Cumulative Prospect Theory: a study of the farmers' decision behavior in the Alentejo dryland region of Portugal

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Abstract:

The mid-term review of the Common Agricultural Policy will change the way the European Union supports its farm sector. The new Common Agricultural Policy will be geared towards consumers, and taxpayers, while giving farmers the freedom to produce what the market wants. In the future, the majority of the subsidies will be paid independentlty from the volume of production. To avoid abandonment of production, Member States may choose to maintain a limited link between subsidy and production under well conditions and within clear limits. These new "single farm payment" will be linked to the respect of environmental, food safety and animal welfare standards. Severing the link between subsidies and production will make farmers more competitive and market oriented, while providing the necessary income stability. As the subsidy becomes a common component of all the alternatives of decision, the farmer will segregate that common component of the problem in the edition phase, starting to make decisions with base in negative results, what can determine the abandonment of the farming activity.

This research work intends to know, to characterize and to identify the farmers' behavior in the Alentejo dryland region of Portugal, when they face to the emerging reality of the new Common Agricultural Policy. The Cumulative Prospect Theory allows to model the farmers' behavior, because besides defining that the results are appraised in agreement with variations in relation to the initial wealth, this theory treats in a differentiated way gains and losses. The value functions and the weighting probabilities are elicited by the Trade-off and Certainty Equivalent methods for a group of farmers in the Alentejo dryland region. These functions will constitute the objective function of a discrete sequential stochastic programming model, whose restrictions describe the crop and livestock farms in their productive, financial, commercial and taxes components.

Model results show that the introduction of the total decoupling payments leads to the abandonment of the crop production in the Alentejo dryland region and an increase of the livestock production in the natural pastures. The crop farms stop producing, except the farms that have good soils continue to produce, although these farms do not produce durum wheat and they start to produce barley and oats. With respect to the beef cattle farms, these farms maintain the number of cattle heads, they increase the pasture and forage areas and they substitute durum wheat for oats and barley. The sheep farms reduce the number of cattle heads drastically and they substitute durum wheat for barley and oats.

Key words: Cumulative Propospect Theory, The Mid-Term Review of the Common Agricultural Policy, Discrete Sequential Stochatistic Programming Model, The Alentejo dryland Region

1- Introduction

This paper intends to know, to characterize and to identify the farmers' decision behavior in the Alentejo dryland region of Portugal, face to the emerging reality of the mid-term review of the Common Agricultural Policy.

If the present subsidies are substituted for a single farm payment, there will be a complexity increase in the decision making process of the farmers, they will start to decide what crops and livestock activities will produce based on climate and soils conditions and the signals revealed by market and not based on subsidies granted to each one of crop and livestock activities.

The farmers will stop deciding with base on subsidies and they will make their decisions independent of crop and livestock activities they choose to produce and they can start to make decisions based on negative results. Cumulative Prospect Theory allows modeling the farmers' behavior, because when defining that the different results are appraised relatively to the initial wealth, it permits its appraisal in terms of gains and of losses. When defining concave function for gains and convex function for losses, this theory permits the existence of risk aversion for gains and of risk seeking for losses.

This research work has two objectives. The first objective seeks to characterize the farmers' behavior before the beginning of the mid-term review of the Common Agricultural Policy. The second objective studies the farmers' behavior of the Alentejo dryland region of Portugal, when the farmers are confronted with the mid-term review of the Common Agricultural Policy and subsidies can be decoupled total or partially what force the farmers to make their decisions according to the signals revealed by the market.

2 - Methodology

Kahneman and Tversky presented a choice model called Prospect Theory in 1979, that explains the violations of the Expected Utiliy Theory for choice among games with a reduced number of results. This theory has two key elements: i) a concave function for gains and a convex function for losses and more sloping for losses than for gains; ii) a transformation nonlinear of the scale of probabilities that overweights the low probabilities and underweights the moderate and high probabilities. This theory had some comments relatively to the detection of dominated solutions, the weak specification of the probability weighting function and the difficulty for applying the games to a high number of results.

Later Quiggin proposed a new representation of the probabilities in 1982, that instead of transforming each probability separately, it transforms the cumulative probability function. This model, called rank-dependent Expected Utiliy, uses an utility function of the type von Neumann-Morgenstern and a nonlinear transformation of the probabilities, where the decision weights are determined by the cumulative probability function. Schmeidler developed a model that allows the application of the Expected Uility Theory to the ambiguity in 1989.

Face to the scientific advances during the 80' s, Tversky and Kahneman developed a new version of the Prospect Theory , which they called Cumulative Prospect Theory. This theory incorporates cumulative probability functions, it extends Prospect Theory to the ambiguity and it allows its application to games with any number of results. The criticism formulated to the old theory is resolved through the inclusion of cumulative probability functions, that avoid the choice of dominated solutions.

A finite set of states of nature is represented by S and the set of the results is represented by X. It is assumed that X includes a neutral result (0) and that all of the elements of X are gains or losses. The game y is a function of S in X, that allocate to each state $s \in S$ a consequence $y(s) = x$, with $x \in X$. The game y is represented then as a sequence of pairs (x_i, A_i), that it originates x_i if A_i to happen. A positive subscript is used to represent the positive results, a negative subscript to represent the negative results and a zero subscript to represent the neutral results. The positive part of y, represented by y+, is obtained by $y+(s) = y(s)$ if $y(s) > 0$, and $y+(s) = 0$ if $y(s) \leq 0$. The negative part of y, repesented by y -, is defined in a similar way.

The games will be assessed through the following expression (Tversky and Kahneman, 1992):

$$V(y) = V(y+) + V(y -) \qquad (1)$$

where:
V– value of the game; and,
y – game.

The positive and negative components of the game are determined by the following expressions, with $-m \leq i \leq n$:

$$V(y^+) = \sum_{i=1}^{n} h_i^+ \, v(x_i) \text{ and } V(y^-) = \sum_{i=-m}^{0} h_i^- \, v(x_i) \qquad (2)$$

where:
h– decision weights;
v– value function; and,
x– results.

The value function has the following characteristics: (i) defined for alterations starting from the reference point; (ii) concave for gains ($v''(x) < 0$, for $x>0$) and convex for losses (v ' ' (x)>0, for x < 0); (iii) more sloping for losses than for gains. The graphic representation is as follows:

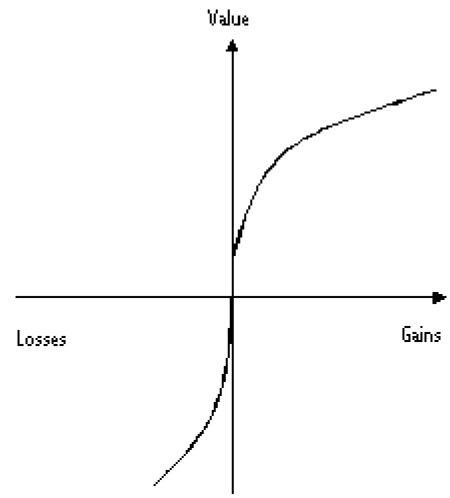


Figure 1 - The value function

The value function is an adaptation of the function proposed by Tversky and Kahneman in1992 and in agreement with to present theory and it is the necessary and sufficient conditions to represent v(x) through the following function:

$$v(x_i) = \begin{cases} \lambda_1 \, x_i^{\omega_1} & \text{if } \; 0 \le i \le s \\ -\lambda_2 \, (-x_i)^{\omega_2} & \text{if } -m \le i < 0 \end{cases} \qquad (3)$$

where:
v– value function;
x_i – results; and,
λ_1, λ_2, ω_1, ω_2 – function parameters.

The parameter λ_1 does not have any effect on the curvature of the function, given that this parameter is only responsible for the utility scale (González and Wu, 1999).

The decision weights (h_i) are defined in a cumulative way through the following expressions:

$$h_s^+ = f^+(p_s) \text{ and } h_i^+ = f^+\left(\sum_{i}^{s} p_i\right) - f^+\left(\sum_{i+1}^{s} p_i\right), \quad 0 \le i \le s-1 \tag{4}$$

$$h_{-m}^- = f^-(p_{-m}) \text{ and } h_i^- = f^-\left(\sum_{-m}^{i} p_i\right) - f^-\left(\sum_{-m}^{i-1} p_i\right), \quad 1-m \le i \le 0 \tag{5}$$

where:
p – probabilities;
f^+, f^- – probability weighting functions; and
h_s and h_m – decision weights.

The value of the decision weights depends on the probability weighting function, that captures psychologically the distortion of the probabilities on the part of the decision makers. The probability weighting functions f^+ and f^- are strictly increasing inside of the interval [0, 1], with $f^+(0) = f^-(0) = 0$ and $f^+(1) = f^-(1) = 1$. They have been the functions used to represent the probability weighting function that should have the inverse-S-shape. This work used the following function of two parameters:

$$f(p) = \frac{\delta p^{\gamma}}{\delta p^{\gamma} + (1-p)^{\gamma}} \tag{6}$$

where:
f– probability weighting function;
p–probabilities;
γ - Parameter that represents the curvature; and,
δ - Parameter that represents an upward.

The graphic representation is as follows:

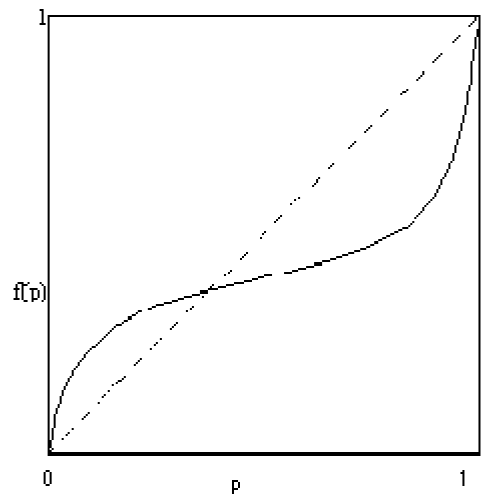


Figure 2 - Probability Weighting Function

González and Wu affirm that this function allows to portray two behaviors of the decision maker: (i) diminishing sensitivity; (ii) attractiveness. The property of diminishing sensitivity presented by Tversky and Kahneman means that the people become less sensitive to alterations in the probabilities as they stand back of the reference point. In the domain of the probabilities, the two points extreme 0 and 1 represent the reference point in the sense that one represents the "certainty that it doesn' t happen" and another represents the "certainty that it happens." In agreement with the principle diminishing sensitivity, increases close to the extreme points of the scale of probabilities have larger effects than increases in the intermediate points of the scale. The sensitivity to alterations in the probabilities decreases as the probabilities stand back of the reference point, what suggests that function is an inverse-S-shape. The "step function" shows smaller sensitivity to alterations of the probabilities than the quasi-linear function, except close to the extreme points 0 and 1. The concept of diminishing sensitivity supplies an incomplete explanation of the representation of probability weighting function. Even if this concept permits to explain the curvature of the probability function, it does not says anything on overweighting and underweighting relatively to the non-transformed probabilities (45º line). The probability weighting function can be completely below or completely above the identity line or it can cut the identity line in any point. The higher is the function the greater is attractiveness of the game. González and Wu refers this concept can be applied to the assessment of a game by two individuals in that one attributes a larger consideration than other for finding the game more attractive, as to interpersonal comparisons in that an individual attributes a larger consideration to a choice domain than the other.

A discrete sequential stochastic programming model is developed to study the decision making process in the Alentejo dryland region. This model that describes the risk behavior of the farmers in the Alentejo dryland region has five states of nature, developed in agreement with the expected value of crop production. The objective function describes the risk behavior of the farmers in agreement with the Cumulative Prospect Theory. This model is constituted by a set of functions (the value function and probability weighting function) differentiated for gains and for losses, in that the total value of the game will be given by the addition of the positive and negative components of the game. The restrictions describe the environment in that the farmers developed their crop and livestock activities in all their components: production (crop and livestock), financial, commercial and taxes. The different alternatives (games), derived from farmer decisions, are assessed for the following model, with $-m \leq i \leq s$:

$$\text{Max } V(y) = \sum_{i=-m}^{0} h_i^{-} v(x_i) + \sum_{i=0}^{s} h_i^{+} v(x_i) \qquad (7)$$

subject to:

$$x_i \in F_D$$

where:
V– value of the game;
y– alternatives (games);
h– decision weights;
v– value function;
F_D – opportunity set;
x_i – results by state of nature; and,
s– number of states of nature (-m,..., s).

The answer to the first objective, that seeks to characterize the farmers' behavior before the beginning of the mid-term review of the Common Agricultural Policy, will be achieved by the adaptation of the optimization model to each farmer for the 2001/2002 agricultural year. Here, the value of the objective function represents the farm income in each nature state. The second objective, that seeks to foresee the farmers' behavior when confronted with the mid-term review of the Common Agricultural Policy, the programming model will be reformulated to contemplate the total and partial decoupled income payments. Due to the effect of segregation of the common components of the problem the farmers will stop incorporating in the decision process the decoupled income payment.

The objective function is obtained through the elicitation near the decision makers that allow to estimate different functions. For elicitation of the value function was used 'trade-off' method (Wakker and Deneffe, 1996), that eliminates completely the distortions determined by the nonlinearity of the probabilities in the measure of the utility. This method notices that the probabilities p, the reference results x_R e x_r (x_R>x_r) and the minimum result x_0 (for example: x_0). It is asked to the decision maker which the result x_1 that turns him indifferent between the game (x_1, p; x_r, 1-p) and the game (x_0, p; x_R, 1-p). The values p, x_r, x_0, e x_R are fixed and the analyst varies x_1 until that the decision maker reveals indifference between the two games. Soon afterwards, it is asked to the decision maker that bids the result x_2 that turns him indifferent between the pair of games (x_2, p; x_r, 1-p) and (x_1, p; x_R, 1-p). Again the values p, x_r, x_1 and x_R are fixed, varying x_2 until that the decision maker reveals indifference between the two games. Substituting the values found in the utility function (u) is obtained the following equality for the first indifference:

$$p\, u(x_1) + (1-p)\, u(x_r) = p\, u(x_0) + (1-p)\, u(x_R) \qquad (8)$$

Then:

$$p\, (u(x_1) - u(x_0)) = (1-p)\, (u(x_R) - u(x_r)) \qquad (9)$$

For the second indifference, it is obtained the following equality:

$$p\, (u(x_2) - u(x_1)) = (1-p)\, (u(x_R) - u(x_r)) \qquad (10)$$

Equaling (9) the (10) and making u(x0) = 0 are obtained the following equality:

$$u(x_2) = 2\, u(x_1) \qquad (11)$$

This procedure continues until that an enough number of results is considered. In a generic way, any x_i is defined such that the decision maker is indifferent between game (x_i, p; x_r, 1-p) and (x_{i-1}, p; x_r, 1-p), that in combination with other indifferences originates that $u(x_i) = i * u(x_1)$. It can establish $u(x_i) = i * \alpha$ for any parameter positive arbitrary $u(x_1) = \alpha$ (for example: $\alpha = 1/n$, with n denoting the index of the last result x_n) (Wakker and Deneffe, 1996). The application of this method to the Cumulative Prospect Theory demands the extraction of two functions, because it is necessary to bid to positive component and negative component of the value function. Then, it is necessary the development of two sets of different questions. To estimate the decision weights in the Cumulative Prospect Theory is also necessary to elicit a function separately for the gains and a function for the losses. For the probability weighting function was used the certainty equivalent method. In this method the procedure for getting the utilities is the following: in first place, they notice two resulted x_H and x_L, with $x_H > x_L$, such that the interval includes all the results of interest; in second place, they are attributed two values arbitrarily to the extreme points, as for instance $u(x_L) = 0$ and $u(x_H) = 1$, soon afterwards it is requested to the decision maker that establishes the certainty equivalent such that this is indifferent for (x_L, p; x_H, 1-p). Substituting this value in the expected utility function, it is obtained the following equality:

$$U(CE) = p\, U(x_L) + (1-p)\, U(x_H) \qquad (12)$$

Varying the probabilities systematically new games are built in which are obtained new values of the certainty equivalent, that are going to be substituted in the previous equation, allowing to determine several points of the utility curve. The use of this method that varies the probabilities and it maintains the same results in all of the games, allows to prevent some inconveniences of other variants of this method that determines the probabilities and vary the results, although it can suffer of the certainty effect, given that the distortion of the probabilities is more pronounced near the extreme points.

The application of this method to Cumulative Prospect Theory suffers some alterations, because to determine the value of the decision weights, it is necessary to know the value function. The obtained certainty equivalent is substituted in the following equality:

$V(CE) = h_1\ v(x_H) + h_2\ v(x_L)$, com $x_H > x_L$ (13)

As $h_1 = f(p_1)$ and $h_2 = f(p_2+p_1) - f(p_1) = 1 - f(p_1)$, solving in order $f(p_1)$, it is obtained the following identity:

$$f(p_1) = \frac{v(CE) - v(x_L)}{v(x_H) - v(x_L)} \quad (14)$$

The function value, that was estimated previously, doesn' t need the knowledge of the decision weights to determine its value. Substituting in the previous equation the value function (equation 3) and given that $x_L = 0$ in the elicitation of the certainty equivalent, then $f^+(p)$ and $f^-(p)$ are calculated by the following expressions:

$$f^+(p) = \left(\frac{CE_1}{x_1}\right)^{\omega_1} \quad \text{and} \quad f^-(p) = \left(\frac{CE_2}{x_1'}\right)^{\omega_2} \quad (15)$$

where:
f^+, f^- – probability weighting function for positive and negative values;
p – probabilities;
CE_1, CE_2 – positive and negative certainty equivalents;
x_1, x_1'– positive and negative results; and,
ω_1, ω_2 – parameters of the value function.

The probability weighting function is estimated by the confrontation of the probabilities presented above to the decision makers with the resulting values calculated by the above formulas. The elicitation process is independent of the value function and of the decision weights used in this research work that was recommended by Quiggin (1993) and used by Bouzit and Gleyses (1996) for estimating the functions of the rank-dependent Expected Utility.

Model validation according to Lady "[refers] to activities to determine how a model performs. In particular [validation refers] to … the degree of fit between the model (results) and reality" (McCarl). The basic validation criteria considered in this research are the assessment of the model conceptualization to portray each farm and the comparison with farm characteristics or with observed in farm production patterns at the Alentejo dryland farming region. Secondly, sensitivity analysis is used to compare model results against farm characteristics or observed changes in farm production patterns in the Alentejo dryland farming region.

3 - Data and Information

The development of an optimization model is extraordinarily demanding in tems of data. The data and information can be divided in general data for each one of the farms as well as specific data to each one of the farms. There are many data sources from studies and research works, Government agencies and European Union. A lot of information was collected in contacts with researchers and technicians in crop and livestock production. To the similarity of the accomplished work Carvalho (1999), Lucas (1995), Marques (1988) and Serrão (1988), it was necessary to get information about the climatic conditions to define the states of nature and to obtain the occurrence probabilities of each one of them. It was defined a set of crop activities (contained in rotations) and livestock (beef cattle and sheep), whose costs were estimated in agreement with the methodology of the Farming Accounting Data. The soils were divided in three categories according to its productivity. Three technologies of beef cattle production were considered, two technologies of sheep production and the year is divided in five periods of animal feeding, that they are related with the annual distribution of the dryland pasture production and with variations of its nutritional value in the Alentejo dryland region. It was considered the farmer' s possibility to finance his own farming activity with equity and with borrowed and purchased funds. There is also considered a tax on the farm income.

The specific data of each one of the farms were obtained through interviews. These interviews allowed the obtaining of specific agricultural data of each one of the farms such an as: area, soil types, crop and livestock technologies, agricultural machinery, workers and perception face to the risk. It was in the interviews that they were obtained the attitudes face to the risk, through the elicitation of the value function and of the probability weighting function. The interviews were accomplished for 35 farmers and it was possible to elicit values for the estimation of the value function and probability weighting function for 9 farmers. The data for these nine farmers are represented in the tables1. It is verified that the farm activities are diversified in terms of the dimension and of the oak-plantation farms where livestock feed. The analysis of the table 1 allows to verify that three of the farms do not have any livestock production, two of them produce sheep and four of them produce beef cattle. These results will be used as a limit superior and a limit inferior in the estimation process of the value functions and the probability weighting function. The average value will be used for validation of the model. The inquiry asked the farmers if they would be willing to change the production technology substantially, all of them answered no and with respect to livestock production, they were not willing to increase their production because they would harm the oak-plantation activities. The inquiry shows that the farmers are extremely dependent of crop production, namely of the durum wheat. All the farmers produce durum wheat in the largest possible area, because it is the crop activity with the largest subsidy value by hectare.

Table 1 - Farm Characteristics

Descriptions	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6	Farm 7	Farm 8	Farm 9
				Agricultural Area					
Total area	1200	660	180	570	600	200	260	1020	550
Cultivated area	1160	360	150	300	480	200	260	620	550
Pastures areas	40	300	30	270	120	-	-	400	-
Good Soils		60							150
				Livestock Production					
Beef cattle	400	150	90					450	
Sheep				100	600				
				Farm Income					
The best	150.0	100.0	40.0	100.0	100.0	30.0	50.0	125.0	60.0
Normal	75.0	50.0	20.0	25.0	15.0	5.0	10.0	75.0	25.0
The worst	-100.0	-50.0	-20.0	-50.0	-75.0	-25.0	-40.0	-75.0	-35.0

Notes: Areas in hectares, Livestock production in animal units and farm income in thousands of Euros.
Source: Data collected by inquiries.

4 - Results

The estimation of the parameters of the objective function is a difficult process, because it is necessary to estimate four different functions (two value functions and two probability weighting functions). The results are presented in table 2. The estimates of the parameters allow to graph the value functions for each one of the farms and make comparisons with the observed values (Figure 3). The x-axis is different for each of the farms because the reference values used in the inquiry to get these functions are also different. This situation does not happen in the y-axis, where the value function, v(x), transforms the results in agreement with the scale from 1 to 10.

The parameters λ_1 and λ_2 do not have any effect in the curvature of the value function, they have influence on the utility scale (Table 2). The aversion to the losses among farmers is compared through the λ_2/λ_1 ratio. The aversion to the losses is practically inexistent for decision makers of farms 2 and 3. The highest value is found for decision makers of farms 1 and 8. The aversion value to the losses is 1.87, what it is identical to the value obtained by Tversky and Kahneman (1992).

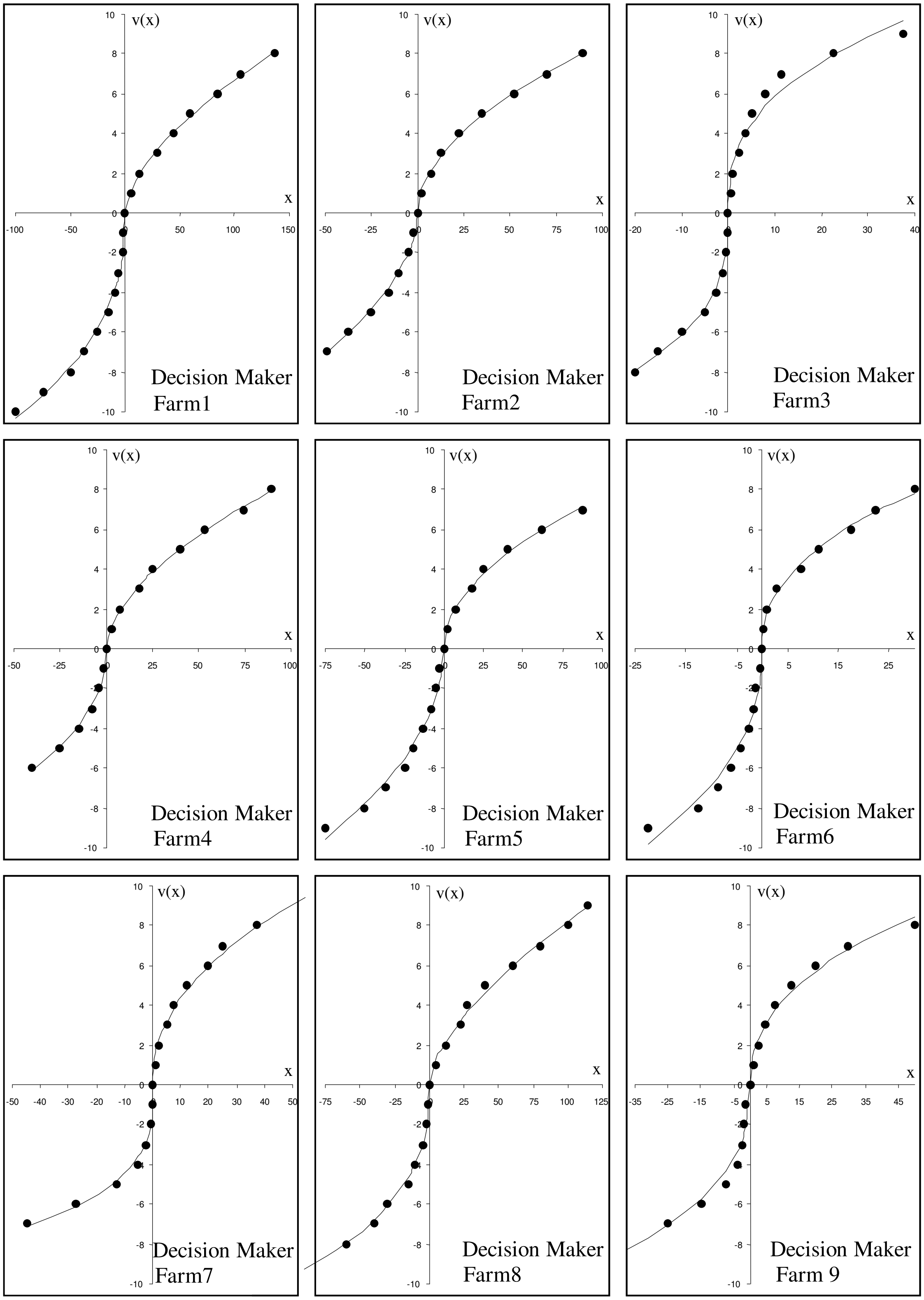
Table 2 - Parameters of the Value Funtion

Farms	λ_1	ω_1	λ_2	ω_2	λ_2 / λ_1
1	0.3927	0.6150	1.5202	0.4157	*3.87*
2	0.7522	0.5267	0.8242	0.5518	*1.10*
3	2.4550	0.3785	2.6771	0.3632	*1.09*
4	0.6060	0.5722	1.0497	0.4800	*1.73*
5	0.7402	0.5069	1.0549	0.5112	*1.43*
6	1.7967	0.4328	2.4738	0.4425	*1.38*
7	1.4796	0.4629	2.2301	0.3044	*1.51*
8	0.4683	0.6215	1.6270	0.3869	*3.47*
9	1.5488	0.4346	1.9669	0.3980	*1.27*
Arithmetic mean		*0.5057*		*0.4282*	*1.87*

Source: Model results

The parameters ω_1 and ω_2 are related to the curvature of the value functions (Table 2). If these values are analyzed separately, they can be interpreted has an aversion measure to risk. The positive part of the function means that the closer of 1 the values are, the smaller the risk preference is. While the negative part of the function represents that the close of 1 the values are, the larger the risk preference is. These parameters vary between 0.3785 and 0.6150, with relation to the positive part of the function, means that the decision maker of the farm 3 presents larger aversion to the risk than the decision maker of the farm 8; and 0.3044 and 0.5518, for the negative part of the function, means that the decision maker 7 presents larger risk preference for negative results than the decision maker 2.

Figure 3 – Value Function



Notes:
——— Estimated Value Function
● Oberved values

This analysis assumes that the value function is independent of the probability weighting function, what it is not true. The Cumulative Prospect Theory works for the whole and a good part of the risk aversion behaviors are explained by the probability weighting function. The parameters of the value functions are used later to estimate the probability weighting functions, whose values are represented in the following table:

Table 3 - Parameters of the Probability Weighting Function

Farms	Positive function		Negative function	
	δ_1	γ_1	δ_2	γ_2
1	1.2407	0.5584	1.3280	0.3627
2	1.1619	0.5762	0.7262	0.6728
3	1.2930	0.3629	1.7574	0.5154
4	0.9341	0.6956	1.4751	0.5969
5	1.4149	0.6600	0.7753	0.6612
6	1.9035	0.5839	1.0478	0.4886
7	1.3532	0.5720	1.5046	0.3766
8	1.0159	0.5155	1.3549	0.4936
9	1.3788	0.4948	1.0584	0.4511
Arithmetic mean	*1.2996*	*0.5577*	*1.2253*	*0.5132*

Source: Model Results

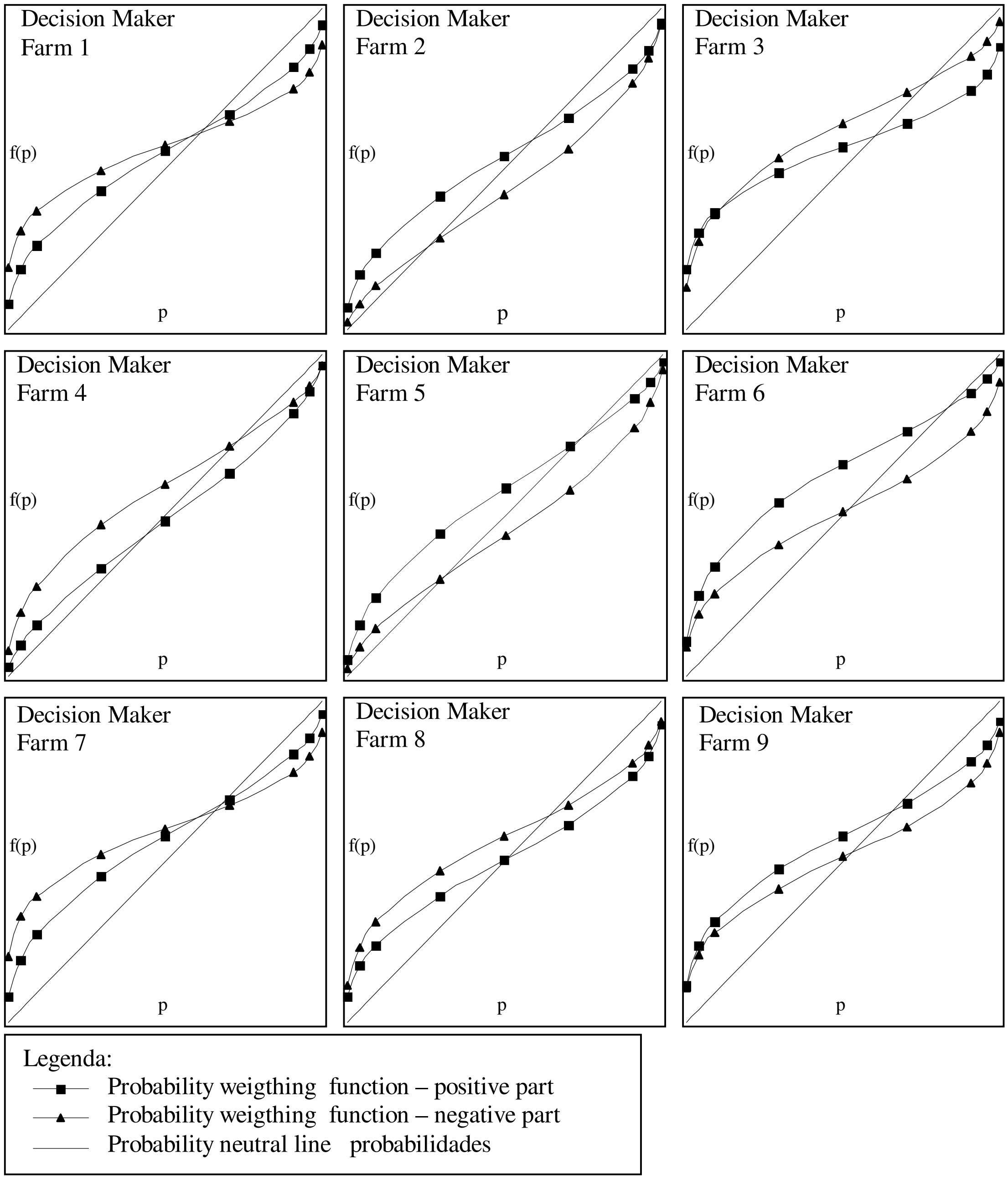
The parameters γ_1 and γ_2 are related to the concept of diminishing sensitivity. In agreement with this concept increases close the extreme points of the scale of probabilities have larger effect than increases near the intermediate points of the scale. The smaller curvature the larger sensitivity to the probabilities. These parameters should vary between 0 and 1 only that one exists an overweighting of the low probabilities and an underweighting of the high probabilities. The parameter of the probability weighting function for the positive results varies between 0.3629 for the decision maker of the farmer 3 and 0.6956 for the decision maker 4. The figure 4 shows that the decision maker of the farm 4 follows the neutral line of the probabilities very closely, what accuses high sensitivity to changes of the probabilities, while the decision maker of farm

3 presents the smallest sensitivity, because his function approximates the "step-function." The parameter of the probability weighting function for the negative results varies between 0.3766 for the decision maker of the farm 7 and 0.6728 for the decision of the farm 2.

With respect to the parameters δ_1 and δ_2, its interpretation is associated to the concept of attractiveness of the game. In agreement with this concept the most attractive for the decision maker is the game the most weighting he allocates it. For the probability weighting function of positive results, this parameter vary between 0.9341 for the decision maker of the farm 4 and 1.9035 for the decision maker of the farm 6. The figure 4 allows to verify that while the function of the decision maker of the farm 4 practically accompanies the neutral line of the probabilities, the function of the decision maker of the farm 6 is practically above that line. For the probability weighting function of negative results, the value of the parameter varies between 0.7262 for the decision of the farm 2 and 1.5046 for the decision of the farm 7.

The figure 4 suggests that the decision makers that present larger sensitivity to the probabilities will also be those that present smaller attractiveness to the proposed games. The decision makers of the farms 2, 4 and 5 present simultaneously larger sensitivity to the probabilities and less attractiveness for the game than the decision makers of the farms 3 and 7.

Figure 4 - Comparison of the Probability Weighing Functions



The introduction of these functions in the optimization models forced to the programming of the objective function with a set of instructions of the type IF…THEN. The models were introduced in the program MINOS, whose results consist of Table 4.

Table 4 – Model Results for the Agenda 2000

Description	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6	Farm 7	Farm 8	Farm 9
Crop Activities									
Durum Wheat	323.7	124.6	35.6	148.0	234.1	75.2	107.5	147.9	267.5
Sunflower		27.0				49.6	45.0		67.5
Oats	13.3	50.0						95.0	
Oats/Vicia	20.9	7.9	14.6	6.6	19.8			57.0	
Pastures	513.4	300.0	100.0	270.0	120.0			500.0	
Setaside	328.7	150.5	29.8	145.4	226.1	75.2	107.5	220.1	215.0
Total Area	*1200.0*	*690.0*	*180.0*	*570.0*	*600.0*	*200.0*	*260.0*	*1020.0*	*550.0*
Livestock Activities									
Beef Catlle	400	150	90					450	
Sheep				1080	625				
Farm Income									
State of Nature 1	-1 338	13 155	2 329	-2 777	-30 904	-8 150	-5 407	2 871	-25 435
State of Nature 2	32 257	27 622	9 031	6 454	-16 445	-3 239	- 417	36 605	-13 662
State of Nature 3	77 788	46 588	17 740	27 334	15 878	5 626	11 104	82 531	19 907
State of Nature 4	115 231	64 154	22 519	44 170	40 538	13 172	21 899	108 768	48 120
State of Nature 5	119 223	68 027	23 458	45 430	42 470	16 302	24 901	113 049	55 045
Subsidies									
Livestock subsid.	129 422	62 036	32 823	25 704	14 859	0	0	142 795	0
Crop subsidies	135 291	62 462	16 141	68 267	96 427	45 403	61 042	74 640	129 990
Total subsidies	264 713	124 499	48 964	93 971	111 287	45 403	61 042	217 435	129 990

Notes: Crop activities in hectares, livestock activities in animal units and monetary values in Euros
Source : Model Results.

These models describe the decision makers behavior well. All of the models choose durum wheat as the main crop activity in the farm dryland production. With respect to the livestock activities, the models choose the maximum that the farmers are willing to produce. The value of the subsidies was calculated in the model, and it corresponds with the value received by the farmers with adjustments when they pass over the maximum area After the validation the models with the 2000 Common Agricultural Policy reform, it was introduced in the models the total decoupling payments and the maximum modulation that will go into effect in the 2006/07 agricultural year. The change relatively to the previous model concerns to the segregation of the subsidies by the decision makers, that the common component in all the alternatives, is subtracted to the value of the results transferred to the objective function. The models generated the following results in Table 5

Table 5– Model Results with the new CAP– Total Decoupling Payments

Description	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6	Farm 7	Farm 8	Farm 9
					Crop Activities				
Barley		27.0	16.8	63.8				69.2	67.5
Oats	135.2	26.3			178.7				130.5
Sunflower	105.3	27.0							67.5
Oats/Vicia	66.4	58.3	37.2		2.7			153.8	
Pastures	866.4	512.6	124.1	270	120.0			677.0	
Setaside	26.7	8.8	1.9	236.2	298.6	200.0	260.0	120.0	284.5
Total area	*1200.0*	*690.0*	*180.0*	*570.0*	*600.0*	*200.0*	*260.0*	*1020.0*	*550.0*
					Livestock Activities				
Beef cattle	400	150	90					450	
Sheep				182	87				
					Farm Income				
State of Nat. 1	23 336	28 627	5 405	25 931	5 964	9 835	17 241	23 117	-4 762
State of Nat. 2	57 492	42 739	13 096	26 671	7 825	9 835	17 241	62 198	3 046
State of Nat. 3	80 383	51 792	16 832	31 914	21 805	9 835	17 241	78 015	21 974
State of Nat. 4	95 615	58 778	19 441	36 830	34 864	9 835	17 241	89 808	39 717
State of Nat. 5	105 341	62 632	20 727	37 076	35 554	9 835	17 241	95 281	46 332
					Subsidies				
Dec. payment	237 259	112 900	45 174	82 912	95 519	40 039	53 534	200 138	111 744

Notes: Crop activities in hectares, livestock activities in animal units and monetary values in Euros.
Source: Model Results.

With the total decoupling payment all of the farm do not produce durum wheat. The crop farms stop producing, except the farm 9 that has good soils continues to produce, although this farm does not produce durum wheat and it starts to produce barley and oats. With respect to the beef cattle farms, these farms maintain the number of cattle heads, they increase the pasture and forage areas and they substitute durum wheat for oats and barley. The sheep farms reduce the number of cattle heads drastically and they substitute durum wheat for barley and oats. As the decoupling payments are not related to farm production, the variability of the results decreases and the difference between the farm income of the nature state 1 and 5 is lower than previously. The level of subsidies decreases due to the new values of the specific subsidy to the durum wheat and the modulation.

Besides the total decoupling payment, the states members might implement the partial decoupling payment. Among various alternatives, the Portuguese government decided to assign to farm production 50% of sheep and goat premia, 100% of veal premium, 100% of suckler cow premium and 40% of slaughter premium. If the Portuguese government decides that agricultural production is not linked to the subsidies for crop activities, farms will have to change their crop choices.

Table 6– Model Results with the new CAP– Partial Decoupling Payments

Description	Farn 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6	Farm 7	Farm 8	Farm 9
				Crop Activities					
Barley		27.0	16.8	23.2				69.2	67.5
Oats	135.2	26.3			121.1				130.5
Sunflower	105.3	27.0							67.5
Oats/Vicia	66.4	58.3	37.2	51.6	26.6			153.8	
Pastures	866.4	512.6	124.1	390.8	164.6			677.0	
Setaside	26.7	8.8	1.9	104.4	287.7	200.0	260.0	120.0	284.5
Total area	*1200.0*	*690.0*	*180.0*	*570.0*	*600.0*	*200.0*	*260.0*	*1020.0*	*550.0*
				Livestock Activities					
Beef cattle	400	150	90					450	
Sheep				952	358				
				Farm Income					
State of Nature 1	23 336	28 627	5 405	18 115	4 338	9 835	17 241	23 117	-4 762
State of Nature 2	57 492	42 739	13 096	22 413	7 386	9 835	17 241	62 198	3 046
State of Nature 3	80 383	51 792	16 832	27 041	18 073	9 835	17 241	78 015	21 974
State of Nature 4	95 615	58 778	19 441	29 764	27 408	9 835	17 241	89 808	39 717
State of Nature 5	105 341	62 632	20 727	30 934	28 429	9 835	17 241	95 281	46 332
				Subsidies					
Dec. payment	172 460	85 667	30 594	70 060	88 089	40 039	53 534	127 238	111 744
Prod. Subsidies	64 799	27 233	14 580	11 324	4 258	0	0	72 900	0

Notes: Crop activities in hectares, livestock activities in animal units and monetary values in Euros.
Source: Model Results.

So, it is necessary to assign the maximum of premium that is allowed to sheep and goat activities and to associate the subsidies to suckler cows to allow the use of the shares of milk cows negotiated with the European Union in 2003.

The inclusion of the Portuguese Government' s proposal in the optimization models only changes the solutions of the sheep farms. The table 6 show that the farms 4 and 5 have different results when the partial decoupling payments are introduced. Crop production reduces and pastures areas and sheep production increase for those farms. The decoupling payments of 50% only have positive effect in the maintenance of the number of cows heads and sheep herds as the Portuguese Government intended. Model results agree to the Portuguese Government' s proposal.

5 - Conclusions

This research work studies the farmers' behavior when they are confronted with the mid-term review of the Common Agricultural Policy. Two objectives are defined in this research work. The first objective develops a model to study the farmers' behavior in the Alentejo dryland region of Portugal during the Agenda 2000. The second objective intends to foresee the farmers' behavior, when they are confronted with the review of the mid-term of the Common Agricultural Policy in 2003, in agreement with the perspectives of total and partial decoupling payments proposed by the Portuguese Government. This research work will have as theoretical base the Cumulative Propspect Theory. This theory allows to model the decision makers' behavior, when defining a concave value function for gains and convex for losses, it permits the existence of behaviors of preference or aversion to risk for the results be classified as losses and gains, respectively. With the mid-term review of Common Agricultural Policy in 2003, the subsidies are not linked to production and the decision makers will stop incorporating the old aids in their decision process, because it is a common situation and without risk in all of the alternative agricultural activities, the farmers can also decide with base in negative results. The theoretical base of this theory constitutes the objective function of a discrete sequential and stochastic programming model, whose restrictions describe the crop and livestock farms in their productive, financial, commercial and taxes components.

Model results show that the decision makers' behavior is very well described by this programming model. All the analyzed farms produce durum wheat as main production and choose the maximum of number of cattle heads and sheep herds. The total decoupling payment lead to the abandonment of the durum wheat production. The farms without livestock production have tendency to abandon the production except for the good soils. The beef cattle farms keep their production, increasing the level of the animal feeding due to the increases of the forages and pastures areas. Finally, the sheep farms reduce their herds drastically.

The introduction of 50% of sheep and goat premia, proposed by the Portuguese Government, raises sheep production, accompanied of the increase of the pasture area. These results permit to conclude that the Portuguese Government' s proposal is sufficiently cautious because, on the one hand, when associating to 100% of suckler cow premium allows the use of the shares negotiated with European Union in 2003 and when associating to 50% of sheep and goat premia permits the maintenance of sheep herd. On the other hand, the Portuguese Government' s proposal of crop subsidies not linked to production forces the farmers to choose alternative agricultural activities in the bad soils.

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