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via Multi-Attribute Utility Theory and E-V analysis

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Modelling farmers' response to a decoupled subsidy via Multi-Attribute Utility Theory and E-V analysis

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Abstract
In this paper we simulate changes in crop land allocations made by farmers in Southern Spain due to the implementation of a flat-rate subsidy. In order to reproduce farmers' decision-making process, we first group farmers by farm size into three categories and then elicit a general utility function for each group. The elicitation of the bi-attribute utility functions, based on observed crop land allocation, does not require interaction with the farmers. The results suggest that, with the same EAGGF expenditure, small and medium-sized farms in this region would benefit from this alternative scheme in terms of higher expected total gross margin, flexibility and freedom of crop choice. The new scheme reduces control and monotoring responsabilities for Member States and the Commission and moves toward a more decoupled subsidy in line with the proposal for the Mid-Term Review of the Common Agricultural Policy.

Keywords: MAUT, E-V analysis, Utility function, Decoupled subsidy.

1. Introduction

Many authors believe that a further reform of the European Union's current Common Agricultural Policy (CAP) will be needed in the next few years (Swinbank and Tangermann, 2001; Gohin and Hervé, 2000). Internal and external pressures are behind this necessity. Among the internal factors we count the growing difficulty of justifying the subsidies to the largest producers from a social point of view, the environmental problems associated with intensive farming and consumer concern about food safety. Among the external pressures are the future enlargement of the EU and the forthcoming Millennium Round of the World Trade Organisation.

In this sense, the EU Commission's proposal for the Mid-Term Review of Agenda 2000 (July 2002) suggests introducing a single decoupled income payment per farm. With this payment, which will be based on historical payments, farmers receiving the new decoupled farm payment will have the flexibility to farm any crop on their land, including those which are still under coupled support. In this paper we model a similar scheme with a flat-rate subsidy, based on previous cereals, protein and oilseed (COP) crops historical payments, irrespective of their crop land allocation choice.

In order to simulate the impact of such a policy, we apply a non-iterative methodology to obtain a linear approximation to the farmers' true utility function, which enables us to predict farmers' responses to a new flat-rate subsidy for arable crops under irrigation in Southern Spain. The subsidy change proposed in this paper implies a movement from "blue-box" support measures (area payment linked to each crop) that are market-distorting subsidies, towards "green-box" measures (same area payment for a group of crops), and therefore, less distorting agricultural policies.

This flat-rate subsidy would be paid on a per hectare basis for the whole farm, and the amount would depend on the previous level of subsidies paid for COP crops. The farmer would receive exactly the same amount as if she/he had continued to sow the same crop mix, keeping EAGGF expenditure unchanged. We suggest that such a support measure could have a positive impact on rural employment and farm income due to the increase in the hectarage of vegetables (highly labour-intensive crops). This increase is explained by the fact that under the flat-rate subsidy the relative profitability of vegetables would be increased by the amount of the subsidy.

This paper is organised as follows: Section 2 presents the methodology used to calculate the utility function from the observed crop land allocation. Section 3 is a description of the area of study and the sources of data. The results are reported in Section 4, with the mathematical form of the nine utility functions, the validation of the models and the simulation of the policy scenario consistent with a flat-rate subsidy. Finally, our main conclusions are summarised in Section 5.

2. Methodology

2.1. Modelling farmers' responses to policy changes

The aim of utility theory is to reduce a decision problem with multiple criteria to a cardinal function that ranks alternatives in terms of a single criterion. Most authors have relied on expected utility theory to elicit such a function. Thus, the utilities of *n* attributes from different alternatives are captured in a quantitative way via a utility function; mathematically, $U = U(x_1, x_2, ..., x_n)$. If the attributes are mutually utility-independent[1] the formula becomes $U = f\{u_1(x_1), u_2(x_2), ..., u_n(x_n)\}$ and takes either the additive:

$$U(x_1, x_2, ..., x_n) = ?\ w_i u_i(x_i), \quad i = 1, 2, ..., n \qquad (1)$$

or multiplicative form:

$$U(x_1, x_2, ..., x_n) = \{?\ (K w_i u_i(x_i) + 1) - 1\}/K, \quad i = 1, 2, ..., n \qquad (2)$$

where $0 ? w_i ? 1$ and $K = f(w_i)$. If the attributes are mutually utility-independent and $?\ w_i = 1$, then $K = 0$, and the utility function is additive. If $?\ w_i ? 1$, then $K ? 0$, and the mathematical form is multiplicative (Keeney, 1974).

Both of these forms have been elicited on the basis of expected utility theory through the use of techniques that involve the choice by the decision-maker between a certain outcome and a lottery (Anderson *et al.*, 1977; Biswas 1997; Hardaker *et al.*, 1997). Since the elicitation of the multiplicative form makes great demands on the introspective capacity of the decision-maker, one or both of the following simplifying assumptions may be made: (a) the attribute utility functions are regarded as linear; or (b) the sum of attribute weights is assumed to be one, so that the utility function is additive. Mathematically, the expression (1) in its simple form becomes:

$$U_i \ ? \ \overset{n}{\underset{j?1}{?}} w_j r_{ij}\,, \qquad i = 1, ..., m \qquad (3)$$

where U_i is the utility value of alternative *i*, w_j is the weight of attribute *j* and r_{ij} is the value of attribute *j* for alternative *i*.

[1] "An attribute x_i is utility-independent of the other *n*-1 attributes x_j if preferences for lotteries involving different levels of attribute x_i do not depend on the levels of the other *n*-1 attributes x_j." (Huirne and Hardaker, 1998).

Although the additive utility function represents a simplification of the true utility function, i.e. the mathematical form, Edwards (1977) and Farmer (1987) have shown that the additive function yields extremely close approximations to the hypothetical true function even when the conditions of utility independence.

2.2. Calculation of the common utility function

The elicitation of utility functions through random lotteries (Dillon and Scandizzo, 1978), as Lins *et al.* (1981) point out, is vulnerable to "interviewer bias" and is "situation specific", to which Ballestero and Romero (1998, p. 73) add "the empirical difficulties of testing independence conditions". Binswanger (1974) shows how "the measurement of risk preferences is substantially affected by whether the decision-maker is evaluating actual or hypothetical gains or losses." In order to avoid these shortcomings, the policy analyst can elicit such a function via direct observation of the agent's economic behaviour (Lins *et al.*, 1981). This is the approach followed in the present paper, which makes use of the farmers' observed crop land allocation to draw conclusions about their attitudes toward risk.

Amador *et al.* (1998) propose a method for eliciting a surrogate of the farmer's utility function without direct interaction between the farmer and the researcher, thus avoiding complex questions in the evaluation of lotteries. Instead, they show how it is possible to elicit a surrogate of the farmer's utility function by observing only the actual crop land allocation. Two recent applications of this methodology can be found in Gómez-Limón *et al.* (2002) and Arriaza *et al.* (2002). To obtain the farmers' utility function, i.e., the common utility function of a stratum, the following methodology was employed:

Step 1. The sampling procedure had three stages. First, three communities of irrigators were selected from the directory of the water authorities following a random procedure without replacement and a probability proportional to the number of farmers in the community. Second, stratified sampling was applied to each community, in which we considered three strata: (a) less than 10 hectares, (b) between 10 and 20 hectares, and (c) more than 20 hectares. The number of farmers selected in each stratum was approximately proportional to the average number of farmers and the hectarage in the stratum, with a minimum of 15 interviews. Third, farmers were selected in each stratum using random sampling in the smallest community and quota sampling in the other two. In order to reduce any bias resulting from the second sampling procedure, we selected the sample of farmers from two different locations in the area of study, where, presumably, any type of farmer might appear.

Step 2. For the average farm size of each stratum (three strata for each of the three communities), two extreme points were obtained: 1) the value of the total gross margin (TGM) and the variance when the total gross margin is maximised, and 2) the value of the total gross margin and the variance when the variance is minimised, subject to the achievement of a minimum TGM. The second is a quadratic risk-programming model (Anderson *et al.*, 1977, p.197; Hardaker *et al.*, 1997, p.186); and the minimum total gross margin corresponds to that obtained by renting out the land. This alternative has no risk and provides a higher TGM than taking the land out of production and receiving the set-aside payment.

Step 3. We calculated the extreme points of each farm in the stratum on the basis of those obtained in the previous step. The new extreme points were worked out by multiplying the extreme point values for the average farm size by the ratio x/y and $(x/y)^2$ for the TGM and the variance, respectively, where x is the total hectarage of the farm and y is the average farm size in the stratum.

Step 4. The weighting (in percentage terms) that farmer *i* places on each objective was calculated by solving the following linear programming model:

$$\text{Min } Z= \frac{n_1 ? p_1}{TGM_i} ? \frac{n_2 ? p_2}{V_i} \qquad (4)$$

Subject to

$w_{i1}\, TGM_{\text{max\_TGM}} + w_{i2}\, TGM_{\text{min\_variance}} + n_1 - p_1 = TGM_i$

$w_{i1}\, V_{\text{max\_TGM}} + w_{i2}\, V_{\text{min\_variance}} + n_2 - p_2 = V_i$

$w_{i1} + w_{i2} = 1$

where the two extreme points are:

Point 1: $V_{\text{max\_TGM}}$= variance of the crop mix that maximises total gross margin.
$TGM_{\text{max\_TGM}}$= maximum total gross margin.

Point 2: $V_{\text{min\_variance}}$= minimum variance (subject to the achievement of a min. *TGM*).
$TGM_{\text{min\_variance}}$= total gross margin obtained with the crop mix.

TGM_i, and V_i are the observed values of the TGM and the variance (they can be obtained by substituting the observed crop land allocation of the farmer in the model used to calculate the extreme points explained before), w_{i1} is the weighting placed on the maximisation of total gross margin, w_{i2} is the weighting placed on the minimisation of the variance; and n_i and p_i are negative and positive deviations.

Step 5. The average of the farmer's weightings in each stratum for the minimisation of the variance was then calculated as ($w_2 = \overset{n}{\underset{i?1}{?}} w_{i2}$ /n), where *n* is the number of farms in the stratum. w_1= 1- w_2 is the average weighting that the farmers in each stratum placed on the maximisation of total gross margin.

These averaged weights are consistent with the following separable and additive function for the stratum (Dyer 1977):

$$U= f(TGM,V)= \frac{w_1}{TGM_{\max\_TGM} ? TGM_{\min\_variance}} TGM ? \frac{w_2}{V_{\max\_TGM} ? V_{\min\_variance}} V ? aTGM ? bV \qquad (5)$$

In considering the mean-variance preference function *U*= *a*·TGM - *b*·Variance, 2·*b/a* is a measure of absolute risk aversion (Pratt, 1964; Arrow, 1965). For comparison, the coefficients of the utility function elicited following the above procedure can be used to calculate the absolute risk aversion coefficients.

We included two attributes in the utility function: gross margin and risk. Several reasons led to this choice: (a) gross margin and risk avoidance are the first two objectives for 77 per cent of farmers as was shown in the survey, (b) other objectives mentioned by the producers, such as the minimisation of external labour, reduction of management difficulty and leisure, are not in conflict with the minimisation of risk, and (c) in similar studies (Gómez-Limón *et al.*, 2002) the weighted goal programming algorithm attached a zero weighting to other objectives than the maximisation of total gross margin and the minimisation of risk.

2.3 Model specification

Objective function

The utility functions have two objectives: the maximisation of total gross margin and the minimisation of risk. With respect to the first, while the crop gross margins changed across communities, they remained the same across strata. This simplification is supported by the analysis of the gross margins of the database of the accounting firm.

With respect to the minimisation of risk, since it was not possible to obtain from the survey a variance-covariance matrix of crop gross margins for each group of farmers, we used the same matrix for all communities and strata. From the accounting firm's database we calculated the average gross margin of each crop over a six-year period. The variance-covariance matrix was obtained from the table of the average crop gross margin by year. In the quadratic programming model (Step 2), the minimisation of risk, a further constraint of minimum total gross margin is added in order to avoid a zero solution for all crops. The minimum total gross margin is based on the average rental value of land. This alternative has zero risk and offers a higher total gross margin than set-aside payments or any other CAP measure to take land out of production for a long period of time.

Constraint set

We took CAP, rotational and resource constraints into account as follows:

?? *CAP constraints*. We set aside 10% of COP area, included durum wheat quotas (each stratum is entitled to a maximum durum wheat area) and sunflower area limitation (50% of COP area). The CAP constraints apply only to the programming exercices aimed at obtaining the maximum total gross margin and the minimum risk (extreme points), but do not appear in the flat-rate programming model.

?? *Rotational constraints*. According to the farmers, no crop is repeated two sowings in succession on the same patch of land. Some crops need longer periods (asparagus, garlic, water melon, melon and onions).

?? *Resource constraints*. The survey showed that small farmers do not consider labour or machinery constraints in their decision-making process. However, for medium and large farmers these constraints were included in the models. The water constraint does not apply to any of the farmers since, in an average pluviometric year, there is enough water for irrigation. The cost of water is fixed and does not depend upon the quantity taken.

3. Area of study and data sources

3.1. Area of study

The study area is located in the *Valley of the River Guadalquivir* in Andalusia with a typical Mediterranean climate, that, under irrigation, permits farmers to sow a wide range of agricultural products such as cotton, vegetables and fruits, apart from the usual continental crops (mainly wheat, sunflower, maize and sugar beet). The following table presents the main crops:

Table 1. Crop land allocation of each stratum of the three communities selected in the study (%)[a]

	Villar			*Valle*			*Bajo*		
	<10 ha	10-20	>20 ha	<10 ha	10-20	>20 ha	<10 ha	10-20	>20 ha
Cotton	69.2	50.9	38.9	49.3	45.2	43.7	72.5	59.9	43.5
Sunflower	18.8	26.3	35.1	0.0	0.1	5.1	2.5	12.8	18.5
Durum wheat	1.0	8.8	19.5	0.0	0.0	0.4	1.0	2.3	4.9
Maize	1.4	3.3	3.1	31.2	32.9	35.5	10.2	13.0	19.6
Vegetables	9.0	7.4	2.2	19.5	21.8	13.2	10.5	3.7	1.7
Others	0.6	3.3	1.2	0.0	0.0	2.1	3.3	8.3	11.8
Total=	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total COPs=	21.8	41.7	57.7	31.2	33.0	41.0	13.8	28.4	43.7

[a] Source: Survey of 175 farmers carried out by one of the authors.

As Table 1 shows, the percentage of COPs (durum and common wheat, sunflower and maize) in the crop mix increases with farm size. This pattern responds to the CAP subsidies-seeking behaviour of large farmers associated with COPs. Small farmers devote a larger proportion of their land to vegetables in order to achieve higher income per hectare and therefore operate riskier enterprises. The average farm size is 10 hectares.

3.2. Data sources

In order to build the models three main sources of data were used in this study: one primary (a survey) and two secondary:

1. Our own survey of 175 farmers in the three communities of irrigators. As explained in Step 1 of the methodology, the sampling design aimed to obtain a sample as representative as possible of the type of farmers in the area.
2. A database of an accounting firm that consists of farm panel data (30 farms for 11 years). Three reasons justify our use of the accounting database: first, in order to model risk a sufficiently long time series was needed. In the second place, we needed to be able to compare farmers' answers with a more objective data source. Third, some data could not be obtained from our own survey, either because the farmers did not remember, or because their answers were too vague.
3. A governmental regional database on production and prices (22 crops for 11 years). These time series allowed the elasticity of demand for some crops to be estimated. These elasticities were included in the mathematical programming model, in order to reduce gross margins as production increased.

4. Results

4.1. Mathematical form of the utility functions

Following the methodology described above to obtain the mathematical form of the utility functions, Table 3 summarises the extreme values, weights in percentage and normalised weights obtained for each stratum of the three communities of irrigators. With regard to the percentage-weighted values, it seems clear that the weighting attached to the maximisation of expected total gross margin decreases as farm size increases. Furthermore, there are some similarities in their absolute value across strata in different communities of irrigators.

Table 2
Weights attached to each attribute in percentage and absolute terms for each stratum. The utility function has the fo

Communitie s of irrigators	Average size (ha)	Range of extreme points				Weights in percentage		Normalised weig
		Maximum TGM (10^3 pta)	Minimum TGM (10^3 pta)	Maximum Variance	Minimum Variance	Maximisation of TGM	Minimisation of variance	Maximisation of TGM
Villar								
<10 ha	5.7	1,106	545	108,692	4,918	81%	19%	0.0014439
10-20 ha	15.7	3,136	1,471	920,664	32,188	52%	48%	0.0003123
> 20 ha	57.1	9,944	4,608	8,874,032	707,609	42%	58%	0.0000787
Valle								
<10 ha	5.8	1,297	594	173,280	7,614	76%	24%	0.0010811
10-20 ha	15.4	3,547	2,138	1,945,784	254,863	69%	31%	0.0004897
> 20 ha	59.9	12,665	8,848	17,112,602	3,855,841	66%	34%	0.0001729
Bajo								
<10 ha	8.1	1,613	738	243,681	23,065	86%	14%	0.0009829
10-20 ha	13.5	2,571	1,548	586,164	41,168	68%	32%	0.0006647
> 20 ha	53.5	9,668	5,856	9,009,064	1,135,648	61%	39%	0.0001600

The following table presents the degree of risk aversion of each stratum.

Table 3. Measure of local risk aversion by group of farmers

Villar			*Valle*			*Bajo*		
<10 ha	10-20	>20 ha	<10 ha	10-20	>20 ha	<10 ha	10-20	>20 ha
0.0025	0.0035	0.0018	0.0027	0.0007	0.0003	0.0013	0.0018	0.0006

There is no clear relationship between farm size and measure of risk aversion. In the three communities of irrigators, large farmers are less risk-averse than small ones. The intermediate stratum does not follow a clear pattern. These mixed results agree with those of other studies (Bond and Wonder, 1980; Hamal and Anderson, 1982).

4.2. Validation of the model

From a point of view based on the accuracy of predictions, the precise mathematical form of the surrogate of the farmers' true utility function does not matter, as long as the ranking of the alternatives (crop mixes) predicted by the model is the same as the ranking of the farmers. In order to test the capacity of the utility functions to rank alternatives, we calculated the utility value of five alternatives, using the utility function elicited in each stratum. Alternative *A* represents the observed crop land allocation of the stratum, that is, the aggregate of all farmers' crop land allocations in the stratum. We presume that, on average, this would be the most preferred crop mix, and thus the crop mix with the highest expected utility. From alternative *A* to *E*, we progressively reduced the percentage of important crops (cotton, cereals and sunflower) and increased the percentage of vegetables, making the crop mix less interesting to the farmers. In every case, the nine utility functions perfectly ranked the five alternatives. Table 4 shows the utility value of the five alternatives in each stratum of the smallest community (the mathematical form of the utility functions is given below). As we can see, the three models rank the alternatives in the same order as the farmers would presumably have done.

Table 4. Expected TGM, variance and utility values of the five crops mixes in Villar.
Figures calculated for average farm size from our survey.

Alternative	Average farm size in stratum: 5.7 ha		
	TGM (10^3 pesetas)	Variance in TGM	Utility values for the smallest stratum (<10 ha)
A	1,065	92,887	1.21
B	1,100	189,774	1.16
C	891	258,497	0.85
D	836	589,483	0.44
E	796	764,938	0.28
Alternative	Average farm size in stratum: 15.7 ha		
	TGM (10^3 pesetas)	Variance in TGM	Utility values for the medium stratum (10-20 ha)
A	2,608	411,248	0.60
B	2,660	883,585	0.43
C	2,163	2,685,827	-0.43
D	1,745	5,156,728	-1.53
E	1,192	9,152,635	-3.28
	Average farm size in stratum: 57.1 ha		

Alternative	TGM (10^3 pesetas)	Variance in TGM	Utility values for the largest stratum (>20 ha)
A	8,133	3,106,915	0.47
B	7,367	4,051,195	0.35
C	6,717	4,762,877	0.24
D	6,077	6,020,289	0.11
E	5,271	8,208,204	-0.11

It should be noted that an expected utility-maximising model with total gross margin as its sole attribute would have ranked *B* over *A* in the first two strata. This is not the case when a utility function with the two first moments of the variable is utilised.

Furthermore, as a second validation procedure, assuming that farmers produce at a point close to their maximum utility, the optimum plan of each stratum should not differ greatly from the observed crop land allocation[2]. The next table compares observed and predicted crop land allocations for the smallest stratum of the smallest community. This also includes a divergence index (the sum of all absolute deviations).

Table 5. Differences between observed and predicted crop land allocation (Villar, <10 ha)

	Observed crop land allocation	Maximum utility	Absolute difference
Cotton	69.2	72.5	3.3
Sunflower	18.8	14.0	4.7
Durum wheat	1.0	1.0	0.0
Maize	1.4	2.6	1.2
Onions	2.9	1.8	1.1
Garlic	3.6	3.5	0.0
Common wheat	0.6	0.0	0.6
Green asparagus	1.8	3.5	1.7
Potatoes	0.7	1.1	0.3
Set-aside	0.0	0.0	0.0
Total	100.0	100.0	13.1

As the divergence index in Table 6 indicates, the optimum crop mix of each stratum was close enough to suggest that the models are a good approximation to the farmers' own decision-making processes.

Table 6. Divergence index of all strata (sum of absolute deviations between observed and predicted crop land allocation)

Villar			*Valle*			*Bajo*		
<10 ha	10-20	>20 ha	<10 ha	10-20	>20 ha	<10 ha	10-20	>20 ha
13.1	11.7	11.2	15.2	19.8	9.3	11.3	13.7	5.3

[2] For a similar validation procedure see Rigby and Young (1996), where they compare the observed and optimum level the of the decision variables.

4.3. Simulation of policy scenario

This study proposes a new European agricultural support programme to deal with the growing pressure on the current CAP. This new scheme is not tied to production controls and can therefore be included in the green-box support measures. Under this new scheme, farmers would receive a flat-rate subsidy irrespective of the distribution of their crops with no upper limit on the percentage of vegetables sown.

We simulate the impact of this policy on the area of study using the farmers' utility functions. This unique area payment includes COPs and vegetables, and excludes cotton and sugar beet (which are not subsidised through area payments). The total amount of such a payment would be equivalent to the total CAP expenditure on COPs (pre-Agenda 2000) divided by the total hectarage of COPs plus vegetables.

In order to illustrate how this subsidy works, let us consider a ten ha farm with five hectares of maize and five hectares of potatoes. The farmer receives an area payment of 500 euro/ha for maize. The total EAGGF expenditure is 2,500 Euros. With the unique area payment, the farmer would receive 250 euro/ha for maize and potatoes. In order totake changes in profitability into account, the gross margin for maize is reduced by 250 euro/ha, while the potato gross margin is increased by the same amount (in the utility function model, the expected gross margin for potatoes is reduced according to the market constraints as optimum hectarage is greater than observed hectarage).

As already explained, this new scheme does not represent a reduction in the farmer's support level. Thus, as long as the farmer continues with the same crop land allocation, the total subsidy he receives does not change. The rise in TGM comes from the substitution of a small percentage of COPs for vegetables. The following table shows the impact of such a policy on all strata of the three communities of irrigators.

Table 7. Predicted changes in the communities under the new fixed subsidy

	Villar			*Valle*			*Bajo*		
	5.7 ha	15.7 ha	57.1 ha	5.8 ha	15.4 ha	59.9 ha	8.1 ha	13.5 ha	53.5 ha
Total hectarage	330	395	1,519	2,223	2,699	10,911	5,289	12,473	29,712
Total COPs	-43.5%	-18.0%	-3.6%	-34.7%	-26.8%	-7.7%	-62.3%	-10.0%	-5.2%
Total vegetables	78.6%	65.8%	57.7%	43.1%	26.3%	22.1%	40.5%	59.0%	56.5%
Expected TGM	10.6%	11.9%	6.7%	4.1%	4.1%	1.0%	4.7%	-3.1%	-3.6%
Variance in TGM	15.5%	23.4%	1.5%	12.3%	17.1%	5.6%	8.1%	-12.2%	-4.3%
Current utility values	1.39	0.61	0.45	1.18	1.44	1.85	1.45	1.39	1.19
Fixed subsidy utility values	1.53	0.67	0.49	1.21	1.46	1.86	1.50	1.40	1.21

The simulation of a flat-rate area payment for COPs and vegetables for *Villar*, the smallest community of irrigators, shows an increase in the farmers' wellbeing in terms of utility value for all strata. The results indicate that the smaller the farm size in the stratum, the greater would be the reduction in COP crops and the increase in vegetables. The simulation for the medium community, *Valle,* indicates that the changes would follow the same pattern as in *Villar*.

There are some differences in the responses of the farmers in the largest community, *Bajo*, compared with the other two. First, although utility does increase in all strata, the expected TGM is reduced in the two largest ones, and is compensated, since they achieve a higher utility value, by a reduction in risk.

The explanation for the reductions in TGM comes from farm size in the largest strata in *Bajo*. Such farms represent 58 per cent of the total area of the three communities. The reduction in area payment for COPs cannot be fully compensated for by an increment of vegetables since, due to their weighting, the gross margin of vegetables falls much faster than in the other two communities.

It should be borne in mind that we have taken a conservative approach to the modelling exercise. Thus, in the case of lack of data for a particular vegetable, the largest elasticity of demand for a similar vegetable was used instead. If more accurate data had been available, a greater rise in the hectarage sown to vegetables would be possible in *Bajo* with a lower reduction of gross margins than predicted here.

When we take the size of each stratum into consideration, we see that the weighted average decrease for total COPs is 9.8 per cent in the areas of study (from 24,338 ha to 21,944 ha), whereas for vegetables the weighted average increase is 36.9 per cent (from 4,077 ha to 5,582 ha). The increase in vegetables, although it seems important in relative terms, when compared with the total hectarage it is less striking: with the proposed flat-rate subsidy, since vegetables would cover 7.7 per cent of the total hectarage of the studied area (previously 5.6 per cent).

The rise of 36.9 per cent in vegetables would have a positive impact on rural employment, since the labour requirement (farm labour plus downstream labour) of vegetables is 47 man-days/(year·hectare)[3], compared to three for COPs. Multiplying the hectarage of each crop by its labour requirements and dividing by the total hectarage we obtained the average amount of total labour per hectare in these three communities: 10.5 man-days/(year·hectare). If the flat-rate subsidy is implemented, the model simulations predict an increase in that average to 11.5 man-days /(year·hectare), that is, an increase in rural employment of 9.3 per cent. Given that rural unemployment may reach 20 per cent in some parts of Andalusia, this policy could help in reducing unemployment, particularly in areas with high horticultural potential.

A further benefit of this policy is the reduction in bureaucracy that it would entail. It would no longer be necessary to record and control COP hectarage. It would also give farmers more freedom to sow what they prefer.

With regard to the impact of this policy on the farmers' level of exposure to risk, the results suggest that most new optimum crop land allocations have a higher variance than the level of variance of the optima under the pre-Agenda 2000 policy. This is automatically associated with the higher average gross margin achieved. We can see that the farmers who would benefit most from this policy, in terms of an increase in their TGM, are the smallest ones.

[3] Crop labour requirements provided by F. Barea and C. Benavides, CIFA. Personal communication.

5. Conclusions

The major advantage of the methodology utilised in this research is that it enables us to elicit the farmers' surrogate utility functions without the use of the traditional random lotteries. Based on observed crop land allocations, a linear utility function with the two first moments of the total gross margin can be obtained. When these linear utility functions are maximised, we locate the optimum in the E-V efficient set. Thus, the tangent to the efficient set is a measure of local risk aversion. The results confirm the widely accepted assumption of decreasing absolute risk aversion (DARA), namely that small farmers are more risk-averse than large farmers.

According to the results of the simulation of the flat-rate subsidy, the overall impact in the region in terms of changes in crop hectarage is not large, with a reduction in COPs (9.8 per cent) and an increase in vegetables (36.9 per cent), that represents, in absolute terms, a change from 5.6 to 7.7 per cent of the total hectarage (72,839 ha) of the area studied. Such an increase in the hectarage sown to vegetables would have a positive effect on rural employment and farm income.

The benefits of this new policy are biased towards small farmers, in terms of the increase in total gross margin and utility values. Only two of the nine strata suffered a reduction in their expected total gross margin; however, this reduction was offset by a reduction of risk, thus offering a overall increase in utility. The greater freedom of crop choice brings, in most cases, an increase in risk-taking as farmers move towards more profitable crops that are therefore more risky.

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