The impact of farmers' risk preferences on the design of an individual yield crop insurance

Douadia Bougherara* Laurent Piet†‡

September 6, 2013

Paper submitted to the 7èmes Journées de Recherches en Sciences Sociales
Angers (France), December 12-13, 2013

Acknowledgments

We acknowledge the financial support from ONEMA project AVERSIONRISK ("Rôle de l'aversion au risque des agriculteurs dans l'utilisation de pesticides et implications pour la régulation") which is part of the research program "Evaluation et réduction des risques lies à l'utilisation des pesticides" in the framework of the "Plan Ecophyto 2018 - Axe 3". We are grateful to the Centre de Gestion et d'Economie Rurale de la Meuse/CER France (ADHEO) for providing the data.

---

*INRA, UMR5474 LAMETA, F-34000 Montpellier

†INRA, UMR1302 SMART, F-35000 Rennes

‡Corresponding author: INRA, UMR SMART, 4 allée Adolphe Bobierre, CS 61103, F-35011 Rennes cedex; laurent.piet@rennes.inra.fr

The impact of farmers' risk preferences on the design of an individual yield crop insurance

Abstract

In this paper, we argue that neglecting that Kahneman and Tversky's Cumulative Prospect Theory (CPT) has proved to be better suited for representing preferences towards risk in place of the traditional von Neumann and Morgenstern's Expected Utility Theory (EUT) may be sufficient to explain why farmers do not contract crop insurance policies as much as they are expected to do. We illustrate our case by modeling the decision to contract an individual yield crop insurance for a sample of 186 farmers of the "Meuse" region located in the North-eastern part of France. We show that, if almost 60% of the farmers in the sample would be willing to contract the proposed insurance under the EUT assumption, virtually none of them would be ready to actually do so under the preferred CPT framework. We also compare the welfare implications of two alternative policies which would allow reaching the EUT-expected level of contracting under the CPT assumption.

Keywords: yield, crop insurance, cumulative prospect theory, public policy

JEL classification: D81, Q10, Q12, Q18

The impact of farmers' risk preferences on the design of an individual yield crop insurance

1 Introduction

The debate on, on the one hand, why farmers do not contract crop insurance policies as much as they should when considering the risk they face and, on the other hand, the ways to remedy the issue by designing optimal insurance contracts, has a long history in the economic research.

From the insurer's point of view, *i.e.*, the supply side of the crop insurance market, authors have identified three main reasons why insurance companies are likely to set too high premiums, namely moral hazard and adverse selection (see Skees, Black, and Barnett (1997), Nelson and Loehman (1987), Quiggin, Karagiannis, and Stanton (1993), Glauber (2004) and Smith and Glauber (2012) among others) and the systemic nature of the risk (Miranda and Glauber, 1997).

From the farmer's point of view, *i.e.*, the demand side of the crop insurance market, it has been noted that farmers are likely to prefer cheaper ways of coping with production risk than insurance (Smith and Glauber, 2012). As far as moral hazard and adverse selection are concerned, authors mainly assumed that they originate from the propensity of farmers to adopt 'fraudulent' behaviors vis-à-vis the insurer in order to exploit information asymmetries (Miranda and Glauber, 1997). In this paper, we argue that such a situation is also likely to simply derive from the preferences of farmers (*i.e.*, 'non fraudulent' attitudes) towards risk.

In effect, the von Neumann and Morgenstern (1947) Expected Utility theory (EUT) has been the dominant invoked theoretical framework in most previous papers to model the decision of risk-averse farmers to get insured or not. However, since the pioneering work of Kahneman and Tversky (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992), many empirical studies have confirmed that the Cumulative Prospect Theory (CPT) is a more adequate framework to represent agents' attitudes towards risk (Tanaka, Camerer, and Nguyen, 2010), farmers being no exception (Galarza, 2009; Bougherara, Gassmann, and Piet, 2011; Godinho Coelho et al., 2012; Bougherara et al., 2012). CPT extends EUT in three respects. Firstly, agents are not only risk averse but also loss averse, that is, the dis-utility of a loss is larger than the utility of a gain of the same absolute amount. Secondly, losses and gains are determined with respect to a threshold which is commonly set to zero for convenience purposes but which is likely to depend on the situation. Thirdly, agents 'distort' the probabilities for events to occur in their utility computation, even when having an objective knowledge of these probabilities; empirically, people generally have been found to overestimate small probabilities and to underestimate high probabilities.[1]

Here, we show that using the theoretical framework of the CPT to model preferences towards risk may be sufficient to explain why farmers do not contract insurance as much as they are expected to under the assumption that they follow the theoretical framework of the EUT. To do so, we model the decision to contract an individual yield crop insurance for a sample of 186 farmers of the "Meuse" region located in the North-eastern part of France, and investigate the policy implications of such an extended theoretical modeling framework.

The paper is organized as follows: section 2 presents the modeling framework; section 3 describes the data used and the functional forms chosen; section 4 reports the results and; section 5 concludes.

2 Modelling framework

We consider N farmers who produce a unique and homogeneous good with an individual-specific yield $\tilde{y}_i$, where $i = \{1, \ldots, N\}$. This yield is random because production is subject to exogenous chocks such as climatic events or pests attacks.

---

[1] For instance, this would explain why some people do not like to travel by plane though the probability of a crash is very low while, symmetrically, some other do not spontaneously fasten their security belt when driving though the probability of an accident is much higher.

In order to secure production against such risks, farmer i may decide to contract an individual yield crop insurance (IYCI) from a unique insurance company. The contract is defined as follows: if, at the end of the cropping season, the realized yield $\tilde{y}_i$ is lower than a critical yield $y_i^* > 0$ defined in advance, he receives an indemnity $n(\tilde{y}_i)$, and nothing otherwise. Formally:

$$n(\tilde{y}_i) \equiv \max(y_i^* - \tilde{y}_i, 0) \tag{1}$$

where, following Miranda (1991) and the subsequent works by Smith, Chouinard, and Baquet (1994), Skees, Black, and Barnett (1997) or Mahul (1999), $n(\tilde{y}_i)$, is expressed in tons per hectare.

We further impose three restrictions on the insurance contract. Firstly, we consider the 'pure community rating' case: in order to get insured, farmer i has to pay a t/ha-equivalent premium ρ which is uniform across farmers. Secondly, we do not allow farmers to insure only a fraction of their area so that the decision to purchase the contract may be modeled through a set of binary variables d_i, where $d_i = 1$ when farmer i actually purchases the contract and $d_i = 0$ when he actually does not. Finally, we do not let the farmer elect the critical yield y_i^*. Each farmer therefore gets the net yield:

$$\tilde{y}_i^{net} = \tilde{y}_i + n(\tilde{y}_i) - \rho. \tag{2}$$

Miranda (1991), Smith, Chouinard, and Baquet (1994) and Skees, Black, and Barnett (1997) assumed that, through insurance, farmers seek to minimize the variance of their net yield or, equivalently, to maximize their yield risk reduction, as measured by the difference between the variance of the yield and the variance of the net yield. Rather, Mahul (1999) and Bourgeon and Chambers (2003) considered that the farmers' objective is to maximize the expected utility stemming from the net yield. We adopt a third approach which is also based on the maximization of the expected utility but consists in viewing the maximization program of the farmer as a lottery choice. Actually, each farmer faces the following two lotteries:

- *'Insurance lottery'*: if the farmer contracts, he faces the following outcomes:
  - if $\tilde{y}_i < y_i^*$, the net yield he expects is $y_i^* - \rho$
  - if $\tilde{y}_i \geq y_i^*$, the net yield he expects is $\overline{y}_i - \rho$
- *'Non-insurance lottery'*: if the farmer does not contract, he faces the following outcomes:
  - if $\tilde{y}_i < y_i^*$, the net yield he expects is $\underline{y}_i$
  - if $\tilde{y}_i \geq y_i^*$, the net yield he expects is $\overline{y}_i$

where $\underline{y}_i \equiv \mathrm{E}(\tilde{y}_i|\tilde{y}_i < y_i^*)$ and $\overline{y}_i \equiv \mathrm{E}(\tilde{y}_i|\tilde{y}_i \geq y_i^*)$. In both lotteries, the 'unfavorable' outcome, *i.e.*, whenever $\tilde{y}_i < y_i^*$, happens with the probability q and the 'favorable' outcome, *i.e.*, whenever $\tilde{y}_i \geq y_i^*$, happens with the probability $1 - q$.

In order to set up a general enough framework to encompass both the EUT and the CPT, we assume that: i) there exists an individual-specific value function $\nu_i(y) : \mathbb{R}^+ \rightarrow \mathbb{R}$ which maps yields into the utility space, and; ii) farmers, when evaluating their utility, distort the cumulative probability of yields through an individual specific weighting function $\psi_i(q) : [0,1] \rightarrow [0,1]$. Further assuming that the 'unfavorable' outcome is less likely than the 'favorable' outcome ($i.e.$, $q < 1/2$), the expected utilities of the above lotteries are given by:

- *'Insurance lottery'*: $\mathrm{E}\big(U_i^I(\rho)\big) = \psi_i(q)\nu_i(y_i^* - \rho) + \big(1 - \psi_i(q)\big)\nu_i(\overline{y}_i - \rho)$
- *'Non-insurance lottery'*: $\mathrm{E}\big(U_i^N\big) = \psi_i(q)\nu_i(\underline{y}_i) + \big(1 - \psi_i(q)\big)\nu_i(\overline{y}_i)$

Under this setting, farmer i will decide to purchase the insurance as long as the 'insurance lottery' will provide him with an expected utility greater than or at least equal to the 'non-insurance lottery':

$$d_i = 1 \quad \Leftrightarrow \quad \mathrm{E}\big(U_i^I(\rho)\big) \geq \mathrm{E}\big(U_i^N\big) \tag{3}$$

For each farmer, we can then find the threshold premium $\hat{\rho}_i$ which leaves him indifferent between both lotteries (*i.e.*, $U_i^I(\hat{\rho}_i) = U_i^N$), that is, his willingness-to-pay (WTP) for transferring his risk to the insurer. Equation (3) then re-writes:

$$d_i \times \big(\mathrm{E}\big(U_i^I(\rho)\big) - \mathrm{E}\big(U_i^I(\hat{\rho}_i)\big)\big) \geq 0 \tag{4}$$

Finally, because the insurer only knows the history of individual yields but does not know the private characteristics of farmers, *i.e.*, their individual-specific functions ν_i and ψ_i, he sets the uniform premium to the following fair level:

$$\rho = \frac{1}{N} \sum_{i=1}^{N} \mathrm{E}\big(n(\tilde{y}_i)\big) \tag{5}$$

3 Empirical study

3.1 Data

We used individual-level data for a sample of French farmers originating from the NUTS3 region Meuse.[2] It was a balanced panel of 186 farmers observed over $T = 12$ years for the period 1992-2003 ($186 \times 12 = 2232$ observations). Though the database included 10 crops, we focused on rapeseed because, according to planted area, it was one of the major crops cultivated by farmers in our sample, and because it was produced every year by all of them.

Insert Table 1 around here

Table 1 reports some summary statistics for our sample. It shows that the average acreage of rapeseed was fairly stable from year to year, amounting to a little

---

[2] The Nomenclature of Territorial Units for Statistics (NUTS) is a hierarchical breakdown system for the European Union territory (see http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:NUTS). France consists of 101 NUTS3 units which correspond to the administrative regions 'départements', five of them being overseas.

more than 30 ha, or around 15% of the total utilized area of farms. There was no clear trend in rapeseed yield, neither at the individual nor at the average level, so it was not necessary to detrend those yields. As shown in Figure 1, the distribution of yields for rapeseed over the whole sample and the whole period was negatively skewed, which is consistent with evidence found by other authors (*e.g.*, Skees, Black, and Barnett (1997)). A detailed review of yield data showed that it was zero in three cases only, corresponding to three different farmers, two of them appearing in 1996 and one in 2002.

Insert Figure 1 around here

3.2 Functional forms and parameters

We used the CPT specification proposed by Tversky and Kahneman (1992) both for $\nu_i(y)$ and $\psi_i(q)$, for any yield y and probability q:

$$\begin{aligned} \nu_i(y) &= \begin{cases} \left(y - y_i^0\right)^{\alpha_i} & \text{if} \quad y \geq y_i^0 \\ -\lambda_i\left(-y + y_i^0\right)^{\alpha_i} & \text{if} \quad y < y_i^0 \end{cases} \\ \psi_i(q) &= \frac{q^{\gamma_i}}{\left(q^{\gamma_i} + (1-q)^{\gamma_i}\right)^{\frac{1}{\gamma_i}}} \end{aligned} \tag{6}$$

where y_i^0 is a individual-specific reference yield which defines the gain ($y \geq y_i^0$) and loss ($y < y_i^0$) domains for each farmer i, and α_i, λ_i and γ_i are individual-specific parameters characterizing the attitude of farmer i towards risk: α_i is the risk aversion coefficient, λ_i is the loss aversion coefficient and γ_i is the probability distortion coefficient.

This specification is general enough to encompass both the CPT and the EUT since, if we set $y_i^0 = 0$, $\lambda_i = 1$ and $\gamma_i = 1$, it reduces to the standard von Neumann and Morgenstern (1947) formulation of the EUT.

4 Results

We investigated the insurance decision each farmer in our sample would have taken conditional on the contract the insurer would have proposed according to what actually happened over the period 1992-2003. To do so, we first computed the indemnity every farmer would have received over the studied period and the premium the insurer would have set. Then, we computed the willingness-to-pay of each farmer for this contract, given his specific preference parameters.

4.1 The insurance contract

The individual-specific critical yield was set for every farmer to his average yield, *i.e.*, $y_i^* \equiv \frac{1}{T}\sum_{t=1}^{T}\tilde{y}_i(t)$. From this definition and the observed yields, we deduced the empirical individual-specific conditional yields $\underline{y}_i$ and $\overline{y}_i$ as:

- $\underline{y}_i = \frac{1}{T}\sum_{i=1}^{T}\tilde{y}_i^-(t)$, with $\tilde{y}_i^-(t) = \tilde{y}_i(t)$ if $\tilde{y}_i(t) < y_i^*$ and zero otherwise;
- $\overline{y}_i = \frac{1}{T}\sum_{i=1}^{T}\tilde{y}_i^+(t)$, with $\tilde{y}_i^+(t) = \tilde{y}_i(t)$ if $\tilde{y}_i(t) \geq y_{i^*}$ and zero otherwise.

We also deduced the probability of unfavorable outcome q as the empirical average probability of experiencing a yield loss:

- $q = \frac{1}{N}\frac{1}{T}\sum_{i=1}^{N}\sum_{t=1}^{T}p_i^-(t)$, with $p_i^-(t) = 1$ if $\tilde{y}_i(t) < y_i^*$ and zero otherwise.

We then used (1) to compute the indemnities each farmer would have received over the studied period conditional on the definition of y_i^*, and we used (5) to deduce the premium ρ the insurer would have charged for the contract.

Insert Table 2 around here

Table 2 reports statistics for the resulting reference yield, conditional yields and expected indemnity. The resulting pure community rating fair premium may be directly read from this table, as it corresponds to the overall average expected indemnity, or 0.27 t/ha. Finally, the probability of unfavorable outcome q was found to be 0.442.

4.2 Risk preferences and the decision to contract

From the input data derived in the previous section, we first computed the WTP $\hat{\rho}_i$ of each farmer under both risk preferences theoretical frameworks, EUT and CPT. Then we deduced the number of farmers who would be willing to contract, N^*, as those with $\hat{\rho}_i \geq \rho$.

Farmers were assumed to be homogeneous, *i.e.*, they all had the same risk preferences parameters or, formally, $\alpha_i = \alpha$, $\lambda_i = \lambda$ and $\gamma_i = \gamma$. The values for the three parameters came from Gassmann (forthcoming) who experimentally estimated them on a different sample of 197 French farmers located near "Meuse" (see also Bougherara et al. (2012) for a detailed description of the sample and the experimental method used) and shows that CPT is a more likely assumption to model preferences for this sample than EUT actually is. Under both preferences assumptions, α was then set to 0.392, assuming that farmers are risk averse. Under CPT, λ was set to 1.185, assuming that farmers are loss averse and γ was set to 0.329, assuming that they overweight lower probabilities and underweight higher probabilities. Finally, departing from Gassmann (forthcoming), y_i^0 was set to y_i^*, assuming that, for each farmer, the reference net yield is his own average yield. Recall that, under EUT, $y_i^0 = 0$, $\lambda = 1$ and $\gamma = 1$.

Insert Figure 2 around here

Figure 2 plots the distribution of farmers' WTP under both risk preferences frameworks, ranked in descending order. Note that the rank of any farmer may change from EUT to CPT so that the x-axis of both WTP curves are actually not directly comparable. We also represented the pure community rating fair premium as a straight line at y-coordinate $\rho = 0.27$. It can then be deduced from Figure 2 that $N^*_{EUT} = 110$ and $N^*_{CPT} = 1$. Furthermore, the analysis of the entire curves reveals that welfare would be much lower under CPT than EUT: individual welfare can be measured as $w_i = \hat{\rho}_i - \rho$ and it can then be computed from Figure 2 that:

- the total welfare, $\sum_{i=1}^{N} w_i$, is 8.01 under EUT and -23.03 under CPT;
- the average welfare of those contracting, $\frac{1}{N^*}\sum_{i=1} w_i$, is 0.116 under EUT and 0.013 only under CPT.

It so appears that, contingent on the values chosen for α, λ and γ, using the traditional EUT preference modeling framework would lead us to expect that almost 60% of the farmers in the sample would be willing to contract the proposed insurance while, using the preferred CPT theoretical framework, virtually none of them would actually do. This confirms our case that ignoring the superiority of the CPT with respect to the EUT may be sufficient to explain why farmers contract less than expected.

4.3 Policy implications

Let's imagine that the true risk preferences of farmers follow the CPT framework, but that the authorities assume that they follow EUT. The authorities only have an estimate for the risk aversion parameter of farmers so that, when the insurance program is implemented, they can only observe that farmers would contract less than expected. Assume now that the authorities want to develop the level of insurance contracting so that the number of willing-to-contract farmers reaches the EUT expected level. We first extend a little our modeling framework in order to simulate two options the authorities could choose to do so.

Indeed, let now assume that farmers initially received a direct subsidy per hectare. The expression of the net yield as given by equation (2) has then to be re-written as:

$$\tilde{y}_i^{net} = s_i + \tilde{y}_i + n(\tilde{y}_i) - \rho. \tag{7}$$

where s_i is the subsidy expressed in tons per hectare. The rest of the model is unchanged, but the quantitative results now depend on the level of the subsidy which acts as a certain initial wealth.

Empirically, we set s_i as homogeneous across farmers with the value $s_i = 2.55$ t/ha for all i. This figure derives from the following simple calculation: in 2003, the coupled direct payment granted to cereals and oilseed under the Common Agricultural Policy (CAP) of the European Union (EU) amounted to 92 €/t for a so-called ‘reference yield’ in the "Meuse" region set to 5.65 t/ha; the per-hectare payment was therefore $92 \times 5.65 = 520$ €/ha while, in the mean time, the national average price of rapeseed was around 204 €/t; the yield-equivalent subsidy corresponding to the direct payment was therefore $520/204 = 2.55$ t/ha. With this figure, the number of willing-to-contract farmers and welfare results are as follows:

- the number of willing-to-contract farmers is 104 under EUT and 10 under CPT;
- the total welfare is 5.51 under EUT and -23.58 under CPT;
- the average welfare of those contracting is 0.103 under EUT and 0.030 only under CPT.

We deduce that the subsidy does not fundamentally change the qualitative conclusions reached in the previous sub-section. Under this extended framework, two types of insurance-promoting policies may be modeled : i) a premium-subsidy; ii) a reduction in the initial wealth. Simulations of both policies are summarized in Table 3.

Insert Table 3 around here

This table shows that the reduction in the direct payment is very substantial. However, it would permit to achieve a higher welfare level, both at the aggregate level and when only willing-to-contract farmers are considered. Notwithstanding the implementation and political costs that both such policies would imply, this second option, *i.e.*, the direct payment reduction, would be preferable from a welfare point of view.

Finally, note that this second option is inappropriate if the authorities were to promote full contracting. With this objective, only the premium subsidy proves feasible, but the subsidy rate would have to be higher than expected under the EUT. Indeed, the WTP of the last willing-to-contract farmer amounts to 0.112 under the EUT while it is 0.051 only under the CPT. As Figure 3 shows, full contracting would therefore imply a premium-subsidy rate of $1 - \frac{0.051}{0.270} = 81\%$ under CPT while the expected EUT premium-subsidy rate would only be $1 - \frac{0.112}{0.270} = 58\%$. Though the studied insurance contract is different, this result is fully consistent with Smith and Glauber (2012) observing that the U.S. federal crop insurance program had to be increasingly subsidised over the 1981-2010 period to reach the desired participatory levels: only 20% of the U.S. farmers participated when the subsidy rate was 30% in the early 1980's, while 80-85% did so when the subsidy rate reached 60% in the late 2000's.

Insert Figure 3 around here

5 Conclusion

In this paper, we have shown that neglecting that Kahneman and Tversky's Cumulative Prospect Theory (CPT) is better suited for representing preferences towards risk in place of the traditional von Neumann and Morgenstern's Expected Utility Theory (EUT) may be sufficient to explain why farmers do not contract crop insurance policies as much as they are expected to do.

Though we are confident that this general qualitative conclusion would remain valid, the model and empirical analysis presented here could be extended in three respects. Firstly, we have assumed that all farmers in the sample are homogeneous with respect to their preferences towards risk, *i.e.*, that they share the same parameter values. It would certainly be more relevant to introduce individual heterogeneity in these preferences; the extension of the structural estimation proposed by Bougherara et al. (2012) towards this direction, as proposed by Gassmann (forthcoming), is a first step to do so. Secondly, we have followed the modeling framework proposed by Miranda (1991) and extended by Mahul (1999) which grounds farmers decisions with respect to the expected net yield. It would be more theoretically sound to express the model in terms of expected profit, which would imply, as Chambers and Quiggin (2002) note, to explicitly introduce the production function in the model. Thirdly, we have modeled the choice of an individual yield crop insurance contract. It would be desirable to turn to the modeling of an area yield crop insurance, which, as several authors like Miranda (1991) show, is less sensitive to adverse selection and moral hazard issues.

References

Bougherara, D., X. Gassmann, and L. Piet. 2011. "A structural estimation of French farmers' risk preferences: an artefactual field experiment." Working Papers SMART - LERECO No. 11-06, INRA, UMR SMART, Rennes (France).

Bougherara, D., X. Gassmann, L. Piet, and A. Reynaud. 2012. "Eliciting farmers' risk and ambiguity preferences in the loss and gain domain." In *Foundations and Applications of Utility, Risk and Decision Theory (FUR) XV International Conference*. Atlanta (Georgia), p. 13.

Bourgeon, J.M., and R.G. Chambers. 2003. "Optimal Area-Yield Crop Insurance Reconsidered." *American Journal of Agricultural Economics* 85:590–604.

Chambers, R.G., and J. Quiggin. 2002. "Optimal Producer Behavior in the Presence of Area-Yield Crop Insurance." *American Journal of Agricultural Economics* 84:320–334.

Galarza, F.B. 2009. "Choices under Risk in Rural Peru." Agricultural and Applied Economics Staff Paper No. 542, University of Wisconsin-Madison, Madison (Wisconsin).

Gassmann, X. forthcoming. "Aversion au risque et à l'ambiguïté des agriculteurs." Ph-d thesis, Université de Rennes 1, Rennes (France).

Glauber, J.W. 2004. “Crop Insurance Reconsidered.” *American Journal of Agricultural Economics* 86:1179–1195.

Godinho Coelho, L.A., C.M. Pacheco Pires, A. Teixeira Dionisio, and A.J. da Conceicao Serrao. 2012. “The impact of CAP policy in farmer’s behavior. A modeling approach using the Cumulative Prospect Theory.” *Journal of Policy Modeling* 34:81–98.

Kahneman, D., and A. Tversky. 1979. “Prospect Theory: An Analysis of Decision under Risk.” *Econometrica* 47:263–292.

Mahul, O. 1999. “Optimum Area Yield Crop Insurance.” *American Journal of Agricultural Economics* 81:75–82.

Miranda, M.J. 1991. “Area-Yield Crop Insurance Reconsidered.” *American Journal of Agricultural Economics* 73:233–242.

Miranda, M.J., and J.W. Glauber. 1997. “Systemic Risk, Reinsurance, and the Failure of Crop Insurance Markets.” *American Journal of Agricultural Economics* 79:206–215.

Nelson, C.H., and E.T. Loehman. 1987. “Further Toward a Theory of Agricultural Insurance.” *American Journal of Agricultural Economics* 69:523–531.

Quiggin, J.C., G. Karagiannis, and J. Stanton. 1993. “Crop Insurance and Crop Production: Empirical Study of Moral Hazard and Adverse Selection.” *Australian Journal of Agricultural and Resource Economics* 37:95–113.

Skees, J.R., J.R. Black, and B.J. Barnett. 1997. “Designing and Rating an Area Yield Crop Insurance Contract.” *American Journal of Agricultural Economics* 79:430–438.

Smith, V.H., H.H. Chouinard, and A.E. Baquet. 1994. “Almost Ideal Area Yield Crop Insurance Contracts.” *Agricultural and Resource Economics Review* 23:75–83.

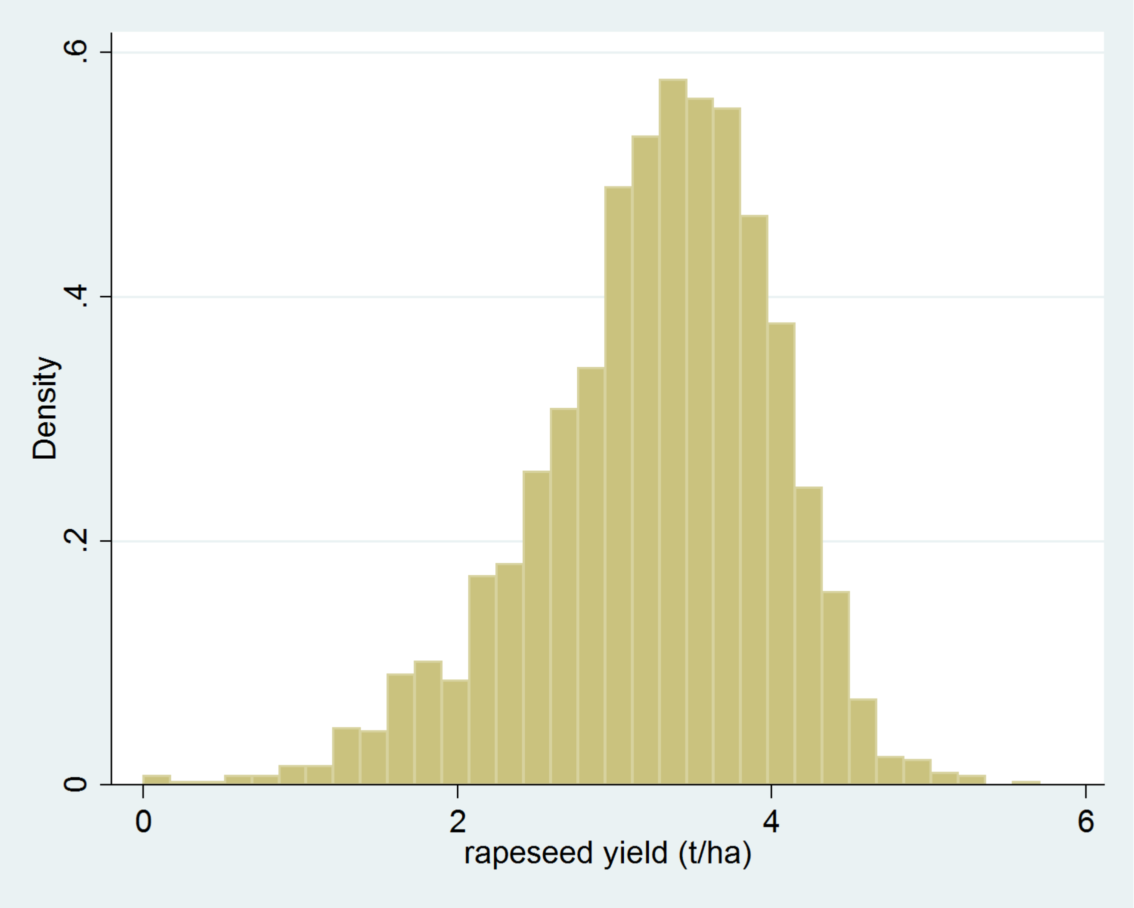
Smith, V.H., and J.W. Glauber. 2012. “Agricultural Insurance in Developed Countries: Where Have We Been and Where Are We Going?” *Applied Economic Perspectives and Policy* 34:363–390.

Tanaka, T., C.F. Camerer, and Q. Nguyen. 2010. “Risk and Time Preferences: Linking Experimental and Household Survey Data from Vietnam.” *American Economic Review* 100:557–571.

Tversky, A., and D. Kahneman. 1992. “Advances in prospect-theory: Cumulative representation of uncertainty.” *Journal of Risk and Uncertainty* 5:297–323.

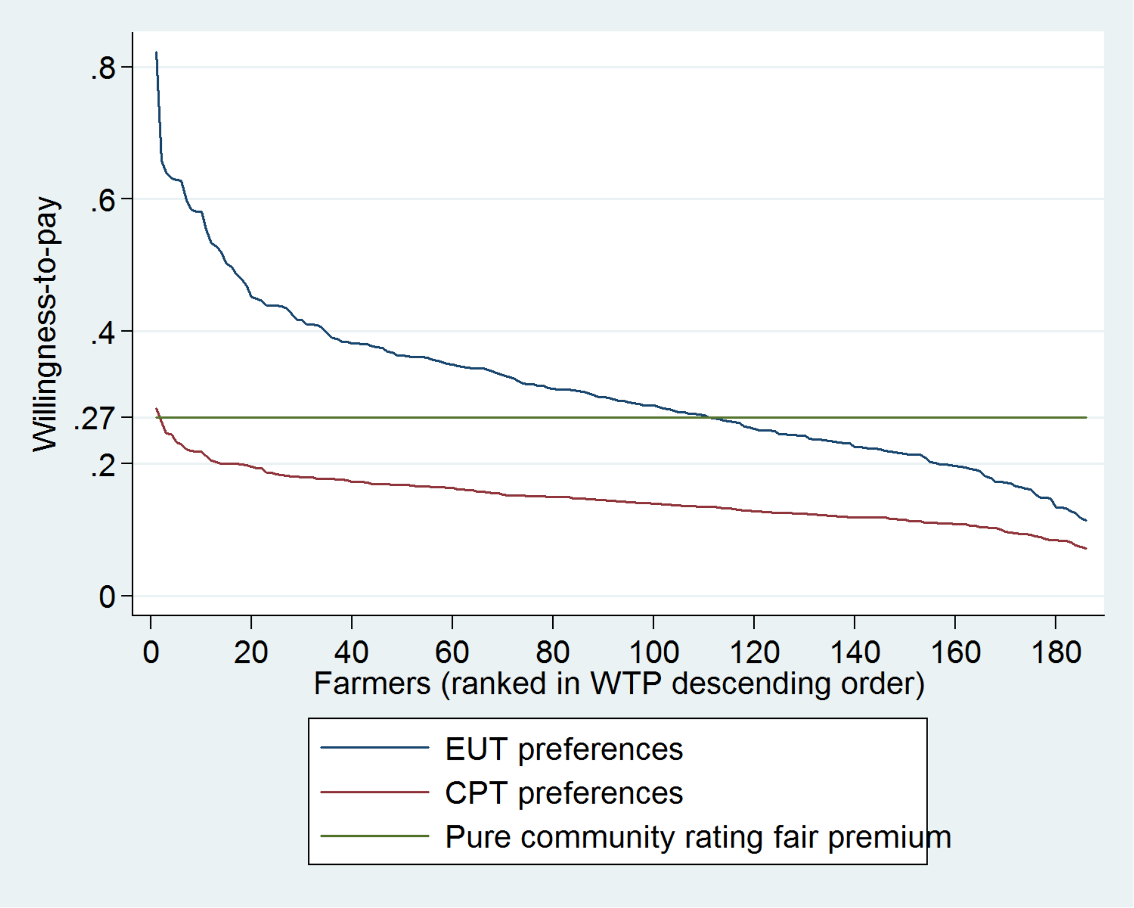
von Neumann, J., and O. Morgenstern. 1947. *Theory of games and economic behavior*. Princeton University Press.

Figure 1: Distribution of yields in the sample (all years)



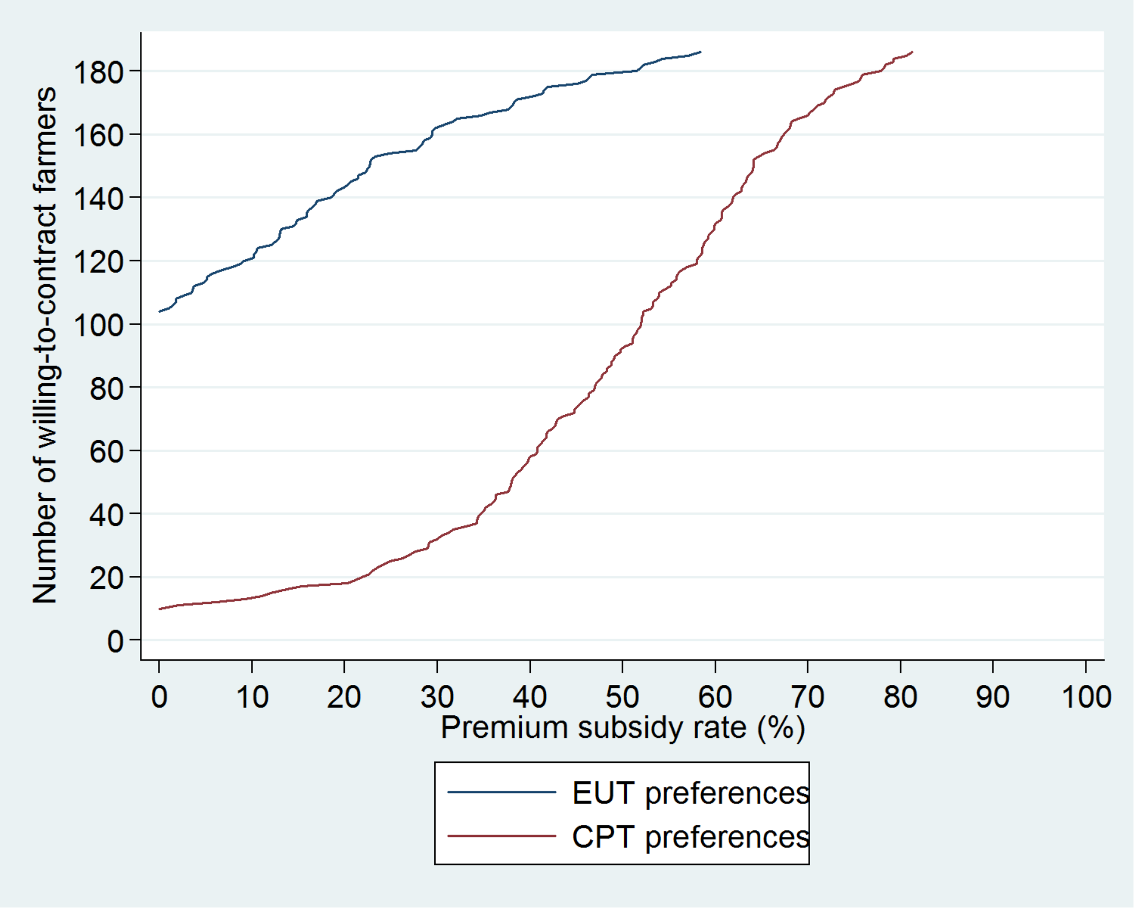
Source: ADHEO, 1992-2003 - authors' calculation

Figure 2: Distribution of farmers' WTP under both risk preferences frameworks (with $\alpha = 0.392$, $\lambda = 1.185$ and $\gamma = 0.329$)



Source: ADHEO, 1992-2003 - authors' calculation

Figure 3: Number of willing-to-contract farmers according to the premium subsidy rate under both risk preferences frameworks



Source: ADHEO, 1992-2003 - authors' calculation

Table 1: Summary statistics

year	obs.	Total area (ha)				Rapeseed area (ha)				Rapeseed yield (t/ha)			
		mean	std. dev.	min	max	mean	std. dev.	min	max	mean	std. dev.	min	max
1992	186	185.94	92.92	60.80	733.00	30.35	22.63	2.00	160.00	2.33	0.68	0.27	3.86
1993	186	198.19	96.61	77.11	720.38	28.15	21.23	1.00	127.50	3.42	0.55	1.30	4.70
1994	186	202.73	97.67	77.56	717.83	29.93	24.94	4.67	214.80	2.77	0.67	0.98	4.38
1995	186	205.34	97.76	77.56	718.10	27.44	22.92	0.93	156.30	3.67	0.58	0.78	5.71
1996	186	207.82	98.21	77.56	717.97	30.66	23.82	0.80	190.44	3.51	0.61	0.00	4.91
1997	186	210.25	99.81	77.56	717.96	34.04	23.81	4.40	162.55	4.02	0.41	2.12	4.85
1998	186	211.08	101.10	77.54	717.30	36.89	25.21	5.86	186.69	3.62	0.44	2.00	4.58
1999	186	211.71	101.68	77.54	716.71	35.39	27.31	2.91	232.80	3.70	0.52	2.54	5.20
2000	186	214.71	102.92	77.54	716.24	32.01	24.05	2.36	190.74	3.26	0.56	1.21	5.30
2001	186	216.04	102.26	77.54	707.92	31.10	22.32	3.52	157.90	2.46	0.63	0.74	4.40
2002	186	215.92	101.82	77.53	707.92	29.20	22.70	0.90	156.09	2.94	0.60	0.00	4.26
2003	186	217.52	103.83	76.34	707.92	27.32	18.83	0.69	113.90	3.34	0.54	1.40	5.22
all years	2232	208.10	99.90	60.80	733.00	31.04	23.53	0.69	232.80	3.25	0.76	0.00	5.71

Source: ADHEO, 1992-2003 - authors' calculation

Table 2: Summary statistics for the reference yield, conditional yields and expected indemnity

	obs.	mean	std. dev.	min	max
Reference yield y_i^* (t/ha)	186	3.25	0.31	2.36	4.07
Unfavorable conditional yield $\underline{y}_i$ (t/ha)	186	2.61	0.42	1.09	3.45
Favorable conditional yield $\overline{y}_i$ (t/ha)	186	3.74	0.31	2.91	4.56
Expected indemnity ρ (t/ha)	186	0.27	0.07	0.14	0.50

Source: ADHEO, 1992-2003 - authors' calculation

Table 3: Policy simulations to reach 104 willing-to-contract farmers under CPT

	Premium subsidy	Wealth reduction
Initial value	0.270 t/ha	2.55 t/ha
Value after policy	0.129 t/ha	0.60 t/ha
Percent change	-52%	-76%
Total welfare	2.65	14.79
Average positive welfare	0.052	0.232

Source: ADHEO, 1992-2003 - authors' calculation