A Cost Function Analysis of Crop Insurance Moral Hazard and Agricultural Chemical Use

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Abstract

This paper employs a cost function analysis method to investigate the existence of moral hazard in cotton buy-up insurance. The trans-log cost function estimates of the own-price elasticity of fertilizer, herbicide, and insecticide is -0.222, -0.143, and -0.121, respectively for Mississippi cotton production. Our results found statistically significant relationship between per acre direct cost and cotton buy-up insurance for year 2001 and 2005 in Mississippi. Our results also indicate that moral hazard can either decrease or increase agricultural input usage depending specific production condition in an individual year. But in general the results support effects smaller than anecdotal evidence would suggest.

Key words: crop insurance, moral hazard, agricultural input use, cost function analysis, cotton

Introduction

Each year over 200 million acres are enrolled in the Federal Crop Insurance Program in the United States. Major crops are protected by various policy and coverage levels. As in other insurance programs, moral hazard has frequently been suggested as an inherient problem. Moral hazard is typically defined as the situation where a contractual relationship suffers from asymmetric information due to the behavior of one or both contractual parties being able to shirk on the contract in a way that alters the expected payout. In the case of crop insurance programs, insured agricultural producers would realize they do not bear full consequences of their actions when bad outcomes are indemnified. Therefore, they may have a tendency to reoptimize input use decisions under the assumption that the insurer will not monitor behavior closely enough to catch the producer shirking from the "good farming practices" which are defined by RMA as:

> *"The production methods utilized to produce the insured crop and allow it to make normal progress toward maturity and produce at least the yield used to determine the production guarantee or amount of insurance, including any adjustments for late planted acreage, which are: (1) for conventional or sustainable farming practices, those generally recognized by agricultural experts for the area; or (2) for organic farming practices, those generally recognized by the organic agricultural industry for the area or contained in the organic plan." (RMA, 2005)*

Anecdotal stories have suggested that moral hazard behaviors exist in producers' agricultural input decisions, in particular, the chemical use of fertilizer, pesticide, and herbicides. For example, the report by Barnett et al. (2002) was commissioned in response to a wide-spread perception that insurance induced significant new cotton acreage into production and that producers shirked on inputs. That study found that acreage shifts were driven primarily by price expectations and failed to draw conclusions regarding input use due to a lack of data.

Cotton provides a fruitful subject to research moral hazard in crop insurance due to the management practices of producing the crop. Cotton typically requires numerous decisions about inputs during the seasons. For example, professional crop scouting is quite common in this crop due to reoptimization of inputs as weather, insect populations and other factors are revealed. Figure 1 shows the fertilizer, herbicides and insecticide per acre cost for Mississippi cotton producers over the period of 1998-2007. It clearly indicates that agricultural chemical inputs vary over times. In addition to factors such as price effects, technological innovation, and other factors, moral hazard potentially is one of reasons that contribute to the fluctuation in agricultural chemical use. How moral hazard changes producers' behaviors in agricultural input usage without question bears important policy implications.

Results from previous empirical studies on the effects of crop insurance on chemical use, however, are not consistent with each other. Horowitz and Lichtenberg (1993) found that crop insurance increased fertilizer and pesticide use in corn production in the Midwest by

19% and 21%, respectively. Their conclusions imply that both fertilizer and pesticides may be risk-increasing inputs and the implementation of crop insurance subsidies is likely to have large adverse environmental impacts as more chemicals are used by farmers due to moral hazard behaviors. Other studies (e.g. Smith and Goodwin, 1996, Babcock and Hennessy, 1996) showed contrary results of modest declines in input use after insurance adoption.

Different research methods have been used in previous studies. For example, Horowitz and Lichtenberg (1993) employed a Heckman selection model and Smith and Goodwin (1996) used instrumental variables (IV) procedure to consider the endogeneity of insurance and input use decisions. Babcock and Hennessy (1996) estimated a stochastic crop production function and indirectly derived the link between input use and crop insurance. Coble *et al.* (1997) and Roberts, Key and O'Donoghue (2006) identified the effect of crop insurance by examining how yields differ before and after farmers sign up for crop insurance.

In lights of the mixed conclusion with regard to moral hazard behavior and agricultural input use, we propose a cost function analysis to examine the effect of crop insurance on agricultural input use. Our study aims to complement previous studies in this area in two very specific aspects. First, to our knowledge no study has examined how insurance adoption affects total agricultural inputs at farm operator level as well as the share of different agricultural inputs. Second, previous studies were conducted for wheat, corn, and soybeans in their respective production regions. Despite being one of the major crops for the Southeastern region and because of input management intensity likely having moral hazard potential, cotton has not been examined. The analysis is made possible by a set of annual survey data among Mississippi cotton producers. The Mississippi Agricultural and Forestry Experiment Station (MAFES) has been conducting cropping practice of major crops on annual basis in Mississippi since 1980s. Crop insurance information was added into the survey design in 1998. Detailed information on insurance coverage enables us to carry out the study.

Conceptual framework

Consider a risk-neutral government insurer offering insurance to a market of risk-averse individuals. Assume also that the insurance market is not competitive, in that no private firm will enter the market and provide competitively rated insurance products. The crop producer's crop insurance coverage level is chosen prior to planting as is mandated by RMA sign-up deadlines. Then consider a risk-averse farm household whose decision issue is to choose a level of input to maximize expected utility of cotton production subject to technology constraint. Denote crop yield as Y, output price as p_y, $p = (p_1,..., p_n)$ is the input price vector and $x = (x_1,..., x_n)$ is a vector of input level, z is the fixed factor. C is the total input cost, which is equal to $\sum_{i=1} x_i p_i$. Denote p_{gL} as the price guarantee provided by insurance coverage level L, p_{rL} as the premium rate at coverage level L. $\overline{Y}$ is the APH yield. Since output Y and total cost are conditional on input level, a producer's optimization problem can be expressed as:

$$\underset{x}{Max}\, EU(\pi) = MaxEU\left[\int_0^{\bar{y}} p_{gL}\left(L\overline{Y} - Y|x_i\right) + \int_{\bar{y}}^{y} p(Y|x_i) - (C|x_i) - p_{yL} L\overline{Y}\right]$$

s.t. $f\left(Y, x, z\right) = 0$

In the empirical estimation using duality theory we specified and estimated a trans-log cost function and a system of share equations of agricultural inputs.[1] The trans-log cost function is specified as:

$$\ln C = \alpha_0 + \alpha_y \ln Y + \frac{1}{2}\alpha_{yy}\left(\ln Y\right)^2 + \sum_i \beta_i \ln p_i + \frac{1}{2}\sum_i \sum_j \beta_{ij} \ln p_i \ln p_j + \sum_i D_i \ln p_i DM\_Buyup$$

$$+ \sum_m \delta_m \ln z_m + D_{ti} DM\_Buyup$$

Where $i, j = 1, \ldots, N$ denote the N different inputs used in production and $\beta_{ij} = \beta_{ji}$.

DM_Buyup is the dummy for buy-up coverage insurance. z_m is the dummies for specific production condition. The share equations of fertilizer, pesticide, herbicide, labor and fuel, and other inputs cost are:

$$S_i = \beta_i + \sum_{j=1} \beta_{ij} \ln p_j + DM_i DM\_Buyup$$

Since the shares of total input cost sums up to one. The estimation of other inputs is omitted. We use the GMM procedure to estimate the cost function and share equation system. Heteroscedasticity is tested and corrected accordingly. We also impose the following restrictions in the estimation to satisfy theoretical properties of cost function:

$$\sum_{i=1} \beta_i = 1$$

[1] We recognize that the trans-log cost function estimated omits the second and higher moments associated with risk. In effect this model is a first-order approximation.

$$\sum_{i=1} \beta_{ij} = \sum_{j=1} \beta_{ij} = \sum_{i=1} \sum_{j=1} \beta_{ij} = 0$$

Data

The Mississippi Agricultural and Forestry Experiment Station and the Mississippi Agricultural Statistics Service conduct a survey of producers of major field crops in Mississippi each year. In this study cotton cropping practice survey data from 1998 to 2007 are used for the analysis. In Mississippi, produces use a variety of agricultural inputs in cotton production. We categorize direct agricultural inputs into five groups, which are fertilizer, herbicide, insecticide, labor and fuel, and other inputs. For each category an aggregate composite input was computed using Fisher's ideal price index. In this study all costs are per acre direct cost in dollars. The descriptive summary of input costs is listed in table1. Table1 shows that on average per acre total direct cost is $156 among surveyed producers. Yield averages near 753 pounds per acre. Fertilizer, herbicide, insecticide and labor inputs share of total cost is 12%, 9%, 6% and 16%, respectively.

Insurance information is available from 1998. Among the 1254 producers, 704 producers (approximately 56% of total producers) purchased catastrophic coverage for the period of 1998-2007. 448 purchased buy-up insurances which accounts for 36%. Table2 shows how insurance purchase pattern changed among cotton producers over the past ten year period. In the late 1990's each year over 70% producers purchased catastrophic coverage. Starting from 2000, the year the Agricultural Risk Protection Act was passed, the proportion of buy-up coverage insurance purchases increased and the percentage of catastrophic coverage purchases decreased from over 70% to a relatively stable range of 50-60%. In this study, we hypothesize that moral hazard is more likely in the case of buy-up insurance, which include buy-up crop yield insurance (MPCI or APH) and buy-up revenue insurance (CRC). This is because higher coverage inherently implies a smaller deductable. As is well-known in insurance literature a deductible serves as an disincentive to moral hazard behavior (Pauly, 1974). We create an insurance dummy to investigate how purchases of buy-up insurance will affect input costs. The insurance dummy is given a value of 1 when buy-up insurance is purchased and 0 when buy-up is not purchased. Our estimated model interacts year specific dummy variables with the insurance dummies. This is done to allow year-specific moral hazard behavior. Coble *et al.* (1997) found that moral hazard behavior varied by crop year and conclude this was due to variation in growing conditions.

The producers in our data were randomly chosen each year, the data therefore is a cross sectional by nature.[2] We created more dummies to account for specific production conditions by year, region, irrigation and trend. Year dummy is created for each individual year from 1998 to 2006 with year 2007 being the base. Region dummy is given a value of 1 if it's located in upper and lower delta region and a value of 0 otherwise. Irrigation dummy denotes if irrigation is used in cotton production.

Results

The estimation results of trans-log cost function are listed in table 3 and table 4. In table 3 coefficient estimates for fertilizer, herbicide, and insecticide prices have expected sign and

[2] A true panel would be preferred for this analysis. We did use various dummy variables across time and region to attempt to address the lack of a true panel.

are statistically at 1% level. Cross price interactions have expected sign and statistically at 1% level. Using coefficient estimates for price and cross-price effects we derived both Allen elasticities of substitution (table 5) and own and cross-price elasticities of input demands for fertilizer, herbicide, insecticide and labor fuel cost (table 6).

Table 5 lists the Allen Elasticities of substitution. The results show that substitution exists between agricultural inputs. Allen elasticity of substitution between fertilizer and labor fuel cost is the highest, followed by the substitution between insecticide and labor fuel cost, fertilizer and herbicide. Table 6 lists the own and cross price elasticities of input demands. The results show that all the own price elasticities have expected negative sign and are inelastic. As agricultural input price increases by 1%, fertilizer, herbicide, insecticide demand will decrease by 0.222%, 0.143%, and 0.121%, respectively. Compared with own price elasticities the magnitude of cross-price elasticities are small. For example, one percent price increase in fertilizer will induce a 0.04% increase in herbicide demand.

As shown in table 4 our results found in general the impact of buy-up cotton insurance on agricultural input cost is not statistically significant for most years that we investigated. However, we found year 2001 and year 2005 buy-up insurance has statistically significant effects on total per acre cost. In Mississippi there was a huge acreage jump in cotton from 1.3 million acres in the previous year to 1.6 million acres in 2001 due to product prices changes in early 2001. In effect, price signals at the time planting decisions were made suggested planting cotton rather than soybeans. Compared with other years, 2005 experienced relative poor cotton production. Our results further indicate that buy-up insurance can have both positive and negative effects on cost. In 2001 the impact of buy-up insurance was to increase the total cost which is consistent with the moral hazard hypothesis under the assumption these inputs are risk decreasing. The magnitude of buy-up insurance effect, however, is small. For example, by our estimation, as fertilizer, herbicide and insecticide price increase by 1%, the total cost will increase by 0.21%, 0.15%, and 0.28%, respectively. In contrast, buy-up insurance purchases in 2001 will only increase total cost by 0.02%. In 2005 the buy-up insurance participation was associated with a decrease the input cost, which is counter to our expectations, but of a relatively small magnitude of 0.03.

Discussion

In this study we adopt a cost function analysis method to investigate the impact of cotton buy-up insurance purchases on agricultural inputs. The results show that moral hazard exist for certain years, but not for all the years from 1998 to 2006. This result appears inconsistent with widespread stories of how common and severe moral hazard behaviors are in cotton production in the Southeastern region. However, as production condition and the marketing environment changes year by year, our results illustrate that moral hazard are likely to be conditional on the growing conditions. Due to data limitation, we are not able to relate producer characteristics to moral hazard behaviors, which may require further studies in the future.

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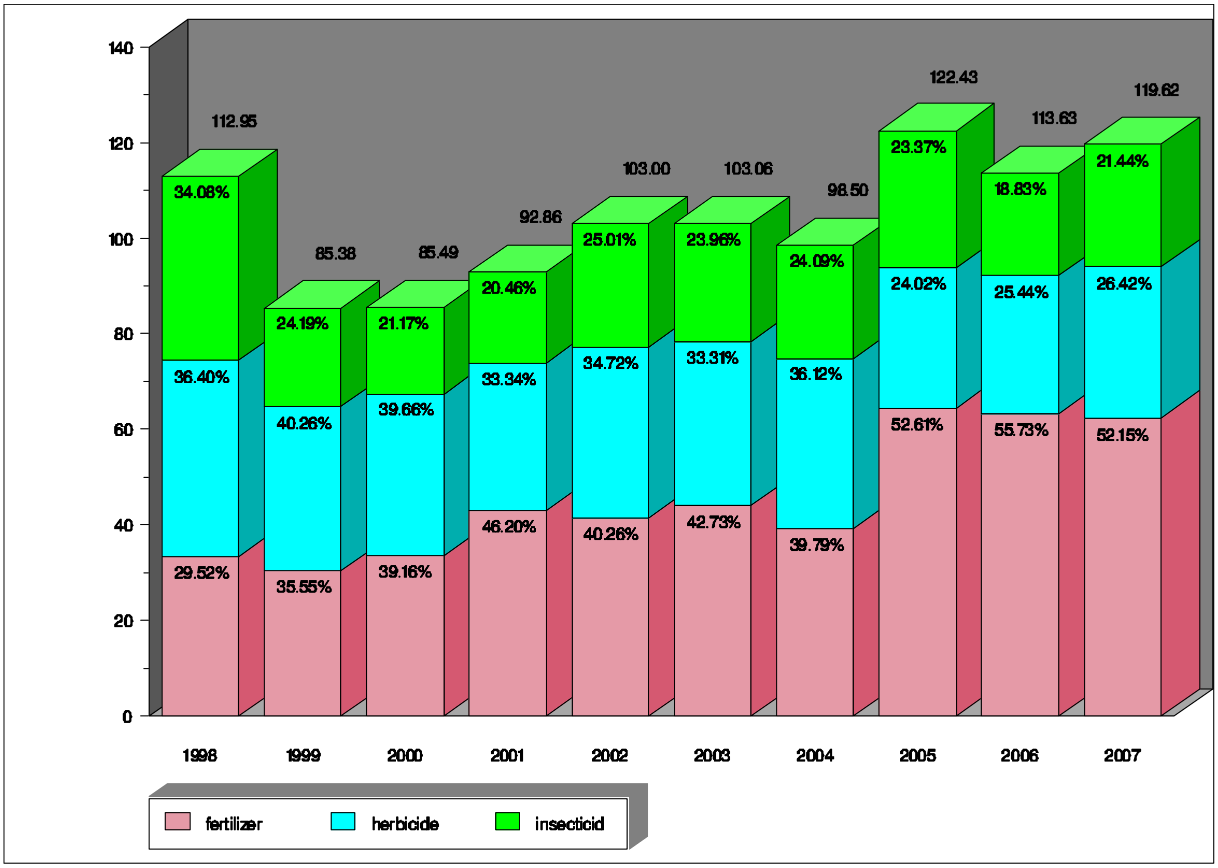

Figure1. Fertilizer, herbicide and insecticide per acre cost for Mississippi cotton producers from 1998-2007.

Table1. Descriptive summary of input cost in Mississippi cotton production from 1998-2007

Variable	N	Mean	Std Dev	Minimum	Maximum
Total per acre direct cost (dollar)	1254	362.29	71.87	185.16	642.27
Cotton yield (pound)	1254	753.18	240.76	44.00	1700.00
per acre fertilizer cost (dollar)	1254	45.06	22.39	0.00	144.05
per acre herbicide cost in dollar	1254	33.52	17.23	0.00	110.96
per acre insecticide cost in dollars	1254	24.26	22.83	0.00	142.83
per acre labor and fuel cost in dollars	1254	55.52	14.63	0.00	113.43
per acre other cost in dollars	1254	203.92	49.66	81.12	410.74
Share of fertilizer cost over total direct cost	1254	0.12	0.06	0.00	0.34
Share of herbicide cost over total direct cost	1254	0.09	0.05	0.00	0.33
Share of insecticide cost over total direct cost	1254	0.06	0.05	0.00	0.30
Share of labor cost over total direct cost	1254	0.16	0.04	0.00	0.34
Share of other cost over total direct cost	1254	0.56	0.08	0.26	0.86

Table 2. Mississippi cotton insurance coverage among surveyed producers from 1998-2007

Year	Insurance Type					Total no.
	Catastrophic Coverage	Buy-up Crop Yield Insurance	Buy-up Revenue Insurance	GRP or GRIP	No coverage	
	No. (% of total no.)	No. (% of total no.)	No. (% of total no.)	No. (% of total no.)	No. (% of total no.)	
1998	87 (75.65)	16 (13.91)	1 (0.87)	3 (2.61)	8 (6.96)	115
1999	111 (73.03)	15 (9.87)	6 (3.95)	5 (3.29)	15 (9.87)	152
2000	81 (54.00)	48 (32.00)	12 (8.00)	2 (1.33)	7 (4.67)	150
2001	41 (34.45)	52 (43.70)	19 (15.97)	4 (3.36)	3 (2.52)	119
2002	64 (47.41)	51 (37.78)	12 (8.89)	2 (1.48)	6 (4.44)	135
2003	54 (51.92)	33 (31.73)	9 (8.65)	1 (0.96)	7 (6.73)	104
2004	63 (57.80)	23 (21.10)	16 (14.68)	2 (1.83)	5 (4.59)	109
2005	74 (59.68)	34 (27.42)	4 (3.23)	2 (1.61)	10 (8.06)	124
2006	75 (51.37)	35 (23.97)	21 (14.38)	5 (3.42)	10 (6.85)	146
2007	54 (54.00)	21 (21.00)	20 (20.00)	1 (1.00)	4 (4.00)	100
Total	704	328	120	27	75	1254

Table 3. Results of price and cross price effects from trans-log cost function estimation

Variable	Label	Parameter	Estimate	Approx Std Err
	Intercept	a0	1.516103	0.9706
$\ln Y$	log of yield	ay	0.026521	0.3133
$(\ln Y)^2$	(log of yield)^2	ayy	-0.00416	0.0503
$\ln p1$	log of fertilizer price	b1	0.214653***	0.00244
$\ln p2$	log of herbicide price	b2	0.193197***	0.00267
$\ln p3$	log of insecticide price	b3	0.148828***	0.00336
$\ln p4$	log of labor price	b4	0.276636***	0.00431
$\frac{1}{2}(\ln p1)^2$	½*(log of fertilizer price)^2	b11	0.081048***	0.00160
$\ln p1 * \ln p2$	log fertilizer price* log herbicide price	b12	-0.00669***	0.00126
$\ln p1 * \ln p3$	log fertilizer price* log insecticide price	b13	-0.00951***	0.00105
$\ln p1 * \ln p4$	log fertilizer price* log labor price	b14	-0.00453***	0.00168
$\ln p1 * \ln p5$	log fertilizer price* log other price	b15	-0.06031***	0.00109
$\frac{1}{2}(\ln p2)^2$	½*(log of herbicide price)^2	b22	0.071434***	0.00179
$\ln p2 * \ln p3$	log herbicide price* log insecticide price	b23	-0.00437***	0.00117
$\ln p2 * \ln p4$	log herbicide price* log labor price	b24	-0.00909***	0.00160
$\ln p2 * \ln p5$	log herbicide price* log other price	b25	-0.05128***	0.00105
$\frac{1}{2}(\ln p3)^2$	½*(log of insecticide price)^2	b33	0.051495***	0.00187
$\ln p3 * \ln p4$	log insecticide price* log labor price	b34	-0.00519***	0.00116
$\ln p3 * \ln p5$	log insecticide price* log other price	b35	-0.03242***	0.00116
$\frac{1}{2}(\ln p4)^2$	½*(log of labor price price)^2	b44	0.119523***	0.00385
$\ln p4 * \ln p5$	log labor price* log other price	b45	-0.10071***	0.00283
$\frac{1}{2}(\ln p5)^2$	½*(log of fertilizer price)^2	b55	0.244726***	0.00313

Note: *** denotes the estimate is significant at 1% level.

Table 4. Results of insurance effects from trans-log cost function estimation

Variable	Label	Parameter	Estimate	Approx Std Err
Y98*DM_Buyup	Interaction of Year 1998 and Buyup insurance	D98	0.008704	0.0288
Y99*DM_Buyup	Interaction of Year 1999 and Buyup insurance	D99	0.001292	0.0216
Y00*DM_Buyup	Interaction of Year 2000 and Buyup insurance	D00	0.012894	0.00974
Y01*DM_Buyup	Interaction of Year 2001 and Buyup insurance	D01	0.022944***	0.00638
Y02*DM_Buyup	Interaction of Year 2002 and Buyup insurance	D02	0.010374	0.00729
Y03*DM_Buyup	Interaction of Year 2003 and Buyup insurance	D03	-0.0017	0.00643
Y04*DM_Buyup	Interaction of Year 2004 and Buyup insurance	D04	0.000299	0.0122
Y05*DM_Buyup	Interaction of Year 2005and Buyup insurance	D05	-0.03112***	0.0105
Y06*DM_Buyup	Interaction of Year 2006 and Buyup insurance	D06	-0.00213	0.0119
DM_delta	Delta region dummy	delta	0.006845***	0.00199
DM_irr	Irrigation dummy	irr	0.001574	0.00496
t	Trend dummy	DM_t	0.00114	0.000899
Lp1*DM_Buyup	Interaction of fertilizer price and Buyup insurance	DM1	-0.0032	0.00204
Lp2*DM_Buyup	Interaction of herbicide price and Buyup insurance	DM2	0.00463***	0.0018
Lp3*DM_Buyup	Interaction of insecticide price and Buyup insurance	DM3	-0.00165	0.00247
Lp4*DM_Buyup	Interaction of labor price and Buyup insurance	DM4	-0.00215	0.00172

Note: *** denotes the estimate is significant at 1% level.

Table5. Allen elasticities of substitution

Allen12	Allen13	Allen14	Allen23	Allen24	Allen34
0.4236	-0.2165	0.7670	0.2595	0.3812	0.4754
(0.1084)	(0.1345)	(0.0863)	(0.1975)	(0.1092)	(0.1169)

Note: Numbers in the parenthesis are the standard errors.

Table 6. Own and cross price elasticities of input demands

	Fertilizer	Herbicide	Insecticide	Labor inputs
Fertilizer	-0.2224	0.0396	-0.0137	0.1204
	(0.0129)	(0.0101)	(0.0085)	(0.0135)
Herbicide	0.0525	-0.1432	0.0164	0.0598
	(0.0134)	(0.0191)	(0.0125)	(0.0171)
Insecticide	-0.0269	0.0243	-0.1205	0.0746
	(0.0167)	(0.0185)	(0.0296)	(0.0183)
Labor inputs	0.0951	0.0357	0.0300	-0.0813
	(0.0107)	(0.0102)	(0.0074)	(0.0245)

Note: Numbers in the parenthesis are the standard errors.