Revisiting the demand of agricultural insurance: The case of Spain[1]

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Abstract

We use the actual insurance records of 52,300 farmers and 11 years to estimate two sets of insurance demands. We define measures of insurance's expected returns, variance and third moment, based on observed insurance data, and infer the expected returns for those farmers that have never had an indemnity. We estimate several probit models and count models for the insuring vs non-insuring strategies, in which the economic returns of insurance and its two measures of dispersion enter as explanatory variables. Results show that farmers' insurance strategies are largely explained by their actual insurance experience as captured by these three variables. Individuals with loss rations greater than 1 do not show more responsiveness that those facing more balanced premium charges. Results show that adverse selection may not be a major source of inefficiency in the Spanish insurance system.

Keywords: Agricultural insurance, insurance demand models, Spain

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1. Introduction

The literature on agricultural insurance seems to provide very few succesful examples (Valdés & Pomareda, ; Hueth et al.). Yet most conclusions are based on a very limited number of experiences and countries, which mostly focus on publicly provided insurance. Many world countries, developed and developing, have agricultural insurance systems or have gone through processes of development, crises, and revitalisation. The European Union is considering shifting part of their income support mechanisms towards safety nets and risk management instruments, including agricultural insurance (EU Commission,).

Conventional wisdom assumes that agricultural insurance is too vulnerable to serious problems of asymetric information (Just & Pope, 2002; Chambers, 1989). In the European Union, the private sector provides basic coverages for a very limited number of hazards, indicating that many of the risks and hazards to which farmers are exposed cannot be insured by private insurance companies. Some EU countries, including Spain, Greece and Italy have developed comprehensive insurance policies as a means to provide safety nets for farmers. In the last ten years, the US, Spain, and Canada, among others, have expanded their insurance systems in terms of insured risks, kinds of policies, and their budgetary allocations to subsidise premia.

Despite its importance in terms of insured acreage, total liabilities and premium subsidies, very little is known about non-US insurance experiences, with the exception of Canada. Most policy reviews provide very superficial treatment to other experiences (OECD, 2002; EC commission, 2000). The Spanish case is especially striking because it has a rich experience in developing new and innovative agricultural insurance, and has been expanding during the last 25 years. And yet it has received scant attention in the literature, and completely ignored as an alternative model to countries in the process of developing their own systems.

This paper focuses on the demand for agricultural insurance in Spain. It seeks to characterise the demand for insurance in Spain and determine the main factors explaining farmers' participation in insurance. The novelty of the approach is that it uses farmers' actual insurance outcomes as the main explanatory factors for insurance participation. Another breakthrough of our analysis is the variety of crops, insurance policies and farming conditions included in the sample, which is formed by more than 52,000 farmers and 12 years of insurance records.

The paper is structured as follows. After reviewing the literature on insurance demand in section 2, we provide a brief description of the Spanish agricultural insurance system and primary factual data in the third section. Section 4 includes the basic model for insurance demand. In section 5 we provide numerical results that enrich the theoretical conclusions. Section 6 describes the database used in the statistical and econometric analyses, whose results are discussed in section 7. The paper's most salient conclusions are summarised in section 8.

2. Insurance demand

Canada, Spain and the US are among the OECD countries with more developed agricultural insurance policies. The three of them have in the last decade increased the budget devoted to premium subsidisation, and the pecentages of farmers and surface with some coverage. As rough measures, these countries spend in subsidising insurance policies an equivalent of 1 to 2% of their total agricultural output. In response to these significant budget allocation, about 50 to 60% of the eligible farmers purchase at least one insurance policy. On average, US spends in insurance subsidies about US$25 per insured hectare, Spain €25, and Canada C$50.

Insurance subsidisation, though important in absolute and relative terms, is not the only means the governments of these countries support agricultural insurance. Agencies directly or indirectly promote research and support continuous innovation, offering a broad menu of insurance options to field crops, fruits and vegetables and livestock farmers. On the demand side, farmers respond changing the crops they insure, the type of policy or the coverage. In Spain, some insurance policies are purchased by 100% of the eligible farmers (banana or tomato in the Canary Islands) and some others by less than 5%, including olive trees or revenue insurance for potato.

Farmers purchase insurance polices because (1) expected benefits are positive, (2) they gain from asymmetric information, and (3) they are risk-averse (Just et al. 2003). The bulk of the literature on agricultural insurance has focused on items (1) and (2), that have been tested under alternative assumptions about item (3).

With insurance, asymetric information implies that insuree and insurer have different information about productive risks and insuree's behaviour. Asymetric information is thought to provide incentives for moral hazard and adverse selection. Quiggin et al. (1993) contend that very often it is not possible to empirically distinguish between moral hazard and adverse selection, however different may be in theoretical terms. Consider the case of a farmer that defers his planting to learn more about soil-moisture and see whether it is in his interest to purchase drought insurance. This type of behaviour is illustrative of both moral hazard and adverse selection. It exhibits adverse selection because insurance is purchased only if a lower yield is expected. It is moral hazard because the decision to defer planting is influenced by the existence of yield insurance. Moschini and Hennessy (2001) review in detail the problems related to asymetric information. What this wealth of literature, entirely based on US cases and data, seems to suggest is that there is disagreement about whether or not asymetric information pose incentives to increase production.

Wright and Hewitt (1990, cited by Moschini and Hennessy, 2001) contend that actual demand for insurance would be lower than is generally believed, because farmers have many other cheaper means to control and reduce their risks. In general, insurance is thought to be an expensive instruments, because policies have to be designed in order to reduce the negative effects of asymetric information. As a result, in the absence of subsidies insurance would not be attractive to most farmers. Ramaswami (1993) divide up insurance effects in two: *moral haza*rd effects and *risk reduction* effects. The first encourages reductions of input use and by the second the insuree would seek greater expected revenue. However, there is some ambiguity with regards to moral hazard effects, because increase-production inputs can be also risk-augmenting. In general, it is thought that fertilisers are risk-augment inputs, and pesticides risk-reduction inputs. However, insurance policies include a number of provision and features that are meant to reduce or eliminate moral hazard, but adding little room for risk reduction effects. While Horowitz and Lichtenberg (1993) found no evidence of moral hazard among US maize growers, and Wu (1999) four very weak evidence among US maize growers, the list of those that found includes Quiggin et al. (1993) with US grain producers, Smith and Goodwin (1996) with wheat producers, Babcock and Hennessy (1996) with simulation models, Coble et al. (1996) with Kansas farms, Serra et al. (2005) with Kansas growers and Mishra et al. with wheat US producers. None of these studies use more than 1,600 farms, or look at other crops.

Combating adverse selection is paramount to being able to offer specific insurance policies to relatively homogenous groups of farmers. For this, insurers must count on objectively discriminatory elements to group of agents under homogenous risk levels, and charge different premia. While the confirmation of moral hazard would lead to the conclusion that insurance is a decoupled policy, the presence of adverse selection needs not be so. What adverse selection indicates is the absence of discrimination elements and the unbalance of premia and indemnities. If adverse-selection provides strong incentives to cultivate marginal land, then insurance may increase production and for that matter should not qualify as a decoupled policy. Yet, as Moschini and Hennessy (2001) indicate the Canadian Prairie Farm Assistance Act (1939) was conceived to grant revenue instability of farmers located in territories to which they should have never been pushed to occupy. While this may be true in many other countries and regions, the passage of time since land was converted to agriculture precludes qualifying these historical processes as adverse-selection. This, despite the fact premium must be heavily subsidised to maintain farmers' interest. Another important factor related to adverse selection is the fact that the required groups' homogeniety to avoid adverse selection depends on farmers' risk aversion. The more risk-averse, the less reluctant they will be to pay premium above their individual actuarial fair premium. Evidence of adverse selection was found by Skees and Read (1986) with soybean and maize US growers, Goodwin (1994) among Kansas farms, Quiggin et al. (1993), Just et al (1999) with US growers, Ker & McGowan (2000) among insurance firms in the casse of wheat producers in Texas, and by Makki & Somwaru (2001) with corn producers from Iowa, using the largest data set (6,000 farms) among those reviewed here.

The evidence in favour of severe asymetric information problems is dubious and mostly based on a limited number of US insurance policies (MCPI and APH), although Makki & Somwaru find strong evidence for adverse selection in presence of four types of policies including revenue insurance,.. The literature seems to suggest that farmers seem to be compelled to purchase insurance attracted by the expected results, which are also dependent on the level of insurance attached to the premium (Just et al. 1999). Makki & Somwaru (2001) show high risk US farmers are more likely to purchase revenue insurance and higher coverage levels, and that low-risk farmers tend to be overcharged.

A controversial issue about the role of subsidies in the demand for insurance still revolves and has not been settled in the literature. Goodwin (2001) finds demand elasticity for insurance is between -0.24 and -0.20. (Serra, Goodwin and Featherstone 2003, p. 109) show that it has be become less elastic in the US as farmers have turned to larger coverages, favoured by ARPA (2002) increased subsidisation.

None of these studies use actual insurance outcomes, such as individual loss ratios, indemnities or expected returns from insuance, to explain farmers' insurance decisions. Even Makki & Somwaru (2001), who use the largest and most insurance-diverse data set, evaluate measures of expected indemnity for Iowa corn growers and include in their polytomous logit model. Just et al. (1999) rely on the comparison between stated yields percentiles and insurance premium, but do not include actual indemnities. Among the major drawbacks of the previous work is the fact that not all cases crop failures or low yields are indemnifiable. So in order to evaluate the demand of insurance, one has to include in the analysis what farmers actually get or would be reasonable to expect from their premia and compare it with the cost.

3. The Agricultural Insurance system in Spain

Agricultural insurance in Spain dates back to the beginning of the 20th century, but remained fairly unimportant and underwent various waves of decline and resurgence until 1978. This year saw the passing of the Agricultural Insurance Act which set the stage for a continuous growth of agricultural insurance in Spain. The Spanish system is based on a mixed public-private model, in which farmers' unions and association do also play a crucial role. Interested readers can learn a complete description of the Spanish insurance system in OECD and EU reports (OECD, 2001 & European Commission, 2000). In Figure 1, we plot the total liability of agricultural production, including livestock production, and the ratios of total expenditures in premium subsidisation over total liability. The graph shows the steady growth of the agricultural insurance, which now reaches about 30 to 40% of all eligible production. Farmers in Spain can choose among more than 200 different policies, that provide coverages to all possible crops and animal production. The system has evolved in the last 20 years to offer a wide menu of products to a wider range of crops and animal production. Premium are subsidised by the Spanish and Regional goverments in a percentage that range from 20 to 45% of the market premium. In the period 1980-2004, loss ratios for all policies, experimental policies and viable policies, were respectively, 99.56%, 114.31% and 82.98% (Agroseguro, 2004), indicating that the system has grown following sound actuarial criteria.

While Spain has followed a traditional approach to define insurable risks and establish loss adjustment procedures, fitting with the model of Multiple-peril Crop Insurance. In the last years, the system has evolved to provide yield insurance, based on individual or zonal records, for many crops including cereal and winter crops, olive trees and a number of other fruit crops. Two kinds on index insurance have been used experimentally with different success. The failed attempt came with a potatoe revenue insurance, based on a price index, offered in seasons 2003 and 2004, which very few farmers purchased. The more succesful example is 'drought' insurance available to range livestock growers, which is based on a vegetation index produced by from satelite images.

4. Data sources and documentation

The statistical and econometric analyses use data from the Spanish agricultural insurance system (ENESA). Our database includes records from individual farm from 7 agricultural diverse *comarcas* (equivalent to US counties). The complete database includes all 52,300 farmers that purchased insurance at least in two years between the period 1993-2004, and a complete characterisation of each farm's insurance strategy, paid premiums, premium subsidies, and collected indemnities. Table 1 summarises the main descriptive elements of each comarca. The database includes a diverse set of crop risks, natural conditions and kinds of insurance policies. For cereals, farmers can choose among three coverage levels, ranging from basic coverage including hailstorm and fire risks to individual yield risks. Fruit growers can choose among two coverage levels. From each farmer and year, records include the following variables: (1) If purchased any insurance (binary); (2) Crops insured, including surface (ha), expected yield (kg/ha), total liability (€), paid premium (€), premium subsidies (€), and the kind of coverage; (3) Indemnities (€) received by crop, coverage and year. In Table 1 we report the counts of dichotomous variable *Insur*, which takes 1 if the farm purchased at least one insurance policy in the corresponding year, and 0 other wise. Since the database contains 12 years, the maximum count is 12. Depending on the comarca, 50% of the farmers purchased at least one insurance policy between 4 and 6 years during 1993-2004.

Insurance demand analysis will be pursued along two different strategies, requiring the computation of different actuarial and behavioral variables. Using the data provided by the insurance records, we've generated a number of variables, that we first define and later on explain:

$Insur_{it}$ -- binary (0,1) -- if buys any insurance policy in year *t*.

$Insurance00\_03_t$ -- categorical (0,4) -- number of years between 2000 and 2003 where *Insur=1* (valid only for t=2003).

Exp_ben_{it} – numerical (≥0) – a dimensionless measurement of the expected benefit resulting from purchasing insurance, computed with the following formula (*i* farmer, *j* comarca, *k* crop, *t* year):

$$Exp\_ben_{it} = \frac{\sum_{t_0}^{t-1}\sum_k Ind_{ikt}}{\sum_{t_0}^{t-1}\sum_k Pmium_{ikt}} \quad \text{if} \quad Pmium_{ikt}>0 \quad \text{for at least one } ikt \tag{1}$$

where Ind_{ikt} is the indemnity (€) and $Pmium_{ikt}$ is the premium paid (€), net of subsidies, for crop *k* and year t. *Exp_ben* provides an idea of the actual expected benefits in terms collected indemnities for one euro spent in purchasing insurance policies.

$Exp\_ben\_in_{it}$– numerical (≥0) – a dimensionless measurement of the inferred expected benefit resulting from purchasing insurance, computed with the following formula (*i* farmer, *j* comarca, *k* crop, *t* year):

$$Exp\_ben\_in_{it} = Insur_{it-1}\frac{Liab_{ikt-1}\sum_k (Lossrat_{kjt-1})}{\sum_k Liab_{ikt-1}} + (1 - Insur_{it-1})\frac{TIns_{ik}\sum_k (Lossrat_{kt-1})}{\sum_k TInst_{ik}} \quad \text{if}$$

$$Ind_{ikt}=0 \ \ \forall kt \qquad (2)$$

$$Exp\_ben\_in_{ijt} = Exp\_ben_{ijt} \quad \text{if} \quad Ind_{ikt} \neq 0 \quad \forall kt \qquad (3)$$

where $Lossrat_{kt-1}$ is defined by $Lossrat_{kjt-1} = \frac{\sum_{t_0}^{t-1}\sum_i Ind_{ijkt}}{\sum_{t_0}^{t-1}\sum_i Pmium_{ijkt}}$, and represents the loss ratio of crop k in comarca k; $Liab_{ikt-1}$ represents total liability (€) of insured crop by farmer i. $Tins_{ik}$ is defined by: $Tins_{ik} = \sum_{t_0}^{t=2003} Ins\_crop_{kt}$; where $Ins\_crop_{kt}=1$ if crop k was insured in year t.

Var_{ijt}– numerical (≥0) – is a dimensionless measurement of the dispersion of the insurance payoffs, evaluated in relative terms, as follows:

$$Var_{ijt} = \sum_{t_0}^{t-1}\beta_t\left[Insur_{it}\frac{\sum_k (Disp_{ikt}Pmium_{ikt})}{\sum_k Pmium_{ikt}} + (1 - Insur_{it})\frac{TIns_{ik}\sum_k (Disp_{kjt})}{\sum_k TInst_{ik}}\right] \qquad (4)$$

where β_t is weighing factor with $\sum_{t_0}^{t}\beta_t = 1$ and $\beta_{t_1} > \beta_{t_0}$ if $t_1 > t_0$;

$$Disp_{ikt} = \left[\frac{Ind_{ikt} - Pmium_{ikt}}{Liab_{ikt}} - \frac{1}{t - t_0}\sum_{t_0}^{t}\frac{\sum_j (Ind_{ikt} - Pmium_{ikt})}{\sum_j Liab_{ikt}}\right]^2 \qquad (5)$$

$$Disp_{kjt} = \left[\frac{\sum_j (Ind_{jkt} - Pmium_{jkt})}{\sum_j Liab_{jkt}} - \frac{1}{t - t_0}\sum_{t_0}^{t}\frac{\sum_j (Ind_{jkt} - Pmium_{jkt})}{\sum_j Liab_{jkt}}\right]^2 \qquad (6)$$

$Third_{ijt}$– numerical (≤0) – is a dimensionless measurement of the third moment of the insurance payoffs, evaluated in relative terms similarly to Var_{ijt}, except for the exponents of $Disp_{ikt}$ and $Disp_{kjt}$, which are 3 instead of 2.

We now discuss the meaning of each of the above variables, with a few caveats in mind. First, our three variables are meant to provide a description of each farmer's past individual insurance experience, using his individual records as the main sources of information. Second, only when the records of a farmer are sparce or limited, we add in the insurance variables of his *comarca* to complete the evaluation of the variables. For instance, in (4) if a farmer did not purchase insurance in a given year *t-1*, then $Insur_{t-1}=0$ and his/her observation for Var_{ijt} is based on a weighted average of the *comarca*'s variance as evaluated by (6). Third, because the three variables are based on past recorded data, they have more explanatory power for the last years of the series, which include a longer history. So no model insurance demand model will be tested for t<1999. Fourth, the three variables are indices, that are meant to provide relative measures of the insurance returns of the farmer, irrespectively of his farm's size, cropping patterns, profitability, crops' risks or location.

The first variable, Exp_ben_{it}, is a typical loss ratio calculated individually along the insurance experience of the farmer. If for any given year it is greater than 1, that means that the farmer collected more indemnities up to year *t-1* than the total premium paid up to *t-1*. Note that premium subsidies significantly increase the loss ratios because the denominator is the sum of all premium, net of subsidies. Using the demand models, we will evaluate how the probabilities of the insurance participation variables may change with changes in the loss ratios under alternative subsidies. Exp_ben_{it} may be 0 if the farmer did not received an indemnity at up to year t-1. If the farmer had not purchased any insurance premium before year t (with t>2000), then Exp_ben_{it} is missing and not used in the analysis.

The fact that Exp_ben_{it}=0 does not imply that the expected benefit of purchasing insurance is zero. So as an alternative formulation, we use the inferred measurement of expected benefit, $Exp\_ben\_in_{it}$, which is based on a weighted average of the comarca's loss ratios of the crops he has purchased (formulated by expressions 2 and 3). Neither Exp_ben_{it} nor $Exp\_ben\_in_{it}$ are perfect indicators of the expected returns of purchasing insurance, but our hypothesis is that they may be good enough to explain farmers' insurance strategies. Figure 3 plots the histograms of *Exp_ben* and *Exp_ben_in*, both evaluated at the most recent year 2003, grouped by variable *Insurance00_03*. The differences of *Exp_ben* and *Exp_ben_in* are clearly associated with the subset of farmers that never received an indemnity. The histograms indicate that the proportion of farmers whose *Exp_ben>1* and *Exp_ben_in>1* is larger for the frequent insurance buyers (*Insurance00_03*>3) and for those who did not purchase insurance in any of the 4 years (*Insurance00*_03=0).

Table 2 reports the statistics and percentiles of *Exp_ben* (all observations and only those greater than 0) and *Exp_ben_in* (for those farmers that never got an indemnity) grouped also by variable *Insurance00_03*. In the first rows, we report *Exp_ben* only for those farmers whose records indicate they receive an indemnity at least once in their insurance history (n=33,291). For these, all *Exp_ben* means are greater than 1, largest for those farmers with *Insurace00_03=2* or *Insurace00_03=3*, and lowest for *Insurace00_03=0*. Medians are slightly above 1 for the frequent purchasers of insurance. The largest percentiles do not vary significantly across variable *Insurace00_03*=0. In the second set of roles, we report *Exp_ben* for all farmers (n=52,334). This would be the source of information required to carry out actuarial studies, as it comprises both farmers that have received at least an indemnity and those that have not. Means for *Exp_ben* range from 0.62 to 0.98, coinciding with those for farmers with *Insurace00_03*=0 and *Insurace00_03*=4, respectively. Medians differ widely and reach 0.7 for the most frequent insurance purchasers. The largest percentiles are similar among groups with different *Insurace00_03* and similar to the farmers with a positive indemnity in their insurance history. In the last set of rows we report the inferred measures of insurance expected benefits, *Exp_ben_in*, for those farmers (n=20,043) including in the records that did not receive an indemnity in their entire insurance history. All statistics of *Exp_ben_in* differ significantly to those just commented. Means and percentiles do not vary significantly across values of *Insurace00_03*, and medians are strikingy similar. The largest percentiles are much lower than those farmers with indemnities recorded in their insurance history.

The statistics reported in Table 2 seem to suggest that larger expected benefits from insurance, either actuar or inferred from the *comarca*, are associated with more frequent insurance purchasing. However, the evidence is dubious and poorly significant to discriminate among the intermediate levels of *Insurace00_03*.

The second and third variables, Var_{ijt} and $Third_{ijt}$, are by construction different from 0 for all farmers, irrespectively of their insurance experience. They are meant to provide a sense of the relative dispersion of the difference between collected indemnities and paid premiums. For this two variables we are assuming that, if the farmer did not purchase any policy in year t, an equivalent measurement of the dispersion of payoffs is provided by his comarca's. Note also that, the inclusion of β_t ensures that more weight is placed on the most recent years up to t ensures. This is the way we introduce a slight degree of memory in the construction of variances, in the same vein as Holt and Chavas (1990) did. As these two variables are meant to provide an idea of the dispersion of the whole insurance experience of the farmer, they are evaluated taking into account the relative importance of each insured crop. Note, however, that Exp_ben_{it} (or $Exp\_ben\_in_{it}$, for that matter) and variables Var_{ijt} and $Third_{ijt}$ provide a completely different description of the insurance experience of a farmer. While Exp_ben_{it} provides a pure return of the money spent in purchasing insurance, Var_{ijt} and $Third_{ijt}$ capture the relative dispersion of the payoffs. In Table 3 we report the statistics of *Var* for 2003 grouped by levels of *Exp_ben*. While the largest mean (0.64) and median (0.68) are for the group with moderately large *Exp_ben* (between 1 and 2.5), the largest 95% percentiles and 99% percentiles belong to the group with the largest *Exp_ben* (>2.5). In sum, Table 3 shows that Var and Exp_ben are somewhat related (ρ=0.09 at p>0.01), but along a rather non-linear relationship. A final note about the different role of our two measures of expected revenue and dispersion of reports (*Var* and *Third*) refers to impact of premium subsidies. While our measures of insurance expected returns are highly sensitive to the level subsidies, *Var* and *Third* are so in a much lesser extent. This will allow us to infer likely changes in the probabilities of insurance participation levels caused by lower premium subsidies, focusing only on the coefficient of *Exp_ben* or *Exp_ben_in* of our insurance demand models.

5. Insurance demand models

Two approaches can be taken to estimate insurance demand models, each which its own variants and assumptions. In the first approach, we only look at the dichotomous choice of purchasing or not purchasing any insurance policy. In the second approach, we estimate a count model of the number of years between 2000 and 2003 farmers purchased any insurance.

In the first case, we assume a farmer will purchase at least one insurance poliy in year *t* if:

$$\Pr(Insur_{it} = 0 | X_{t-1}) = \Pr(\beta' X_{t-1} + \varepsilon_{it} > 0) \quad (7)$$

where the explanatory variables X_{t-1} are those defined in the previous section, which are entirely based on the farmer's past insurance experience, and a set of dummies specific for each *comarca*. Variants of this model are estimated as a probit models[3]. The major difficulty of this approach is choosing the variable capturing the expected returns from insuring, namely, choosing an inferred or guessed variable or using the actual returns based on the farmer's records. Having no a priori clue of what is appropriate, we base our choice on the econometric results, models' predicting accuracy and goodness of fit.

Table 4 reports the results for three specifications (*Exp_ben*, *Exp_ben_in*, and *Exp_ben* using only farmers for whom $Ind_{ikt} \neq 0$ for any *t*). The models are run for 2003, 2002 and for all observations including 2000-2003. The reason the 2003 runs have more observations than 2002

[3] A comparison of logit and probit estimates was carried out, finding very similar coefficients and goodness of fits. Yet, based on better accuracy on Sensitivity and Specificity for *Insur*, probit models performed slightly better.

is because there are about 2,200 farmers that became insurers in 2003 for the first time. All runs have reasonable good sensitity and specificity indicators. These in turn are similar within the same models, indicating that both the *1*s and the *0*s are predicted with similar accuracy. Also, the monotonicity of the estimates for expected benefit, *Var* and *Third* is very consistent across models, in the sense that larger estimates of one coefficient are accompanied by larger estimates of the other two.

The estimates of coefficients for *Var* and *Third* do not vary significantly across models and time-periods. Farmers seem to respond positively to larger variances of loss ratios (*Var*) and negatively to larger absolute values of the third moment of the loss ratios (recall that *Third* is always negative). Interpreting this result is not straightforward, because *Var* and *Third* provide similar although slightly differerent measurements of dispersion of loss ratios. What it seems to suggest is that the probability of purchasing insurance is greater when loss ratios exhibit greater variation, but are less negatively skewed around the expected loss ratio.

The most significant differences across models and time-periods come from the comparison of the coefficients of *Exp_ben_in* and *Exp_ben*, which range from 0.265 in the model with *Exp_ben*>0 (7th column in Table 4) to a minimum of 0.05 in the model with *Exp_ben* with 2002 data. This is partly due to the fact that both the median and the mean of *Exp_ben* are smaller in 2002 than in 2003, but also because with *Ex_ben* we include a large proportion of farmers that have never received an indemnity. The last three columns in Table 4 report the largest coefficients for those farmers with *Exp_ben*>0. They are quite stable across periods, and jointly with the other coefficients, contribute to the best model's fits. On average, they indicate that if a farmer's past experience is associated with a loss ratio of 1, the probability of purchasing insurance is about 25%.

In table 5 we report the probit models for 2003 and the sample with *Exp_ben*>0, but the observations divided by the threshold of *Exp_ben* =1. In the first column, we report the probit regression results of those with 0<*Exp_ben*<1 (n=16,649), and in the second column we report those with *Exp_ben*>1 (n=15,542). The coefficients for the three key variables differ across samples, being significantly larger for those with loss ratios smaller than 1. While one would expect that the coefficient of expected benefits is larger for the group with 0<*Exp_ben*<1, it is telling that those for *Var* and *Third* do also differ in such large extent considering the low correlation between *Exp_ben* and *Var*. This result is an indication that farmers respond to both the expected benefits from insurance as well as the dispersion of their loss ratios with respect to the loss ratios relevant to them. But it suggests that some farmers are willing trade-off some expected benefits from insurance in return for larger loss ratios' dispersion. For those farmers

0<*Exp_ben*<1, with this can only occur if indemnities are larger relative to liabilities but less frequent.

Insurance demand models can also be estimated as a count models, counting the number of years that a given farmer decides to purchase any type of insurance policy. This is what we do in our second approach. The dependent variable is *Insurance00_03*, which is evaluated in 2003 and takes on values from 0 (no insurance purchased during 2000 and 2003) to 4 (insurance is purchased in all years during 2000-03). The model is estimated as a Zero-inflated model (ZIP)[4], using the same explanatory variables used for the probit models. ZIP models are used when zero outcomes could arise out of two regimes. In our case, the fact that for some farmers *Insurance00_03=0* is qualitative different from the case of *Insurance00_03>0.* In the first case insurance may not be purchased because the farmer simply retired or sold hos/her farm. In the second case, purchasing insurance may not always be a desirable risk management instrument because of low expected returns or inadequate indemnity regimes. ZIP model includes a binary probability model (logit or probit) that determines whether a zero or nonzero outcome occurs, and then in the second case a Poisson distribution describes the positive observations. Following the specification proposed by Greene (2000, p.890), let z dente a binary indicator of regime 1 (z=0) or regime 2, and let y* denote the outcome of the poisson process of regime 2. If z is determined by a set of covariates Z_{it-1}, the model is formulated as:

$$\Pr(z_i = 1) = F(Z_{it-1}\gamma) \tag{8}$$

$$\Pr(y_i = j | z_i = 1) = \frac{e^{-\mu_i}\mu_i^j}{j!(1-e^{-\mu_i})}, \text{ with j=1,2,3,4} \tag{9}$$

Note that the covariates included in the first regime, (8), Z_{it-1} may be different from those of the second regime, $X_{it-1.}$ ZIP models also differ from standard Poisson in that ZIP models do not impose that the mean and variance be equal (overdispersion), as Poisson model does. However, overdispersion may be caused by agents' heterogeneity or by the regime splitting mechanism. In the first case, the true model is a Negative Binomial Regression Model (NBREG) and in the second case there may be a true regime splitting mechanism. Checking whether a NBREG process explains the data can be done with a Likelihood ratio test of the null hypothesis of $\alpha=0$, this parameter being the degree of overdispersion (Long and Freese, 2001).

[4] Greene (2000) notes that this model has been coined in the literatura as 'With Zeros' (WZ), 'Zero Inflated Poisson' (ZIP) and 'Zero-Altered Poisson' (ZAP).

If H_0 is not rejected then there is no overdispersion and the process is Poisson. As regard the other issue, whether or not overdispersion is due to a regime splitting mechanism, Voung (1989) proposed a test statistic for nonnested models, such as ZIP and Poisson. Since we rejected the presence of overdispersion caused by heterogeneity (H_0: $\alpha=0$) for all specifications, the NBREG model was not used.

Voung test gave support of the ZIP model over the standard Poisson model (as shown in Table 6), indicanting that the zero-split regime seems to fit well with farmers' records of *Insurance00_03*. For the regime 1 model we have used a probit specification with *Exp_ben*, *Var* and *Third*, ommitting comarca's dummies[5]. The reason for including these three variables is due to the conjecture that they may also affect the decision of not purchasing insurance in none of the four years between 2000 and 2003.

The results of the ZIP model are thus reported in Table 6, together with the median predictions for *Insurance00_03* for year 2003. While we only report the coefficients for *Exp_ben* or *Exp_ben_in*, *Var* and *Third*, all regressions have been run including an intercept and the comarca's dummies. All coefficients are highly significant and quite similar across regressions. Signs, order of magnitude and differences between Expected benefit, Var and Third follow the same pattern found with probit models reported in Tables 4 and 5. The ZIP model is thus a complementary approach to the probit models shown before.

Predicted values for the dependent variable $Insurance00\_03_t$ are centered on the observed values, except for the cases where $Insurance00\_03_t$=1. In this case the prediction is biased towards 2, especially in the regression which includes only those *Exp_ben>0* (third column). The models seem to predict better when $Insurance00\_03_t$>2, than if $Insurance00\_03_t$<2.

The role of premium subsidies and changes in the indemnities schemes

The literature on insurance demand is clear about the effect of premium subsidies. If, as all available evidence overwhelmingly shows, farmers respond to the economic incentives that agricultural insurance policies provide, they would necessarily respond to changes in the premium subsidies. Average premium subsidies range from 20-45% of the comercial premium, but the difference of expected benefits with subsidies and without subsidies is much smaller (for instance in Guadalentín *Exp_ben* average and median 0.49 and 0.09 with subsidies, and 0.42 and 0.06 without subsidies). Variable *Var* is slightly smaller without subsides (average=0.47 &

[5] The results for the regime 1 (probit) model are not reported in the paper, but can be obtained from the authors upon request.

median=0.42) than subsidies (average=0.56 & median 0.49). So with lower subsidies there would be a double disincentive to purchase insurance via lower expected revenue and lower variance. As the third moments are primarily driving by the asymmetry of the expected results, we do not expect them to change significantly as premium subsidies become lower.

Table 7 reports the point estimates for $Insurance00\_03_t$ for the three ZIP specification models on Table 6. These estimates are evaluated for four values of expected benefits from insurance (0.375; 0.625; 0.875; 1.125), three values of Var_{t-1} (0.3; 0.45; 0.6), the comarca of Guadalmellato and the average value of $Third_{t-1}$. The estimates for the remaining comarcas were not much different to merit a new table of point estimates. Results show that the impact of changes of Var_{t-1} is significantly larger than those of any measure of expected benefits. We find that a reduction of subsidies would add little to the demand for insurance, as long as Var_{t-1} is below 0.45 and expected benefits are below 0.625. For farmers with intermediate expected benefits (between 0.625 and 0.875), a strong reduction of subsidies (so that benefits fall by 0.25) would reduce insurance purchasing counts by a range of 0.02 and 0.4. When expected benefits are very high (1.125), a reduction of 0.25 points in expected benefits would reduce insurance counts by 0.02, if Var_{t-1}=0.3, and by 0.20, if Var_{t-1}=0.6. These results indicate that farmers respond to premium subsidies, and the way their expected benefits from insurance are driven by the actual cost of premia, but they are significant more responsive to the variance of the expected benefits.

8. Summary and conclusions

In this study, we have analysed the demand for agriculture insurance using a new empirical approach that takes into account farmers' insurance actual results. Using the complete records of all farmers of 7 Spanish comarcas with any insurance experience in 11 years, we computed three two alternative measures of individual expected benefits, variance and the third moment. Results show that farmers' insurance uptaking are robustly explained by these three variables describing the observed economic returns from insurance and its variability are enough to explain insurance demand patterns found across widely different agricultural conditions. We hypothesize that farmers with insurance records who never collected an indemnity respond to a measure of expected benefit that is based on a weitghted average of loss ratios of his comarca and his crops.

We developed a two alternative demand models in order to include in the analyses the observations related to farmers that, even if they show evidence of being active insurees, they have never received an indemnity. Both binary models (probit) and count models (Zero-inflated

Poisson model) provide consistent results, and show evidence of farmers being responsive to our measures of the patterns of economic returns to agricultural insurance. Yet, all models and specifications show that the variability of returns (variance and third moment) have much more influence than the expected benefits. The main policy conclusion of these results is that premium subsidies play a minor role in comparison of the indemnities' patterns. More dispersed indemnities patterns, in amount and frequency, are followed by more insurance participation. This implies that farmers purchase insurance primarily to seek insurance coverage from occasional and greater indemnities, and secondarily to get return from their insurance premia.

The analyses carried out here are just a small fraction of the issues that the database invites to look at. We have completely left out promising analyses of the farmers' choice of coverage and more crop-specific insuring strategies.

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Tables

Table 1. Description of the study comarcas and insurance data

Comarca’s Name	Autonomous Community	Main insured crops	No. of farmers	Number of years between in which *Insur=1* between 1993-2004				
				Mean	perc25	Median	perc50	perc95
Mancha	Castilla-La Mancha	Vineyards, Vegetables, Cereals	12846	5.69	2	5	9	12
Campina	Andalusia	Cereals, Citrus, Cotton, Olive, Sunflower	5095	5.88	3	5	8	11
Segria	Catalonia	Fruits, Cereals, Vineyards, cereals	6324	6.58	3	6	10	12
Guadalentin	Murcia	Vegetables, Greenhouse crops, Grapes, Fruits	2112	4.81	2	4	7	11
Campos	Cast-Leon	Cereals, Sugar Beet, Leguminosae	4323	6.69	4	6	10	12
Albaida	C. Valenciana	Fruits, Grapes, Vineyard, Citrus, Vegetables	2677	6.22	3	5	9	12
Jucar	C. Valenciana	Fruits, Citus, Vegetables	18957	6.26	4	6	9	12

Total	52334	6.10	3	6	9	12

Source: ENESA

Table 2. Reports of *Exp_ben* and *Exp_ben_in* for year 2003

***Exp_ben* (only those with *Exp_ben>0*)**

Insurance00_03	N	mean	perc25%	median	perc75%	perc95%	perc99%
0 (No ins 2000-03)	7943	1.14	0.43	0.85	1.55	3.33	4.42
1 (Once 2000-03)	1974	1.19	0.37	0.77	1.69	3.69	4.53
2 (Twice 2000-03)	3181	1.39	0.47	1.00	2.02	3.91	4.77
3 (Three 2000-03)	3356	1.39	0.50	1.08	1.99	3.85	4.66
4 (All years 2000-03)	15837	1.28	0.51	1.02	1.79	3.33	4.42
All observations	32291	1.26	0.47	0.96	1.77	3.50	4.51

***Exp_ben* (all farmers including those with *Exp_ben=0*)**

	N	mean	perc25%	median	perc75%	perc95%	perc99%
0 (No ins 2000-03)	6626	0.83	0.41	0.75	1.18	1.53	2.19
1 (Once 2000-03)	2390	0.84	0.39	0.76	1.18	1.72	2.23
2 (Twice 2000-03)	3667	0.91	0.46	0.78	1.38	2.09	2.26
3 (Three 2000-03)	2586	0.86	0.38	0.78	1.23	2.13	2.98
4 (All years 2000-03)	4774	0.97	0.56	0.78	1.50	2.13	2.99
All observations	20043	0.88	0.41	0.77	1.24	1.98	2.26

***Exp_ben_in* (all including farmers)**

	N	mean	perc25%	median	perc75%	perc95%	perc99%
0 (No ins 2000-03)	14569	1.00	0.41	0.76	1.33	2.62	4.13
1 (Once 2000-03)	4364	1.00	0.38	0.76	1.30	2.79	4.18
2 (Twice 2000-03)	6848	1.14	0.47	0.83	1.45	3.13	4.43
3 (Three 2000-03)	5942	1.16	0.42	0.83	1.50	3.30	4.48
4 (All years 2000-03)	20611	1.21	0.52	0.94	1.57	3.10	4.30
All observations	52334	1.12	0.45	0.84	1.49	3.02	4.31

Source: ENESA

Table 3. Statistics of *Var* for all observations, based on *Ex_ben* for 2003 (all observations)

Values of Exp_ben	N	mean	perc25%	median	perc75%	perc95%	perc99%
Exp_ben = 0	20043	0.40	0.19	0.34	0.56	0.85	0.97
0.5> *Exp_ben* > 0	8526	0.59	0.35	0.65	0.82	0.96	1.04
1 > *Exp_ben* > 0.5	8123	0.61	0.33	0.68	0.87	1.01	1.11
2.5> *Exp_ben* > 1	11407	0.64	0.33	0.68	0.94	1.15	1.35
Exp_ben > 2.5	4235	0.60	0.26	0.53	0.90	1.32	1.71
Total	52334	0.53	0.24	0.51	0.80	1.05	1.26

Table 4. Probit models of insurance demand (dep variable $Insur_t$)

	Model Exp_ben (all)			Model Ex_ben_in			Model Exp_ben (only >0)		
	2003	2002	2000-03	2003	2002	2000-03	2003	2002	2000-03
Exp_ben_{t-1}	0.126	0.050	0.059				0.265	0.237	0.231
	0.007	*0.007*	*0.003*				*0.009*	*0.010*	*0.005*
$Exp\_ben\_in_{t-1}$				0.205	0.096	0.122			
				0.008	*0.008*	*0.004*			
Var_{t-1}	6.174	5.569	5.529	6.713	5.838	5.845	7.641	7.270	7.333
	0.113	*0.109*	*0.056*	*0.116*	*0.112*	*0.056*	*0.137*	*0.137*	*0.070*
Third	3.373	2.813	2.905	3.813	3.040	3.169	4.398	3.912	4.061
	0.101	*0.097*	*0.049*	*0.103*	*0.099*	*0.050*	*0.116*	*0.114*	*0.058*
Campiña_dum	0.184	0.213	0.265	0.156	0.192	0.235	-0.174	-0.195	-0.070
	0.024	*0.024*	*0.012*	*0.024*	*0.024*	*0.012*	*0.037*	*0.038*	*0.019*
Segria_dum	0.147	0.230	0.239	0.071	0.191	0.183	0.076	0.123	0.204
	0.022	*0.023*	*0.011*	*0.023*	*0.023*	*0.012*	*0.027*	*0.029*	*0.014*
Guadalentin_dum	-0.094	0.038	-0.020	-0.089	0.039	-0.020	-0.077	0.074	0.070
	0.036	*0.035*	*0.018*	*0.036*	*0.036*	*0.018*	*0.050*	*0.051*	*0.025*
Campos_dum	0.031	0.051	0.103	-0.020	0.028	0.074	-0.025	-0.009	0.030
	0.017	*0.018*	*0.009*	*0.018*	*0.018*	*0.009*	*0.023*	*0.025*	*0.013*
Albaida_dum	0.199	0.233	0.187	0.200	0.235	0.189	0.188	0.285	0.316
	0.031	*0.031*	*0.016*	*0.031*	*0.031*	*0.016*	*0.042*	*0.044*	*0.022*
Jucar_dum	0.787	0.787	0.796	0.729	0.772	0.773	0.792	0.695	0.764
	0.018	*0.019*	*0.009*	*0.020*	*0.020*	*-0.010*	*0.027*	*0.030*	*0.015*
Intercept	-1.703	-1.668	-1.572	-1.843	-1.736	-1.660	-2.152	-2.283	-2.217
	0.018	*0.019*	*0.009*	*0.020*	*0.020*	*-0.010*	*0.027*	*0.030*	*0.015*
Sensitivity Pr(+| D)	0.798	0.811	0.792	0.80	0.812	0.7941	0.871	0.881	0.879
Specificity Pr(-|~D)	0.745	0.720	0.705	0.75	0.7258	0.7063	0.716	0.726	0.718
Positive predictive value Pr(D| +)	0.786	0.780	0.777	0.787	0.7838	0.7778	0.818	0.820	0.823
Negative predictive value Pr(~D| -)	0.758	0.757	0.724	0.759	0.7593	0.726	0.791	0.811	0.799
McFadden's R2	0.294	0.288	0.269	0.299	0.289	0.271	0.359	0.379	0.369
No. Obs	52334	49917	195230	52334	49917	195230	32291	28830	111136

All coeficients assymptotically significant at p>0.01

Standard deviations reported in the cells below the coefficients

Table 5. Probit models of insurance demand (dep variable Insur) differentiating Exp_ben>1 and Exp_ben<1

(year=2003)	Only if Exp_ben_{t-1}>0 & Exp_ben_{t-1}<1	Only if Exp_ben_{t-1}>0 & Exp_ben_{t-1}>1
Exp_ben_{t-1}	0.397	0.209
	0.0459	*0.0139*
Var_{t-1}	10.08	7.00
	0.316	*0.193*
$Third_{t-1}$	6.769	3.926
	0.3104	*0.162*
Sensitivity Pr(+| D)	0.866	0.88
Specificity Pr(-|~D)	0.753	0.68
Positive predictive value Pr(D| +)	0.814	0.83
Negative predictive value Pr(~D| -)	0.82	0.76
McFadden's R2	0.391	0.326
n. Obs	16649	15642

All coeficients assymptotically significant at p>0.01

Standard deviations reported in the cells below the coefficients

Table 6. Zero-inflated regression models of insurance demand (Dependent Variable *Insurance00_03* $_t$)*

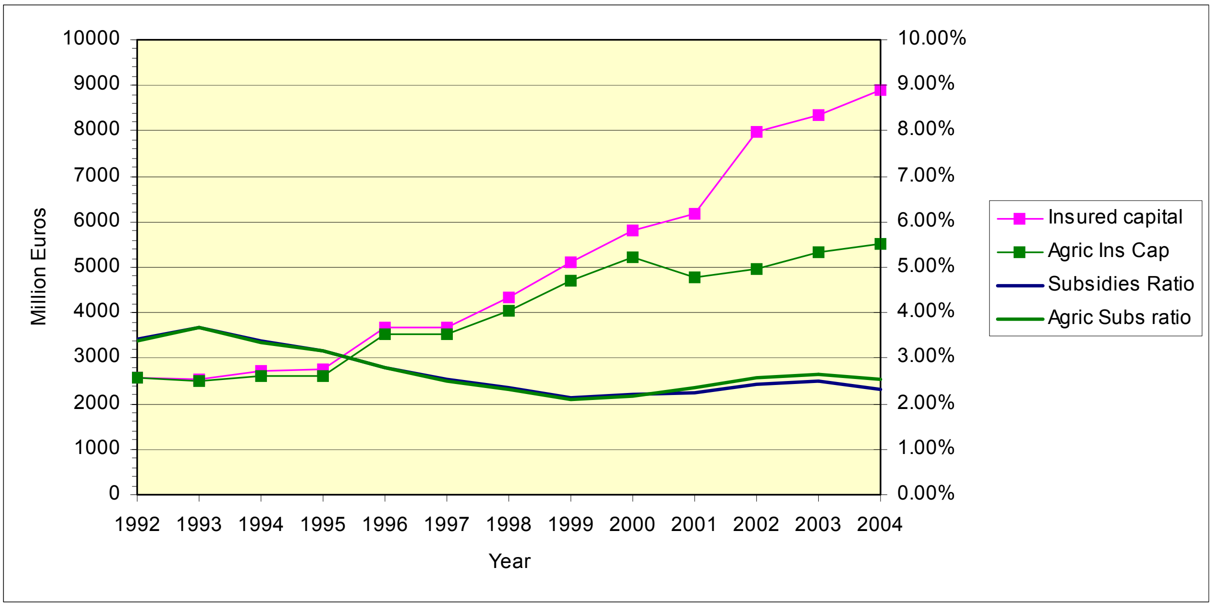
	Exp_ben (all)	Exp_ben_in (all)	Exp_ben>0
Exp_ben $_{t-1}$	0.0424		0.0603
	0.003		*0.004*
Exp_ben_in $_{t-1}$		0.0712	
		0.004	
Var $_{t-1}$	2.818	3.068	2.532
	0.052	*0.056*	*0.066*
Third	1.583	1.780	1.434
	0.045	*0.047*	*0.052*
Log likelihood	-72702.9	-72613.8	-45229.1
n.obs	52331	52331	32290
Non-zero obs	37762	37762	24347
Vuong Test	67.28	66.1	66.1
Predictions Insurance00_03		median	
Insurance00_03=0	0.47	0.47	0.28
	0.63	*0.63*	*0.68*
Insurance00_03=1	1.53	1.57	2.07
	0.84	*0.83*	*0.91*
Insurance00_03=2	1.74	1.74	2.35
	0.93	*0.93*	*0.96*
Insurance00_03=3	2.59	2.59	2.96
	0.89	*0.90*	*0.88*
Insurance00_03=4	3.62	3.60	3.67
	0.71	*0.72*	*0.62*

*The coefficients of the comarca's dummies and intercept are ommitted in the Table, but used in the regression
All coeficients assymptotically significant at p>0.01
Standard deviations reported in the cells below the coefficients

Table 7. Point estimates of predicted counts based on the expected returns of insurance and variance (Using ZIP models reported on Table 6 for Guadalentín, and average value of $Third_{t-1}$)

(year=2003)		Central values for expected benefits			
Equation	Var_{t-1}	0.375	0.625	0.875	1.125
Exp_ben	0.3	0.9955	1.008	1.008	1.0335
	0.45	1.85	1.87	2.16	2.215
	0.6	2.5	2.505	2.945	3.07
Exp_ben (only>0)	0.3	0.85	0.87	0.87	0.91
	0.45	1.73	1.77	2.085	2.185
	0.6	2.43	2.43	2.87	3.075
Exp_ben_inf	0.3	0.85	0.91	0.91	1.03
	0.45	1.74	1.8	2.13	2.24
	0.6	2.465	2.465	2.925	3.135

Figure 1. Total agricultural insurance liability and ratios of Premium subsidies over liability in Spain (1992-2004)



Source: ENESA (2005)

Figure 2. Histograms for Exp_ben (when >0) and Exp_ben_in (year 2003) based on Insurance00_03