## Government policies in changing climate and the demand for crop insurance

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**Contributed Paper prepared for presentation at the 88th Annual Conference of the Agricultural Economics Society, AgroParisTech, Paris, France**

**9 - 11 April 2014**



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Funding from the Ministry of Agriculture and Forestry in Finland is acknowledged

### Abstract

*Crop insurance markets are exposed to unpredictable weather conditions. Yield risks are systemic in nature, and public intervention is often a necessity for the functioning private crop insurance markets. Climate change is expected to increase catastrophic weather events and yield volatility. This paper addresses the question how government actions related to extreme weather events affect the demand and farmers willingness to pay for crop insurance products. The analysis is based on farmers' stated preferences with split data approach. Our results reveal that farmers' willingness to pay for crop insurance was different when government disaster relief was possible compared to the situation where disaster relief was not possible. Results show that possibility for disaster relief payments in catastrophic event will lead to extensive misuse of taxpayers' money if crop insurance premiums are subsidized simultaneously.*

**Keywords** disaster relief, crop insurance, choice experiment, willingness to pay

**JEL code** Q12, Q18, G22

## 1. Introduction

Crop insurance markets are exposed to unpredictable weather conditions. Climate change is expected to increase the variability of weather conditions and the frequency of extreme weather events. Increasing crop yield volatility leads to more volatile farm incomes between years. Government disaster relief payments are widely used in agriculture. However, governments can help farmers to prepare against adverse weather events also in other ways. Crop insurance is one of the most common measure. Crop insurance is designed to cover income fluctuations caused by yield variability and governments are prepared to cover catastrophic losses, both of which are expected to increase in the future due to climate change.

Because yield risks are systemic in nature, public intervention is often a necessity for the development of private crop insurance markets (Miranda and Glauber, 1997). More specifically premium subsidies are used. This study addresses the question, how governments' actions related to disaster relief affect the demand and willingness to pay for crop insurance. The analysis is based on a choice experiment (CE) examining the willingness of Finnish farmers to buy yield insurance products. We show in this article that the outcomes of two governmental actions related to unpredictable weather events, crop insurance premium subsidies and disaster relief, are conflicting and taxpayers' money is thus wasted.

Previous research on the demand for crop insurance has mainly focused on revealing factors affecting crop insurance purchase decisions among farmers. The challenge has been in forecasting and explaining insurance purchase decisions mostly for the needs of insurance companies to predict adverse selection (Goodwin, 1993; Smith and Baquet, 1996; Sherrick et al., 2004; Velandia et al., 2009). The systemic effects between insurance and investments (moral hazard) have also attracted considerable interest (Smith and Goodwin, 1996; Mishra et al., 2005). This is because insurance may reduce investments in measures that reduce yield variability. Moral hazard and adverse selection have been considered as the main problems to be solved when designing new insurance policies. However, once the worst-case scenario is realised and large-scale yield losses occur through catastrophic events, there is political, social and media pressure to help people in distress. These *ad hoc* measures may lead to the failure of crop insurance markets. As yield risks and extreme weather events are expected to increase in the future, situation where *ad hoc* measures are needed also increase. Thus, we believe that government actions related to disaster relief are as important for the successful development of insurance markets as questions related to moral hazard and adverse selection. This has also been a growing interest of agricultural economic research related to yield insurance (Duncan and Myers, 2000).

Yield insurance operates in the market niche between the deductible level and governmental disaster relief. Small yield variation is covered by the deductible, and these risks are thus carried by farmers, while Governments typically prepare to cover catastrophic risks. The WTO rules for green box subsidies state that if government support is given for crop insurance, the deductible has to be at least 30% (WTO, 1994). EU legislation follows this limit. When comparing a 30% deductible to the yield distribution in Finland, this means that a yield loss that meets with the green box requirement occurs once in every 10 to 15 years (Myyrä and Jauhiainen, 2013). On the other hand, a catastrophic event, an event where yield losses are correlated across large spatial areas, occurs once every 25 to 30 years[1]. Yield potential is expected increase in Finland due to climate change. However, yield risks are also expected to increase because of increasing pest and disease pressure as well as more frequent extreme weather events (Peltonen-Sainio et al., 2009). The

[1] Estimated from Finnish yield statistics.

expectations related to government action in the case of a catastrophic event have a strong impact on the viability of private yield insurance. Furthermore, if farmers expect government compensation in the case of a catastrophic event, they will take additional risks and perhaps change their insurance purchase decisions (Skees and Barnett, 1999).

Finland is at the northern end of Europe, where the harsh climate and high yield variability increases the yield risks of farming. The currently operating and purely publicly funded and administrated Crop Damage Compensation (CDC) system is designed to cover yield losses. The CDC system has been shown to suffer from major moral hazard problems (Myyrä and Pietola, 2011). Furthermore, because compensation payments are based on regional average yields, the CDC system does not cover farmers operating at high yield levels. As a result of European Commission objections and obvious deficiencies in the CDC system, the programme is about to end. A new risk management tool covering crop damage losses in Finland should be in place from 2015 onwards. The new policy will rely on yield insurance built on public–private partnership. According to the European Council and Parliament agreement on the future the CAP, from 2015 onwards the government and the EU could cover 65% of the insurance premium. Moreover, the deductible cannot be less than 30% (EU, 2013). At the same time as the new insurance scheme is being developed, rules for *ad hoc* disaster relief for farmers need to be defined.

The policy renewal in Finland inspired this research, but we believe that our approach will reveal some general conclusions also applicable in other countries. The current situation concerning the old CDC system and new upcoming possibilities for private crop insurance introduced in the CAP offer a fruitful opportunity to examine the influence of farmers' expectations regarding government involvement in crop damage on their willingness to pay for new yield insurance products. For this reason, we conducted a split sample choice experiment where the role of government disaster relief was included in the choice experiment as a constant variable. Half of the survey questionnaires included a statement that the government will not under any circumstances grant disaster relief in the case of a catastrophic event. The other half indicated that *ad hoc* catastrophic yield loss compensation would still be possible, but farmers would need to have voluntary yield insurance to obtain it.

The aim of the study presented in this paper was to: (1) reveal the demand for crop insurance products in Finland; (2) investigate the relationship between government disaster relief and the demand for private crop insurance; (3) examine the effect of government disaster relief on the willingness of farmers to pay for crop insurance products; (4) design attractive insurance policies regarding government disaster relief decisions; and (5) assist government officials in formulating disaster relief rules.

We present a stated preference survey using choice modelling with an error component logit (ECL) estimation method to investigate the factors affecting crop insurance purchases. Furthermore, we compute the willingness to pay (WTP) estimates for different attributes of crop insurance products for two different hypothetical situations regarding government intervention following catastrophic crop losses.

## 2. Data and experimental design

The choice experiment design was included in a mail survey conducted in late 2012. It also included questions about farmers' attitudes towards risk and agriculture risk management tools. The survey was sent to total of 5,000 farmers, which is some 8% of all farms in Finland.

The discrete choice method is used to describe the choices of decision makers among alternatives. The experimental design, i.e. the combination of alternatives and different levels of attributes, was created for our questionnaire in accordance with efficient design. Efficiency was sought for the multinomial logit model (MNL). Efficient design aims to result in a dataset that generates parameter estimates with standard errors that are as small as possible. The complete experimental design consisted of 126 choice cards that were grouped into 21 blocks. In order to create an efficient design, some prior information about the parameter values was needed. In this study, the questionnaire was pretested with a pilot survey that was sent to 105 farmers. The number of responses from the pilot study was not sufficient to be modelled. However, we obtained valuable information on the expected signs of the parameters that enabled us to improve the final design.

In the choice experiment design, respondents were shown six insurance product cards. On every choice card there were two crop insurance products with differing crop insurance attributes. Farmers were asked to choose the more suitable crop insurance product from the two alternatives. Respondents could also choose not to purchase crop insurance at all (Figure 1). Because Finnish farmers have no prior hands-on experience of private market crop insurance, the respondents were given information about insurance attributes before they were asked to make the insurance choices. All four attributes were described in detail.

| INSURANCE CARD 1 | Insurance 1 | Insurance 2 | I would not purchase insurance |
|---|---|---|---|
| Insurance premium €/hectare | 12 | 16 | |
| Deductible | 20% | 20% | |
| Insurance type | Yield index insurance, farm inspection is not needed. | Farm yield insurance, inspection of loss at the farm is needed. | |
| Expected compensation €/hectare | 300 | 600 | |
| MY CHOICE | □ | □ | □ |

Figure 1. Example of choice card.

The attributes chosen for insurance products were the price, deductible, insurance type and scale of insurance. The price of insurance was determined per cultivated hectare and ranged from 4 to 32 Euros/hectare. The deductible, i.e. insurance coverage, determines the share of the loss that is covered by the farmer and in this experiment was set at 10%, 20% or 30%. The insurance type was either index or farm-specific insurance (Table 1). In farm-specific insurance, loss inspection is needed if the farm experiences a crop loss. In index insurance, the compensation is based on regional indices, e.g. the regional yield. If the value of the index falls below the deductible level, an insured farmer is eligible for compensation, even if he has not experienced crop damage. The scale of insurance, i.e. the expected compensation, was also determined per cultivated hectare. The expected compensation had three different levels, which were 100 Euros/hectare, 300 Euros/hectare and 600 Euros/hectare.

Table 1
Crop insurance product attributes in the choice experiment design

| Attribute | Levels |
|---|---|
| Price | 4, 8, 12, 16, 24, 32 Euros/hectare |
| Deductible | 10, 20, 30% |
| Scale | 100, 300, 600 Euros/hectare |
| Insurance type | Index insurance, Farm-specific insurance |

In this study, yield insurance was a hypothetical product. There was no prior information about the demand for crop insurance in Finland, and private crop insurance has not been available for Finnish farmers. We applied a split sample approach to study the market-distorting effect caused by a government policy complementary to crop insurance products. Farmers in the two samples were given different status quo options. The role of government disaster relief was included in the choice experiment setting as a constant variable. Before farmers were asked to complete the insurance choices, it was stated in half of the questionnaire forms that the government will not under any circumstances grant disaster relief in the case of a catastrophic event (NO). In the other half of the questionnaire forms it was stated that government disaster relief is possible, but the condition for compensation is that farmers have purchased private crop insurance (YES) (Table 2). The aim of this structure was to determine whether market-distorting effects are present when government disaster relief is available. In addition, the split sample approach reveals how the willingness to pay for crop insurance products varies across products when the government intervenes in crop insurance markets.

Table 2

Information given to the respondents before they were asked to complete the choices

| |
|---|
| Respondent group NO.<br>Remember that the governments will no longer under any circumstances participate in crop damage compensation. |
| Respondent group YES.<br>Remember that for some crop losses the government may provide so-called disaster relief. The requirement for disaster relief is that you have purchased crop damage insurance. |

A total of 1,170 from the 5,000 mailed survey forms were returned. After missing responses were removed from the dataset, there were 6,105 completed insurance choices. The average age of respondents was 53 years and 90% of them were males. The average size of the farms, 40 hectares, was almost the same as the average farm size in Finland, which is 39 hectares. The main occupation of the respondents was agriculture and forestry (59%). Half of the respondents were grain producers and 23% were other crop producers. One-fifth of the returned questionnaires were from cattle husbandry farms and some 8% from other livestock producers. The distribution of production lines among the respondents resembled the overall production line distribution in Finland. The obtained dataset was representative of Finnish farmers.

Table 3 describes the explanatory variables included in the discrete choice models. The variable means and standard deviations are also presented. The crop insurance attributes in the choice experiment design are described in Table 1, and the mean values of the two samples and pooled data are presented. There were no major differences in attribute means between the split samples. The rented agricultural area is a continuous variable that represents the rented cultivated area of farms. The farming practices, including the yield risk management of the rented agricultural area, differ from the number of hectares owned by the farmer. For example, uncertainty over lease contract renewal reduces the willingness of leaseholders to maintain drainage systems. The rent paid by the farmer also lowers the profit margin on rented hectares and the farmer is more exposed to income waivers caused by yield and price variability.

Two of the explanatory variables were categorical. The opinions of farmers concerning the government's role in compensating crop damage in the future were enquired with five response categories. The other categorical variable concerned whether the farmer considered that his/her farm yield variability was higher than the average yield variability in the county where the farm was located.

Information on the age of the farmers and cultivated farm area are from 2012. A dummy variable was included concerning whether the farm had received a CDC payment at least once in the preceding 18 years. Farms that had experienced a crop loss and collected CDC payments during this period were also expected to be more likely to buy crop insurance. An area dummy was included for the northern and eastern parts of Finland, where the demand for crop insurance products was expected to be lower, because crop and plant production is focused in the southern and western parts of the country. The production line was expected to affect the level of insurance purchases. It was expected to be more common for farms only involved in crop production to suffer losses than animal husbandry farms producing mainly feed crops. Thus, farms specialized in plant production were expected to yield higher utility from insurance products and be more likely to purchase crop insurance.

Table 3
Mean values (standard deviation in parentheses) of explanatory variables

| Variable | | Whole sample (POOLED) | Sample with disaster relief not possible (NO) | Sample with disaster relief possible (YES) |
|---|---|---|---|---|
| Rented agricultural area | Continuous variable: farm's rented cultivated area in hectares | 21.65 (23.26) | 22.36 (23.19) | 21.04 (23.32) |
| Government should compensate crop damage in the future | Categorical variable (1=Totally agree. 5=Totally disagree) | 2.28 (1.05) | 2.34 (1.06) | 2.23 (1.04) |
| Yield variability is higher on my farm than on other farms in my province | Categorical variable (1=Totally agree. 5=Totally disagree) | 3.50 (0.90) | 3.48 (0.89) | 3.50 (0.91) |
| Age | Continuous variable: farmer's age in years | 53.11 (11.45) | 52.83 (11.25) | 53.42 (11.53) |
| Cultivated area | Continuous variable: farm's cultivated area in hectares | 40.14 (38.47) | 40.97 (40.21) | 39.41 (36.90) |
| Farm has received crop damage compensation | Dummy variable. 1 = farm has received crop damage compensation at least once in the past 18 years | 0.18 (0.39) | 0.18 (0.39) | 0.18 (0.38) |
| Northern and Eastern Finland | Dummy variable. 1 = farm is located in the northern or eastern part of Finland | 0.26 (0.44) | 0.31 (0.46) | 0.23 (0.42) |
| Production line is plant production | Dummy variable. 1 = farm's production line is crop or other plant production | 0.80 (0.40) | 0.79 (0.41) | 0.80 (0.40) |

## 3. Estimation method

The choice experiment is an application of the characteristics theory of value (Lancaster, 1966), combined with random utility theory. Based on random utility theory, we assume that farmers can choose the best alternative from different insurance product choices in the choice set. The overall utility from a good can be divided into attributes:

$$U_{in} = V_{in}(Z_i) + \varepsilon_{in}, \quad (1)$$

where $U_{in}$ is the utility of alternative i for individual n, $V_{in}$ is the explained part of the utility, $Z_i$ denotes product-specific attributes and $\varepsilon_{in}$ is a random error, which is independent of other terms and independently and identically distributed (IID) with an identical type I extreme value distribution, representing the unobserved heterogeneity.

Discrete choice models describe individual choices among alternatives. The probability $p_{in}$ of an individual *n* choosing alternative *i* is equal to the probability that the utility of alternative *i* is greater than, or equal to, the utility associated with an alternative *j* for every alternative in the choice set. Formally:

$$p_{in} = prob\left[(V_{in} + \varepsilon_{in}) \geq prob\left(V_{jn} + \varepsilon_{jn}\right) \quad \forall j \ \in j = 1, \dots, J; i \neq j\right]. \quad (2)$$

The MNL model is derived under the assumption that the error term is independent and identically distributed for all *i*. The logit probability is (McFadden 1974):

$$p_{n,i} = \frac{e^{\beta V_{n,i}}}{\sum_{j=1}^{J} e^{\beta V_{n,j}}}. \quad (3)$$

Limitations of the assumption about the independent and identically distributed error term in the MNL model can be obviated by using a more flexible mixed logit model (MMNL). This is achieved by allowing for random taste variation, an unrestricted substitution pattern and correlation in unobserved factors over time. Mixed logit probabilities are the integrals of standard logit probabilities over a density of parameters. The mixed logit probability is (Train, 2003):

$$p_{n,i} = \int \left( \frac{e^{\beta V_{n,i}}}{\sum_{j=1}^{J} e^{\beta V_{n,j}}} \right) f(\beta) d\beta, \quad (4)$$

where $f(\beta)$ is the density function. The mixing distribution $f(\beta)$ gives weights to the mixed logit probability. Therefore, it is a weighted average of the logit formula evaluated at different values of β. In the mixed logit model, coefficients can vary between respondents. This allows us to estimate the mean coefficients and standard deviations of the random parameters, representing unobserved heterogeneity in preferences, in order to accommodate heteroscedasticity. The parameters of all models are estimated with maximum simulated likelihood using 1,000 Halton quasi-random draws.

With discrete choice models, the utility of respondents is measured. Thus, the estimated model coefficients are not interpretable in economic terms. Therefore, in order to reveal the overall WTP for a crop insurance product, implicit price (IP) estimates of crop insurance attributes are calculated as:

$$IP_k = -\left(\frac{\beta_k}{\beta_p}\right), \quad (5)$$

where $\beta_k$ is the parameter of *k*th attribute, and $\beta_p$ is the price coefficient.

The estimated utility of crop insurance for a farmer was assumed to depend on the insurance price, deductible level, expected compensation and the type of insurance. A normally distributed zero mean random parameter was added to the model in order to allow for different variance in the two insurance options and the no insurance choice. Thus, the discrete choice method applied is an extension of the mixed logit model known as error components logit (ECL). It was expected that respondents would treat the no insurance choice in a different manner to the two hypothetical insurance products. A shared error component term was included in the utility function for the two crop insurance products, but not for the no insurance alternative. This shared random effect captures unobserved heterogeneity that is alternative specific (Greene and Hensher, 2007). The error components are normally distributed random variables with zero mean and a standard deviation of $\sigma_i$. In this study, the estimated standard deviation was related to the correlation of the different alternatives. We assumed that the two insurance choices were close substitutes for each other, but not for the no insurance choice. Therefore, a nested system for three alternatives was specified.

Various combinations of explanatory variables and insurance product attributes were tested, but only significant variables were included in the final model. Coefficients were estimated for the combined insurance alternatives, because the explanatory variables did not cause the utility level to differ between the alternatives 1 and 2 presented in the choice cards. Categorical and socioeconomic variables were included in the utility specification of insurance purchase. We assumed that the coefficient of socioeconomic variables captures the utility difference between insurance and no insurance. The utility specifications for the error component models were:

$$U_{insurance} = \beta_i X_{in} + \sigma_i \varepsilon_i + \epsilon_i, \quad (6)$$
$$U_{no\ insurance} = \beta_i X_{in} + \epsilon_i. \quad (7)$$

Normal and other forms of distribution, such as lognormal, were tested for all the insurance attributes. In order to maintain the overall significance of the model, a normal distribution was only specified for the price attribute.

## 4. Results

An insurance product was chosen in 46.5% of the cases in the entire dataset. The availability of disaster relief did not have a major effect on the number of insurance cards chosen. In the part of the sample where disaster relief was possible if the farmer had purchased compulsory crop insurance, 47.1% of the respondents chose insurance. When disaster relief was not possible, insurance was chosen in 45.8% of the cases. The possible availability of disaster relief when farmers had compulsory crop insurance may have increased the number of respondents choosing an insurance product. In other words, some farmers may have chosen the insurance product in order to obtain the extra cover provided by the government. However the main conclusion is that disaster relief did not have a major effect on the number of insurance purchase decisions.

### *4.1. Parameter estimates*

The first column of Table 4 provides the estimated coefficients of the MNL model for the entire dataset. The coefficients of insurance attributes were significant with the expected signs. The pseudo R-square for the MNL model was 0.2034. The independence assumption of the MNL model was tested with Hausman's specification test (Hausman and McFadden, 1984), which revealed that the IIA assumption did not hold with our dataset. Therefore, the logit model could be rejected in favour of the ECL model, and in the remainder of this article we only discuss the results for the ECL models.

In the pooled and the two subsample ECL models, a normal distribution was specified for the price attribute, as this yielded the best model fit. The pseudo R-square for the pooled ECL model was 0.2162. All the coefficients of insurance attributes had the expected signs. The price and deductible had a negative effect on the utility of the farmer. The expected compensation, i.e. the scale of the insurance, had a positive effect on the utility of the farmer. The coefficients for insurance types were negative and significant, indicating that the farmers preferred index insurance over farm-specific insurance. In the pooled model, random coefficients for price were positive and highly significant ($p < 0.01$). This implies significant unobserved heterogeneity in preferences towards the price choice attribute. The additional standard deviant error term was significant and large in all three ECL models, which implies larger variance of the two insurance alternatives than of the no insurance alternative.

The coefficients of the interaction variables reveal that the scale attribute was valued more by those farmers who had a greater rented agricultural area. In contrast, those farmers with a large rented agricultural area worried less about the price of insurance. This result is in line with the assumption that farmers operating with a high proportion of rented area are more exposed to yield and price variability in their business due to lowered risk management at the field level, as well as lease payments, which lower the profit margin per hectare. Attitudes towards crop insurance affect the utility derived from crop insurance products. Farmers who stated that the government should not have any role in compensating yield losses in the future were also more likely to buy crop insurance products. Farmers who stated that yield variability is smaller on their farm than on average in their area were less likely to buy crop insurance products. Insurance companies can use this knowledge in the future when marketing crop insurance products to farmers. Possible adverse selection problems can also be detected.

Socioeconomic variables were added to the model to reveal which farmers were most likely to purchase crop insurance. In contrast to previous studies (Sherrick et al., 2004; Mishra & Goodwin, 2003), age had a negative effect on the crop insurance demand. However, our results are consistent with Velandia et al. (2009), in that older farmers were less likely to use risk management tools. Crop insurance is a complex and hypothetical product for Finnish farmers. Young farmers may be more willing to apply new risk management strategies, and may also see crop insurance as being an important risk management tool, especially in the future.

The demand for crop insurance increased as a function of the cultivated area of the farm. This effect was not statistically significant in the subsample for which disaster relief was possible with voluntary crop insurance. The demand was lower in the northern and eastern parts of Finland. Connections to production lines were obvious, as full-time crop and plant production is focused in the western and southern parts of Finland. Farms in the eastern and northern parts of the country are smaller on average.

If a farm had received CDC payments in the past, the farmer was also more likely to buy insurance. This observation has a connection to the moral hazard problem. It has been shown that some farmers more frequently face yield damage than others. This might be because of the production line, unfavourable local conditions or farmer-specific management skills and goals. The data reveal that those farms that had faced yield damage in the past (under the CDC scheme) expected that they would also face yield damage in future. The frequency of yield damage will also be higher among insured than uninsured farms under the new commercial yield insurance. This will have implications for the pricing of such insurance products due to the yield density function of insured farms, which does not equal with the currently available yield statistics.

Table 4

Results of the multinomial logit model, pooled error components logit model and two error components logit models of subsamples for insurance (SE in parentheses)

| Parameter means | Multinomial logit Model (POOLED) | Error components logit model POOLED | Sample disaster relief not possible (NO) | Sample disaster relief possible with insurance (YES) |
|---|---|---|---|---|
| **Choice experiment attributes** | | | | |
| Price | -0.03853*** (0.00332) | -0.11832*** (0.01357) | -0.11469*** (0.02003) | -0.12116*** (0.01873) |
| Deductible | -2.98088*** (0.27113) | -4.13768*** (0.39203) | -3.63248*** (0.54158) | -4.7144*** (0.58152) |
| Scale | 0.00335*** (0.00014) | 0.00463*** (0.00023) | 0.00427*** (0.00035) | 0.00492*** (0.00032) |
| Farm insurance | -2.91735*** (0.28914) | -1.84059*** (0.6141) | -2.24020** (0.9941) | -3.36345*** (0.81348) |
| Index insurance | -2.69479*** (0.2869) | -1.56555** (0.61231) | -2.03605** (0.99377) | -3.01716*** (0.80562) |
| **Random parameter estimates** | | | | |
| Price | N/A | 0.09375*** (0.01708) | 0.07962*** (0.02633) | 0.10852*** (0.02303) |
| **Interaction variables** | | | | |
| Rented agricultural area*Scale | 0.00011224*** (0.00004343) | 0.0002639*** (0.0000837) | 0.0002129* (0.000115) | 0.00036678*** (0.0001291) |
| Rented agricultural area*Price | -0.00034*** (0.00011) | -0.00040* (0.00021) | -0.00016 (0.00027) | -0.00076** (0.00034) |
| **Categorical variables** | | | | |
| GCOMP | 0.12814*** (0.02596) | 0.34919*** (0.07845) | 0.52166*** (0.13418) | 0.17891* (0.10236) |
| YVAR | -0.07695** (0.03011) | -0.21287** (0.08734) | -0.26825* (0.13688) | -0.16754 (0.11534) |
| **Socioeconomic variables** | | | | |
| Age | -0.01850*** (0.00256) | -0.05080*** (0.00857) | -0.05871*** (0.0142) | -0.04696*** (0.01091) |
| Cultivated area | 0.00499*** (0.00103) | 0.01084*** (0.00299) | 0.01828*** (0.00492) | 0.00361 (0.00384) |
| CDC | 0.28269*** (0.07074) | 0.81950*** (0.217) | 0.51449** (0.2476) | 0.56615*** (0.1942) |
| NE | -0.23610*** (0.06511) | -0.64471*** (0.19222) | -0.51830* (0.2832) | -0.84594*** (0.2736) |
| PLANT | 0.18032** (0.07242) | 0.55338*** (0.20864) | 0.17015 (0.32022) | 0.91343*** (0.28801) |
| Standard deviant error component | N/A | 4.12126*** (0.43721) | 4.41796*** (0.71422) | 3.916*** (0.55593) |
| Log-likelihood | -5343 | -5257 | -2470 | -2771 |
| N | 6105 | 6105 | 2860 | 3245 |
| Pseudo- R-square | 0.2034 | 0.2162 | 0.2139 | 0.2228 |
| AIC | 10713 | 10546 | 4972 | 5574 |

***, **, * Significant at 1, 5 and 10% level

The aim of this study was to reveal how the prospect of government disaster relief affects the willingness to pay for crop insurance products. This was studied with the split data approach. The difference in the parameter values for the two different samples compared to the pooled data was tested with the log likelihood method. The test statistic, $\chi^2 = -2*(LL_{pooled\ sample}-(LL_{Sample\ disaster\ relief\ not\ possible}+LL_{Sample\ disaster\ relief\ possible\ with\ insurance}))$, was derived, where $LL_{pooled}$ is the log likelihood of the model from entire dataset. The test statistic ($\chi^2 = 33$) indicates that we can reject the null hypothesis of equal parameter values at the 1% level. However, this test only shows that there are differences in farmers' preferences when the government intervenes in crop insurance markets; it does not reveal how the willingness to pay for yield insurance changes between the two samples.

*4.2. Willingness to pay for crop insurance attributes*

Because discrete choice models reveal the utility derived from crop insurance products, the levels of estimated parameters do not matter in an economic sense. However, what matters is the ratio of product and price attributes. Thus, implicit prices are derived and are presented in Table 5. Implicit prices are the marginal rate of substitution between price and product attributes. These reveal how willing farmers are to trade one attribute for another attribute. Because choice experiments always also include price or some other cost attribute, the monetary value of other attributes can be revealed.

Implicit prices and their confidence intervals for two separate samples were derived by a method proposed by Krinsky and Robb (1986) with 5,000 replications. The difference in IP estimates between the two subsamples was tested with the t-test. The null hypothesis of equal values could be rejected for all IPs based on high t-values. Thus, we can conclude that the WTP differed between the two subsamples.

Table 5
Median implicit price estimates of choice experiment attributes and t-test

| | Sample disaster relief not possible (NO) | | Sample disaster relief possible with insurance (YES) | | Average % change in IP ((NO-YES)/-NO)*100 % | t-value |
|---|---|---|---|---|---|---|
| Deductible | -31.67 | (-44.90 to -22.76) | -38.94 | (-51.26 to -30.20) | -23.0% | 64.91 |
| Scale | 0.038 | (0.028 to 0.056) | 0.041 | (0.031 to 0.057) | 8.4% | 21.50 |
| Farm insurance | -19.76 | (-44.20 to -2.31) | -27.66 | (-46.29 to -14.31) | -39.9% | 41.13 |
| Index insurance | -17.31 | (-41.89 to -0.50) | -25.00 | (-43.81 to -11.30) | -44.5% | 39.73 |

Confidence intervals in parentheses based on the 2.5th and 97.5th percentiles of the simulated IP distribution.

The deductible level is a major factor affecting the demand for crop insurance in Finland. Our results reveal that government involvement in crop insurance markets would reduce the WTP of the deductible. The difference was statistically significant and the deductible attribute was 23% smaller in the YES sample compared to the NO sample.

In contrast to the deductible attribute, farmers were willing to pay more for the scale of insurance when disaster relief was possible with voluntary crop insurance. The WTP for the scale attribute was 8.4% higher in the YES sample compared to the NO sample.

The implicit prices for both insurance types were higher in the NO subsample. Thus, the level of WTP for farm or index crop insurance products was lower when it was stated that the government would intervene in the crop insurance markets. The confidence intervals were wider in the sample where disaster relief was not possible. This implies higher variance in WTP when government intervention is not in place.

Although there was statistically significant difference in attribute IPs between the two subsamples, the difference in the overall WTP for the hypothetical crop insurance products was conditional on the characteristics of the supplied insurance product. Table 6 illustrates the overall WTP of farmers for the hypothetical insurance products. The expected compensation or coverage varied from 100 to 500 Euros/hectare and the deductibles were set at 30%. Crop insurance WTPs were separately derived for farm-specific and index insurances.

The WTP values for index insurance were higher than for farm-specific insurance. The WTP for the crop insurance product was higher in the NO sample when the expected compensation was low and the deductible level was high. When the expected compensation was increased, the difference in WTP between the two insurance products decreased. Government disaster relief had the biggest influence on insurance designed to cover losses to crops that have a low level of expected compensation. In crop production, crops such as wheat and barley fall into this category. If farmers expect government disaster relief payments, they will not be concerned about crop losses for the most common crops. Wheat and barley are the main arable crops in the study area, and the government's stated actions regarding forthcoming disaster relief will therefore have a major effect on the design of yield insurance contracts.

Table 6
Median WTP Euros/ha for hypothetical insurance products with 30% deductible and difference between the two policy scenarios

| | Disaster relief not possible (NO) | | | Disaster relief possible with insurance (YES) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Expected compensation Euros/ha | | | Expected compensation Euros/ha | | | Difference Euros (%) | | |
| | 100 | 300 | 500 | 100 | 300 | 500 | 100 | 300 | 500 |
| Farm-specific insurance | 6.2 | 13.7 | 21.2 | 3.7 | 11.8 | 19.9 | -2.5 (-40.5%) | -1.9 (-13.7%) | -1.2 (-5.9%) |
| Index insurance | 8.6 | 16.1 | 23.6 | 6.3 | 14.5 | 22.6 | -2.3 (-26.6%) | -1.7 (-10.3%) | -1.0 (-4.4%) |

The demand for crop insurance can be encouraged by introducing insurance premium subsidies. If the government is willing to pay disaster relief payments, the subsidy level for cereal crops needs to be increased. This will lead to extensive use of taxpayers' money. Thus, the government should either grant disaster relief payments and refrain from insurance premium subsidies or introduce an insurance premium subsidy, but refrain from disaster relief payments.

## 5. Conclusions

Climate change is expected to increase yield risks in the future. There are several ways to help farmers to cope with income volatility due to extreme weather events. Disaster relief and premium subsidies for yield insurance are among of the most popular means. Our results highlight that disaster relief payments and crop insurance premium subsidies should not be used simultaneously, as this would waste taxpayers' money and lead to a situation where farmers take more production risks. We realise that in the case of a catastrophic event, there is political, social and media pressure to help people in distress, but this point is also a test for risk carrying. Who will carry the risks?

The results reveal that the WTP of farmers for crop insurance products was not equal when government disaster relief was possible with compulsory crop insurance compared to the situation where disaster relief would no longer be granted under any circumstances. In general, the WTP was higher when disaster relief would no longer be granted. However, the effect varied between the insurance attributes. The difference in the median overall WTP for hypothetical insurance products was greatest when the deductible was set at a high level, namely 30%, and the expected compensation, i.e. the coverage, was low.

The results have major implications for crop insurance product development and policy design when preparing for more unpredictable weather conditions in agriculture. In the EU, the limit for the deductible level in subsidized crop insurance products is set to 30%. If insurance products are developed to give a small amount of cover against crop losses, the possibility for government disaster relief will have a large negative impact on the overall WTP of farmers. This will lead governments to use high premium subsidies for yield insurance to obtain a large share of farmers under commercial crop insurance schemes.

In this study we only considered whether government involvement would have an impact on the WTP of farmers. A further question is at what stage the government can grant *ex post ad hoc* disaster relief, if any. When extensive crop damage is realised, there is not only social pressure, but also pressure from the media to help farmers in distress. This makes the situation complicated, especially for the politicians in charge. Due to the systemic nature of yield losses, reinsurance or disaster relief provided by the government can help the development of crop insurance markets. However, if rules for disaster relief are vague, decision makers will also have the urge to help farmers in situations that could be dealt with using market instruments. This may lead to state where the market niche for crop insurance between deductible and disaster relief is too small. This can be avoided by defining *ex ante* catastrophic risks and situations where government intervention is permitted following catastrophic events affecting agriculture.

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