POTENTIAL EFFECTS OF CROP INSURANCE ON FARM ECONOMIC STRUCTURE

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Abstract

The objective of this paper is to examine the potential impacts of crop insurance on farm economic structure using Nebraska county level data from 1980-1998. Using a profit function we fit input demand and output supply equations accounting for insurance premiums and indemnities to examine the economic impacts of crop insurance.

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SALEEM SHAIK AND JOSEPH ATWOOD

Crop insurance, one of U. S. Department of Agriculture's primary policy instrument in protecting farmers against risk has been the subject of substantial research. The Federal Crop Insurance Corporation through the Risk Management Agency offers several crop insurance policies (Multli-Peril Crop Insurance, Crop Revenue Coverage, Revenue Assurance, Income Protection and Group Risk Protection) relying on private companies for product delivery, service, and loss adjustment. With the Freedom to Farm act of 1996, crop insurance has become much more important as a farm policy instrument and replacing others as the principal means of managing risk. While the causes of the switch to crop insurance are still controversial, as are the predicted outcomes, there is strong interest in the potential economic effects on resource use and production mix leading to important policy implications.

Several aspects of crop insurance has been examined related to moral hazard (Chambers, 1989; Just and Calvin, 1993; Coble et al, 1997), adverse selection (Atwood and Shaik, 1999; Just and Calvin, 1995; Skees and Reed, 1986; Quiggin et al, 1994), demand for crop insurance (Coble et al, 1996), rating methodologies (Olivier Mahul, 1999; Goodwin and Ker, 1998; Skees, Black and Barnett, 1997; Goodwin, 1993) and the effects of insurance availability upon resource allocation (Horowitz and Lichtenberg, 1993; Atwood et al, 1996; Smith and Goodwin, 1996). Current research had addressed crop-specific effects of insurance programs on farm

economic structure, including adverse selection, moral hazard, demand for insurance, rating methodologies, and the potential environmental effects. This line of research is valid due to the current setting of insurance programs that is crop specific. In general, the effects of crop insurance effects encompass a simultaneous impact on the farm economic structure -resource use and output production mix rather then in isolation to individual crops. The effects on farm economic structure encompass the following question--would the premiums and indemnities influence the producer decision to alter factor use patterns and output production mix. A producer or firm's objective is to maximize profits without crop insurance can be represented as $\pi = pY - wX$. With crop insurance the profit can be represented as $\pi = pY + I(Y) - wX - \zeta(Y)$, where $I(Y)$ and $\zeta(Y)$ represents the indemnities received and premiums paid respectively. For this analysis Nebraska was specifically chosen due to the availability of output, input and crop insurance data for corn, soybean and wheat data which together accounts for 77% of the insured acres in the state of Nebraska for the year 1999.

Specifically we examine the influence of crop insurance premium and indemnity received on the use of capital, labor, chemicals and other inputs leading to potential changes in the production mix between insured crops, non-insured crops and livestock. An earlier state-level analysis seems to poorly identify the implications of crop insurance on the farm economic structure due to the use of aggregate data and short time series. In this paper we attempt to examine the potential economic effects of crop insurance premiums and indemnities received on resource use and output production mix using Nebraska county level data from 1980-1999.

The paper is organized into the following sections. In the next section, the theoretical and the econometric model based on the profit function along with system

of input (includes capital, farm labor, capital, chemicals and other input) and output [included are corn, wheat, soybean, other crops and livestock) equations are presented. The construction of the output, input, crop insurance policy premiums and policy indemnities index for Nebraska agriculture counties for the time period 1980-1997 are detailed in the third section. The results are presented in the fourth section illustrating the potential impacts of crop insurance on farm economic structure. Finally, a section including the summary and conclusion are presented.

THEORETICAL OVERVIEW

In aggregate sectoral analysis one observes non-allocable input quantity $\underline{X} = (x_1, x_2, ..., x_i) \in \Re_+^I$ and price $\underline{w} = (w_1, w_2, ..., w_i) \in \Re_+^I$ vector to be used in the production of output quantity $\underline{Y} = (y_1, y_2, ..., y_j) \in \Re_+^J$ and price $\underline{p} = (p_1, p_2, ..., p_j) \in \Re_+^J$. A producer or firm's (in our case, Nebraska agriculture sector) objective is to maximize profits with input quantity ($\underline{X}$) and price ($\underline{w}$) vector capable of producing output quantity ($\underline{Y}$) and the price ($\underline{p}$) vector. So profit in the absence of crop insurance can be represented as $\pi = pY - wX$. With aggregate county data[1], profit can be represented as $\pi = pY + I(Y) - wX - \zeta(Y)$, where $I(Y)$ and $\zeta(Y)$ represents the indemnities received and premiums paid respectively. Since the insurance is yield-acreage driven policy, the premiums, subsidies, and indemnities revolve around the actual[2] or expected yield and net insured acres for the producer. To this effect, the first step involves adjusting the county-level aggregated

crop insurance premiums and indemnities received in the individual crop's revenue. In the second step a premium (zero if crop insurance premium was not purchased and one other wise) and indemnity dummy (one if received an indemnity payment and zero other wise) generated are used in the system of input demand and output supply.

Due to the separable assumption, it is possible to examine the aggregate effects of crop insurance on factor use patterns and output production mix independently. Utilizing Shephard's lemma, the cost minimizing derived input demands including crop insurance policy premiums examines the potential effects of crop insurance on the factor use patterns. Similarly utilizing Shephard's, the revenue[3] maximizing output supply including policy indemnities examines the effects of crop insurance on output production mix. The cost function $C(w, Y)$ and the revenue function $R(p, X)$ satisfying the properties as defined in Chambers (1988) under non-Hicks neutral technical change are postulated. Alternatively the system of input and output equations can be represented by a Translog profit function as

$$
\begin{aligned}
\pi(p, w) = \alpha_0 &+ \sum_{j=1}^{J} \beta_j \ln p_j + \sum_{j=1}^{J} \sum_{k=1}^{J} \beta_{j,k} \ln p_j \ln p_k \\
&+ \sum_{i=1}^{I} \beta_i \ln w_i + \sum_{i=1}^{I} \sum_{h=1}^{I} \beta_{i,h} \ln w_i \ln w_h \\
&+ \sum_{i=1}^{I} \sum_{h=1}^{I} \gamma_{j,i} \ln p_j \ln w_i + \varepsilon
\end{aligned}
$$

(1)

The required cost and revenue shares for estimating the system of input demand and output supply equations can be derived using net profit (NP)

$= \text{Revenue} - \text{Cost} \equiv p_j y_j - w_i x_i$.

$$
\begin{aligned}
RS_j &= \frac{\partial \ln NP}{\partial \ln y_j} = \frac{\partial NP}{\partial y_j} * \frac{y_j}{NP} \equiv \frac{p_j y_j}{NP} = RS_j \; (\text{always positive}) \\
CS_i &= \frac{\partial \ln NP}{\partial \ln w_i} = \frac{\partial NP}{\partial w_i} * \frac{w_i}{NP} \equiv \frac{w_i x_i}{NP} = CS_i \; (\text{always negative})
\end{aligned}
$$

(2)

where CS =cost shares, RS =revenue shares, w_i =input prices, p_i =input prices, x_i =input quantity and y_j =output quantity. Due to the use of net profit, the revenue shares should be positive and the cost shares should be negative with the sum of revenue and cost shares equal to one. The logarithmic first order conditions of the profit function provides the system of input demand and output supply equations for Hicks neutral technology and represented as:

$$
RS_j = \frac{\partial \ln NP}{\partial \ln y_j} = \frac{\partial NP}{\partial y_j} * \frac{y_j}{NP} \equiv \frac{p_j y_j}{NP} = RS_j \quad \text{(always positive)}
$$

(3)
$$
= \alpha_i + \sum_{j=1}^{5} \beta_{j,y} \ln p_j + \sum_{m=1}^{3} \gamma_m \, DP + \sum_{m=1}^{3} \gamma_m \, DI + \varepsilon
$$

$$
CS_i = \frac{\partial \ln NP}{\partial \ln w_i} = \frac{\partial NP}{\partial w_i} * \frac{w_i}{NP} \equiv \frac{w_i x_i}{NP} = CS_i \quad \text{(always negative)}
$$

$$
= \alpha_i + \sum_{i=1}^{4} \beta_{i,y} \ln w_i + \sum_{m=1}^{3} \gamma_m \, DP + \sum_{m=1}^{3} \gamma_m \, DI + \varepsilon
$$

where the DP is the individual crop specific dummies for premiums and DI is the individual crop-specific dummies for indemnities and the remain variables are defined in equation (2). Symmetry and linear homogeneity in input (output) prices are imposed in the cost (revenue) share equations respectively. The homogeneity condition requires

(4)
$$
\sum_{j=1}^{J} \beta_j + \sum_{i=1}^{I} \beta_i = 1
$$
$$
\sum_{j=1}^{J} \sum_{k=1}^{J} \beta_{j,k} + \sum_{i=1}^{I} \sum_{h=1}^{I} \beta_{i,h} = 0
$$

and the symmetry

(5)
$$
\sum_{j=1}^{J} \sum_{k=1}^{J} \beta_{j,k} = \sum_{j=1}^{J} \sum_{k=1}^{J} \beta_{k,j}
$$
$$
\sum_{i=1}^{I} \sum_{h=1}^{I} \beta_{i,h} = \sum_{i=1}^{I} \sum_{h=1}^{I} \beta_{h,i}
$$

NEBRASKA COUNTY LEVEL INPUT, OUTPUT AND CROP INSURANCE DATA

Nebraska agriculture input, output and crop insurance data for the period 1980-98 was constructed from the various sources. The output data are constructed utilizing three different sources – National Agricultural Statistical Service (NASS) county level yield and acreage, state level price data; Census of Agriculture data (for the following years, 1982, 1987, 1992 and 1997); and the Regional Economics Information System, database, 1969-98 published by Bureau of Economic Analysis (BEA). The cash receipts shares of the three insured crops – corn, wheat and soybean are obtained from the Census data and time series shares are generated using linear interpolation. These shares are then applied to the county level crop cash receipts data to obtain the insured crop cash receipts. Dividing the cash receipts with county level yields should provide the crop specific implicit price index.

The input data on capital, hired farm labor, chemicals and other inputs are obtained from the Regional Economics Information System, database, 1969-98 published by Bureau of Economic Analysis (BEA). State level quantity index is used in the construction of an implicit price index for each of the inputs at the county level. The construction of the price and quantity indexes was borrowed from Shaik (1998) for the relevant year, 1980-1998. However for this paper we use data from 1980-1997. The five output price indexes are corn, wheat, soybean, other crops and livestock. Similarly four implicit input price indexes are also constructed for capital (land and capital), labor, chemicals and other inputs. Aggregate crop insurance premium and indemnity are adjusted in the individual crop's revenue for the insured crops – corn, wheat and soybean.

The Risk Management Agency (RMA) complies data on the quantity (number of) and cost of crop insurance policy premiums and indemnities paid based on the insurance type and coverage for each crop, aggregate at the county level for the time period 1980-1997. Utilizing these county data, the state data is computed for each of the three major crops grown in Nebraska that constitutes 77 percent of the total crop insurance policies issued in 1999. A crop insurance premium quantity index is constructed by share weighted average of the number of policy premiums across the three crops. Similarly a crop insurance indemnity quantity index is constructed by share weighted average of the number of policy indemnities across the three crops. Finally the aggregate output and input quantity indexes are used to adjusted the crop insurance indemnities and premiums respectively.

EMPIRICAL APPLICATION AND RESULTS

To examine the potential effects of crop insurance on farm economic structure the system of input demand and output supply equations defined in equation (3) with the homogeneity conditions are estimated using Nebraska county level data for the time period 1980-1997. The nonlinear estimates of the Translog function imposing homogeneity and symmetry in system of outputs supply and input demand equations independently are presented in Table 1.

Under the null hypothesis, with degrees of freedom equal to number of restrictions, Hick neutral technical change is tested using the likelihood ratio test statistic[4]. The null hypothesis is examined by estimating system of input demand and

output supply equations for an unrestricted and restricted model. With the likelihood ratio test we are unable to reject the Hicks neutral technical change at a 5% level of significance. The necessary and sufficient conditions for monotonicity are violated given that the cost and revenue shares should be equal to one.

The estimates from the system of input demand and output supply equations presented in Table 1 indicate the crop specific dummies for premiums and indemnities did not have a statistically significant effect on the factor use or output production mix for the time period 1980-1997. Further the premium dummies had a negative effect while the indemnities had a positive effect on the input and output share equations. These results indicate with increased participation or purchase of crop insurance premiums, will have a negative but insignificant impact on capital, labor, chemicals and other inputs. This negative sign on the chemical input indicates, with increased crop insurance less of chemicals will be applied implying the existence of moral hazard.

Overall the empirical county level analysis of Nebraska agriculture sector aggregate data from 1980-1997 indicate potential impacts of crop insurance on the farm economic structure but not significant. This is based on the estimation of input demand and the output supply functions accounting for premiums and indemnities. A more through investigation of estimating individually insured crop's acreage and premiums purchased would provide clear and robust impacts due to crop insurance on factor use. Further simultaneous estimation of system of input demand and output supply equations along with the profit function would provide the detailed impact analysis of the potential impacts of crop insurance premium on the factor use as well as shifts in the crop production mix.

CONCLUSIONS

This paper examines the potential impacts of crop insurance on county level Nebraska agriculture sector based on the system of input demand and the system of output supply equations using a profit function for the time period 1980-1997. The likelihood ratio tests fail to reject the hypothesis of Hick-neutral technical change in both inputs and outputs for the same time period. So under Hicks-neutral technical change, the overall impacts of crop insurance on agriculture sector based on the system of input demand and output supply equation even though indicate correct signs on the coefficient estimates, are not statistically significant.

Further research needs to be explored based on longer time series and disaggregate input data to isolate the crop wise impacts of crop insurance on the farm economic structure.

TABLE 1. PARAMETER ESTIMATES FOR A TRANSLOG PROFIT FUNCTION FOR NEBRASKA COUNTY LEVEL AGRICULTURE SECTOR, 1980-98

Coefficients of Explanatory Variables	SHARES OF THE INPUT AND OUTPUT VARIABLES OF THE PROFIT FUNCTION							
	CORN	WHEAT	SOYBEAN	OTHER CROPS	LIVESTOCK	CAPITAL	LABOR	CHEMICALS
INTERCEPT	**7.819**	**1.4195**	**1.5417**	**24.61**	**25.441**	**30.749**	**2.4985**	**4.4822**
CPRN	-0.00108							
WHEAT	-0.0004	**0.0096**						
SOYBEAN	**-0.001**	-0.005	**0.0102**					
OTHER CROPS	-0.00346	0.00155	-0.003	**0.036**				
LIVESTOCK	-0.00227	**0.0038**	-0.003	-0.007	**0.0217**			
CAPITAL	**0.008**	-0.003	**0.0027**	**0.013**	8.8E-05	**0.0159**		
LABOR	0.00039	-0.00093	**-9E-04**	-0.00016	7.4E-05	**0.0011**	**0.0086**	
CHEMICALS	**0.0022**	**-0.004**	-0.0005	**-0.003**	-0.00137	**0.0033**	**-0.006**	**0.0125**
CORN_PREM_D	-0.00453	-0.00453	-0.00453	-0.00453	-0.00453	-0.00453	-0.00453	-0.00453
CORN_INDEM_D	0.15706	0.15706	0.15706	0.15706	0.15706	0.15706	0.15706	0.15706
SOYBEAN_PREM_d	-0.03064	-0.03064	-0.03064	-0.03064	-0.03064	-0.03064	-0.03064	-0.03064
SOYBEAN_INDEM_d	0.38317	0.38317	0.38317	0.38317	0.38317	0.38317	0.38317	0.38317
WHEAT_PREM_D	-0.27402	-0.27402	-0.27402	-0.27402	-0.27402	-0.27402	-0.27402	-0.27402
WHEAT_INDEM_D	0.10564	0.10564	0.10564	0.10564	0.10564	0.10564	0.10564	0.10564

Coefficient estimates in bold are statistically significant at 5 % level of significance

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FOOTNOTES

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[1]   The crop wise analysis is consequential and renders pertinent information, however the difficulty associated with this type of analysis is two-fold. First, the unavailability of crop wise allocable input quantity and price data, second is the lack of sufficient time series. More over at the producer level, the analysis would be binding due to the truncation of the indemnities received (i.e., positive (zero) if the producer takes (does not take) a hit) and premiums paid (participation rates, i.e., positive (zero) if the producer buys (does not buy) insurance). Further given the availability of crop insurance premiums, indemnities and subsidies at the aggregate level, which suits our needs to examine the aggregate effects of crop insurance.

[2]   Even with producer level since we do not known a priori the producers expected yield at the time of purchasing insurance. So a proxy for the producers expected yield is the 4-10 year moving average of the producers yield given the availability of up to 10 years data. A similar approach is followed with aggregate data to disaggregating the premiums paid and indemnities received into price and quantity data, based on the expected yield, percent election and indemnity trigger.

[3]   Since under the separable output-input assumption, to examine the system of output supply functions the revenue function (outputs are exogenous with given input) rather than profit function (both inputs and outputs are endogenous) is appropriate.

[4]   The likelihood ratio test statistic is –2 [restricted model – (–unrestricted model)] and is chi-squared, with the degrees of freedom equal to the number of restrictions imposed.