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

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Abstract

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1 Introduction

Crop insurance programs have been a part of U.S. agricultural policy since the 1930s and their prominence has increased in recent years as the programs have expanded. Over most of their history, U.S. crop insurance programs have been intended to protect agricultural producers from yield risk by paying indemnity payments whenever realized yields fell beneath some guaranteed level. Though the programs have undergone many changes over their history, the basic components and operation of crop insurance programs were largely unchanged until recent years.

Over the last several years, U.S. crop insurance programs have undergone significant changes. The 1980 Federal Crop Insurance Act significantly expanded the program and provided large subsidies to encourage participation. In 1994, the Crop Insurance Reform Act brought about a brief period of mandatory participation in the program and instituted a "catastrophic" (CAT) level of protection that was intended to replace disaster relief payments at a very low cost to producers.[1] The 1994 Act also mandated development of insurance programs that would provide "cost of production" coverage to agricultural producers. These programs along with innovations driven by private insurers led to the development of several different revenue insurance programs that provided protection against lost revenue occurring from any combination of low prices and/or yields. There are currently three primary revenue insurance products— Crop Revenue Coverage (CRC), Revenue Assurance (RA), and Income Protection (IP). Participation has grown substantially in response to these new programs and other policy changes that have made crop insurance more attractive to producers.[2]

Critics of the U.S. crop insurance program have noted the program's relatively poor actuarial performance. Between 1981 and 1999, the average subsidy-adjusted loss ratio was 1.89, which implies that for each dollar paid in by a farmer, an average of $1.89 was received back in indemnity

[1] CAT coverage is nearly free, requiring only a small administrative fee.

[2] For example, in 1995, total liability for corn insurance was $6.7 billion. In 2000, total liability for corn had grown to over $9.8 billion, with $5.7 billion being accounted for by the CRC program (USDA-RMA, 2000).

payments.[3] Thus, insurance programs convey rather large net transfers from the government to agricultural producers. Questions have been raised as to whether insurance programs are attractive to producers because they alleviate risk or rather because of the net transfer implied by loss ratios above 1.0. Recent research by Just, Calvin, and Quiggin (1999) concluded that the risk reduction benefit was less relevant to participation than was the economic welfare transfer conveyed by the program.

Whether the primary benefit to producers conveyed by federal crop insurance programs comes through risk reduction or income enhancement is debatable. What is clear, however, is that the provision of such programs provides 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 1970's, when observers speculated that the disaster payments program was encouraging production in high risk areas (see, for example, Gardner and Kramer, 1986). 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.

In addition, considerable concern that risk management programs provide inducements for production of riskier crops in riskier regions has recently been raised. Environmental concerns lie at the heart of this debate. The issue has typically been framed in terms of the "extensive margin" of production. There are two fundamental margins at issue. The first involves land within a region (e.g., a county) that, in the absence of risk management programs, may not be planted because of its relatively high risk. The second margin involves land in other growing regions that may be brought into production if programs are provided to assist producers with the higher degree of production risk associated with that crop in that region. The conventional wisdom is that riskier regions and riskier land within a region tend to be more environmentally fragile. Thus, programs which permit producers to assume more production risk may actually damage the environment by encouraging production on environmentally-fragile, marginal land. Goodwin, Smith, and Hammond

[3] Loss ratios were calculated using unpublished data from the RMA. Note that this loss ratio does not include the amount of premium paid by the government through premium subsidies. Of course, if such subsidies are included in premiums, loss ratios are lower. In this light, what we consider to be poor actuarial performance may reflect large subsidies that are applied to premiums, which may in fact be actuarially sound.

(2000) considered a reduced-form model of the effects of risk management and conservation reserve programs on measured patterns of soil erosion. Their results revealed a modest positive effect of increases in participation in crop insurance programs on soil erosion. A larger positive effect was exerted by direct government payments and a very significant negative effect was found for the Conservation Reserve Program (CRP).

A closely related though distinct issue involves the extent to which new land was brought into production by the expansion of risk management programs in the 1980s. Increases in erosion could reflect production shifts to more erodible land or, alternatively, simply expansion that brought more land into production. Recent research results presented by Keeton, Skees, and Long (2000) implied that expansions in risk management programs 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, approximately 35 million acres, was accounted for by land put into the Conservation Reserve Program. An alternative analysis by Young, Vandeveer, and Schnepf (2001) suggested very modest aggregate U.S. acreage responses to the provision of risk management programs.

Acreage effects brought about by participation in crop insurance programs could be important for several reasons. First, if the acreage response to insurance is large, there could be overproduction and negative effects on price. The premium subsidy benefits would be partially offset by lower crop prices. These effects could also carry over into input markets, affecting the demand for fertilizer, seed, chemicals, fuel, land, and so on. Some regions of the country would be at a disadvantage relative to others regarding production of particular crops. Overproduction, if large enough to affect prices, would also affect trade patterns. Negative environmental consequences, such as greater soil erosion and water quality problems could result if marginal land was brought into production or if land switched into production of crops with greater chemical use and potential for erosion. If crop insurance is encouraging acreage expansion, particularly onto marginal lands, then it may be working at cross-purposes with other government programs such as the Conservation Reserve Program, which is paying farmers to switch land out of crop production into conserving uses.

The existing research has provided important insights into the effects of the expansion of risk management programs on production patterns. However, a wide gap exists in the implications of existing studies, with some results (Keeton, Skees, and Long (2000)) pointing to large effects

and others (Goodwin, Smith, and Hammond (2000) and Young, Vandeveer, and Schnepf (2001)) showing modest effects. An additional limitation associated with 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. For example, net indemnities for cotton, which tends to be largely regional in production, are much higher than those commonly observed for other crops. Likewise, loss-ratios are much higher in some regions than in others, even for the same crop. This heterogeneity suggests that a focus on aggregate effects, though valuable, may conceal crop- and region-specific effects.

In this light, 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 relatively homogeneous growing regions. 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 of variables reflecting the endogenous decisions of agricultural producers to simulate the possible effects of large premium changes. Our results reveal that increased participation in the federal crop insurance program is indeed correlated with more acreage for a given crop. However, the magnitude of the effect, though statistically significant in most cases, is small. Our results do reveal, however, that different effects are realized for different crops in different growing regions. Our conclusions are in agreement with earlier, more aggregate studies (Young, Vandeveer, and Schnepf (2001)) that have concluded that the increases in acreage in production brought about by risk management programs are modest.

The plan of our paper is as follows. The next section discusses conceptual issues and an empirical modeling framework for considering the effects of risk management programs on acreage allocation decisions. The third section presents estimates of structural econometric models of acreage response for competing crops, insurance demand, CRP participation, and input usage. Three separate analyses are considered. The first evaluates midwestern corn and soybean production during the 1985-93 period. The second considers barley and wheat production in the Northern Great Plains over the same period. The third extends the corn and soybean analysis to a more modern period (1997-98) that was characterized by a different policy environment. Simulations of the effects of premium changes are considered using the model estimates. The final section contains a review of the analysis and offers some concluding remarks.

2 Modeling Framework and Discussion of Data

Theoretical considerations of the demand for insurance generally consider 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, such 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 Conservation Reserve Program (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), 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, and conservation program participation for multiple crops. The motivated reader is referred to Innes and Ardila (1994) for 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 as to this effect exist in the literature. Though a simple consideration of the demand for insurance does not provide a prediction as to the expected 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.

Previous research (Smith and Goodwin (1996)) demonstrated that fertilizer and chemical usage

for Kansas wheat producers tended to be negatively correlated with insurance purchases. That is, growers that 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 (1993) suggested that fertilizer and chemical inputs raise risk and thus were correlated with insurance purchases. In more recent work, Wu (1999) found that changes in the crop mix may make 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 our county-level data. The first two segments of our analysis cover the years 1985-1993 while the latter portion of our analysis utilizes data for 1997 and 1998. 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 is cross-sectional, being derived from a large sample of counties observed over a relatively few number of years. Farms in these counties are all subject to a number of changes over time which mainly arise from a few variables which affect all farms in a homogeneous manner. Such factors include the effects of prices and price uncertainty (assumed constant across all farms in a year) as well as general policy changes. Although a variety of empirical procedures have been developed to directly address issues related to omitted factors, nonindependence, and heterogeneity of error variances across cross-sectional units, we assume a relatively simple model form and apply standard instrumental variables estimation techniques.[4] We hypothesize that individual farms are subject to a number of common, fixed "time" effects, representing factors relevant to acreage, input usage, and insurance demand decisions. Such factors would include input and output prices, price risk, policy parameters (e.g., diversion payment rates, annual changes in policy parameters, etc.), and changes in loan rates. Such effects are common across all farms in a year, though the effects likely vary across years. To represent these fixed effects, our models include annual dummy variables.[5]

[4] 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.

[5] We also considered direct inclusion of input and output prices, deficiency payment rates, and other relevant policy variables. The overall implications of our analysis were completely robust to such specification differences.

As we noted above, we suspect that a considerable degree of heterogeneity exists in insurance participation and acreage allocation patterns for different crops across the U.S. In this light, we wish to focus our analysis on relatively homogeneous growing regions. To do so, we utilize the Farm Resource Regions of the USDA-ERS to define relatively homogeneous regions.[6] 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 region" 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).[7] Returns to insurance will be influenced by premium rates as well as the expected indemnity payments. Goodwin (1993) and Smith and Baquet (1996) 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. 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

The annual effects confounded identification of the parameters for such variables that had little variation in the cross-sections. In some cases, this led to unexpected signs and unreasonable price coefficients. It should be noted that such a modeling approach does not account for cross-sectional differences in local prices and price risk. We assume that such differences are modest within our areas of study (the U.S. corn belt and northern great plains) when compared to the year-to-year changes captured in our models.

[6] It must be acknowledged that some degree of heterogeneity is likely to exist over any aggregated region and thus our results may neglect to consider potentially relevant differences across counties. For a discussion of the definitions of farm resource regions, see Heimlich (2000).

[7] 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. Our measure of participation captures such adjustments.

quality for a given county (the proportion of land in capability classes one and two).[8]

Our empirical models of acreage allocations essentially consider factors that are relevant to the expected return from producing the crop in question. The typical approach to modeling acreage response in the literature (see, for example, Morzuch, Weaver, and Helmberger (1980)) 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. As noted above, in many cases we utilize fixed annual effects to capture the effects of variables relevant to returns that only vary over time. 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 on observed acreage decisions.

It is important that our analysis adequately capture the effects of farm program constraints which 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). Target prices (as well as input and output prices) are common to all farms, though base acreage varies substantially from farm to farm (i.e., county to county).[9] We capture this effect by including a measure of the adjusted base acreage as an explanatory variable. This measure was constructed by adjusting the preceding year's base acreage for required diversions under the ARP program. 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.[10]

[8] 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.

[9] In a version of our analysis that included prices directly, we used the higher of the planting-time price of a harvest-time futures contract or the target price as the relevant price variable. Again, our overall results and policy implications were unchanged in this alternative specification.

[10] As is true with all proxy measures, the limitations associated with our measurement of county level base acreage

Our empirical analysis is complicated to a degree by the fact that the CRP program was introduced in 1986. CRP program participation is important to our analysis as 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:

$$CRP_{it} = \delta(X_{it}\beta) + e_{it} \tag{1}$$

where CRP_{it} is an indicator of CRP enrollment and δ 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.[11]

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 measures of land capability as well as a measure of the proportion of agricultural land in each county that was in grass and pasture in 1982. These latter variables are intended to reflect exogenous soil and other land characteristics that may be relevant to productivity and thus input usage patterns.

In short, for our analysis of soybean and corn acreage response and insurance participation, the preceding discussion 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. Finally, a similar specification is used to evaluate Heartland corn and soybeans for 1997 and 1998. As is discussed below, however, the specification is amended to account for the introduction

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.

[11]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 in light of the fact that 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 transparent to the manner of modeling CRP participation.

of several revenue insurance programs that have had a major influence on insurance participation in recent years.

Data were collected from a wide variety of sources. Insurance program data were taken from the RMA's unpublished county level experience database. An important caveat associated with the use of such data should be noted at this point. 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. 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 (REIS) database. CRP statistics were taken from unpublished data obtained from the Economic Research Service. Soil characteristics and land use patterns (grass and pasture) in 1982 were taken from the NRCS National Resource Inventory (NRI) database. Nominal economic variables were deflated using the producer price index. Market prices used to define insurance liability were those quoted prior to planting time (January) for a post-harvest futures contract (November or December). These were taken from the Bridge database.

Measurement of the level of insurance participation is challenging as 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 sixty-five percent of the average yield for the preceding ten 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 in that 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. Variable definitions and summary statistics for the variables included in the three segments of our empirical analysis are presented in Table 1. The analysis of corn and soybeans over the 1985-93 period utilized 6,142 observations. The analysis of wheat and barley over the same period utilized 1,090 observations.[12] The analysis of corn and soybeans in the post-FAIR policy environment utilized 1,130 observations.

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

Concerns could be raised regarding the potential for censoring in our insurance and CRP participation equations.[13] In the case of insurance, there is little likelihood that one would observe either complete participation or a zero level of participation and thus censoring is not a concern.[14] In the case of CRP enrollments, the issue of censoring is more of a concern. In the years after 1986, about 10% of the counties did not realize any enrollments. As an alternative estimation approach, we applied the methods recently introduced by Shonkwiler and Yen (1999) for controlling for censored dependent variables in a system of equations to the CRP equation. The results were very similar and thus we have maintained our original specification which ignores the modest level of censoring.[15]

Finally, it should be acknowledged that our estimation 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. We considered a series of White-type tests for heteroscedasticity (presented below). 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 (1987).[16] 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. Our particular estimation approach involves the application of instrumental variables estimation techniques within the context of the generalized method of moments.

[13] We are grateful to an anonymous reviewer for raising this point and to Scott Shonkwiler for helpful discussions on this issue.

[14] 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.

[15] Censored dependent variable estimators, which typically model the response for a latent variable (such as the desire to enroll land in CRP at a given rental rate) that can assume negative values, may not be appropriate in our case since we are interested in actual enrollment effects rather than some latent indicator of desired enrollment. However, the distinction is of diminished importance in light of the small degree of censoring and the similarity of results across alternative estimators.

[16] 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.

3 Empirical Results

The empirical models were applied in three distinct applications. The first involves corn and soybean production and insurance purchases in the corn belt over the 1985-93 period that included substantial expansion of 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. The third section reconsiders corn and soybeans for a more recent period that includes the introduction of revenue insurance policies.

3.1 Heartland Corn and Soybeans (1985-1993)

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 correction 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 -0.396. Likewise, for soybeans, the estimates imply an elasticity of -0.404. 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, for example, 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

[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 twenty year loss experience in each county is used to define rates. Details regarding methods for premium rate determination can be found in Goodwin (1994).

hazard, has been identified in other studies (see, for example, Smith and Goodwin (1996)). 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 since 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 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. Counties with more productive land, as represented by the land capability class variable, appear to purchase more insurance. Though this may at first glance be surprising, it is important to recognize that we have conditioned on yield variability by including the yield coefficient of variation in the insurance demand equation. In both cases, a higher yield CV appears to be correlated with greater demand for insurance. Thus, the land capability measure likely reflects the higher value of the crop being insured in those areas with more productive land.

An interesting though not surprising finding is that higher average loss ratios, which correspond to higher expected relative indemnities, are 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, separately identifying the effects may be difficult. Increases in acreage of either of the two crops is correlated with a more insurance purchases for each crop. This finding is in agreement with the results of other research (see, for example, Goodwin (1993) and Black and Dorfman (2000)) 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.[18] Lagged acreage, representing partial adjustment (along with the adjusted base acreage) are highly significant in both the corn and soybean equations. The adjusted base and lagged acreage terms are, of course, highly correlated and thus their individual effects may be difficult to identify. The adjusted corn base variable is statistically significant only in the soybean equation. We included total acreage in the county as an indicator of the scale of a county's total size.[19]

As expected, the acreage response equations reveal a strong negative effect from CRP enrollment. In both cases, 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. Increases in corn acreage do not appear to be correlated with less soybean acreage and vice versa.[20]

Key to our analysis is the effect of increases in corn and soybean participation on acreage of each respective crop. The equation for corn acreage reveals significant positive effects on planted acreage from increases in corn insurance participation. Likewise, soybean insurance participation also appears to have a small, though statistically significant positive effect on soybean acreage. This would seem to support other research that has concluded that the increases in participation which occurred in response to expansions in crop insurance programs brought about 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 0.013. For soybeans, the corresponding elasticity is essentially zero (0.008). Thus, small positive increases in corn acreage appear to occur as increased participation in the corn insurance program takes place, 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 significant effect on acreage whereas almost no such effect exists for soybeans.

[18] An alternative version of this model that contained policy-adjusted price variables exhibited positive though very inelastic price responses.

[19] An alternative version of this model (not presented here) included total crop acreage in a county. Identical results and implications were obtained in this model, though concerns regarding the endogeneity of total acres led us to this alternative specification. Of course, county size is exogenously fixed.

[20] An interesting result obtained when using total crop acres rather than total county acres was that evidence of shifting among crops, such that increases in one crop tended to bring about decreases in the other, did exist. As a reviewer has pointed out, 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.

Finally, the input usage equation estimates reveal many of the expected effects. More corn acreage increases input usage, as does increased purchases of corn insurance.[21] In contrast, more soybean acreage and greater participation in the soybean insurance program lowers input usage. These effects are as expected since corn has much greater fertilizer requirements than soybeans. Counties with a high proportion of grass lands (i.e., land more suitable for pastures) tend to have greater input usage while counties with higher quality land tend to exhibit less input usage per planted acre. Again, it is relevant to point out that our input usage applies to all crops and thus it is difficult to identify the effects associated with individual crops.

3.2 Northern Plains Wheat and Barley (1985-1993)

Table 3 contains GMM parameter estimates and summary statistics for the analysis of Northern Great Plains wheat and barley production for the 1985-1993 period. Again, the White specification tests suggest the presence of heteroscedasticity in standard three stage least squares estimates and thus support our GMM estimation approach. Hausman tests again suggest the need for instrumental variables estimation techniques, though the cross-equation correlation correction implicit in our joint estimation procedure does not appear to be necessary in order to obtain efficient estimates.

The insurance demand equations reveal a statistically significant negative relationship between 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 -0.17 for wheat and 0.06 for barley. The elasticity for barley is very close to zero and thus likely corresponds to 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 -0.40 for corn and soybeans in the Heartland region.

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 terms are actually negative, though 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

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

[22] Insurance participation may not respond to premium increases if expected returns to insurance are highly positive.

relatively consistent with those presented for Heartland corn and soybeans.

Fertilizer and chemical expenditures exhibit the expected negative effect for wheat. In the case of barley, however, the effect is positive, though not statistically different from zero. For wheat, this result implies 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 (1996) 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 several land quality indicators 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. Counties with more productive land, as represented by the land capability class variable, appear to purchase more barley insurance. Land quality does not appear to have a significant effect on wheat insurance purchases. Results for Heartland corn and soybeans implied a positive relationship between land productivity and insurance participation.

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 suggested a significantly positive relationship between average loss ratios and insurance demand. As expected, the coefficient on the yield CV term is positive for barley, though the effect is significantly negative 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 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, separately identifying the individual effects may be difficult and the wheat equation may reflect this difficulty. Increases in acreage for each crop is 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 that incentives for selling on the part of agents working on commission are likely to be greater in such cases.

The most striking aspect of the results for wheat and barley in the Northern Great Plains lies in the strong, positive effect of insurance participation on wheat acreage. In elasticity terms, a

doubling of insurance participation will increase wheat acreage by 4.5%, a small but significant amount (i.e., the elasticity of acreage response to insurance participation is 0.045). The insurance participation effect in the barley equation is positive and statistically significant, though relatively small with an elasticity of 0.028. In the case of barley acreage, the elasticity with respect to insurance participation is similar to what was revealed for corn and soybeans above. In total, our results indicate that increases in insurance participation will yield small increases in crop acreage.

The dummy variables that were added to capture price and policy changes are of mixed signs and degrees of significance. While these dummy variables are intended to capture the impacts of crop prices and aggregate policy changes, it is difficult to separately identify individual effects from changes that had a common impact on all counties. We would again note, however, that similar results were obtained when prices and various policy parameters were modeled directly rather than by using fixed effects.[23] Again, the total scale of the county (total county size) does not have a significant impact on acreage response. Again, this likely reflects the fact that lagged acreage fully captures the scale effect.

CRP enrollment has a negative effect on the acreage of barley. In contrast, the coefficient of CRP acreage in the wheat equation is positive, though not statistically significant. We find some evidence of shifting among the alternative crops. Increases in wheat acreage are correlated with less barley acreage and vice versa. This effect is statistically significant only for the effect of wheat acreage in the barley equation. The results suggest that more barley acreage and insurance participation increase input usage, while the wheat insurance variable exhibited a significantly negative relationship with input usage. Increases in acres planted in wheat essentially had no effect on input usage, with a coefficient that was close to zero and not statistically significant. Likewise, the effect of insurance participation for barley on input usage is positive and significant, though quite small.

Input usage does not appear to be influenced by the suitability of land for pastures. Counties with more grass lands do not appear to have different uses of agricultural chemicals and fertilizer. Higher quality land tends to be associated with less input usage per planted acre. This is consistent with findings for corn and soybeans. Again, it is relevant to point out that our input usage applies to all crops and thus it is difficult to identify the effects associated with each individual crop.

[23] These results are available from the authors on request.

3.3 Heartland Corn and Soybeans (1997-98)

As we discussed above, the underlying structure of crop insurance programs underwent significant changes during the mid- and late-1990s. Most significant of these changes was the introduction of revenue insurance programs in 1997 and their expansion in subsequent years. These programs significantly altered the extent and nature of insurance participation, with an increasing proportion of total liability being accounted for by revenue insurance products (especially Crop Revenue Coverage—CRC). Other policy changes also had a dramatic effect on U.S. agriculture, especially those that occurred with the 1996 FAIR Act. To account for these fundamental changes, we estimated a separate model using 1997-98 data for Heartland corn and soybeans. The specification of insurance participation was amended to capture the gradual introduction of revenue insurance. In particular, the participation equations included a variable representing the proportion of total liability accounted for by revenue insurance.[24] Of course, this variable is jointly determined with other choice variables in the system and thus it is modeled endogenously as a function of the premium rate for revenue insurance and lagged insurance participation.

Parameter estimates and summary statistics are presented in Table 4. Again, preliminary specification tests confirmed the presence of heteroscedasticity and the endogeneity of several right hand side choice variables. As expected, the coefficients on the revenue liability variables are positive and highly significant. This confirms suspicions that expansions in revenue insurance offerings (and participation) had a significant influence on overall crop insurance demand. The revenue insurance equations do not exhibit strong responses to premiums, suggesting that revenue insurance is not especially sensitive to the premiums charged. While it is difficult to determine the extent to which shifting occurred from APH to revenue insurance, we can conclude that the availability of revenue insurance significantly increased the overall level of insurance participation in the Heartland region.

Again, a higher average loss ratio appears to significantly decrease the responsiveness of agents to premium changes. These findings are relatively consistent with those presented above for the earlier period. Fertilizer and chemical expenditures exhibit the expected negative effect for both crops. The ratio of livestock sales to total farm sales is again significantly positive in both the corn and soybean cases, suggesting that farms (counties) with greater relative sales from livestock

[24] We should note that we do not believe our dependence on cross-sectional variability limits our modeling of revenue insurance since such insurance was gradually introduced and adopted in limited geographic areas.

commodities are more likely to purchase insurance. This is again consistent with the findings for the earlier period. Counties with more productive land, as represented by the land capability class variable, appear to purchase less insurance.

Higher average loss ratios, which correspond to higher expected relative indemnity payments, exhibit a negative relationship with corn and soybean insurance demand, though the effect is small in both cases and is statistically significant only for soybeans. Results for the earlier period suggested a significantly positive relationship between average loss ratios and insurance demand. The coefficients on the CV of yields are positive, again suggesting that there may be risk reduction benefits to producers. Increases in acreage are correlated with more insurance purchases for each crop. Overall, the insurance participation equations would seem to suggest that premium decreases and corresponding loss ratio increases would not be expected to evoke significant participation responses. Several factors make insurance demand less elastic in the later period, including the wider array of revenue insurance products available, higher premium subsidies, and higher degree of overall participation.

In the earlier period, corn exhibited a statistically significant though small acreage response to increases in insurance participation rates. In the 1997-1998 Heartland equations, both corn and soybeans exhibit positive relationships with insurance participation, though the effect is statistically significant only for soybeans. The elasticities of acreage response with respect to insurance participation are 0.004 and 0.012 for corn and soybeans, respectively. This indicated a small reduction over the corn elasticity and a modest increase in the soybean elasticity relative to those found in the earlier period (.013 and .008, respectively). In both cases, the results indicate that the acreage response is of a very small magnitude. In total, our results indicate that increases in insurance participation will yield small increases in crop acreage.

In contrast to expectations though in accordance with the results for the earlier period, increases in the acreage of one crop tend to be correlated with increases in the acreage of the other crop though the magnitude of the effects is quite small. This may reflect the shifting away from relatively minor crops such as wheat that occurred following the FAIR Act.

Input usage again appears to decrease with insurance participation, perhaps again providing support for moral hazard arguments that maintain insuring farmers tend to use less inputs. The result is significant only for soybeans. The input usage equation again suggests that more corn

acres increases input usage while more soybean acres, other things constant, decreases input usage. These effects are expected since corn has much greater fertilizer requirements than soybeans.

Counties with land more suitable to pastures again tend to exhibit more input usage, a result that is consistent with the findings in the earlier period. Counties with more land suitable to grass tended to exhibit an insignificant impact on fertilizer and chemical expenditures. Lower quality land tends to exhibit less input usage per planted acre. This is again consistent with findings for the earlier period. Again, it is relevant to point out that our input usage applies to all crops and thus it is difficult to identify the effects associated with individual crops.

3.4 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 or 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. Thus, our simulations incorporate the increases in loss ratio that the decreases in premiums imply. Note again that the premium variable used in our analysis is the farmer-paid premium (net of the subsidy). 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]

Results of the policy simulations are presented in Table 5. The first policy simulation concerns a change in subsidies that results in a 50% decrease in corn insurance premiums, holding soybean insurance premiums fixed for the 1985-93 period. Corn participation (as measured by the ratio

[25] We randomly draw from a multivariate normal distribution defined by the original parameter estimates and the estimated covariance matrix.

of liability to maximum possible liability) increases by 37.08%. The effect is highly significant. A slight though statistically significant decrease is realized in soybean participation, which occurs as resources are allocated away from soybeans toward corn. Corn acreage responds to the significant decrease in premium subsidies with a modest though statistically significant increase of about 0.54%. Soybean acreage realizes a very small, statistically insignificant increase.

A second policy simulation considers the effects of a 50% decrease in soybean insurance premiums, leaving corn premiums constant. The results are analogous to what was realized for the change in corn premiums. Soybean participation increases substantially (34.7%) and corn participation realizes very small increase (3.27%). Changes in soybean acreage triggered by the premium decrease are very small (0.31%) though are statistically different from zero, suggesting a very modest effect of insurance participation on soybean acreage.

A third policy simulation considers the effects of across-the-board premium decreases of 50% for both corn and soybeans. Insurance participation again increases substantially for both crops. In particular, corn participation increases by 39.34% while corresponding increases in soybean participation are about 32.75%. Again, corn acreage reveals a modest increase of about 0.59% while soybean acreage shows a considerably smaller increase of 0.31%. In every case, the results are statistically significant, though the acreage responses are very modest.

An analogous simulation was conducted for the 1985-93 wheat and barley model estimates. A 50% decrease in wheat premium subsidies evokes a significant increase in wheat insurance participation as well as a modest decrease in barley insurance participation. The wheat response is highly significant though the barley response is not significantly different from zero. Perhaps most important and impressive is the wheat acreage response. The decrease in premiums evokes a substantial 2.92% increase in wheat acreage. A small though statistically significant decrease in barley acreage is realized as acreage shifts from barley to wheat.

An equivalent 50% decrease in barley premiums (with a corresponding increase in loss ratios), holding wheat premiums constant, evokes a 39.1% increase in barley insurance participation and a 8.1% decrease in wheat insurance participation. A 1.45% increase in barley acreage is realized as a result of the premium change. The responses are statistically significant in every case. Finally, we consider a simultaneous 50% decrease in both wheat and barley premiums. In this case, large increases in insurance participation (44-56%) are realized for the two crops. Wheat acreage increases

by 2.54% while barley acreage realizes a small increase of 0.8%. The wheat acreage response is statistically significant while the barley response is not.

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 50% premium decreases are also presented in Table 5.[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, premium subsidy increases raise corn acreage by 1.07%, while soybean acreage does not appear to be affected. Almost no acreage effect is realized in the later period for corn while the soybean model actually implied a decrease in acreage as a result of increased premium subsidies. In the case of wheat and barley, the increase in wheat acreage is larger in the early period while barley acreage actually decreases. In the latter period, the implied increase in wheat acreage is slightly larger, at 2.86%, than what is implied for the entire period. In short, the simulation results are largely robust to the period of study, with the largest increases in acreage being realized by wheat. However, in every case, the results suggest that any changes in acreage that occur as a result of insurance premium changes are modest, especially for corn and soybeans.

Finally, the premium change simulation was repeated for the more recent model of corn and soybeans. In light of the inelastic response of insurance demand to premiums and loss-ratios, we would not anticipate large effects from premium changes. Indeed, a 50% decrease in corn premiums (and corresponding increase in loss ratios) does not appear to significantly influence corn insurance participation. This reflects the very inelastic nature of corn insurance demand in recent years. 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

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

surprising.[27] In particular, the large positive expected returns to insurance (for example, $1.80 per dollar of premium paid) would imply that producers are not likely to be very responsive to premium changes. In addition, recent legislative changes undertaken as a result of the 2000 Agricultural Risk Protection Act (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 essentially no effect on corn insurance participation or corn acreage. In contrast, a very large 50% decrease in soybean premiums does tend to evoke a modest (13.5%) increase in participation and a very small increase of about 0.17% in soybean acreage. Similar results are obtained when both corn and soybean premiums are decreased by 50%. 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 case, large premium decreases trigger significant increases in participation but do not bring about large increases in planted acreage for corn and soybeans. In the most extreme case, a 50% decrease in premiums which is accompanied by an analogous doubling of expected loss-ratios brings about only an additional 1.1% 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 wheat. In particular, lowering wheat insurance

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

premiums by 50% significantly increases wheat insurance participation and brings about modest, though economically significant, increases in wheat acreage of about 2.5%. Thus, while it is difficult to extend our results beyond our time period and sample of counties, our results 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 indeed occurred and parameters underlying these effects are statistically significant, the responses are quite modest, though potentially economically significant.

4 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 multi-equation 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 (50%) reveal that the effects on acreage of such policy changes are very modest, even for wheat. In particular, in the most extreme case we consider, an across-the-board premium decrease of 50% for wheat only increased planted acreage by about 2.5%. Thus, our results would seem to support research opinions that suggest that increases in insurance participation bring about relatively small acreage responses.

Table 1. Variable Definitions and Summary Statistics

Variable	Definition	Mean	Std. Dev.
	Heartland Corn and Soybeans (1986-1993)		
Insurance Participation (corn)	liability / maximum possible liability	0.1992	0.1554
Input Usage	fertilizer and chemical expenditures (real $thousand) / planted acre	0.0497	0.0142
Land Capability	proportion of land in capability classes 1 and 2	0.2904	0.1429
Livestock Sales	livestock revenues / total farm sales	0.4526	0.1850
CV Yield (corn)	CV of historical corn yields	21.7186	8.2519
LR (corn)	historical mean loss ratio (corn)	1.8406	1.2196
Acres Planted (corn)	acres planted of corn (ten thousand)	7.3307	5.5150
Insurance Participation (soybeans)	liability / maximum possible liability	0.1683	0.1372
CV Yield (soybeans)	CV of historical soybean yields	16.4915	6.9401
LR (soybeans)	historical mean loss ratio (soybeans)	1.7542	1.0504
Acres Planted (soybeans)	acres planted of soybeans (ten thousand)	6.2910	4.3957
CRP Enrollment	proportion of land enrolled in CRP program	0.0165	0.0471
K-Factor	universal K-factor representing land erodibility	0.3389	0.0499
T-Factor	t-factor representing tolerance to soil loss	4.3286	0.4884
Adjusted Base (corn)	adjusted base for corn (ten thousand)	7.7055	5.0576
Rental Rate	real CRP rental rate / acre	56.8530	28.6196
Cost Share	real cost share payments for CRP / acre	38.5028	49.5498
Erosion Index	soil erosion index	5.3216	3.3556
Grass_{82}	proportion of county acres in grassland in 1982	0.0485	0.0389
Pasture_{82}	proportion of county acres in pasture in 1982	0.1487	0.1045
County Acres	total acres in the county	3.1781	1.1318
Premium (corn)	insurance premium rate (corn)	0.0474	0.0192
Premium (soybeans)	insurance premium rate (soybeans)	0.0509	0.0243
	Great Plains Wheat and Barley (1986-1993)		
Insurance Participation (wheat)	liability / maximum possible liability	0.4504	0.2444
Input Usage	fertilizer and chemical expenditures (real $thousand) / planted acre	0.0242	0.0166
Land Capability	proportion of land in capability classes 1 and 2	0.2592	0.1294
Livestock Sales	livestock revenues / total farm sales	0.5093	0.2542
CV Yield (wheat)	CV of historical wheat yields	27.3581	10.2465
LR (wheat)	historical mean loss ratio (wheat)	2.0337	1.2564
Acres Planted (wheat)	acres planted of wheat (ten thousand)	14.7960	10.7548
Insurance Participation (barley)	liability / maximum possible liability	0.3299	0.2767
CV Yield (barley)	CV of historical barley yields	29.4300	12.2127
LR (barley)	historical mean loss ratio (barley)	2.1462	1.4127

Table 1. (continued)

Variable	Definition	Mean	Std. Dev.
Acres Planted (barley)	acres planted of barley (ten thousand)	4.0228	4.3302
CRP Enrollment	proportion of land enrolled in CRP program	0.0550	0.1173
Total Harvested Acres	total planted acres (all crops) (ten thousand)	19.9140	14.7457
K-Factor	universal K-factor representing land erodibility	0.2885	0.0410
T-Factor	t-factor representing tolerance to soil loss	4.3493	0.5598
Rental Rate	real CRP rental rate / acre	27.0499	17.1063
Cost Share	real cost share payments for CRP / acre	121.1617	21.0245
Pasture_{82}	proportion of county acres in pasture in 1982	0.0477	0.0370
Premium (wheat)	insurance premium rate (wheat)	0.0684	0.0213
Premium (barley)	insurance premium rate (barley)	0.0892	0.0308
County Acres	total acres in the county	10.0245	5.9807
Adjusted Wheat Base	adjusted base acreage for wheat (ten thousand)	10.1246	8.0253
Adjusted Barley Base	adjusted base acreage for barley (ten thousand)	3.2537	3.6306
	Heartland Corn and Soybeans (1997-98)		
Insurance Participation (corn)	liability / maximum possible liability	0.3224	0.1375
Input Usage	fertilizer and chemical expenditures (real $thousand) / planted acre	0.0631	0.0142
Land Capability	proportion of land in capability classes 1 and 2	0.3065	0.1427
Livestock Sales	livestock revenues / total farm sales	0.3789	0.1822
CV Yield (corn)	CV of historical corn yields	20.3097	7.7919
LR (corn)	historical mean loss ratio (corn)	1.7133	1.0634
Acres Planted (corn)	acres planted of corn (ten thousand)	8.6031	5.8739
Insurance Participation (soybeans)	liability / maximum possible liability	0.2896	0.1367
CV Yield (soybeans)	CV of historical soybean yields	14.3260	6.6400
LR (soybeans)	historical mean loss ratio (soybeans)	1.1487	0.7613
Acres Planted (soybeans)	acres planted of soybeans (ten thousand)	8.3612	4.9136
K-Factor	universal K-factor representing land erodibility	0.3291	0.0479
T-Factor	t-factor representing tolerance to soil loss	4.3962	0.4865
Grass_{82}	proportion of county acres in grassland in 1982	0.0511	0.0407
Pasture_{82}	proportion of county acres in pasture in 1982	0.1405	0.1056
Premium (corn)	insurance premium rate (corn)	0.0657	0.0530
Premium (soybeans)	insurance premium rate (soybeans)	0.0371	0.0349
D97	dummy variable for 1997	0.4569	0.4984
County Acres	total acres in the county	3.3316	1.1367
Revenue Liability (corn)	revenue insurance liability / total liability	0.2612	0.1749
Revenue Liability (soybeans)	revenue insurance liability / total liability	0.2556	0.1733
Revenue Premium (corn)	(revenue premium - subsidy) / revenue liability	0.0600	0.0219
Revenue Premium (soybeans)	(revenue premium - subsidy) / revenue liability	0.0538	0.0232

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

Variable	Estimate	Standard Error	t-Ratio
Corn Insurance Participation			
Intercept	0.0628	0.0224	2.80*
Premium	−1.9539	0.1690	−11.56*
Premium*LR	0.1577	0.0639	2.47*
Fertilizer	−2.9581	0.3411	−8.67*
Land Capability	0.1717	0.0163	10.53*
Livestock Sales	0.1507	0.0116	13.02*
CV Yield	0.0042	0.0003	15.19*
LR	0.0257	0.0032	7.96*
Corn Acres	0.0062	0.0005	12.84*
County Acres	−0.0028	0.0019	−1.49
D86	0.0268	0.0056	4.76*
D87	0.0427	0.0063	6.81*
D88	0.0109	0.0062	1.76*
D89	0.0829	0.0077	10.71*
D90	0.1024	0.0067	15.22*
D91	0.0816	0.0063	12.98*
D92	0.0975	0.0064	15.27*
D93	0.1149	0.0073	15.68*
Soybean Insurance Participation			
Intercept	0.0547	0.0237	2.31*
Premium	−1.7986	0.1216	−14.79*
Premium*LR	0.2635	0.0662	3.98*
Fertilizer	−1.6103	0.3485	−4.62*
Land Capability	0.1087	0.0151	7.22*
Livestock Sales	0.2029	0.0107	19.03*
CV Yield	0.0016	0.0003	6.02*
LR	0.0099	0.0037	2.67*
Soybean Acres	0.0070	0.0006	10.83*
County Acres	0.0062	0.0018	3.45*
D86	−0.0085	0.0052	−1.62
D87	−0.0062	0.0061	−1.01
D88	−0.0357	0.0058	−6.21*
D89	0.0581	0.0071	8.17*
D90	0.0571	0.0065	8.73*
D91	0.0304	0.0058	5.22*
D92	0.0529	0.0064	8.29*
D93	0.0532	0.0070	7.56*
Corn Acreage Response			
Intercept	−0.5424	0.1779	−3.05*
Corn Acres$_{t-1}$	0.9442	0.0049	191.57*
Soybeans Acres	0.0411	0.0042	9.79*
Participation Corn	0.4622	0.1120	4.13*
CRP Enrollment	−2.0402	0.7071	−2.89*
K-Factor	0.5325	0.2669	2.00*
T-Factor	0.1467	0.0263	5.57*
Adjusted Corn Base	0.0038	0.0028	1.38
County Acres	0.0356	0.0131	2.72*
D86	−0.9232	0.0351	−26.29*
D87	−1.2467	0.0605	−20.62*
D88	0.0178	0.0336	0.53
D89	0.1108	0.0402	2.76*
D90	−0.2139	0.0327	−6.55*
D91	−0.1927	0.0338	−5.71*
D92	−0.0307	0.0320	−0.96
D93	−0.9883	0.0319	−31.00*

[a] Numbers in parentheses are standard errors. An asterisk indicates statistical significance at the $\alpha = .10$ or smaller level.

Table 2. (continued)

Variable	Estimate	Standard Error	t-Ratio
Soybean Acreage Response			
Intercept	−0.3461	0.1379	−2.51*
Soybean Acres$_{t-1}$	0.9597	0.0031	309.92*
Corn Acres	0.0372	0.0040	9.21*
Participation Soybeans	0.2899	0.1488	1.95*
CRP Enrollment	−5.9344	0.5439	−10.91*
K-Factor	0.7101	0.2108	3.37*
T-Factor	−0.0140	0.0226	−0.62
Adjusted Corn Base	−0.0105	0.0034	−3.14*
County Acres	−0.0068	0.0092	−0.74
D86	0.1983	0.0296	6.70*
D87	0.4467	0.0522	8.56*
D88	0.1890	0.0353	5.36*
D89	0.5223	0.0286	18.24*
D90	0.0169	0.0314	0.54
D91	0.4973	0.0343	14.51*
D92	0.1930	0.0300	6.43*
D93	0.4011	0.0320	12.53*
CRP Enrollment			
Intercept	0.0010	0.0010	0.94
Rental Rate	0.0000	0.0000	2.10*
Cost Share	0.0000	0.0000	−3.81*
Erosion Index	0.0030	0.0002	19.28*
County Acres	−0.0003	0.0003	−0.95
D86	0.0296	0.0033	9.00*
D87	0.0026	0.0017	1.52
D88	−0.0019	0.0013	−1.42
D89	−0.0083	0.0012	−7.05*
D90	−0.0135	0.0011	−12.60*
D91	−0.0104	0.0012	−8.92*
D92	−0.0081	0.0012	−6.63*
D93	−0.0096	0.0013	−7.58*
Input Usage			
Intercept	0.0603	0.0007	86.19*
Participation Corn	0.0295	0.0037	7.99*
Participation Soybeans	−0.0344	0.0049	−7.00*
Corn Acres	0.0007	0.0001	11.12*
Soybean Acres	−0.0015	0.0001	−18.98*
Grass$_{82}$	0.0146	0.0061	2.41*
Pasture$_{82}$	0.0031	0.0026	1.19
Land Capability	−0.0214	0.0013	−16.53*
D86	−0.0009	0.0005	−1.62
D87	0.0004	0.0006	0.70
D88	−0.0063	0.0006	−10.26*
D89	−0.0088	0.0006	−13.69*
D90	−0.0051	0.0006	−8.09*
D91	−0.0001	0.0006	−0.07
D92	0.0051	0.0007	7.64*
D93	0.0071	0.0007	9.66*
System Degrees of Freedom	36,753		
System R^2	0.96		
Hausman Test: OLS vs. 2SLS	333.7*	Hausman Test: 2SLS vs. 3SLS	2821.0*
White's Test: Corn Insurance	2505.0*	White's Test: Soybean Insurance	1390.0*
White's Test: Corn Acreage	1686.0*	White's Test: Soybean Acreage	1461.0*
White's Test: CRP	605.5*	White's Test: Input Usage	487.9*

[a] Numbers in parentheses are standard errors. An asterisk indicates statistical significance at the $\alpha = .10$ or smaller level.

Table 3. GMM Estimates of Wheat/Barley Model

Variable	Estimate	Standard Error	t-Ratio
Wheat Insurance Participation			
Intercept	0.7209	0.0468	15.39*
Premium	−3.1012	0.3494	−8.88*
Premium*LR	0.9614	0.1770	5.43*
Fertilizer	−9.7990	0.6660	−14.71*
Land Capability	−0.0258	0.0428	−0.60
Livestock Sales	−0.1431	0.0244	−5.87*
CV Yield	−0.0015	0.0007	−2.33*
LR	0.0379	0.0127	2.98*
Wheat Acres	0.0031	0.0007	4.61*
County Acres	0.0050	0.0008	5.99*
D86	0.0114	0.0169	0.67
D87	−0.0685	0.0201	−3.41*
D88	0.0104	0.0213	0.49
D89	−0.0951	0.0197	−4.83*
D90	0.0556	0.0204	2.73*
D91	0.0897	0.0218	4.12*
D92	−0.1002	0.0202	−4.96*
D93	−0.0306	0.0212	−1.44
Barley Insurance Participation			
Intercept	−0.0475	0.0594	−0.80
Premium	0.4859	0.3304	1.47
Premium*LR	−0.1478	0.1721	−0.86
Fertilizer	0.8930	1.1569	0.77
Land Capability	0.1618	0.0536	3.02*
Livestock Sales	−0.3068	0.0342	−8.96*
CV Yield	0.0053	0.0007	7.19*
LR	0.0858	0.0153	5.61*
Barley Acres	0.0098	0.0017	5.60*
County Acres	0.0040	0.0011	3.55*
D86	0.0022	0.0186	0.12
D87	−0.0196	0.0195	−1.01
D88	−0.0249	0.0181	−1.38
D89	0.0133	0.0203	0.66
D90	0.0532	0.0224	2.38*
D91	0.1680	0.0245	6.86*
D92	0.0163	0.0216	0.75
D93	−0.0628	0.0214	−2.93*
Wheat Acreage Response			
Intercept	−0.3678	0.6704	−0.55
Wheat Acres$_{t-1}$	1.1056	0.0391	28.29*
Barley Acres	−0.1050	0.0877	−1.20
Participation Wheat	1.4807	0.3668	4.04*
CRP Enrollment	2.7382	2.3160	1.18
K-Factor	−1.6257	1.2543	−1.30
T-Factor	0.2236	0.1170	1.91*
Adjusted Wheat Base	−0.1893	0.0533	−3.55*
Adjusted Barley Base	0.2549	0.0931	2.74*
County Acres	−0.0050	0.0091	−0.55
D86	−1.4372	0.1882	−7.64*
D87	−2.4259	0.2939	−8.26*
D88	−1.8097	0.4941	−3.66*
D89	1.7016	0.2634	6.46*
D90	−0.4865	0.2261	−2.15*
D91	−2.7327	0.2273	−12.02*
D92	1.6667	0.2201	7.57*
D93	−0.0854	0.2935	−0.29

[a] Numbers in parentheses are standard errors. An asterisk indicates statistical significance at the $\alpha = .10$ or smaller level.

Table 3. (continued)

Variable	Estimate	Standard Error	t-Ratio
Barley Acreage Response			
Intercept	2.2499	0.2763	8.14*
Barley Acres$_{t-1}$	1.0094	0.0442	22.82*
Wheat Acres	−0.0520	0.0122	−4.28*
Participation Barley	0.3394	0.1507	2.25*
CRP Enrollment	−5.0493	1.0367	−4.87*
K-Factor	−2.6350	0.5846	−4.51*
T-Factor	−0.1009	0.0478	−2.11*
Adjusted Wheat Base	0.0785	0.0133	5.88*
Adjusted Barley Base	−0.0763	0.0551	−1.38
County Acres	0.0029	0.0044	0.65
D86	−0.4913	0.0893	−5.50*
D87	−0.9641	0.1517	−6.35*
D88	−0.4287	0.2237	−1.92*
D89	−0.7339	0.1280	−5.73*
D90	−1.2193	0.1118	−10.90*
D91	−0.9900	0.1185	−8.35*
D92	−1.5129	0.0965	−15.68*
D93	−1.1616	0.0971	−11.96*
CRP Enrollment			
Intercept	−0.0204	0.0035	−5.77*
Rental Rate	−0.0002	0.0001	−1.45
Cost Share	0.0001	0.0001	1.88*
Erosion Index	−0.0045	0.0013	−3.50*
County Acres	0.0020	0.0004	5.71*
D86	0.1074	0.0104	10.30*
D87	0.1851	0.0154	11.99*
D88	0.0874	0.0100	8.77*
D89	0.0872	0.0088	9.89*
D90	0.0216	0.0056	3.87*
D91	0.0245	0.0056	4.35*
D92	0.0259	0.0056	4.62*
D93	0.0262	0.0059	4.47*
Input Usage			
Intercept	0.0296	0.0016	18.38*
Participation Wheat	−0.0376	0.0060	−6.23*
Participation Barley	0.0132	0.0053	2.51*
Wheat Acres	0.0000	0.0001	−0.63
Barley Acres	0.0010	0.0001	9.15*
Grass$_{82}$	−0.0074	0.0089	−0.83
Pasture$_{82}$	0.0120	0.0096	1.25
Land Capability	−0.0064	0.0029	−2.24*
D86	−0.0003	0.0010	−0.28
D87	0.0011	0.0013	0.82
D88	0.0096	0.0014	6.80*
D89	0.0004	0.0011	0.40
D90	0.0062	0.0014	4.57*
D91	0.0061	0.0015	4.02*
D92	0.0011	0.0016	0.71
D93	0.0045	0.0015	2.93*
System Degrees of Freedom	6,679		
System R^2	0.90		
Hausman Test: OLS vs. 2SLS	165.2*	Hausman Test: 2SLS vs. 3SLS	0.0
White's Test: Wheat Insurance	908.6*	White's Test: Barley Insurance	475.6*
White's Test: Wheat Acreage	676.4*	White's Test: Barley Acreage	1016.0*
White's Test: CRP	132.1*	White's Test: Input Usage	155.4*

[a] Numbers in parentheses are standard errors. An asterisk indicates statistical significance at the $\alpha = .10$ or smaller level.

Table 4. GMM Estimates of 1997-98 Corn/Soybean Model

Variable	Estimate	Standard Error	t-Ratio
Corn Insurance Participation			
Intercept	0.3576	0.0366	9.78*
Revenue Liability	0.2748	0.0218	12.60*
Premium	0.6605	0.2928	2.26*
Premium*LR	0.5329	0.1156	4.61*
Fertilizer	−4.0985	0.4247	−9.65*
Land Capability	−0.0741	0.0203	−3.65*
Livestock Sales	0.0574	0.0134	4.29*
CV Yield	0.0043	0.0004	9.74*
LR	−0.0054	0.0038	−1.41
Corn Acres	0.0117	0.0006	19.63*
County Acres	−0.0222	0.0026	−8.38*
D97	−0.0269	0.0045	−6.00*
Soybean Insurance Participation			
Intercept	0.3512	0.0342	10.28*
Revenue Liability	0.4760	0.0182	26.12*
Premium	−2.3104	0.2611	−8.85*
Premium*LR	0.8946	0.1528	5.86*
Fertilizer	−3.4596	0.4159	−8.32*
Land Capability	−0.0688	0.0191	−3.61*
Livestock Sales	0.0370	0.0138	2.68*
CV Yield	0.0050	0.0005	9.86*
LR	−0.0116	0.0058	−2.00*
Soybean Acres	0.0056	0.0007	8.48*
County Acres	−0.0050	0.0025	−1.98*
D97	−0.0223	0.0044	−5.13*
Corn Acreage Response			
Intercept	−0.7575	0.3719	−2.04*
Corn Acres$_{t-1}$	0.9092	0.0083	110.06*
Soybean Acres	0.0810	0.0087	9.28*
Participation Corn	0.1183	0.1627	0.73
K-Factor	0.4760	0.5090	0.94
T-Factor	0.1376	0.0526	2.62*
County Acres	0.0015	0.0226	0.07
D97	0.1122	0.0406	2.76*
Soybean Acreage Response			
Intercept	−0.6987	0.3529	−1.98*
Soybean Acres$_{t-1}$	0.9170	0.0069	132.27*
Corn Acres	0.0498	0.0066	7.58*
Participation Soybeans	0.3374	0.1650	2.04*
K-Factor	−0.1261	0.4829	−0.26
T-Factor	0.0921	0.0538	1.71*
County Acres	0.2073	0.0249	8.33*
D97	0.2131	0.0401	5.31*
Corn Revenue Insurance Participation			
Intercept	0.2338	0.0138	16.94*
Insurance Participation $_{t-1}$	0.3981	0.0292	13.63*
Revenue Premium	0.0060	0.0065	0.93
D97	−1.6697	0.1209	−13.81*
Soybean Revenue Insurance Participation			
Intercept	0.1547	0.0123	12.58*
Insurance Participation $_{t-1}$	0.5838	0.0262	22.30*
Revenue Premium	−0.0074	0.0061	−1.21
D97	−1.1914	0.1182	−10.08*

[a] Numbers in parentheses are standard errors. An asterisk indicates statistical significance at the $\alpha = .10$ or smaller level.

Table 4. (continued)

Variable	Estimate	Standard Error	t-Ratio
Input Usage			
Intercept	0.0796	0.0013	62.45*
Participation Corn	−0.0020	0.0080	−0.25
Participation Soybeans	−0.0333	0.0080	−4.15*
Corn Acres	0.0012	0.0001	9.46*
Soybean Acres	−0.0013	0.0001	−9.49*
Grass_{82}	0.0002	0.0081	0.03
Pasture_{82}	0.0232	0.0044	5.28*
Land Capability	−0.0239	0.0024	−10.09*
D97	−0.0022	0.0005	−4.22*
System Degrees of Freedom	7,573		
System R^2	0.96		
Hausman Test: OLS vs. 2SLS	250.4*	Hausman Test: 2SLS vs. 3SLS	13247.0*
White's Test: Corn Insurance	530.9*	White's Test: Soybeans Insurance	644.6*
White's Test: Corn Rev. Ins.	100.2*	White's Test: Soybeans Rev. Ins.	49.6*
White's Test: Corn Acreage	236.9*	White's Test: Soybeans Acreage	138.9*
White's Test: Input Usage	238.4*		

[a] Numbers in parentheses are standard errors. An asterisk indicates statistical significance at the $\alpha = .10$ or smaller level.

Table 5. Premium Rate Change Simulation Results

Corn and Soybeans (1985-93)

Premium Change	Percent Change in: Corn Insurance	Soybeans Insurance	Corn Acreage	Soybeans Acreage
-50% Corn, 0% Soybeans	37.0757	−2.7388	0.5403	0.0034
	(1.5172)*	(0.7387)*	(0.1340)*	(0.0144)
0% Corn, -50% Soybeans	3.2677	34.6765	0.0510	0.3094
	(0.6545)*	(2.3094)*	(0.0144)*	(0.1619)*
-50% Corn, -50% Soybeans	39.3425	32.7480	0.5910	0.3128
	(1.5536)*	(2.2094)*	(0.1436)*	(0.1508)*
-50% Corn, -50% Soybeans	43.9238	38.6836	1.0738	0.1240
(1985-1989)	(1.8992)*	(3.1149)*	(0.2160)*	(0.1802)
-50% Corn, -50% Soybeans	28.1386	22.9615	−0.0214	−0.9942
(1990-1993)	(2.8887)*	(3.0652)*	(0.1361)	(0.2783)*

Wheat and Barley (1985-93)

Premium Change	Percent Change in: Wheat Insurance	Barley Insurance	Wheat Acreage	Barley Acreage
-50% Wheat, 0% Barley	49.8450	−3.0191	2.9232	−0.6493
	(6.0289)*	(4.0483)	(0.8129)*	(0.2781)*
0% Wheat, -50% Barley	−8.0919	39.1332	−0.3976	1.4501
	(4.5513)*	(5.0871)*	(0.2120)*	(0.6387)*
-50% Wheat, -50% Barley	45.0078	37.1018	2.5371	0.8102
	(4.8434)*	(6.2884)*	(0.6994)*	(0.5878)
-50% Wheat, -50% Barley	44.3208	56.2207	2.2153	−2.0547
(1985-1989)	(3.7781)*	(6.1370)*	(0.7505)*	(0.8423)*
-50% Wheat, -50% Barley	39.5881	21.9625	2.8557	1.1187
(1990-1993)	(7.4301)*	(11.3892)*	(1.2610)*	(1.8389)

Corn and Soybeans (1997-98)

Premium Change	Percent Change in: Corn Insurance	Soybean Insurance	Corn Acreage	Soybean Acreage
-50% Corn, 0% Soybeans	−2.4082	−0.0195	−0.0105	−0.0008
	(1.9039)	(0.1123)	(0.0198)	(0.0018)
0% Corn, -50% Soybeans	1.7859	13.4792	0.0210	0.1671
	(0.5594)*	(2.1686)*	(0.0133)	(0.0844)*
-50% Corn, -50% Soybeans	−0.5791	13.4621	0.0105	0.1663
	(1.9817)	(2.1892)*	(0.0166)	(0.0844)*

[a] Numbers in parentheses are standard errors. An asterisk indicates statistical significance at the $\alpha = .10$ or smaller level.

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