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Droughts: Farmers' domestic and productive attitudes and behaviours

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Abstract. Originally perceived as an occasional natural hazard, drought is now a phenomena, for which one can be prepared, despite the difficulties in determining its beginning and end. It is therefore crucial to understand the individual and social behaviour, in order to adopt effective measures and policies to mitigate the negative effects of that phenomenon, reducing costs and losses.

Keywords. Drought – Risk – Discrete stochastic programming – Farmer's behaviour.

Sécheresses : les attitudes et les comportements sociaux et productifs des fermiers

Résumé. *Pendant longtemps les sécheresses ont été perçues comme des risques naturels occasionnels, mais elles sont devenues un phénomène auquel on doit être préparé, en dépit des difficultés dans la détermination de leur début et leur fin. Il est donc crucial de comprendre les comportements individuels et sociaux, afin d'adopter des mesures et des politiques efficaces pour atténuer les effets négatifs de ce phénomène, en réduisant les coûts et les pertes.*

Mot-clés. *Sécheresse – Risque – Programmation stochastique discrète – Comportement des agriculteurs.*

I – Introduction

The term "drought" has been used to describe a set of poorly defined phenomena, corresponding to situations where "a significant water deficit is observed in a sufficiently extensive region" (Cunha, 1982).

As they are climate risks (rainfall deficiencies in relation to the annual or seasonal average) with hydrological consequences, droughts are quite naturally the principal cause of random water shortage: the drought both reduces available water resources, while increasing the demands for natural water (Mediterranean Water Scarcity & Drought Report). Originally perceived as occasional disasters, droughts can now also be viewed and defined as expected phenomena, for which one can be prepared (Vlachos, 1990), despite difficulties in determining their beginning and end.

In terms of typologies, droughts can be classified as meteorological, agricultural, hydrological, and socio-economic. Agricultural drought is defined more commonly by the lack of availability of soil water to support crop and forage growth than by the departure of normal precipitation over some specified period of time. The relationship between precipitation and infiltration of precipitation into the soil is often not direct. Infiltration rates vary depending on antecedent moisture conditions, slope, soil type, and the intensity of the precipitation event. Soil characteristics also differ. Socio-economic drought differs markedly from the other types of drought because it reflects the relationship between the supply and demand for some commodity or economic good that is dependent on precipitation (Drought Risk Reduction Framework and Practices).

In Portugal, Santos (1998) concluded that droughts affected more than half of the area of the territory during 17 years (31%), and affected the whole territory during 10 years (18%) and also that in the southern region of the country the return periods are significantly shorter than in the northern region.

The evaluation of the intensity and the gravity of a drought must be based at the same time on various variables of natural state (duration, geographical extension, variation with the averages known as "normal") and on the socio-economic estimate of the consequences (Mediterranean Water Scarcity & Drought Report). Farmer's attitudes and behaviours concerning droughts must be analyzed from two perspectives: viewing them as consumers and as producers. As consumers it is important to know how this social group integrates this phenomenon on water management within the domestic economy and individual behaviours. From an agricultural point of view, farmers can plan their farms to include the expectation of drought, even when technology does not provide the possibility of controlling and successfully manipulating the water resources for storage and distribution what would make them less vulnerable to the phenomena. The direct linkage between the main types of drought and precipitation deficiencies is reduced over time because water availability in surface and subsurface systems is affected by how these systems are managed. Changes in the management of these water supplies, as the adoption of appropriate tillage practices, can either reduce or aggravate the effects of drought. Therefore, the effects of drought are a product of both the physical nature of the hazard and our ability to manage risk and the purpose of this work is to simulate the farmer's decision making process and its ability to manage risk.

II – Methodology

Primary data is based on 404 individual surveys and 30 interview surveys. The field work was done in 4 rural parishes located in the municipalities of Aljustrel, Fereira do Alentejo, Serpa and Mértola of Baixo Alentejo interior (NUT III).

A discrete stochastic programming model applied to the characteristics of one representative farm in the District of Beja from the zone of skeletal schist soils was used. The model is stochastic to the climatic conditions – the relationship between temperature and precipitation, which allows the establishment of six states of nature (Martins, 2003). The decision problem can be represented by the decision tree in the Fig. 1.

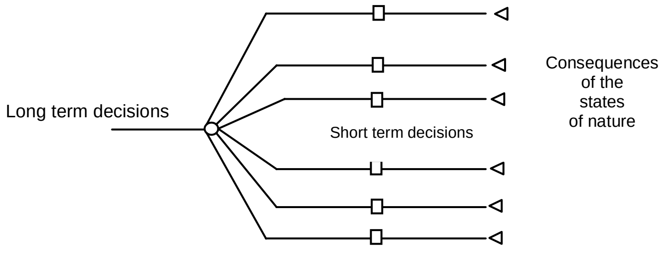

Fig. 1. Decision tree of the stochastic problem.

The farmer takes its decisions based on his empirical knowledge about the weather and its consequences on the farm results, which can be translated by the probabilities and margins of crop and livestock activities in each state of nature. The model, expressed in the following equations and inspired on the models of Jacquet and Pluvinage (1997), Fragoso (2001), Fragoso and Marques (2003), Martins (2003) and Noéme and Fragoso (2004), describes how the farmer takes its long term decisions about livestock heads and investment on tillage equipments as the result of short term strategies adopted in each state of nature. The short term decisions include crop area decisions and feed purchases on the market, which depends on productions (grain, straw and pasture) and number of days available for agricultural operations. Investments on livestock heads and tillage equipments are fixed decisions that once are taken are irreversible. However all decisions related with crop areas and feed purchase can be adjusted in each state of nature.

$$Max\ U = \left(K + \sum_n p_n D_n\right)^a \tag{1}$$

$$s.t.$$

$$D_n = \sum_j g_j^n Y_j^n - p_b \sum_f B_f^n + \sum_l g_l W_l - p_I I \tag{2}$$

$$\sum_j Y_j^n \leq S \tag{3}$$

$$\sum_j h_j^p Y_j^n \leq d_n^p I \tag{4}$$

$$\sum_l W_l m_l^f \leq \sum_{pt} Y_{pt}^n e_{pt}^f + \sum_{st} ST_{st,n}^f e_{st} + B_f^n \tag{5}$$

$$\sum_f ST_{st,n}^f \leq Y_{st}^n . pd_{st}^n \tag{6}$$

$$X_j = \sum_n p_n Y_j^n \tag{7}$$

$$Z = \sum_n p_n D_n \tag{8}$$

$$DV_n = D_n - Z \tag{9}$$

The objective function is the maximization of the producer utility. The functional form utilized is a power function which exhibits decreasing absolute risk aversion. The argument of the function includes a constant (*K*), the initial producer wealth, and annual gains and losses (D_n) in each state of nature (*n*) weighted by their occurrence probabilities (p_n). The coefficient of absolute risk aversion, *a*, varies between 0 and 1. In this case the value used was 0.025.

The gains and losses D_n represents the farm gross margin in each state of nature and are calculated in the equation (2). Equations (3) to (6) represent the problem constraints which includes the uses of agricultural land (2), tillage equipments (4), livestock nutrient (5) and straw production (6). Equations (7), (8) and (9) are equalities that are used to calculate the expected crop areas (X_j), the expected farm gross margin (*Z*) and the negative deviation of the farm gross margin (DV_n), respectively.

III – Results and final remarks

Concerning the domestic economy and individual behaviour the analysis of empirical data allowed distinguishing 2 temporal periods: from 1930 to 1973 and from 1974 until now. In the first period one can say that underlying water management and individual behaviours of consumers there were adaptative strategies in order to minimize the negative impacts of water scarcity and there was a culture of social valorisation of water; the water was managed, partial and collectively, as a natural and scarce good. Since 1974, the adaptative strategies were substituted by adjustment strategies and the culture of social valorisation of water was substituted by a culture of non valorisation of water; the water is managed individually as a commodity.

In what concerns farmer behaviour, the model provides different strategies and farm gross margin for each state of nature and in terms of expected values. Table 1 presents the model results obtained for three different investment options in tillage technology. The agricultural prices and subsidies of 2004 were used and the level of livestock activities was fixed.

Table 1. Results of the stochastic discrete programming model

	Probability of the States of nature							
	Units	**11% State 1**	**14.5% State 2**	**14.5% State 3**	**22% State 4**	**19% State 5**	**19% State 6**	**Expected results**
Traditional tillage								
Soft wheat	ha	50.0	50.0	50.0	13.2	47.7	50.0	41.5
Durum wheat	ha	50.0	50.0	0.0	0.0	0.0	0.0	12.8
Natural pasture	ha	400.0	276.7	400.0	400.0	400.0	400.0	382.1
Subterranean clover pasture	ha	263.7	92.0	292.4	308.4	395.3	358.7	295.8
Fallow	ha	79.3	374.3	100.6	122.4	0.0	34.3	110.8
Concentrate	Ton	398.3	317.3	410.4	633.4	522.2	482.4	479.6
Gross margin	Euros	52,662	70,458	35,854	4,842	8,826	19,750	27,703
Gross margin deviation	Euros	24,959	42,755	8,151	-22,861	-18,877	-7,953	20,926
Bovine	Heads							65
Sheep	Heads							2,082
Tillage package	Num.							2.6
Reduced tillage								
Soft wheat	ha	50.0	50.0	50.0	9.2	50.0	50.0	41.0
Durum wheat	ha	50.0	50.0	50.0	0.0	0.0	21.4	24.1
Natural pasture	ha	400.0	289.8	400.0	400.0	400.0	400.0	384.0
Subterranean clover pasture	ha	263.5	76.9	261.8	290.6	385.9	309.4	274.1
Fallow	ha	79.5	376.3	81.2	143.1	7.1	62.2	119.7
Concentrate	Ton	387.7	264.4	388.4	624.1	494.0	490.9	461.7
Gross margin	Euros	44,505	109,071	40,723	0	10,639	16,132	31,702
Gross margin deviation	Euros	12,803	77,369	9,020	-31,702	-21,063	-15,570	27,921
Bovine	Heads							65
Sheep	Heads							2,006
Tillage package	Num.							2.4
Direct seeding								
Soft wheat	ha	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Durum wheat	ha	50.0	50.0	50.0	0.0	0.0	47.3	29.0
Natural pasture	ha	400.0	296.5	400.0	400.0	400.0	400.0	385.0
Subterranean clover pasture	ha	283.1	80.0	281.1	375.6	393.0	318.8	301.4
Fallow	ha	59.9	366.5	61.9	17.4	0.0	26.9	77.6
Concentrate	Ton	411.9	280.7	402.5	542.9	528.3	510.2	364.2
Gross margin	Euros	40,335	112,926	43,457	11,874	9,985	18,644	35164
Gross margin deviation	Euros	5171	77,761	8,293	-23,290	-25,179	-16,520	26,036
Bovine	Heads							65
Sheep	Heads							2,082
Tillage package	Num.							2.1

Source: Model results.

In what concerns traditional tillage technology option it is remarkable that soft wheat and durum wheat areas reaches 100 ha only in the states of nature 1 and 2. In the other states that have lower levels of grain production, the soft wheat areas varies between 50 and 13 ha, being zero in the case of durum wheat. The states of nature 4, 5 and 6, present negatives deviations from the average values of 22,681, 18,877 and 7953 Euros, respectively. In order to accommodate the negative effects of the different states of nature associated with drought situations, the farmers purchase more concentrate, its consumption attaining more than 480 tonnes in the states 4 to 6.

The option for reduced tillage or direct seeding technologies allows increases in the farm gross margin. These increases do not imply greats changes in crop pattern, but contrary to what was expected the farm gross margin absolute mean deviation is higher under the two alternative tillage technologies (24 to 33% than under the traditional technology). In the states of nature 4, 5 and 6, which represent drought situations, the farm gross margin negative deviation is 31,702, 21,063 and 15,570 Euros under the reduced tillage and 23,290, 25,179 and 16,259 Euros for the direct seeding technology, respectively. These numbers represent an increase on the risk indicator of 2% for direct seeding and almost 40% for reduced tillage in the state 4. In the state 5 these increases are 11% to reduced tillage and 33% to direct seeding and in state 6 they almost double.

The results shows that reduced tillage and direct seeding are not interesting strategies to contradict the negative effects of drought situations, being even more risky than the traditional tillage technologies. This result is not due to worse grain production with these technologies but to worse straw and stubbles productions obtained under the two innovative technologies, as these products are well valued by the very extensive farming systems more oriented to livestock production, as it is this case in the Alentejo region.

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