Revenue insurance as an income stabilization policy : an application to the Spanish olive oil sector

María BIELZA
Alberto GARRIDO
José M. SUMPSI

María BIELZA*, Alberto GARRIDO*, José M. SUMPSI*

L'assurance-recette comme politique de stabilisation des revenus : une application au secteur de l'huile d'olive en Espagne

Résumé – Plusieurs types d'assurance de revenus ont été appliqués au Canada et aux États-Unis avec succès. Dans cet article, nous analysons des combinaisons différentes de politiques agricoles traditionnelles et d'assurances de revenus et de rendements, pour le secteur de l'huile d'olive en Espagne. En utilisant une base de données comprenant un demi-million de producteurs espagnols d'huile d'olive pendant 8 campagnes, nous étudions cinq politiques possibles dont nous examinons les résultats d'après des critères différents, à savoir : le revenu moyen et sa variabilité, les gains d'utilité des producteurs, le coût pour les contribuables, ainsi que l'efficacité du transfert du support. Les politiques analysées sont : (1) la non-intervention ; (2) la politique actuellement en place en Espagne, qui combine une aide à la production avec une assurance de rendements ; (3) une assurance de revenu, seule ; (4) une assurance-revenu en combinaison avec l'aide à la production ; et (5) une aide par arbre en combinaison avec l'assurance-revenu. La méthodologie consiste en des simulations de type Monte-Carlo accomplies sur une centaine de groupes de producteurs regroupés en fonction des rendements espérés et de leurs variabilités. En estimant les corrélations de prix et de rendements pour chaque groupe de producteurs, l'analyse permet de faire des comparaisons cohérentes à un niveau très disjoint. À partir des résultats, les politiques ont été rangées sous les critères signalés ci-dessus, aux niveaux provincial et national. Les résultats montrent que le régime actuel d'aides européennes à la production d'huile d'olive annule l'avantage qui devrait résulter du passage de l'assurance-récolte à l'assurance-revenu. On peut ainsi conclure que le niveau de soutien fourni par les aides à la production ne peut pas être atteint avec une assurance-revenu, même avec des premiums complètement subventionnés. Finalement, la politique qui combine l'aide à l'arbre avec l'assurance-revenu donne de bons résultats pour tous les critères d'examen.

Mots-clés :
politique agricole, assurance agricole, secteur de l'huile d'olive

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Summary – *This paper analyses five combinations of agricultural policies and revenue and yield insurance for the Spanish olive sector: (1) non-intervention; (2) the policy currently in force with production aid and yield insurance; (3) revenue insurance; (4) revenue insurance combined with production aid; (5) aid per tree combined with revenue insurance. Each combination is tested with respect to various criteria: average revenue and its variability, growers'utility, taxpayers cost, and the transfer efficiency of support. We performed Monte-Carlo simulations on 100 statistically significant groups of growers. Three rankings of the five policy scenarios show that the current regime of EU production aids on olive oil eliminates the advantage of extending the current yield insurance to a revenue insurance at a reasonable cost. We also show that the level of support delivered by production aids can by no means be reached with revenue insurance even with 100% subsidized premia, and that scenario (5) exhibits good results based on all criteria.*

Key-words:
agricultural policy, agricultural insurance, olive oil sector

* *Dpto. Economía y CCSS Agrarias, ETSI Agrónomos, Ciudad Universitaria, 28040 Madrid- SPAIN*
e-mail: mbielza@eco.etsia.upm.es

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THE denomination 'revenue insurance' comprises a variety of mechanisms for stabilizing the revenue of farmers based on the theory of agricultural insurance. All these mechanisms have the common objective to reduce farmers'revenue variability. As they are based on the joint treatment of production risks and market risks, they permit insuring farmers against reductions in revenue caused by a drop in prices, lower levels of yield or a combination of both causes.

The idea of insuring farmers'revenue by extending the traditional methods of price stabilization or yield insurance, which were used separately until very recently, stems from various factors. On the one hand, the liberalization of the agricultural markets could be associated to greater price instability (Meuwissen *et al.*, 1999). On the other hand, the greater degree of market competition could lead farmers to look for economic efficiency based on production specialization, thus making their economic results more sensitive to the variability in yield and to the prices of a reduced number of products. The fact that, in agreement with the World Trade Organization (WTO), public subsidies in the field of agricultural insurance policies would be qualified under certain conditions as 'green box' (European Commission, 2001) has had considerable importance. Lastly and, perhaps the main reason, is the idea that revenue insurance policy may be a more efficient alternative to the traditional policies of revenue stabilization, shifting the taxpayers burden from the latter to subsidize farmers'insurance premiums.

At the beginning of the 90's, the US and Canada began to develop different mechanisms of revenue insurance policies, by applying formulas based on the stabilization of the revenue of a single product, of the whole farm revenues or by developing mechanisms more along the lines of mutual societies (Goodwin and Ker, 1998; Skees, 2000). In 2002, about half of total US crop insurance premiums were spent in some form of revenue insurance (Mahul and Wright, 2003). The European Commission has commissioned several studies focusing on the broader topic of agricultural risks, among which revenue insurance policies have received special attention, and has motivated empirical work to examine various formulas of revenue insurance (Meuwissen *et al.*, 1999). In Alava (Spain), the Potato Compensation Fund was initiated in 1997 under the form of individual accounts. Although it has not received much attention, perhaps due to the fact that only 150 growers are members (year 2001), it is worth analyzing in detail since it is applied to a sector without a Common Market Organization (CMO) and that takes in clearly differentiated productions depending on the crop varieties and collection dates (Sumpsi *et al.*, 2001). This experience follows a formula similar to the Canadian NISA (Net Income Stabilization Accounts), but in the case of Alava the state contribution to each member's account is based on the surface planted each year and not on the farmer's sales.

The overall results of the international experiences show that revenue insurance policies are difficult to design and administer (Meuwissen *et al.*, 2003). On top of the traditional problems of crop insurance, such as moral hazard and adverse selection, there is the difficulty of carrying out a statistical analysis of the prices (Goodwin *et al.*, 2000) and evaluating the correlation between prices and farmers' yields, or at least area average yields (Turvey and Amanor-Boadu, 1989; Skees, 2000). From an actuarial point of view, sound revenue insurance premiums are clearly dependent on the reliability with which the correlation between prices and yields can be estimated.

Further difficulties are encountered when trying to analyze the pros and cons of revenue insurance that totally or partially replaces a traditional instrument to stabilize or support farmers' revenue. While in general insurance policies should be used only for stabilization purposes, loss ratios in the neighborhood of 1.5 (as in the US) are an indication that premiums are consistently lower than the paid indemnities, and that insurance delivers also revenue support in addition to revenue stabilization. In their analysis of the Common Agricultural Policy (CAP) and possible ways for reform, Buckwell *et al.* (1997) sustain that, although a clear distinction should be made between policies for sustaining farmers' revenues and policies for revenue stabilization, the dividing line is not always that clear. This debate, of both a conceptual and empirical nature, is present in the relevant literature, perhaps due to the strong implications for future negotiations on agricultural trade in the World Trade Organization (Wu and Adams, 2001; Young *et al.*, 2001).

Several authors have made comparisons of different revenue stabilization policies using a variety of formulas of revenue insurance. Calkins *et al.* (1997) show that revenue insurance allows the agricultural farmers of Quebec to obtain greater expected income than a price insurance added to a yield insurance, or than a system of individual savings accounts that receive state contributions. Their results also show that revenue insurance ensures greater efficiency of public expenditure, measured in terms of increase in gross margin per dollar of taxpayers contribution. Coble *et al.* (2000) show that revenue insurance policies are potential substitutes for other risk reduction strategies, such as hedging in futures and options. This indicates that revenue insurance has some properties that can be assimilated to the use of derivative markets, although it could constitute a more efficient tool for risk reduction by also protecting against drops in yields. Miller *et al.* (2000) find no clear advantages of revenue insurance over yield insurance in the case of peach growers because of the low correlation between yields and prices. Stokes *et al.* (1997) show that insuring for the whole farm's revenues is more efficient than insuring each crop by a different revenue insurance policy.

In spite of the increasing interest from both the methodological and analytical viewpoint ignited by the advent of revenue insurance policies, few works have tackled the alternative of replacing or complementing traditional tools of income support for farmers with revenue insurance policies. Hennessy *et al.* (1997), in a study that is considered a key antecedent of this current work, show that revenue insurance would guarantee producers 75% of their expected revenue by way of deficiency payments offered to maize and soy producers in the USA, at a fifth of the taxpayers cost. Such a degree of superiority of revenue insurance over the program of deficiency payments gives rise to many methodological and empirical queries concerning the possible generalization of this result to other sectors or circumstances. For example, the fact that all the Monte-Carlo simulations are carried out on the same representative farm or that the target price for the deficiency payments is considered fixed and not variable with the simulated production, could be assumptions that may be too restrictive for other contexts. In a more recent study, Mahul and Wright (2003) show that revenue insurance contracts may be complementary with typical hedging instruments, such as options and futures, when the indemnity payment is contingent on price and/or yield indexes that are not identical to individual growers'prices and yields. Mahul (2003) also considers futures prices unbiasedness in other to determine whether they are complementary to revenue insurance policies.

OBJECTIVES

The objective of this work is precisely to carry out a comparative analysis of a series of tools for stabilizing olive oil growers revenues based on revenue insurance products, with other classical tools for sustaining and stabilizing revenues. The policies analyzed are: (1) non-intervention; (2) the policy currently in force in Spain that combines a production aid with a yield insurance; (3) a revenue insurance, only; (4) revenue insurance combined with a production aid; and (5) an aid per tree in combination with revenue insurance. The comparison will be carried out for the Spanish olive oil sector, although the conclusions derived from the analysis might be generalized to the other two European Union (EU) main producers, Italy and Greece, given that the same support policy is applied to the olive oil sector in the EU.

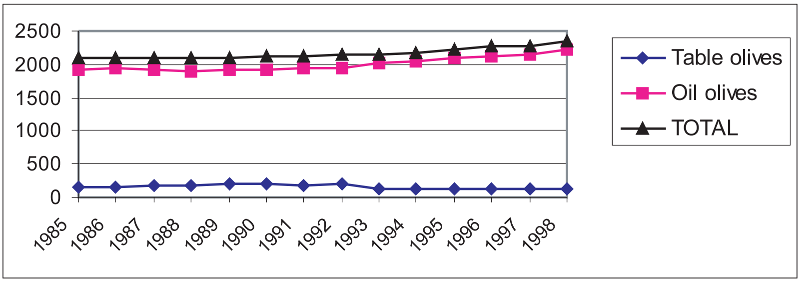
The olive oil sector is of special interest due to its economic and territorial importance and to the intense level of support granted by the EU Olive oil Common Market Organization. At the EU level, more than 5 million hectares are planted with olive trees and managed by 2,5 million growers (European Commission, 2002). From a methodological point of view, this work is a contribution to the literature on the subject since it goes into a detailed analysis of the correlation between prices and yields, estimated for groups of homogeneous growers. It also incorporates the correlation of production aid, whose magnitude varies with each EU member state total production, and farmers' yields. This allows for detailed policy comparisons at a very disaggregate level, and it also relaxes restrictive assumptions commonly found in the literature, that could affect the reliability of the premiums calculated on the basis of such assumptions (Hennessy *et al.*, 1997 ; Meuwissen, 2000 ; Calkins *et al.*, 1997 ; Miller *et al.*, 2000).

This study is motivated by the interest of ENESA (Spanish National Agency of Agricultural Insurance), the public body that implements the agricultural insurance policies in Spain, to study the possibility of converting some of its lines of yield insurance into revenue insurance. The database available for the study, which ENESA administers and updates systematically, containing in the case of the olive oil sector more than 500,000 growers with individual yields for 8 campaigns, provides a context setting very unusual for similar kinds of policy analysis.

THE EUROPEAN AND SPANISH OLIVE OIL SECTORS

The EU olive production is concentrated on five member states : Spain, Italy, Greece, Portugal and France. Table 1 provides a few descriptive facts about the sector in the EU. Olive groves in Spain cover an area of more than 2.4 million hectares, of which only 5.3% is dedicated to the growing of table olives. Figure 1 shows that olive growing has experienced a slight upward trend in the last fifteen years. This study will focus only on seven Spanish provinces (Jaén, Córdoba, Málaga, Badajoz, Toledo, Lérida and Tarragona), which together represent 62% of the surface and 73.7% of the total production.

Figure 1.
Evolution of the surface dedicated to olive-growing in Spain (1 000 hectares)



Source : Data from MAPA[1] Yearbooks

As the coefficient of variation of production reported on table 1 indicates, yields are very sensitive to climatic conditions, specially to meteorological droughts. This is one of the reasons why, since the 2000-2001

[1] MAPA : *Ministerio de Agricultura, Pesca y Alimentación* (Ministry of Agriculture, Fisheries and Food)

crop year, there now exists in Spain a yield insurance that guarantees overall production in the face of any adverse climatic conditions.

Table 1. **The olive oil sector in the EU**

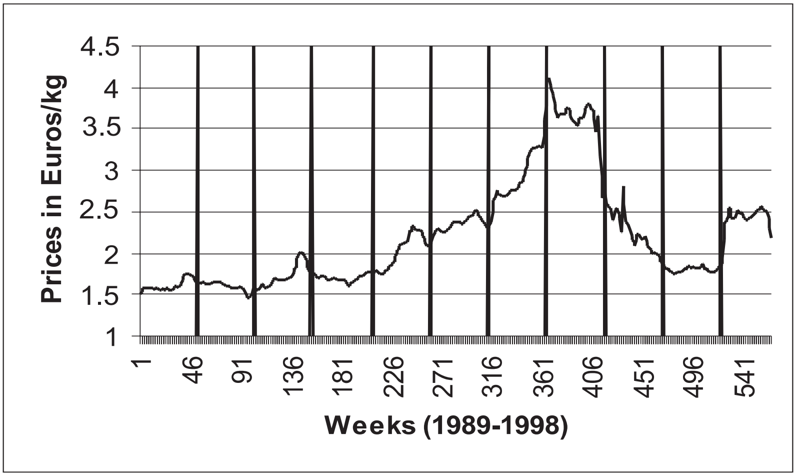
	Production of olive oil (1 000 t)					
Year	Italy	Spain	Greece	Portugal	France	Total
1989/90	585	573	316	35	2.8	1 511.8
1990/91	148	700	171	20	2.3	1 041.3
1991/92	650	610	430	35	3.4	1 728.4
1992/93	410	636	314	17	1.8	1 378.8
1993/94	550	588	323	27	2.4	1 490.4
1994/95	458	583	390	29	2.4	1 462.4
1995/96	625	375	445	34	2.4	1 481.4
1996/97	410	986	494	37	2.4	1 929.4
1997/98	712	1 147	492	39	2.5	2 392.5
1998/99	452	900	562	34	2.4	1 950.4
1999/00	791	747	464	47	2.7	2 051.7
2000/01	540	1 075	479	25	2.2	2 121.2
Average	527.6	743.3	406.7	31.6	2.5	1 711.6
Coefficient of variation (x100)	30.7	30.1	25.5	25.4	14.8	21.4
Maximum guaranteed amounts	543	760	419	51	3.3	1 776.3
Acreage (1 000 ha) (year 2000)	1 162	2 486	765	369	17	4 799
Yields (average 1997-2000)	0.87	0.79	0.84	1.41	1.35	0.83

Sources: European Commission (2002); Eurostat - Agriculture annuaire statistique (2002)

The EU is the world leader in the production of olive oil and in foreign trade, contributing 70% of the world figures in both fields. The remaining 30% of the production is divided between Tunisia, Morocco and Turkey. The largest importers are the USA (46% of world imports) and the EU (44%), followed by Japan, Brazil, Australia and Canada who are also importers but of much less importance.

During the course of a marketing campaign the variability of prices is small due to the fact that the stock linking one campaign to the next attenuates in part the variations in production. Yet there is evidence that the level of the connecting stock between one campaign and the next is insufficient to absorb the impact caused in the market by important rises and falls in harvest levels. Figure 2 shows the sequence of weekly prices, referring to the index prices collected by the Spanish Ministry of Agriculture, from the first week of calendar year 1989 to the last week of 1999. The continuity between campaigns can be clearly appreciated, although the abrupt rise at the beginning of 1996 (week 361) and 1998 (week 522) is worth pointing out.

Figure 2.
Weekly olive oil prices



Source: Data from the Spanish Ministry of Agriculture, Food and Fisheries

Since 1970, the olive oil sector of the EU has been subjected to different intervention policies. Until the 1998 reform the olive oil CMO was based on a production aid, a consumption aid and a purchase intervention mechanism, which guaranteed producers a minimum price (intervention price). From the 1998 campaign onwards, a new Common Market Organization was established. It was initially intended for the following three campaigns but is still in force today, and it consists in a maximum production aid of 1.29 €/kg of olive oil but with no intervention mechanisms. The aid of 1.29 €/kg suffers reductions proportional to the surplus of overall Spanish production over 760 027 Tn of olive oil, a fact that has key implications for policy analysis purposes.

Nowadays the olive oil CMO also counts on a support system for private storage, which is applied when the price of olive oil falls below the reference price fixed by the European Commission at 95% of the intervention price applicable to the 1997-98 campaign, equivalent to 1.66 €/kg of olive oil. But to date, the use of subsidized private storage has been very limited.

METHODOLOGY

Policy scenarios

With the aim to analyze the efficiency of several alternative policies for protecting farmers'revenue, a series of Monte-Carlo simulations have been carried out. This has made it possible to generate 5,000 hypothetical situations of prices and yields for 100 groups of farms, (with an average of 196 farms per group), formed according to criteria which are later described on the basis of the real data observed. The effects of different policies on farmers'revenues and levels of utility have been simulated in the hypothetical situations. Five policy scenarios have been chosen for the simulation: four combine stabilization and support revenue tools (insurance and direct payments) and the fifth is a reference policy, with which the rest are compared, that consists in a policy of non-intervention at all in the sector (see table 2).

Table 2. **Description of the five policies studied for sustaining revenue**

Scenario	Production aid	Tree aid	Yield insurance	Revenue insurance	Revenue per farmer i and period t (evaluated in €/tree)
1. Free market	No	No	No	No	$R_i^t = P^t \times Y_i^t$
2. Current situation	Yes	No	Yes	No	$R_i^t = (1.29\text{-f}(Y^t)) \times Y_i^t + P^t \times \max[Y_i^t, E(Y_i^t)] - s \times \Pr[E(Y_i^t), \sigma_{Y_i}]$
3. Revenue insurance only	No	No	No	Yes	$R_i^t = \max[(P^t \times Y_i^t), 0.7 \times E(P^t \times Y_i^t)] - s \times \Pr[E(P^t \times Y_i^t), \sigma_{Yi \times Pt}]$
4. Production aid and revenue insurance	Yes	No	No	Yes	$R_i^t = (1.29\text{-f}(Y^t)) \times Y_i^t + \mathrm{Max}\{(P^t \times Y_i^t), 0.7 \times E(P^t \times Y_i^t)]\} - s \times \Pr[E(P^t \times Y_i^t), \sigma_{Yi \times Pt}]$
5. Tree aid and revenue insurance	No	Yes	No	Yes	$R_i^t = TA + \mathrm{Max}\{(P^t \times Y_i^t), 0.7 \times E(P^t \times Y_i^t)]\} - s \times \Pr[E(P^t \times Y^t), \sigma_{Yi \times Pt}]$

With the following notation:

R_i^t: revenue per tree in the farm i and campaign t, expressed in €/tree

P^t: random price of olive oil in campaign t, expressed in €/kg of oil

Y_i^t: random yield per tree in the farm i expressed in kg of oil/tree

$(1.29\text{-f}(Y^t))$: production aid expressed in €/kg, as a result of having subtracted from 1.29 €/kg the corresponding penalty that depends on the random national production Y^t, when it surpasses 760 027 Tn

s: proportion of insurance premiums paid by growers (it is fixed at 0.5 in policies 2, 4 and 5; 0 for policy 3)

$\Pr(E(Y_i^t), \sigma_{Y_i})$: individual yield premium, evaluated according to the average yields and the typical deviation of the individual farmer, calculated in €/tree

$\Pr(E(P^t \times Y_i^t), \sigma_{Yi \times Pt})$: individual revenue insurance premium, evaluated taking into account the average income of the individual producer and its typical deviation, calculated in €/tree

TA: aid per tree, expressed in €/tree

Modeling assumptions

The simulation of the above policy scenarios was carried out making the following assumptions:

- **Production aid**: As stated above, the subsidy per kilo of olive oil was fixed by the European Commission at 1.29 €/kg of olive oil. However, when overall production of each member state surpasses its guaranteed maximum quantity (see table 1), this aid per kilo is reduced in proportion to the excess of production. This guarantees that the aggregate level of support delivered to the olive sector of each member state is constant. If yields are subject to systemic risks, caused generally by drought periods, the production aid is truly a random variable that depends on total production. Thus, for policy comparisons it is important to take into account in the Monte-Carlo simulations the correlation between national production and individual yields, because the latter will be indirectly correlated with the production aid. In order to calculate the aid to the producer for each of the 5 000 simulations we do the following: we take the 5 000 draws from the probability distribution of yields specific to each group of producers, and using the empirical correlation between the group yields and national average yields, we obtain the most likely value of national production following the procedure developed by Johnson and Tenenbein (1981) that we explain below. When this national production has surpassed the maximum guaranteed quantity of 760 027 Tn of olive oil, the final aid of 1.29 €/kg is reduced proportionally. In this way, when the yields of a group of producers is strongly correlated with the overall production of the country, the unitary aid in €/kg will be negatively correlated with the yield of the group.

- **Yield insurance and revenue insurance**: Both yield insurance and revenue insurance have a coverage level of 100%, with a 30% absolute franchise. The evaluated premiums charged to growers have a markup to include administrative costs of the insurance system. As an average for agricultural insurance sector in Spain, these costs amount to 40% of the premium. The farmer receives a subsidy of 50% of the premium in policies 2, 4 and 5, and a subsidy of 100% in the policy that only uses revenue insurance (policy 3). For the case of revenue insurance, the revenue which is compared with the insured level is simply the result of the yield multiplied by market price, for each of the 5 000 pairs of yield-price observations generated. The insured revenue is the average of the result of the 5 000 prices multiplied by the 5 000 yields. The final revenue is the result of multiplying price by yield minus the part of the premium paid by the farmer, plus the indemnity payment when it exists.

- **Aid per tree**: In policy 5, production aids are substituted by a fixed aid per tree. These are considered fixed grants for each tree on the farm, being only differentiated at two levels: one, a larger grant (4.4 €/tree) for farms with an average yield that surpasses the average national yield, and the other, a smaller grant (3 €/tree), for all those farms with an average yield below the national average. In this way differences between the various provinces are avoided. The figure of 6.9474 kg of olive oil per tree has been taken as the average national yield.

Analysis and origin of the data

- **Yields**: The data, made available by ENESA, are obtained from the declarations presented by olive growers from all over the country in order to obtain the CAP production aids from 1991-1998. The basic data for each grower consist in the number of olive trees and the declared yield in each campaign. The work has been done with groups of farms in order to carry out the simulations of the different scenarios of policies and insurance, taking the group of farms as an analysis unit. Growers were grouped taking into account: (1) the province to which they belong; (2) their average yields, following the 19 typologies used in the existing yield insurance (< 3; 3-5; 5-7; ..., 51-57 and > 57 kg olive oil/tree); (3) their level of risk, taking as the risk indicator the coefficient of variation (CV < 0.4; 0.4 ≤ CV < 0.8; 0.8 ≤ CV < 1.2; CV ≥ 1.2). This criteria of grouping producers ensures that the results obtained for each group are highly significant for all the farms included in the analysis. The work sample is selected from the set of all growers operating in seven provinces (Badajoz, Córdoba, Toledo, Jaén, Málaga, Lérida and Tarragona), which pass the following filters: (1) having complete historical records; (2) not being a small farmer, as defined by the CMO; (3) having average yields falling in one of the following seven categories: < 3, 7-9, 13-15, 19-21, 28-32, 40-45, > 57 kg olive oil/tree (which means that we arbitrarily remove from the complete sample those growers whose average yields fall in the remaining 12 typologies). The final work sample results in a selection of 100 groups (19,600 growers).

- **Prices**: For olive oil prices we have taken the annual averages of the virgin olive oil index prices with a < 1° level of acidity, from the MAPA. The prices have been deflated and the temporal trend has been eliminated with the aim to find the risk level of the prices. Nevertheless, prior to 1998 there was a market intervention tool in the EU which was added to the production aid and avoided price reductions below intervention level. Therefore, in order to calculate the expected price of olive oil it has been necessary to eliminate this effect. Taking into account that the increase in the average price due to the intervention mechanism could be roughly estimated in 0.42 €/kg, the series of prices gave an average value in 2002 of 1.98 €/kg. It is further assumed that the standard deviation is constant both during the intervention period as well as after 1998.

Simulation

5 000 yields for each group of farms and 5 000 possible prices for the year 2000 have been generated from the distribution function of prices and yields, taking into account the correlation between both. Many

authors have used asymmetric density functions to reproduce yield distributions, being the Beta distribution one of the most commonly used in the literature (Skees *et al.*, 1997 ; Babcock and Hennessy, 1996 ; Hennessy *et al.*, 1997). The parameters have been calculated according to the average and typical deviation of the groups and whose maximum is the group's maximum yield and the minimum is 0. Thus, we avoid the problems of adverse selection found by Meuwissen (2000) in the simulation of yield and revenue insurance for 3 potato-growing farms in Baden-Würtemberg. The adverse selection problems arise when the premium rates are calculated using a distribution function that corresponds to the total yields from all the farms, and then premiums and indemnities are applied to individual risk-heterogeneous farms. The use of beta distributions has been challenged by Goodwin and Ker (2002) when only first and second moments are considered[2]. In our case, since we impose the maximum observed value for each unit, as Borges and Thurman (1994) do, our beta functions allow for skewness in either direction.

It is assumed that olive oil prices follow a lognormal distribution function, the average and standard deviation as explained above. This follows the suggestion of Goodwin *et al.* (2000), who analyzed the distribution of prices, concluding that assuming normality of prices would give rise to important errors in insurance premiums rates. Their analysis points to combinations of normal and lognormal distributions, the weight of the latter being predominant.

In order to measure the correlation between the group yields and national prices the Spearman's coefficient of correlation has been used. The generation of both variables has been carried out according to the procedure developed by Johnson and Tenenbein (1981), which is explained in the appendix.

Growers'utility measures

We assume farmers'preferences are Decreasing Absolute Risk Aversion (DARA) or Constant Relative Risk Aversion (CRRA). Among possible specific functions that fit with these properties, and following other authors'references (Nicholson, 1997 ; Coble *et al.*, 2000 ; Mahul, 2003), we have chosen the exponential function :

$$U(R) = \frac{R^{(1-rr)}}{1-rr}$$

where R is farmers'total revenue, including market and policy receipts, and rr is the relative risk aversion coefficient. Further, we assume that $rr=0.5$, which as the literature suggests, falls within a plausible range of

[2] We acknowledge the comments made on this point by one anonymous reviewer.

coefficients of relative risk aversion between 0 and 4 (Antle, 1987; Arrow, 1971; Binswanger, 1980; Hamal and Anderson, 1982; Little and Mirrlees, 1974).

With this utility function, to evaluate the welfare effects of our five possible policies we use the certainty equivalent (CE) that results from the following expression:

$$CE = U^{-1}(E(U(\tilde{R}))$$

The certainty equivalent provides a utility measure that has been used in the literature by other authors in similar works (see, for example, Hennessy *et al.*, 1997).

RESULTS AND DISCUSSION

The simulated data have been obtained from the work sample of 100 groups mentioned above. The level of representation of this sample in the total's ENESA database fluctuates between 9.5% and 22.5% depending on the province, and is 11.7% for the whole of Spain.

The Spearman's rho (ρ_s) coefficient of correlation of prices and yields for the different groups fluctuates between -0.023 of a group in Badajoz and -0.548 of a group in Jaén (Kendall's tau (τ) between -0.017 and -0.409). The Spearman's rho (ρ_s) coefficient of correlation between group yields and national production fluctuates between 0.143 for a Badajoz group and 0.976 for a group from Jaén, the average being 0.64.

All results are expressed in euros/tree. Table 3 reports the results per province and for the sum of the provinces considered for the 5 policy scenarios that have been described above.

Table 3. **Results for the 5 policies (in €/tree)**

Policy 1	E(R)	CV	CE	PE	ΔCE/ PE	ΔE(R)/ PE
7 provinces	12.75	0.52	11.77	0	-[a]	-[a]
Badajoz	5.74	0.59	5.18	0	-	-
Córdoba	12.93	0.53	11.88	0	-	-
Jaén	13.59	0.49	12.63	0	-	-
Lér+Tar	6.22	0.62	5.53	0	-	-
Málaga	18.62	0.54	17.13	0	-	-
Toledo	6.18	0.69	5.29	0	-	-

[a] These ratios are not defined as there is no public expenditure.

Policy 2	E(R)	CV	CE	PE	ΔCE/PE*	ΔE(R)/PE*
7 provinces	20.86	0.40	20.02	8.92	0.93	0.91
Badajoz	9.33	0.47	8.84	3.98	0.92	0.90
Córdoba	21.13	0.42	20.20	9.00	0.92	0.91
Jaén	22.23	0.38	21.43	9.46	0.93	0.91
Lér+Tar	10.23	0.50	9.63	4.54	0.90	0.88
Málaga	30.63	0.44	29.25	13.23	0.92	0.91
Toledo	10.30	0.55	9.57	4.85	0.88	0.85

Policy 3	E(R)	CV	CE	PE	ΔCE/PE	ΔE(R)/PE
7 provinces	13.76	0.40	13.27	1.69	0.89	0.60
Badajoz	6.31	0.45	6.04	0.95	0.91	0.60
Córdoba	14.01	0.42	13.48	1.80	0.89	0.60
Jaén	14.59	0.39	14.10	1.66	0.88	0.60
Lér+Tar	6.92	0.46	6.61	1.18	0.92	0.60
Málaga	20.17	0.42	19.41	2.58	0.89	0.60
Toledo	7.05	0.48	6.70	1.46	0.97	0.60

Policy 4	E(R)	CV	CE	PE	ΔCE/PE	ΔE(R)/PE
7 provinces	20.83	0.41	19.94	8.76	0.93	0.92
Badajoz	9.33	0.47	8.84	3.97	0.92	0.90
Córdoba	21.11	0.43	20.15	8.90	0.93	0.92
Jaén	22.19	0.39	21.33	9.26	0.94	0.93
Lér+Tar	10.22	0.51	9.59	4.47	0.91	0.89
Málaga	30.59	0.44	29.14	13.00	0.92	0.92
Toledo	10.27	0.57	9.47	4.67	0.90	0.88

Policy 5	E(R)	CV	CE	PE	ΔCE/PE	ΔE(R)/PE
7 provinces	17.20	0.31	16.82	5.25	0.96	0.85
Badajoz	9.58	0.29	9.39	4.25	0.99	0.90
Córdoba	17.32	0.33	16.90	5.21	0.96	0.84
Jaén	18.16	0.30	17.79	5.37	0.96	0.85
Lér+Tar	10.17	0.31	9.96	4.49	0.99	0.88
Málaga	23.26	0.35	22.64	5.86	0.94	0.79
Toledo	10.48	0.31	10.26	5.02	0.99	0.86

* The two criteria for efficiency ΔCE/PE and ΔE(R)/PE - increase in certainty equivalent over public expenditure and increase in expected income over public expenditure, respectively - are referred to policy 1, which has intervention.

Table 3 provides results for two measures of efficiency transfer of support:

- The increase of certainty equivalent over public expenditure ΔCE/PE, referred to policy 1 (non intervention) as the reference point, gives an indication of efficiency transfer of support based on the utility gains per € of taxpayers cost.

- The increase of expected revenue over public expenditure ΔE(R)/PE, also referred to policy 1, provides indication of the efficiency transfer of support based on the increase of expected revenue per € of taxpayers cost.

On examining the results of table 3, the following conclusions can be extracted:

Expected revenue: The policies with production aids (policies 2, 4 and 5), ensure a much greater level of revenue than policy 3 (revenue insurance, only). Even subsidizing 100% of the premiums of revenue insurance would not be enough to reach revenue levels similar to the current ones, and similar to the ones obtained in all policies that include the production aid currently granted by the EU to olive oil growers. This implies that revenue insurance is insufficient to deliver an equivalent level of support delivered by the production aid. Policy 5, based on tree aids and revenue insurance, provides slightly lower expected revenue.

Distributional effects: The policy that makes the most equal distribution of expenditure, in terms of €/tree, is policy 5. In this case, the average public expenditure per tree fluctuates between 4.25 for Badajoz and 5.86 €/tree for Málaga. The one which makes the least equal distribution of expenditure is policy 2, reaching 13.23 for Málaga and 3.98 €/tree for Badajoz. This shows that the substitution of all or part of the production aid with insurance subsidies has redistribution effects. Channeling taxpayers'cost from production aid to subsidies to insurance premiums tend to reduce the level of support to farms with a greater average yield, specially farms in irrigated areas in which the variation in yields is significantly lower. This leads to a smaller dispersion of subsidies and levels of revenue between the different provinces.

Taxpayers'cost: The most costly policy in terms of €/tree is policy 2, reaching an average of 8.92 €/tree. We estimate that the total cost for Spain would reach 1 233.46 million €/year with 50% of olive trees covered by insurance policies (table 4). The next policy in terms of cost would be scenario 4, with an average cost of 8.76 €/kg, whose total cost has been estimated at 1 221.91 million €/year. The least costly policy, with the exception of policy 1 that does not incur in public expenditure, is number 3 (revenue insurance with a 100% subsidy), with an average of only 1.69 €/tree. However, it has to be taken into account that the final expected revenue is much lower than the current revenue (Policy 2).

Table 4. **Estimated taxpayers cost for the work sample (100 groups) and for Spain**

Policy	Cost of premium subsidies €/olive tree	Cost of production aids or tree aids €/olive tree	Total average cost* €/olive tree	Total cost in Spain* (million €/year) (146 553 195 olive trees)
Policy 2	1	7.92	8.42	1233.46
Policy 3	1.69	0	0.84	123.10
Policy 4	0.77	7.92	8.31	1 217.86
Policy 5	1	4.25	4.75	696.13

*Supposing that 50% of the olive trees are covered by the different insurance policies.

In order to compare the results of each policy, three rankings have been carried out. The indicators used in each ranking are: 1) the minimum coefficient of variation, 2) the maximum of the ratio between the increase of expected revenue and public expenditure (denoted by

ΔE(R)/PE), and 3) the maximum of the ratio between the increase of certainty equivalent and public expenditure (denoted by ΔCE/PE). The following scoring criteria has been used: (1) the results of each policy in each group are compared; (2) we give a score of 1 to the policy that wins in each group and 0 to all the rest; (3) the weighted average score for each policy is calculated, with the number of olive trees that represents each group in each province as a weighting criteria. Table 5 shows the results of the ranking according to the three criteria.

Table 5. **Ranking of policies according to three criteria**

	Minimum of CV		ΔE(R)/PE		ΔCE/PE	
Geographical Area	Best policy	Second Best	Best policy	Second Best	Best policy	Second Best
All 7 provinces	5	3	4	5	5	4
Badajoz	5	3	5	4	5	3
Córdoba	5	3	4	5	5	4
Jaén	5	2	4	5	5	4
Lérida +Tarragona	5	3	5	4	5	3
Málaga	5	3	4	5	5	4
Toledo	5	3	4	5	5	3

The policies are: (1) no intervention; (2) yield insurance + production aids; (3) only revenue insurance; (4) revenue insurance + production aids; (5) revenue insurance + tree aids.

Policy rankings shown on table 5 are now discussed. First, policy 5 ensures the lowest variability of revenues followed by policy 3. According to the first criterium of efficiency of public expenditure, ΔE(R)/PE, the first place is occupied by both policy 4 (current aids and revenue insurance with a 50% subsidy) and policy 5 (aids per tree with revenue insurance with a 50% subsidy). It can be seen that in the provinces with lower expected yields (Badajoz, Lérida+Tarragona and Toledo), policy 5 is the preferred one. Whereas in Málaga, Jaén and Córdoba, with an expected yield of twice the size of the previous provinces, policy 4 is preferred.

According to the second proposed criterium for efficiency transfer of support, ΔCE/PE, policy 5 comes in first, both for all the 7 provinces together and for each province on its own. This denotes that in combination with the revenues insurance, the tree aid reduces risk more effectively than the production aid.

Given that the total taxpayers cost of policy 5 is lower than for policies 3 and 4, it may seem likely that if public expenditure were increased in policy 5, its efficiency would be reduced due to the concavity of the utility function, and thus we would end up with similar results to the ones in the previous point, with policies 3 and 4 nearing second place. Of course, to what extent public expenditure in policy 5 must be increased to have the same efficiencies of policies 3 and 4 is dependent on the coefficient of relative risk aversion which characterizes the concavity of the utility function. This result can be generalized by stating that policy 5 ensures higher efficiency transfer of support as long as the *rr* is sufficiently large. Hence, with *rr* close to zero, as would the case under the risk neutrality assumption, the superiority of policy 5 over 3 and 4 vanishes. However, if we take on the minimum CV as a complementary criterium, policy 5 turns out to be superior to policy 4, and this ordering holds irrespectively of the risk preferences assumed for the growers.

We can see in table 5, that in spite of the fact that policy 4 surpasses policy 2 in all rankings, the degree of efficiency of both policies is very similar. Thus we deduce that the greater degree of efficiency of revenue insurance is partially offset by the fact that production aid drops when yields grow, imperfectly reproducing the foundations of any revenue insurance when price and yields are negatively correlated.

Having observed that the results of policies 2 and 4 do not differ very much, it is interesting to make a comparison of revenue insurance and yield insurance in an isolated way. To do this the indemnities payments that would have been made in the 1991-1998 campaigns if both insurance policies had existed have been simulated. From the results obtained, which are summarized in table 6, we deduce that the yield insurance's impact is much stronger than revenue insurance's for two reasons. First, because average indemnity payment is almost three times higher for yield insurance than for revenue insurance. This confirms that vis-à-vis revenue insurance is much cheaper than yield insurance. Secondly, because revenue insurance is also more balanced, as its simulated maximum indemnity is much lower and the minimum is higher than yield insurance's. This suggests that the cost of reinsurance of revenue insurance is, in relative terms, much lower than the cost of reinsurance of yield insurance.

Table 6. **Comparison of the indemnity payments for yield insurance and revenue insurance***

Years 1991-1998	Yield insurance (Policy 2)	Revenue insurance (Policies 4 & 5)
Average indemnities	20.8	7.1
Maximum annual indemnities	151.5	46.1
Minimum annual indemnities	0.01	0.13

*Indemnities evaluated in millions of € for the national total assuming that 50% of the olive trees in Spain are covered by the different insurance policies.

A final discussion addresses the robustness of the above rankings and the importance of some of the key assumptions. Clearly, two of our ranking criteria (shown on the first columns in table 5) are only sensitive to the quality of our database, and the manipulations carried out for the

Monte-Carlo simulations. The remaining and third criteria, based on ΔCE/PE, is clearly dependent on the assumptions related to the way growers'preferences have been modeled. On these bases, our comparisons show that policy 5 defeats the closest candidates by a slight margin, indicating that a significant departure of our assumptions would likely reverse the results. In this the third ranking is far from robust. However, in our view, the large differences found on taxpayers cost (table 4) suggest that policy 5, or any other variation of it, is by far the best it can be offered to the growers at a reasonable taxpayers cost.

CONCLUSIONS

Five different policies that support or stabilize olive oil producers' revenues have been analyzed: (1) no intervention (provides the comparison reference); (2) current EU production aid and yield insurance; (3) revenue insurance; (4) revenue insurance and EU current production aid; (5) revenue insurance and tree-based aid. Results demonstrate that policy 5 has shown the best properties. First, it places most of the budgetary cost in the tree aid, which is thought to provide a quasi-decoupled form of revenue support (on average, 81% of the cost would be assigned to tree aid, and 19% to subsidize revenue insurance premiums); secondly, it reduces variability of revenue to a minimum; thirdly, it is the most equitable in terms of total expenditure per olive tree; and fourthly, it ensures the most efficient transfer of support from taxpayers to producers. The main disadvantage of scenario 5 is that the national average revenue would diminish in about 3 €/tree with regard to scenarios 2 and 4. This differences are sharply marked looking at expected revenue losses in the provinces with the highest yields, like Málaga which would lose around 7 €/tree and Jaén with a loss of 4 €/tree.

We leave for future research going further into the study of a policy of aids per tree or perhaps per hectare, to which a revenue insurance could be added. Special care would have to be taken with this modality of aid, so that although it may vary with the provincial or county average yields, it would need to preserve the characteristic of an aid partially decoupled from production.

As far as revenue insurance is concerned we found that the current policy that combines a production aid with yield insurance gives results that are very similar to the ones that would be obtained by maintaining the current production aid and substituting the yield insurance for a revenue insurance. The theoretical superiority in efficiency of revenue insurance is offset by the way production aid is calculated for each year and EU member state. Thus, the results show without any ambiguity that a revenue insurance that were to replace the yield insurance, maintaining the regime of production aids, would not offer important improvements for any of the proposed analysis criteria, neither at national level nor for each of the provinces analyzed. This result is motivated by the combination of two interrelated factors. The first one is that yields of Spanish olive are subject to climatic risks that are strongly and positively correlated. And, in second place, since the quantity of production aid (in €/kg) depends on the total production of the country, it happens that high yields are associated with less aids and vice-versa. The resulting effect from both factors is to eliminate to a large degree the interest in substituting the yield insurance with revenue insurance, as long as the production aid is maintained in its current formula. If the yields of Italy and Greece are equally subjected to climatic processes that affect most of their olive-growing farms, the results obtained in this study can be generalized in full for these two EU countries.

Another outstanding conclusion of this study is that when the level of support provided by a policy to a sector is very high, as is clearly the case of the olive oil sector in the EU, then a revenue insurance policy reveals itself incapable of replacing it in an efficient way, even supposing that it were to subsidize the overall premium of the producers. However, if a part of the support for the sector is totally decoupled from production and the other part is channelled by way of a revenue insurance, the resulting policy would be much cheaper and more efficient. This would be the case of the tree aids combined with revenue insurance (policy scenario 5 in this study).

From a methodological perspective, it is shown that using micro-level data, instead of area, county or province data, broadens the analysis and implications in a number of ways. First it allows for making cross-section comparisons not only based on geographical grounds but also on the level of market and yield risks that each individual grower faces. Secondly, it ensures that actuarially-based individual premiums are calculated more accurately, which in turn permits making policy comparisons at the most disaggregate level. Lastly, it makes realistic assumptions about the expected receipts granted to each grower by policies that embody budget stabilizing mechanisms, such as the EU production aid to olive growers.

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APPENDIX

The procedure developed by Johnson and Tennenbein (1981) consists in generating a number (5 000 in our case) of random values for each of two variables U' and V', drawn from two normally distributed distribution functions (0,1). From these variables we generate two new variables, U and V being:

$$U = U' \text{ and } V = cU' + (1-c)V'$$

Where c is a coefficient that reflects the relation between the yield and price variables. "c" can be calculated from Spearman's Rho coefficient or from Kendall's Tau coefficient of correlation. U and V are correlated with each other and their distribution functions are the following:

$$H_1(U) = N(0,1) = F(U) \text{ and } H_2(V) = F(V/(c^2+(1-c)^2)^{1/2}))$$

Where $F()$ is the accumulated probability function for a normal standard variable. Finally, we obtain the sought variables, the yield Y, which follows a beta distribution function (B) and price (P), with lognormal distribution function (L):

$$Y = B^{-1}(H_1(U))$$

$$P = L^{-1}(H_2(V)) \text{ if the correlation is positive}$$

$$P = L^{-1}(1-H_2(V)) \text{ if the correlation is negative}$$