Testing for Moral Hazard and Ranking Farms by Their Inclination to Collect Crop Damage Compensations

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Abstract:
This paper tests for the extent of moral hazard problem within a Crop Damage Compensation (CDC) program that is similar to traditional multi peril crop insurances but is publicly funded and openly accessible for all farmers in Finland. We further estimate the potential of using the observed farmer and farm characteristics in ranking and classifying farms according to their incidence towards losses when they are protected.

The data are the claimed and granted indemnity payments for each farm over the fifteen year period of 1995-2009. These data are complemented by data on total farm population in 2005.

The data suggest that most of the farmers (60%) have not made any claims in the CDC program over the 15 year period. Those farms that claimed compensation did so typically either once or twice within the 15 year period. Nevertheless, a substantial number of farmers have claimed and also granted indemnity payments more regularly than can be justified by the exogenous (aggregate level) yield distributions. Based on the logit models, farmers and farms with certain observed characteristics are more inclined to the losses than the others. In general presence of animals declines the probability of crop damage. However, the existence of different animals on the farm classifies the farms by their inclination to collect crop damage compensations. In addition, the fixed municipality effects are significant indicating that the persons in charge for appraising the losses implement different standards.

Introduction

In traditional yield insurances, the indemnity payments are based on the difference between the farm specific yields and reference yields that are determined e.g. by the farm's yield history or the average yields in the county. The existing literature indicates that within these insurance contracts, the losses as well as the resulting indemnity payments are partially endogenous for a farmer and, therefore, the efficiency of the contracts is significantly decreased by asymmetric information problems (Just et al. 1999). The reason is that insured agents can use private information to change their behaviour to the cost of the insurer. An example is to increase the likelihood to experience yield losses by decreasing the use of risk decreasing inputs (Chambers 1989; Smith and Goodwin 2006). This, so called moral hazard problem, can make the yield risks non-insurable and break down the whole market for these risks.

Typical solution to get yield risks insurable through traditional yield insurances has been to allocate substantial public supports to the insurance programs. EU countries, for example, can pay up to 65% premium supports to multi peril crop insurances under the CAP. Different national systems also exist and, for example, the Finnish approach has been to maintain a Crop Damage Compensation (CDC) program that is publicly funded and provides similar protection as a multi peril crop insurance. In this system, all farmers cultivating the crops eligible in the program are nevertheless automatically covered by the program. Therefore, the program suffers from moral hazard, but not from adverse selection[1]. The CDC program provides, therefore, a unique possibility to identify and test for the implications of moral hazard so that the results isolate from other economic problems and behavioural issues driven by asymmetric information. The moral hazard problem raises several important questions and within the subsidized insurance schemes one question is the allocation of public supports amongst farmers with different performance and how consistent these supports are with regards to other policy goals, such as increasing the resilience and productivity of the agricultural sector.

This paper analyses the implications of moral hazard using unique data on the Finnish CDC program. Our goal is further to estimate observable proxies and farm characteristics that can be used to classify farms by their true risk exposition when they are insured. A particular strength our analysis is that we have data on farm specific indemnity payments each year over a fifteen year period of 1995-2009. With regards to other farm characteristics, our data are for the total population and, thus, they cover farms that have not made any claims in the CDC program. Further, our data allow us to test for the potential bias (fixed effects) caused by the inspectors who appraise the farm specific losses after a farmer has filed a claim. So, we can test on how significant problems may rise by subjective appraisal of the damages. This information is invaluable e.g. in comparing the pros and cons between the traditional insurance mechanisms and more exogenous index based mechanisms.

Accurate estimates of farm-level crop yield density functions are an important starting point for studying crop insurance programs (Goodwin and Ker 1998; Ker and Coble 2004; Sherrick et al. 2004). They are not only important for researchers and government officials but also more significantly so for producers operating under risk and uncertainty. However, farm level crop yield density functions are difficult to estimate due to lack of sufficient farm yield data. Sometimes the actual yields are unknown even for farmers, and farmers are asked about the frequency of good and bad yields (Smith and Baquet 1996).

The observed farm level yield data is typically a product of process biased by self selection, due to the fact that the worst performing farms are not willing to take part on voluntary yield databases where farmers compare their farming methods and yields. These databases are commonly used in farm adviser services also in Finland (www.proagria.fi/tuotteet/atk/lohkot/). Also the usability of book keeping farm databases is questionable from the reason mentioned above, even if book keeping data would be interesting because of long histories of individual farms being involved in the records (www.mtt.fi/economydoctor). From other data sources have been found useless in predicting farm level crop yield density function because historical farm level data are typically short in time horizon.

Farm level crop yield density functions are derived from aggregated national yield statistics with mixed results. Xu 2004 has listed three main obstacles on this task. First, yield volatility is lowered at the country, district, and state or nation level due to averaging effect. This effect is confirmed in numerous studies (Kimura et al. 2010). The

[1] Unless farming and exit decision are not affected by the CDC program.

outcome is logical because good yields in some areas overdo the crop damages in some other areas within the aggregation area. If this issue is not considered it leads to significant underestimation of farm level crop damage risks. Second, time series of crop yields are found to be non stationary. Sophisticated time series methods like time varying distributions are used to detrend the aggregated yield statistic before converting to farm level statistics (Zhu et al. 2008). Some errors have found, because of errors in filtering and unreliable crop yield produced (Maradiaga 2010). Third, crop yield may not be normally distributed. However, this claim has given a lot of rejecting opinions as well as support (Just and Weninger 1999). From the crop insurance viewpoint, the density of the lowest yields is the most interesting part of yield density function. Ker and Coble (2004) have shown that Beta yield distribution based premium rate could be more than two times greater than premium rates based on normal yield density distribution estimated from the same yield data.

Farm characteristics could be used for explaining the fixed farm effect and could be used in risk classification. Farm characteristics helps to find farm specific yield means, but the farm specific crop yield density function with in these characterised farm croups remains uncertain. This leads to the situation where crop yield insurances could be differently prices between the farm groups, but the fair prices with in these groups' remains uncertain. However the result is useful compared to situation where we do not have any risk classification for farms.

The CDC program

The main characteristics of the Finnish Crop Damage Compensation (CDC) program are similar to those in the traditional multi peril crop insurance. A Farmer is entitled to a crop damage compensation (an indemnity payment) if the whole farm yield is damaged to the extent that it is at least 30% below the corresponding reference yield. The reference yield is the regional yield average which has stayed stable over the years. The program compensates only quantity losses that exceed the 30% threshold and average producer prices are used to determine the monetary amount of compensation. With regards to the quantity losses the coverage of the indemnity payments is 100%, because all losses exceeding the 30% threshold are all compensated. Nevertheless, with regards to quality losses, the coverage is zero, as the losses due to decreased quality are not compensated at all. As the result, the true protection level (usually referred as coverage) is lower for high performance (yield & quality) farmers than for low performance farmers (figure 1).

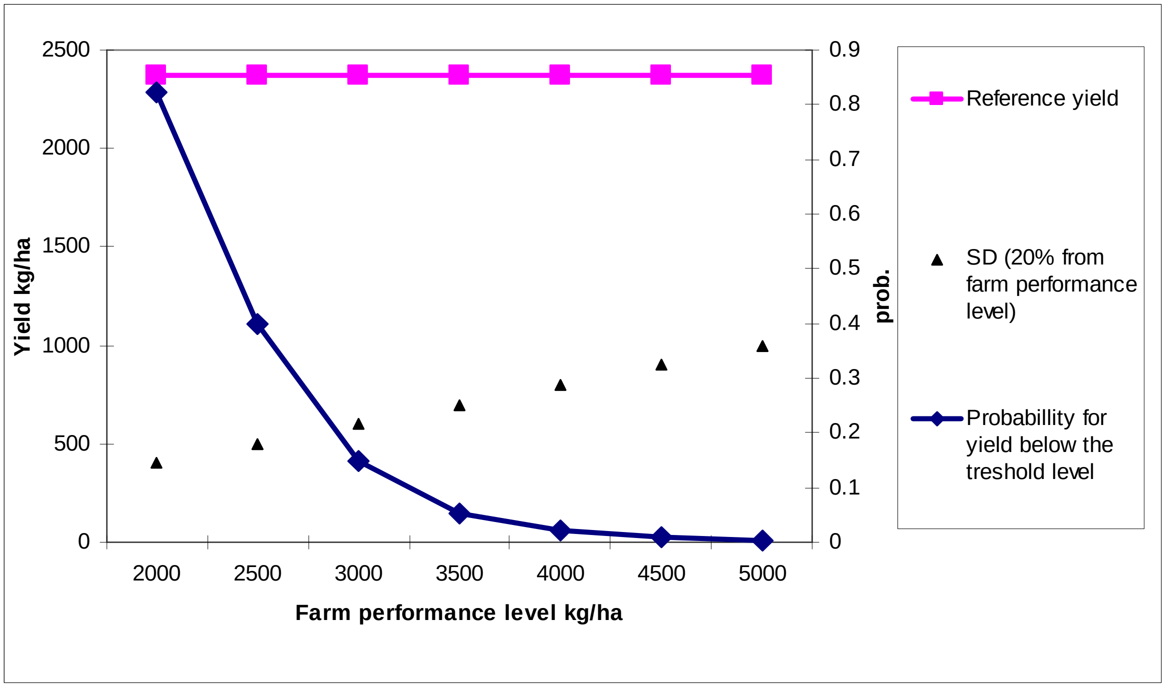

Figure 1. The impact of the farm average yield (x-axis) and yield variation (dotted upward sloping path) on the probability for yield losses (down sloping curve) of at least 30% from the reference yield (horizontal line).

Figure 1 is an example of CDC and calculation are based on normal distribution prediction in crop yield distribution. We accept the prevailing consensus that crop-yield distributions are non-normal (Sherrick et al 2004).

The CDC is more inflexible than many crop insurance products. The terms of the program, such as the coverage, are fixed so that a farmer cannot purchase a better protection through upgrading the scale and the coverage of the program even if he would be willing to pay full cost of the upgrading. Thus, the optional terms of upgrading the program cannot be used to rank and classify farmers according to their risk preferences.

Formally the indemnity payment ($\tilde{n}_i$) for farm (*i*) is

$$\tilde{n}_i = \max\,(\bar{y}_c - \tilde{y}_i\,, 0) \times \bar{p}$$

where

$\bar{y}_c = \bar{\mu}_c \times 0.7 = strike$

$\bar{\mu}_c$ = the critical yield (crains, hey, silage etc.), based on the average yields in the county,

$\tilde{y}_i$ = realization of the stochastic yield of farm *i*

$\bar{p}$ = average output prices at the farm gate

Statistical methods for farm ranking

Logit models were used to analyze which farm characteristics best explain observed yield losses. In this cased dependent variable is binominal. Variable got value 1 if yield loss has occurred at least ones with in 15 years and 0 if there is zero record of yield losses referred by CDC program. The logit mode used is

$$P(loss) = \frac{e^{\beta' x}}{1 + e^{\beta' x}},$$

where P(loss) is the cumulative distribution function of the logistic distribution, β is the parameter vector and *x* includes the independent variables.

We start the analysis by regress the number of yield losses against farm characteristics. Thereafter the standard logit model is implemented. Finally the logit model is extended by using ordered logit model to explain the number of yield losses in 15 years.

Data

We have two data sets. The first data are the claimed and granted crop damage compensations for each farm over the fifteen year period of 1995-2010. This dataset is large, including farm and field plot specific data among the granted indemnity payments. However, the data include only the farms that have claimed compensation under the CDC-program for at least once in 1995-2010.

The second data are for all farms, also including those farms that have never made any claims in the CDC-program. These data are nevertheless only a cross section for year 2005. The two datasets are fully matched by the farm identification codes. The cross section data include farm coordinates (the location), Municipal identification, arable land area, leased area, production technology (organic / conventional), farmer age and the number of different animals on the farm. So, most of these variables are fixed across time and can be matches quite well with the annual data on indemnity payments.

The total number of farms in the country was 95,562 in 1995 and it had decreased to 63,716 farms in 2010. All together 40,276 farms claimed crop compensation within the fifteen year sampling period at least once. In average one out from four claims were turned down and the remaining 29,073 farms received the compensation at least once. Thus, over the fifteen year period, the compensation was granted at least once for less than half of all farms in the country. About 25,000 farmers received the compensation exactly either once (19,506) or twice (6,300) (table 1).

Table 1. Cross section of Finnish farms in 2005 by the number of received CDC compensations in 1995-2009.

Number of received CDC compensations	Frequency of farms
0	45784
1	19506
2	6300
3	2057
4	700
5	292
6	109
7	51
8	32
9	14
10	5
11	5
12	1
13	1
14	0
15	0

The choice of farm specific attributes to be associated with the occurred yield loss is driven by attempt for transparency and visibility as farm specific yield density functions are not visible. The purpose of the study is to rank and classify farms according to their incidence towards losses when they are protected by CDC. Unobservable and latent variables are in this sense useless, unless they associate latent groups to be identified with observable variables (e.g., Maybery et al. 2005; Ross-Davis and Broussard 2007).

Pervious studies have confirmed that capital, either human or monetary, plays an important role on farmers ability to smooth income waives or protect against unfavourable weather conditions through on farm investments. Smith and Baquet (1996) showed that purchasing and coverage level decisions are significantly connected to the farmer's education level. We use age as a proxy for farmer's experience. In Finnish data this is plausible, because weather conditions have soil type specific impacts on yield. Every farmer has to learn these weather-soil relationships to avoid yield losses and obtain good yields. Farmer age might also have a positive correlation to yield losses if aged farmer loses his/her interest in farming and relay on safety nets of CAP and CDC programs.

We do not have any figures of farm level income or capital assets. All farmers keep records of their income and costs for tax authorities but these records are not accessible for insurers. We observe only a farm size in terms of the arable land area and the number of animal on the farm. Arable land area is expected to be a proxy for farm capital. Even if we do not know the exact debt ratio we could expect that financial institutions and land owners have studied the collateral related financing the land rents or debts. It is assumed and proved that accumulated capital will have a negative effect on the demand for crop insurances due to farmers increased capability for self-insurance. On the other hand, Coble et al. 1996 found that increasing farm size increased the probability to take yield insurance. They concluded that spreading of fixed transaction cost of yield insurances to more insured acres would overdo the absolute risk aversion with increasing wealth. Phenomenon compared to above could also be found from CDC program. Small farms with small expected indemnity payment might neglect the claim procedure due to higher transaction cost compared to expected indemnity payment.

Ownership of the farm has connection to average yield level due to land tenure insecurity. Lacking or delayed land improvements on leased plots might lover the average yield. Also the yield volatility might be increased. In Finnish conditions adverse weather events compounded to broken drainage systems might cause significant yield losses. Misha and Goodwin 2006 found that tenants are 13% more likely to purchase on revenue insurance compared to full-owners. In Finland we do not have pure tenant farmers, but we could control the share of rented area.

For our knowledge, farm level yield risk rankings based on the number of animals are absent on yield insurance literature. Conventional multi peril crop insurances are tailored for cash crop farms but not for all type of farms like CDC. This gives an opportunity to test if general presence of animals decreased the probability of crop damage because intensive animal husbandries increase incentives to harvest a good roughage yields on the farm. Different animal types are equalised with weights[2] and effects are thereafter tested.

Results

We first regress the farm characteristics on the frequency of indemnity payments granted for each farm over the whole sampling period. This linear OLS model does not exploit the panel structure yet, but it provides consistent estimates. Efficiency of these estimates is also decreased since the discrete characteristics and the boundaries of the dependent variable are not fully utilized in the estimation. These results can nevertheless be used as the first step and to see how robust our results are with respect to different specifications and how much the Logit models improve the efficiency of the parameter estimates.

Despite the different approaches on dependent variable all models give robust results. The linear model suggests that most of the used explanatory variables are significant (Table 2). The second specification defines the dependent variable equal to one if the farmer has received the indemnity payment for at least once. Otherwise the variable equals zero. We estimate this specification as the logit model.

The logit model suggests that the likelihood for claiming the indemnity payments for at least once is smaller in the north and east than in the south and west. Even if municipal

[2] Weights are taken from Publication "Finnish Agriculture and Rural Industries"

level fixed effect is controlled the data suggest a systemic correlation on yield damages and compass directions. The regional tendencies are also visible when the yield losses where plotted on map.

The regional differences may be explained by the different crop mixes, since in the north and east the farms allocate more land on grass and less to milling grains and other high risk crops as compared to the south and west. The effect of land allocations is supported also by the number of different animals on the farm. The more the farm has ruminants, e.g. cows, and hence the more it is specialized on roughage production on the land, the smaller is the probability of having granted the indemnity payment at least once. An intensive hog production increases the likelihood for yield loss.

The likelihood for yield loss increases significantly with the farm's arable land area, but does not depend significantly on how large share of this land is leased. The parameter estimates do not, therefore, reveal significant land tenure insecurity problem implying more frequent crop damages. However, the result does not necessarily confirm that yield losses do not happen more frequently on leased plots than on the plots owned by the farmer. The reason is that those farmers who have expanded their operations are the best performance farmers and a major share on increased farm size is based on land leasing. This means that high productive farmers and low productive leased plots are mixed on this explanatory variable. Due to these reasons it is obvious that share of own field does not explain crop damages.

Farm size is positively correlated to crop damages in Finland. The CDC scheme should be farm size neutral, but it might be that transaction costs related to the smallest indemnity payments cut the distribution of indemnity payments. This might reveal the true transaction costs related to the CDC scheme and further research on this mater is needed.

In general the number and presence of livestock on farm decreases the possibility for crop damage. However different livestock lines have a different relationship with crop damages. Typically farms having silage or hey (cow, sheep, horse) does face less crop damages than those specialised on grains (grain as a reference and hog) on their arable farming. Markets for silage and hey might be thin or absent in sparsely populated rural areas in Finland. Therefore it is important for milk and beef farmers to have a certain self sufficiency. The effect of horses is negative but not significant. Self sufficiency of forage may be maintained on extensively cultivated horse farms at lower yields and indemnity payments through CDC scheme will do as well.

Table 2. Parameter estimates of the linear OLS and ordered logit regressing the farm characteristics on the number of indemnity payments granted for the farm. On logit model the dependent variable is binary (at least one crop damage).

Parameter estimates	Linear regression	*Pr > |t|*	Logit	*Pr > ChiSq*	Ordered logit	*Pr > ChiSq*
intercept12					13.3543	***
intercept10					14.4535	***
intercept9					14.7415	***
intercept8					15.4354	***
intercept7					15.6591	***
intercept6					16.1306	***
intercept5					16.8265	***
intercept4					17.9243	***
intercept3					18.9486	***
intercept2					20.455	***
intercept1	5.80118	***	21.4676	***	22.1251	***
north	-0.00038	***	-0.00125	***	-0.00135	***
east	-0.00089	***	-0.00426	***	-0.00423	***
farm size	0.00432	***	0.011	***	0.011	***
share of own field area	0.000711		0.00912		0.0013	
cow	-0.00369	***	-0.00742	***	-0.00858	***
hog	0.00117	***	0.00452	***	0.00293	***
horse	-0.00042		-0.00495		-0.005	
poultry	1.89E-05		-0.00496	***	-0.00378	***
sheep	-0.00818	***	-0.0177	*	-0.0179	**
farmer age	0.00245	***	0.00599	***	0.00638	***

Crop damage rates 11 and 13 are missing, because data is reduced due to missing variables in farmer age. Hit rates 14 and 15 does not exist in the data.
Pr <0.01***, <0.05** and <0.1*

Farmer age is a critical independent variable, but it is also linked to the number of observations, since the data have a large number of missing farmer age observations. However the estimated results are robust and do not change with reduced data when variable age is used. Farmer age has a significant and positively correlation with crop damages in Finland.

Fixed municipal effect is on the other hand crucial when results are presented. In general fixed municipal effect is significant, but due to large number of municipals (482) we do not present all the fixed effects. It is still notable that this phenomenon is important and indicates that the persons in charge for appraising the losses implement different standards. The logit model for the first yield loss in 15 years and ordered logit model explaining the number of yield losses gained results similar to each other (Table 2). However the efficiency of estimates is improved with ordered logit model.

Conclusions

Identification of farm characteristics related to yield losses is important for insurance providers. Farm specific yields and underlying yield density functions are latent and not known by anybody else than farm operator. The coal of this paper is to identify those visible farm characteristics that could be connected to yield losses in general. The identification of these characteristics would be beneficial to insurance providers, policy makers, and agencies in their efforts designing insurance programmes better suited to the risk-reduction needs of farmers.

The data suggest that most of the farmers (60%) have not made any claims of yield loss in the program over the 15 year period. Those farms that claimed compensation did so typically either once or twice within the 15 year period. Nevertheless, a substantial number of farmers have claimed and also granted indemnity payments more regularly than can be justified by the exogenous (aggregate level) yield distributions.

Based on used logit models farmers and farms with certain observed characteristics are more inclined to the losses than the others. In general presence of animals lowers the probability of crop damage. Intensive animal husbandries increase incentives to harvest a good roughage yields on the farm. However, the existence of different animals on the farm classifies the farms by their inclination to collect crop damage compensations. In addition, the fixed municipality effects are significant indicating that the persons in charge for appraising the losses implement different standards.

Due to the fact that we just have a cross section data we could not identify the connection between farming exit decisions and yield losses. Also the efficiency of estimated parameters would be improved with panel data.

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