	CRP Enrollment		
Rental Rate	−0.0077	0.0059	−1.30
Cost Share	0.0016	0.0016	1.03
Erosion Index	0.0844	0.0221	3.82*
D86	0.1316	0.3110	0.42
D87	1.1296	0.3300	3.42*
D88	1.1110	0.3540	3.14*
D89	0.5544	0.3310	1.68*
D90	0.7652	0.3423	2.24*
D91	−0.4506	0.3124	−1.44
D92	−0.0190	0.2999	−0.06
D93	−0.0282	0.2958	−0.10
County Acres	0.0012	0.0042	0.30
CRP Acres $_{t-1}$	0.0000	0.0000	6.06*
δ	−0.0993	1.2953	−0.08
	Input Usage		
Intercept	0.0321	0.0022	14.45*
Participation Wheat	−0.0086	0.0124	−0.70
Participation Barley	−0.0218	0.0136	−1.60
Wheat Acres	−0.0004	0.0001	−4.73*
Barley Acres	0.0020	0.0002	9.43*
Land Capability	−0.0010	0.0038	−0.27
D86	−0.0038	0.0023	−1.64*
D87	−0.0017	0.0018	−0.93
D88	0.0148	0.0023	6.33*
D89	0.0043	0.0018	2.46*
D90	0.0106	0.0023	4.63*
D91	0.0115	0.0029	3.91*
D92	0.0075	0.0033	2.23*
D93	0.0081	0.0028	2.89*

An asterisk indicates statistical significance at the $\alpha = 0.10$ or smaller level.

premium rates and the level of participation for wheat while the barley equation shows a positive but statistically insignificant relationship. At the data means, the results imply elasticities of demand of −0.12 for wheat and 0.03 for barley. The elasticity for barley is very close to zero and thus implies a very inelastic (not significantly different from zero) demand for barley insurance. This is not surprising given the high average loss ratios for crops in these regions.[22] These can be compared to the elasticities of about −0.28 and −0.33 for corn and soybeans, respectively, in the Heartland region over the same period.

In the case of the wheat equation, a higher average loss ratio appears to significantly decrease the responsiveness of agents to premium changes. In the case of barley, however, the interaction term is very small and is not statistically significant. Again, identification of this adverse selection effect may be confounded by the inclusion of loss ratios as a regressor. These findings are relatively consistent with those presented for Heartland corn and soybeans.

Fertilizer and chemical expenditures again exhibit the expected negative effect for wheat and barley, suggesting that fertilizer and chemical applications will tend to decrease as adoption of crop insurance rises. This effect may represent moral hazard on the part of insuring producers, who use less inputs when purchasing crop insurance. Such an effect was revealed by Smith and Goodwin for Kansas wheat producers. Alternatively, this may reflect unobservable differences in land quality and other fixed factors that vary from county to county, though our inclusion of a land quality indicator would presumably condition for such an effect.

The ratio of livestock sales to total farm sales is significantly negative in the cases of wheat and barley. Higher average loss ratios, which correspond to higher expected relative indemnities, are positively correlated with greater demand for insurance for wheat and barley. The Heartland corn and soybean results also suggested a significantly positive relationship between average loss ratios and insurance demand. As expected, the coefficient on the yield CV term is significantly positive for barley, though the effect is essentially zero for wheat. In cases where both higher loss ratios and higher yield CVs are positively correlated with insurance demand, such as for barley, the results suggest that there are benefits to producers both from the income subsidy effects of insurance as well as from the risk reduction brought about by crop insurance. As we have noted, however, that separately identifying the individual effects may be difficult and the wheat insurance demand equation may reflect this difficulty. Increases in acreage for each crop are correlated with more insurance purchases for that crop. Again, this finding is in agreement with the results of other research and the results for corn and soybeans above, implying that insurance purchases are likely to be greater for larger farms or larger areas in which incentives for selling on the part of agents working on commission are likely to be greater in such cases.

The price coefficients in the wheat and barley acreage equations are negative, though again this reflects correlation of prices with the annual dummy variables. When these dummy variables are omitted, the price elasticity of wheat is still negative at −0.04 though it is not statistically different from zero. In the case of barley, omission of the fixed annual effects implies an acreage elasticity of 0.19. These price effects are not as unusual as may first appear as they may reflect the influences of a mandatory ARP for wheat during the 1980s. Perhaps of greatest interest are the effects of insurance participation on wheat and barley acreage. In the case of wheat, there is no statistically significant effect of participation in crop insurance on wheat acreage. In the case of barley, a statistically significant positive effect is revealed. In elasticity terms, a doubling of insurance participation will increase barley acreage by 5%, a relatively modest but economically and statistically significant amount (i.e., the elasticity of acreage response to insurance participation is 0.05). In the case of barley acreage, the elasticity with respect to insurance participation is similar to, though somewhat larger than, what was revealed for corn and soybeans above. In total, our results indicate that increases in insurance participation will yield small increases in barley acreage and no discernable change to wheat acreage.

The annual dummy variables are of mixed signs and degrees of significance. While these dummy variables are intended to capture the aggregate market impacts of crop prices and policy changes, it is difficult to separately identify individual effects from changes that had a common impact on all counties. The total scale of the county (total county size) does not have a significant impact on wheat acreage though a negative effect on barley acreage is suggested. Again, scale is also represented by lagged acreage, which is highly significant in each case.

[22] Insurance participation may not respond to premium increases if expected returns to insurance are highly positive. Average loss ratios suggest returns (indemnities) of \$2.12 and \$2.05 for each dollar spent on premiums for wheat and barley, respectively.

CRP enrollment has a negative effect on the acreage of barley. In contrast, the coefficient of CRP acreage in the wheat equation is positive. However, neither acreage equation exhibits a statistically significant effect from CRP enrollment. We find no evidence of shifting among alternative crops in that wheat acreage is positively correlated with barley acreage and vice versa. These positive effects are very small and are only significant in the wheat equation. Again, this may reflect regional patterns of the suitability of land for producing both wheat and barley. The results suggest that barley and wheat insurance participation decrease input usage, though the effects are not statistically significant. Increases in barley acreage are correlated with slightly greater use of inputs while increases in wheat acreage were correlated with less input usage. The coefficients are statistically significant in each case. Input usage does not appear to be influenced by the capability of land. This may reflect the fact that crop acreage adjusts according to the capability of land and thus any effects on input usage are reflected through crop acreage.

Policy Simulations

In order to evaluate the implications of our analysis for the effects of insurance participation on acreage response, we consider a number of policy simulations. In particular, we simulate the effects of large premium subsidy increases (i.e., premium decreases) on insurance participation and land use patterns. Premium changes are "across-the-board" meaning that all counties' premium rates are decreased by a proportionally equivalent amount. The rate change simulations essentially involve exogenously changing premium rates (from their mean values) while holding all other variables at their mean values. We then use the structural equation systems to evaluate how predictions regarding insurance participation and acreage allocations change. Our simulations recognize the fact that agent's expected loss ratios (expected returns to insurance) will be altered in a corresponding fashion (i.e., increased) by decreases in premiums. Note that the premium variable used in our analysis is the farmer-paid premium (net of the subsidy). Thus, our simulations can be interpreted as the effects of increases in premium subsidies, which occurred during the 1980s and 1990s. In particular, the 1980 Crop Insurance Act established premium subsidies at a level of 30% of the total premium for coverage at the 65% level.[23] The 65% coverage-level premium subsidy was increased to 42% by the 1994 Crop Insurance Reform Act and other legislative actions during the 1990s. Most recently, the premium subsidy rate was increased to 59% by the 2000 Agricultural Risk Protection Act (ARPA). Thus, insuring producers realized premium subsidy increases of about 30% between the mid 1980s and the current period.[24] It is important that we account for the uncertainty underlying our structural model parameter estimates. To this end, we utilize Monte Carlo simulation methods to randomly draw from the estimated parameter covariance matrix and thus obtain standard error estimates for the simulated effects.[25] In the case of the wheat and barley analysis, we utilize the bootstrapping replicates to calculate standard errors for the policy simulations.

Results of the policy simulations are presented in table 4. The first policy simulation concerns a change in subsidies that results in a 30% decrease in corn and soybean insurance premiums. Corn participation (as measured by the ratio of liability to maximum possible liability) increases by 24.93% while soybean insurance participation increases by 20.24%. The effects are highly significant. Corn acreage responds with a modest 0.28% increase while no statistically significant change in soybean acreage is implied. A second policy simulation considers the effects of a 30% decrease in soybean insurance premiums, leaving corn premiums constant. The results are analogous to what was realized when both premiums were changed. Soybean participation increases substantially (23.91%) while corn participation realizes a more modest increase (8.29%). Changes in soybean acreage triggered by the premium decrease are essentially zero and are not statistically significant. A third policy simulation considers the effects of an analogous 30% decrease in corn premium rates, holding soybean rates constant. The effects are quite similar to those realized when both premium

[23] During the period of our study, the vast majority of crop insurance was purchased at the 65% yield coverage level. This was because premium subsidies favored this coverage level.

[24] Actual aggregate subsidy rates are higher in that the entire premium for catastrophic coverage is subsidized. Underwriting and administrative subsidies to insurance companies are also relevant. Without such subsidies, one would expect these costs to be reflected in insurance premiums.

[25] We randomly draw 5,000 replications of parameters from a multivariate normal distribution defined by the original parameter estimates and the estimated covariance matrix. We then adjust the insurance premium rates, holding other variables constant, and evaluate the effects on predicted insurance participation and acreage levels.

Table 4. Premium Rate Change Simulation Results

	Percent Change			
Premium Change	Corn Insurance	Soybean Insurance	Corn Acreage	Soybean Acreage
	Corn and Soybeans			
−30% Corn, −30% Soybeans	24.9314	20.2359	0.2832	0.0592
	(0.8955)*	(1.2853)*	(0.0748)*	(0.0585)
0% Corn, −30% Soybeans	8.2865	23.9132	0.0877	0.0662
	(0.7270)*	(1.3559)*	(0.0243)*	(0.0709)
−30% Corn, 0% Soybeans	17.9609	−4.6944	0.1956	−0.0070
	(0.8232)*	(0.6493)*	(0.0522)*	(0.0127)
−30% Corn, −30% Soybeans (1985–1989)	26.9145	20.2321	0.4917	−0.0904
	(1.1573)*	(1.8172)*	(0.1089)*	(0.0618)
−30% Corn, −30% Soybeans (1990–1993)	17.1987	12.8445	−0.1657	−0.0602
	(1.1902)*	(1.5376)*	(0.0561)*	(0.0672)
−30% Corn, −30% Soybeans (1997–1998)	−1.6790	7.4620	−0.0494	−0.0080
	(0.8227)*	(0.9124)*	(0.0257)*	(0.0553)
Premium Change	Wheat Insurance	Barley Insurance	Wheat Acreage	Barley Acreage
	Wheat and Barley			
−30% Wheat, −30% Barley	20.6190	19.1944	0.1202	1.0176
	(2.3685)*	(3.5760)*	(0.7488)	(0.4446)*
0% Wheat, −30% Barley	1.3206	18.5614	0.0355	0.9807
	(0.8768)	(3.3948)*	(0.0547)	(0.4343)*
−30% Wheat, 0% Barley	19.5276	0.7620	0.0850	0.0373
	(2.4065)*	(1.2429)	(0.7060)	(0.0714)
−30% Wheat, −30% Barley (1985–1989)	24.1300	26.5943	−1.1346	0.4137
	(2.8200)*	(5.3827)*	(1.3219)	(0.6081)
−30% Wheat, −30% Barley (1990–1993)	13.1381	8.9220	0.9930	1.1239
	(2.8685)*	(4.3000)*	(0.5464)*	(0.6441)*

Numbers in parentheses are standard errors. An asterisk indicates statistical significance at the $\alpha = 0.10$ or smaller level.

rates are adjusted. Corn insurance participation rises by 17.96% and corn acreage increases by 0.20% while there is no statistically significant effect on soybean acreage. In all, the results imply very modest though statistically significant increases in corn acreage with no significant effect on soybean acreage.

An analogous simulation was conducted for the 1985–1993 wheat and barley model estimates. A 30% decrease in the wheat and barley insurance premium rates triggers statistically significant increases in insurance participation rates. In particular, wheat insurance participation increases by 20.62% while barley insurance participation increases by 19.19%. These changes trigger a statistically significant increase in barley acreage (1.02%) but no significant increase in wheat acreage. Very similar results are obtained when only the barley premium rate is decreased, with insurance participation rising by 18.56% and acreage rising by 0.98%. Likewise, when wheat premium rates are lowered while keeping barley rates constant, insurance participation rises by a statistically significant 19.53% while acreage is again unchanged. In all, the simulations suggest that substantial decreases in insurance premium rates will trigger increases in participation and a modest though statistically significant increase of about 1% in barley acreage. However, no significant changes in wheat acreage are implied by insurance participation changes.

The structure of U.S. agricultural policy and, in particular, crop insurance policies underwent changes over the period of our study. Especially notable events included the substantial disaster relief that was provided in 1988 and 1989 in response to widespread droughts. To address concerns regarding the extent to which our structural models and simulation results may have been affected by such structural changes, we repeated the simulations using models estimated from subsamples of our estimation data. In particular, we split the data at 1989 and reestimated the models for both subsamples. Results for the simulated effects of the 30% premium decreases are also presented in table 4.[26] The results are quite similar to what was obtained when the data are considered for the entire period. The results suggest less elastic responses to premium changes in the later periods, with large premium decreases evoking considerably smaller participation increases. In the earlier period, simultaneous decreases in both premium rates raises corn acreage by 0.49% while actually lowering soybean acreage by a modest 0.09%. In the latter period, a very small decrease in corn acreage is implied by such changes. In the case of wheat and barley, decreases in premiums have no significant effect on wheat and barley acreage in the earlier period though, interestingly, both wheat and barley acreage are implied to increase by about 1% in the latter period as a result of such a change. Again, all such implied changes are modest, even in cases where they are statistically significant. In short, the simulation results are largely robust to the period of study, with the largest increases in acreage being realized by barley. To put any such changes in barley acreage into perspective, it should be noted that barley acreage is only about one-third of wheat acreage in the typical Northern Great Plains county—suggesting that such 1% changes are small. In every case, the results suggest that any changes in acreage that occur as a result of insurance premium changes are modest, especially for wheat and soybeans.

Finally, the premium change simulation was repeated using the more recent model of corn and soybeans that is discussed above. An interesting result is that premium decreases do not provoke large increases in overall insurance participation, especially in the case of corn. However, such changes substantially increase the share of participation accounted for by revenue insurance products. While one may raise questions regarding the lack of a response to premium rate changes, a consideration of facts relevant to recent crop insurance programs makes such a response not at all surprising.[27] In particular, the large positive expected returns to insurance (e.g., $1.80 per dollar of premium paid) would imply that producers are not likely to be very responsive to premium changes. In addition, as we have noted, recent legislative changes undertaken as a result of the 2000 ARPA greatly increased premium subsidies, providing an opportunity to examine the extent to which farmers would respond to such changes and thus evaluate our models and simulations out of sample. In 2000, premium subsidies totaled $951 million and implied a premium subsidy rate (the ratio of premium subsidy to total premiums) of 37.47%. Under the provisions of ARPA, premium subsidies increased to $1.77 billion, with the premium subsidy rate rising to 59.82%. To the extent that the demand for insurance was responsive to premium changes, this should have substantially increased participation. However, total liability only rose from $34.4 billion to $36.72 billion while net insured acreage rose from 206 million to 211 million. These adjustments represent relatively modest increases in participation and thus would tend to support our findings suggesting that insurance demand has been relatively unresponsive to premiums in recent years.

Our simulation results suggest that premium decreases have almost no effect on corn insurance participation or corn acreage. In contrast, a very large 30% decrease in soybean premiums does tend to evoke a modest (7.5%) increase in participation though again there is no significant effect on soybean acreage. Thus, the results for the recent period are consistent with the recent experience in the crop insurance market, where large premium decreases that occurred with the 2000 ARPA legislation had small effects on participation and acreage.

The overall implications of our results are quite clear. Even in the most extreme cases, large premium decreases trigger significant increases in participation but do not bring about large increases in planted acreage. In the most extreme case, a 30% decrease in premiums that is accompanied by an analogous increase in expected loss ratios brings about only an additional 0.49% increase in planted corn acreage. The results for wheat and barley in the Northern Great Plains, an area more often considered to represent the "extensive margin," suggest more substantial increases in acreage, at least for barley. In particular, lowering wheat insurance premiums by 30% increases wheat insurance participation and brings about modest increases in barley acreage of about 1.0%. When the analysis is confined to a more recent period, similarly modest increases in wheat acreage of about 1% are realized. Thus, while it is difficult to extend our results beyond our time period and sample of counties, our results

[26] Parameter estimates for the subsamples are not presented here but are available from the authors on request.

[27] The statistics presented here were taken from the RMA's online summary of business database.

would seem to imply that expansions in the federal crop insurance program have not resulted in large increases in planted acreage, even in the most extreme cases. Though the increases have occurred and parameters underlying these effects are statistically significant in some cases, the responses are quite modest.

A number of alternative model specifications were considered in order to evaluate the extent to which our results are robust to model specification choices. In particular, we considered a model that included additional county-specific land quality measures (the presence of pasture and grasslands), a model that omitted prices and instead represented market effects within the context of the fixed annual dummy variables, a model that excluded the fixed annual effects (which clearly are correlated with aggregate price movements), and a model that ignored the relatively modest degree of censoring present in our data. In every case, our results and policy implications (i.e., that acreage effects arising from crop insurance programs are always very modest, though often are statistically different from zero) were fully robust to these model specification alternatives.

Concluding Remarks

Significant expansions of the U.S. federal crop insurance program have led many to question the extent to which the risk protection and subsidies inherent in the programs triggered an expansion in production. To address this issue, we considered samples of reasonably homogeneous counties in the U.S. Corn Belt and Northern Great Plains regions. In particular, we considered estimation of multiequation structural models that evaluated acreage and insurance decisions.

Our empirical estimates suggest that the demand for crop insurance is generally quite inelastic, especially in recent years. Our results also confirm that increased participation in crop insurance programs is indeed correlated with additional acreage in wheat and, to a lesser extent in corn. However, simulations of the effects of large premium decreases (30%) reveal that the effects on acreage of such policy changes are very modest. In particular, in the most extreme case we consider, an across-the-board premium decrease of 30% for barley only increased planted acreage by about 1.1%. In the case of corn, acreage increases of the order of about 0.28–0.49% are suggested. Thus, our results would seem to suggest that increases in insurance participation bring about relatively small acreage responses.

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