How decoupling could mean dismantling of the Cotton Sector in Spain[1]

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Abstract

An analysis is made of the impact of the latest reform of the EU Cotton Regulation of 29th April 2004, which will come into force in the 2006/07 season, on the cotton production sector of Andalusia. Using an initial characterization of producers based on a survey carried out in 2004, the impact of two policy scenarios is assessed: (a) the implementation of the reform without any additional measures, and (b) the addition of a complementary environmentally-based area payment plus the modulation of the decoupled subsidy according to the raw cotton quality. In the first scenario, the producers would reduce inputs to a minimum and leave the raw cotton in the fields. In the second scenario, the production of cotton would shift from conventional to Integrated Production with a 30% reduction with respect to the current hectareage.

Résumé

Cette étude analyse l'impact de la dernière réforme du règlement sur le coton du 29 avril 2004, qui sera appliqué en 2006/07, sur la production de coton en Andalousie (Espagne). A partir de la caractérisation des producteurs, on évalue l'impact de deux scénarios politiques: (a) l'application de la réforme sans mesures additionnelles, et (b) l'introduction d'un paiement sur base environnementale en plus du désaccouplement des aides selon la qualité du coton. Dans le premier scénario, les agriculteurs réduiraient les intrants au minimum et abandonneraient le coton. Dans le deuxième scénario, la production de coton serait réalisée dans le cadre de la gestion intégrée, avec une réduction de la surface cultivée égale à 30%.

1. Introduction

Cotton is the most important irrigated arable crop in Andalusia (97.4% of total Spanish cotton production), with an average of 92,410 hectares (Consejería de Agricultura y Pesca, 2004 -period 1999-2003-) being grown by 9,200 farms. In addition to its extent, cotton cultivation in this Objective 1 region has an undoubted relevance from a social point of view, employing 1.47 million men-days (Farm Accountancy Data Network, 2000) and two-thirds of the total farm labour generated from irrigated extensive arable crops (Arriaza et al., 2000, Rodríguez and Ruiz-Avilés, 1996). Furthermore, the cotton production involves a complex economic sector of input supplier companies and 27 ginning firms.

This study analyses the economic viability of the cotton cultivation in Spain after the implementation of the Council Regulation (EC) No 864/2004 of 29 April 2004 in the season 2006/07. Following the decoupling of the subsidies of this reform, the producer receives 65% of the subsidies obtained during the reference period (2000-2002) as a fixed payment of 1,509 €/ha, for an eligible area of 70,000 ha, and 35% as area payment (up to 1,039 €/ha). In order to receive this area payment, the producer does not need to harvest the raw cotton; the only requirement is to reach the open capsule stage. This requirement would make it more profitable for most producers to shift from conventional production to semi-abandonment cotton production, which would involve a drastic reduction in input usage (fertilizers, pesticides and irrigation water) and no harvest. Obviously, this possibility would have a very negative impact, jeopardizing rural development in these irrigated areas as a result of an increase in unemployment and a drop in input provider (agro-chemical, machinery, seeds, etc.) and ginning industry incomes.

Within this framework, the first objective of the paper is to analyse the foreseeable impacts of the implementation of subsidy decoupling and check the above hypothesis regarding the breakdown of the Spanish cotton sector.

In order to prevent crop abandonment, two additional policy measures might be considered under the new rules:

- A supplementary crop-specific environmental area payment to encourage a shift from conventional production to integrated production. This new payment could be justified due to current environmental problems, especially non-point source pollution, related to the current intensive use of fertilizers and pesticides in this crop.
- The modulation of the cotton area payment to a maximum of 50%, according to the quality of the raw cotton that producers sell to the ginning companies.

The second objective of the paper is to evaluate the convenience of both measures and consider their effects on the cotton sector.

The paper is structured as follows. Section 2 analyses the current and future profitability of raw cotton production in Spain. Section 3 introduces the theoretical model employed to simulate the behaviour of cotton growers who face the various policy scenarios proposed. Section 4 describes the

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simulation results. Finally, some conclusions are drawn.

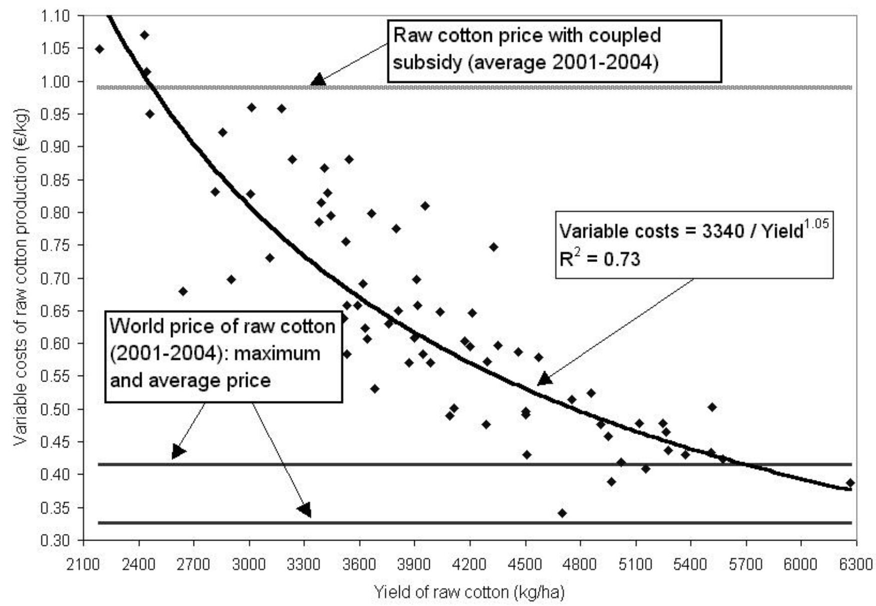
2. Economic analysis of cotton cultivation in Spain

The first step to define the market behaviour is the analysis of the most important variables and of their interrelations. To better understand the model, the four equations and their variables will be illustrated separately.

2.1. Source of data

The database of an accounting company containing data on 125 farms for the seasons1999/2000 to 2002/2003 was used to calculate average yields, variable costs and gross margins of cotton and other crop substitutes such as cereals, oilseed, sugar beet and vegetables. The cotton output response to input dosage (water and fertilizer) was estimated from the Andalusian Agricultural Experimental Network (RAEA) trials. Finally, a mail survey carried out in 2004 through the EAGGF regional board targeted the census of cotton producers in Andalusia, which had a response rate close to 10% (835 valid questionnaires), made it possible to build a typology of farmers to distinguish among different responses to agricultural policy scenarios according to individual utility functions.

Figure 1. *Relationship between variable costs and yields in cotton cultivation*



Source: Data on variable costs and yields of 73 farms during the period 2000/01-2002/03

2.2. Cotton variable costs per yields

Statistical analysis of the data revealed that variable costs per kg of raw cotton depend on cotton yield, which itself depends on the farm irrigation system (gravity, sprinkler or drip) and the type of sowing (with or without plastic protection). The following table summarizes the results of the statistical analysis (Tab 1).

Furthermore, according to these results, the size of the cotton plot has no effect on either variable costs per unit of output or yield. The analysis of the production variables costs therefore does not consider either farm size or any other structural characteristic, but exclusively cotton yields, as the following figure shows (Fig. 1).

The average cotton price that producers received with the previous coupled subsidy, and the inverse nonlinear relationship between variable costs and yields shown in Figure 1, mean that for most cotton producers, the optimum strategy has been the maximization of production (yields increase). However, following the reform undertaken in April 2004, the price of raw cotton for EU producers in the 2006/07 season would not be able to cover their variable costs. Even assuming the maximum world price in the 2001-2004 period, only producers with yields above 5,600 kg/ha would do it. In the survey, which returned 835 valid questionnaires, only 2% of producers match this target. The initial conclusion becomes straightforward: unless some corrective measures are introduced, Spanish cotton cultivation, or at least its harvest, will come to an end (Tab. 2).

Table 1. *Statistical relationships among economic, structural and production variables*

	Yield (kg of raw cotton/ha)	Area of cultivated cotton (ha)	Sowing with plastic protection (yes/no)	Type of irrigation system (G, S, D)[1]
	Correlation analysis		*Analysis of variance*	
Variable costs (€/kg of raw cotton)	r= -0.803 p-value= 0.000*	r= -0.111 p-value= 0.291	F= 1.98 p-value=0.162	F=1.97 p-value= 0.106[2]
Yield (kg of raw cotton/ha)		r= 0.073 p-value= 0.077	F= 6.47 p-value=0.012*	F= 30.60 p-value=0.000* (mean D>S=G)

[1] G= gravity; S= sprinkler; D= drip.
[2] There are no significant pairwise differences among the means.
* Significant at the 0.05 level.

As the data suggest, pesticides and pesticide management are the most important costs, representing approximately one fourth of total variable costs, followed by ploughing, harvesting and irrigation costs, each of them ranging between 15 and 17% of the total. The use of plastic for the protection of the plants at the initial stages represents some 11% of the costs.

If the price of raw cotton falls to a level similar to that of the world price, a significant reduction in use of plastic, fertilization, pesticides and irrigation can be expected. Even so,

Table 2. *Structure of cotton variable costs by sowing technique and irrigation system (€/ha)*

Group	Concept	Gravity		Sprinkler		Drip	
		No plastic	*Plast.*	*No plastic*	*Plast.*	*No plastic*	*Plast.*
Purchase of inputs	Seeds	102*					
	Fertilizers	203					
	Pesticides	430					
	Materials	16	136	16	136	16	136
Crop tasks	Sowing	57	110	57	110	57	110
	Fertilization	35					
	Sowing; plastic handling	0	122	0	122	0	122
	Ploughing	328					
	Irrigation	228	228	383	383	292	292
	Pesticide management	96					
	Harvesting	278	319	263	288	352	388
Misc.	Insurance, financial costs...	65					
Total variable costs (€/ha)		*1,838*	*2,174*	*1,978*	*2,298*	*1,976*	*2,307*
Yield (kg of raw cotton/ha)		*3,018*	*3,469*	*2,860*	*3,129*	*3,831*	*4,217*

Source: Data from 125 farms during the period 1999/00 to 2002/03.
*Rows with only one data imply equal costs for all type of farms.

Table 3. *Cotton profitability in Spain in 2002-2004 with coupled subsidy*

	Gravity		Sprinkler		Drip	
	No plastic	*Plast.*	*No plastic*	*Plast.*	*No plastic*	*Plast.*
Raw cotton yield (kg/ha)	3,018	3,469	2,860	3,129	3,831	4,217
Total variable costs (€/ha)	1,838	2,174	1,978	2,298	1,976	2,307
Sale of raw cotton (1.01 €/kg)*	3,048	3,504	2,889	3,160	3,869	4,259
Gross margin (€/ha)	1,210	1,330	911	862	1,893	1,952

* Average price received by Spanish farmers in 2002-2004 (Directorate-General for Agriculture).
Source: Yields from survey in 2004 and total variable costs from accounting data firm.

Table 4. *Cotton profitability of conventional cultivation after decoupling of subsidies*

	Gravity		Sprinkler		Drip	
	No plastic	*Plast.*	*No plastic*	*No plastic*	*Plast.*	*No plastic*
Raw cotton yield (kg/ha)	3,018	3,469	2,860	3,129	3,831	4,217
Cotton fibre yield (kg/ha)	966	1,110	915	1,001	1,226	1,349
Farmer's total variable costs (€/ha)	1,838	2,174	1,978	2,298	1,976	2,307
Ginning costs (€/ha)[1]	363	417	344	376	460	507
Sale of cotton seed(€/ha)	261	300	247	270	331	364
Sale of cotton fibre -min pr- (€/ha)[2]	744	855	705	771	944	1,039
Sale of cotton fibre –aver pr- (€/ha)[2]	985	1,132	934	1,021	1,250	1,376
Sale of cotton fibre –max pr- (€/ha)[2]	1,255	1,443	1,190	1,302	1,594	1,754
Area payment (€/ha)	1,039	1,039	1,039	1,039	1,039	1,039
Gross margin -min pr- (€/ha)	*-157*	*-397*	*-331*	*-594*	*-123*	*-371*
Gross margin –aver pr- (€/ha)	*84*	*-120*	*-102*	*-343*	*184*	*-34*
Gross margin –max pr- (€/ha)	*354*	*191*	*154*	*-63*	*527*	*344*

[1] Ginning costs provided by two ginneries.
[2] World minimum price of 0.77 €/kg, average of 1.02 €/kg and maximum of 1.30 €/kg for the period 2001-2004.

such a reduction would not bring variable costs below the product price, so the rational decision would be to sow cotton with a drastic reduction of all inputs and not to harvest it in order to optimize the area payment of 1,039 €/ha, for which the only requirement is to bring the crop to the open capsule stage but not to harvest it. This new activity is described in our study as "semi-abandonment".

2.4. Crop profitability

Taking into account the variable costs of cotton and the average raw cotton price that farmers have received in the previous three years, it turns out that cotton cultivation has been a relatively profitable activity in comparison with other irrigated extensive arable crops in Southern Spain (mainly maize and sugar beet), as Table 3 shows.

This higher profitability in comparison with maize and sugar beet has compensated producers for the higher level of risk associated with cotton production due to the fluctuations in world fibre prices and crop yields. In order to estimate the profitability of this crop in the future, we calculate the gross margin for the minimum, maximum and average prices for the past four seasons, as shown in Table 4.

The above tables enable us to draw some conclusions about the continuation of cotton production in Spain:

• For most producers, a cotton area payment of 1,039 €/ha and average world prices do not cover their total variable costs.

• Even for high world prices, only farms with drip systems would achieve a gross margin similar to that of maize. For production systems, the gross margin is close to those of wheat and sunflower, both of which crops have much

Table 5. *Economic results for the semi-abandonment system of cotton production*

Group of costs	Type of cost	% of cost reduction*	Sowing without plastic		
			Gravity	*Sprinkler*	*Drip*
Input purchase (€/ha)	Seeds	63	38	38	38
	Fertilizers	88	25	25	25
	Pesticides	88	54	54	54
	Materials	75	4	4	4
Crop tasks (€/ha)	Sowing	28	41	41	41
	Fertilization	50	18	18	18
	Sowing; plastic handling	50	0	0	0
	Ploughing	72	91	91	91
	Irrigation	58	95	159	122
	Pesticide management	88	12	12	12
	Harvesting	100	0	0	0
Misc.		67	33	33	33
Total variable costs			*411*	*476*	*438*
Gross margin (area payment – total variable costs)			*628*	*563*	*601*

* Average reduction from a panel of experts.

lower production costs and more stable world prices.

Under these circumstances, current cotton production and all related social externalities favouring rural development seem to be at risk, since any COP (cereals, oilseeds and protein crops) alternative is more attractive from an economic and management point of view. However, the continuation of cotton in Spanish fields as a semi-abandonment production system does seem to be possible. Under this assumption, cotton would be sown and managed with minimum use of inputs, as shown in Table 5.

Given the gross margins in Table 5, rational economic behaviour would be to sow cotton and leave the crop in the field. This semi-abandonment of the cotton cultivation is slightly more profitable than sowing COP crops.

Now that we have established the impact of the CAP reform on cotton production profitability, and thus how this new Regulation actually jeopardizes the future of this sector, we attempt to simulate the productive behaviour of cotton growers in order to quantify the foreseeable impact on areas sown to cotton and other related indicators.

3. Methodology

3.1. Key elements of simulation modelling

Before the proposed methodology can be discussed, a brief presentation of the elements on which it is based is required: i.e. the classification (aggregation) of farmers into homogeneous groups and the scenarios proposed for cotton sector regulation.

Aggregation bias and cluster analysis

Modelling agricultural systems at any level other than that of the individual farm involves problems of aggregation bias. In fact, the introduction of a set of farms in a unique programming model overestimates the mobility of resources among the production units, allowing combinations of resources that are not possible in the real world. The final result of these models is that the value obtained for the objective function is always upwardly biased and the values obtained for decision variables tend to be unachievable in real life (Hazell and Norton, 1986).

This aggregation bias can only be avoided if the farms included in the models fulfil strict criteria regarding homogeneity (Day, 1963): technological homogeneity (same possibilities of production, same type of resources, same technological level and same management capacity), pecuniary proportionality (proportional profit expectations for each crop) and institutional proportionality (availability of resources to the individual farm proportional to average availability).

As noted above, cotton production in Spain is concentrated in Andalusia, more precisely in irrigated areas of the Guadalquivir river valley. This is a relatively wide territory (approximately 250,000 ha) which can be divided into two sub-areas: High Guadalquivir, including farms in the provinces of Jaen and Cordoba, and Low Guadalquivir, in the provinces of Seville and Cadiz. Each sub-area can be regarded as fairly homogeneous in terms of soil quality and climate, and in each sub-area the same range of crops (including cotton) can be cultivated and have similar yields. Furthermore, all the farms within these sub-areas operate the same technology at a similar level of mechanization. Given these conditions, it can be assumed that the requirements regarding technological homogeneity and pecuniary proportionality are basically fulfilled.

In view of the existence of efficient capital and labour markets, the constraints included in modelling this system have been limited to the agronomic requirements (crop rotations) and the restrictions imposed by the Common Agricultural Policy (set-aside land, sugar-beet quotas, etc.) that are similar for all farms. The requirement of institutional proportionality may thus also be regarded as having been met.

We can thus see that agricultural systems of this kind can be modelled by means of a unique linear program with relatively small problems of aggregation bias. However, it is essential to note that the requirements discussed above have been outlined from the point of view of neo-classical economic theory, which assumes that the sole criterion on which decisions are based is profit maximization. If a multi-criteria perspective is being considered, an additional homogeneity requirement emerges in order to avoid aggregation bias; viz., homogeneity related to choice criteria. This kind of similarity has been implicitly assumed in studies based on a unique multi-criteria model for the whole set of farmers in the area being analyzed (e.g. Gómez-Limón and Arriaza, 2000).

Nevertheless, the experience that has been accumulated

Table 6. *Comparison of previous cotton situation and policy scenarios in the simulation*

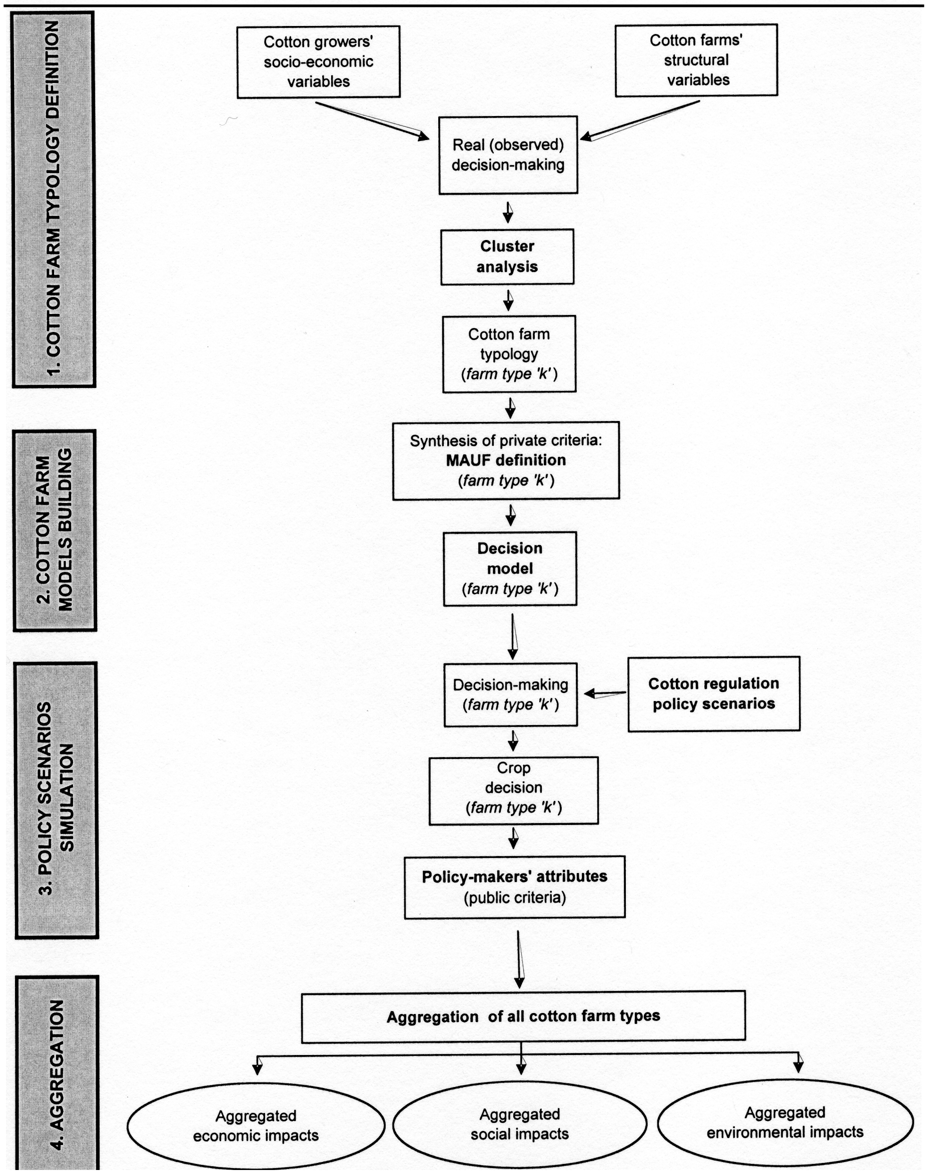
	In force	*Coupled subsidy*	*Single producer's payment*	*Area payment*	*Additional area payment for integrated production*
Before reform of April 2004	End 31/Dec/05	106,3 €/100 kg	0	0	0
After reform of April 2004 (*Scenario A)*	From 01/Jan/06	0	1,509 €/ha	1,039 €/ha	0
Alternative scenario (*Scenario B)*	Under discussion	0	1,509 €/ha	1,558 – 520 €/ha depending on raw cotton quality	352 €/ha

in this field leads us to suspect that the decision criteria of farmer homogeneity do not reflect the normal situation in real agricultural systems. This suspicion, as will be discussed below, has been confirmed by a survey of the area analyzed. In fact, the decision criteria are primarily based on psychological characteristics of the decision-makers, which differ significantly from farmer to farmer. According to this perspective, the differences in decision-making (crop mix) among farmers in the same production area must be primarily due to differences in their objective functions (in which the weightings given to different criteria are condensed), rather than to other differences related to the profits of economic activities or disparities in resources requirements or endowments.

In order to avoid aggregation bias resulting from lumping together farmers with significantly different objective functions, a classification of all farmers into homogeneous groups with similar decision-making behaviour (objective functions) is required. For this issue, we have taken the work of Berbel and Rodríguez (1998) as a starting point. As pointed out by these authors, we can assume that in a homogeneous agricultural area any differences in the crop mix among farmers will mainly be due to their different management criteria (utility functions) rather than to other constraints such as land quality, capital, labour or water availability. Thus, the surface (in percentage) devoted to the different crops (proxies of the real criteria) can be used as classification variables to group farmers using the cluster technique, as required for our purposes.

In this respect, it is also important to note that the homogeneous groups obtained in this way in each sub-area can be regarded as "fixed" in the medium and long run. As noted above, the decision criteria are based on psychological features of the decision-makers, which is why they may be regarded as producers' structural characteristics. In fact, these psychological features, and thus the criteria, are unlikely to change in the near future. This means that the selection variables chosen allow farmers to be grouped into clusters irrespective of any change in the policy framework. In other words, once the homogeneous groups of producers have been defined for actual data (crop mix), we can assume that all elements inside each group will behave in a particular way when the policy vari-

Figure 2. *Outline of methodology*



ables change; that is, crop-mix decisions will be modified in a similar fashion by all farmers within a cluster, although such modifications would differ among the individual groups defined.

Scenario proposals for cotton sector regulation

The forthcoming CAP scenario, which envisages the price of raw cotton falling to the world price level and a fully decoupled area payment of 1,039 €/ha (Scenario A), is compared with a scenario (Scenario B) with an additional "environmental" area payment of 352 €/ha for producing cotton under an integrated production regime and with the maximum modulation (50 per cent) of the area payment (1,039 €/ha), according to the Council Regulation (EC) No 864/2004. This modulation would mean an area payment of 1,559 €/ha for producers whose cotton produces the best quality cotton fibre and 520 €/ha for those that do not harvest the raw cotton in the field. The table 6 compares both scenarios with the situation before the latest reform.

3.2. Outline of methodology

On the basis of the key elements identified above, the methodology adopted by this study can be graphically displayed as in Figure 2. According to this plan, the proposed methodology can be divided into four principal stages, as outlined below.

The first stage differentiates among the different groups of cotton growers to be analyzed. These groups, as has been observed, should be sufficiently homogeneous in their decision-making behaviour (weighting of the objectives considered) to allow aggregate models to be constructed and resolved without unwanted bias. This classification of farmers was performed by the cluster analysis referred to above.

Once homogeneous groups of farmers have been defined, the second stage builds the mathematical models. For each cluster a different multi-criteria model was developed, in order to allow independent simulations based on the decision-making behaviour of the various groups of farmers to be run.

The classification criterion used in the cluster analysis allows us to assume that all the farmers in the various groups are homogeneous in the way in which they consider the objectives that they wish to achieve. In other words, a unique objective utility function in their decision-making can characterize the set of farmers that makes up each cluster. The estimate of this utility function for each cluster will be made using the multi-criteria procedure described in the next section.

Estimates of the respective utility functions were obtained by models fed with data gathered for the current CAP situation. Here it is important to note that we assume that the utility functions obtained at this point can be regarded as a structural feature of each cluster. As these objective weightings are the result of the farmers' own attitudes, it is reasonable to assume that they will remain constant in the medium and long runs. This assumption is a key point of the methodology, since the estimated utility functions are assumed to be those that the farmers in each cluster will attempt to maximize in the future, under any scenario that they will need to face.

The third stage of the study performs the simulations. Thus, considering from the regulation for the cotton sector scenarios already explained, the decisions taken, i.e. crop mixes, by the clusters of farmers were obtained in the different cases.

From the crop mixes obtained in the model simulations we analyze certain attributes to measure the impacts of the policy instrument. These are indicators relevant to policymakers from an economic (farmers' income and the budget burden), social (direct employment generated in the agricultural sector) and environmental (fertilizer and water consumptions) point of view. The calculation of these attributes at aggregated (national) level and the analysis of the efficiency of the economic instrument proposed will be the core of the fourth stage of our methodology.

3.3. Multi-criteria programming approach

As opposed to the neo-classical approach, we have assumed that not only profit determines the level of farmer's utility, but that other attributes such as risk, leisure time, management complexity, etc. are also involved in farmers' decision-making. For discussions of MCDM techniques in agriculture see Anderson et al. (1977), Hazell and Norton (1986) and Romero and Rehman (1989).

Taking into account the evidence about how farmers take their decisions while trying to simultaneously optimize a range of conflicting objectives, we have proposed Multi-Attribute Utility Theory (MAUT) as the theoretical framework for the MCDM programming modelling technique to be implemented. MAUT, particularly as developed by Keeney and Raiffa (1976), has often been claimed to have the soundest theoretical structure of all multi-criteria techniques (Ballestero and Romero, 1998). At the same time, from a practical point of view, the elicitation of utility functions has presented many difficulties. In this paper, we have followed a methodology that tries to overcome these limitations, assuming some reasonable simplifications.

The aim of MAUT is to reduce a decision problem with multiple criteria to a cardinal function that ranks alternatives according to a single criterion. Thus, the utilities of n attributes from different alternatives are captured in a quantitative way via a utility function, mathematically, $U = U(x_1, \quad c, ..., x_n)$, where U is the Multi-Attribute Utility Function (MAUF) and x_i are the attributes regarded by the decision-maker as relevant in the decision-making process.

If the attributes are mutually utility-independent, the formulation becomes separable: $U = f\{u_1(x_1), u_2(x_1), ..., u_n(x_1)\}$. In modelling the agricultural sector, among the family of separable utility functions, additive functions have often been adopted. This study has also opted to follow this approach, and it bases its analysis on mathematical models using an additive MAUF as the objective function. These MAUFs take the following mathematical form:

$$U_j = \sum_{i=1}^{n} w_i u_i(r_j), \rightarrow i = 1, \ldots, m \rightarrow (1)$$

where Uj is the utility value of alternative j, wi is the weight of attribute i and ui(rj) is the value of the additive utility due to attribute i for the alternative j.

In an additive MAUF, alternatives are ranked by adding contributions from each attribute. Since attributes are measured in terms of different units, normalization is required to enable them to be added. The weighting of each attribute expresses its relative importance.

Although the additive utility function represents a simplification of the true utility function, the mathematical form, Edwards (1977), Farmer (1987), Huirne and Hardaker (1998) and Amador et al. (1998) have all shown that the additive function yields extremely close approximations to the hypothetical true function even when the conditions of utility independence are not satisfied (Fishburn, 1982; Hardaker et al., 1997).

Having justified the use of the additive utility function, we take the further step of assuming that the individual attribute utility functions are linear. Hence, the expression (1) becomes its simplest mathematical form:

$$U_j = \sum_{i=1}^{n} w_i r_{ij} \rightarrow j = 1, \ldots, m \rightarrow (2)$$

where rij is the value of attribute i for alternative j.

This formulation implies linear utility-indifferent curves, a rather strong assumption that can be regarded as a close enough approximation if the attributes vary within a narrow range (Edwards, 1977; Hardaker et al., 1997, p.165). We therefore adopt this simplification in the elicitation of the additive utility function.

Finally, from a theoretical point of view, it is worth mentioning that in addition to the theoretical advantages of this approach explained above, the additive-linear utility specification used in this paper has been chosen on the basis of a comparison with other specifications, as explained in Arriaza and Gómez-Limón (2003).

After a survey of the study area, we concluded that cotton growers choose a crop distribution that takes the following objectives into account:

- Maximization of total gross margin (TGM), as a proxy of profit. TGM is obtained from the average crop gross margins from a time series of seven years (1993/1994 to 1999/2000) in constant 2000 euros.
- Minimization of variable cost (TVC). This objective implies not only a reduction of costs but also a decrease of risk assumed by farmers and a reduction of managerial involvement (variable costs-intensive crops are most risky and require more technical supervision).

These objectives, which are selected a priori, were analyzed for the different clusters in accordance with the methodology described above. This analysis enables us to assess the importance of each objective in the decision-making process for each homogeneous group of cotton growers. In this way, TGM and TVC will be the attributes that would be included as arguments in the MAUFs of the individual clusters of farmers.

3.4. MAUF elicitation technique

Once we have agreed to use additive linear utility functions, the ability to simulate real decision-makers' preferences is based on estimating relative weightings. We have selected a methodology that avoids the necessity of a process of interaction with farmers, and in which the utility function is elicited on the basis of the revealed preferences implicit in the real values of decision variables (i.e. the actual crop mix). The methodology adopted for the estimation of the additive MAUFs is based on the technique proposed in Sumpsi et al. (1997) and extended by Amador et al. (1998). It is based upon weighted goal programming and has previously been used by Arriaza et al. (2002), Gómez-Limón et al. (2002 and 2004) and Gómez-Limón and Riesgo (2004).

In order to avoid unnecessary repetition, we refer to the papers mentioned above for details of all aspects of this multi-criteria technique. Here, we wish only to point out that the results obtained by this technique are the determination of the weighting of objectives (wi) that imply utility functions that are capable of reproducing farmers' behaviour as actually observed. As Dyer (1977) demonstrated, the weights obtained are consistent with the following separable and additive utility functions:

$$U = \sum_{i=1}^{q} \frac{w_i}{k_i} f_i(x) \rightarrow\rightarrow (3)$$

where ki is a normalizing factor.

3.5. Models for scenario simulations

In order to simulate the various cotton regulations considered, we have decided to estimate optimal crop-mixes in each case (groups of cotton growers and policy scenarios) through the individual mathematical models developed. These models include a set of decision variables representing the surface devoted to each crop. Thus, the cotton growers' production adjustments as they face different policy scenarios are based on substitution of crops, depending on their contribution to the farmers' MAUFs.

At this point it is necessary to point out that it is possible to sow cotton with minimum use of inputs and to leave it in the field. We have called this new activity “cotton in semi-abandonment”. Two further cotton production possibilities exist: the conventional system (“conventional cotton”), without the 352 €/ha environmental area payment in Scenario B, and the integrated system (“PI cotton”), which includes that area payment. The modulation considered in scenario B applies to all three cotton production possibilities.

Table 7. *Characteristics of the farm clusters*

	High Guadalquivir			Low Guadalquivir		
	Cluster H1	*Cluster H2*	*Cluster H3*	*Cluster L1*	*Cluster L2*	*Cluster L3*
Main crops	Cotton (47%) Maize (36%)	Cotton (39%) Wheat (23%)	Cotton (99%)	Cotton (45%) Maize (39%)	Cotton (44%) Sugar b. (27%)	Cotton (98%)
Average farm size (ha)	43.1	49.2	4.4	30.2	45.2	6.9
% of producer's income from farming	83%	80%	72%	88%	87%	76%
% of farmers that hire workers	76%	64%	35%	76%	66%	48%
% of irrigation systems (gravity-sprinkler-drip)	52%-29%-19%	39%-39%-22%	33%-12%-55%	13%-5%-82%	32%-21%-47%	28%-10%-62%
Number of farmers	49	36	101	87	128	215
Aggregated area	2,112	1,771	444	2,627	5,784	1,492

Source: Survey of cotton producers in Andalusia (2004)

For each group of cotton growers a utility function was elicited in order to simulate their response to the policy scenarios. These MAUFs, as explained above, are the ones to be considered as objective functions.

In order to model building we identify the following constraints applied to each group of farmers:

- Land constraint. The sum of all crops must be equal to the total surface available to the farm type of each cluster.
- CAP constraints:
  - The level of the area payment is proportionately reduced as eligible cotton area exceeds the maximum area (70,000 ha for Spain).
  - It is forbidden to substitute either COP crops or cotton for vegetables. The maximum increase of vegetables is limited to 10% more than the observed area.
  - Sugar beet is limited because of the quota. In each cluster this crop is limited to the maximum area sown during the period studied (1999-2004).
- Rotational constraints. These were taken into account according to the criteria revealed for the farmers in the survey.
- Market constraints. We decided to limit the area of perishable crops (vegetables) to the maximum in the period 1999-04 because of the inelasticity of demand for these crops.

Finally, it is also worth noting that the implementation of CAP Reform developed through the Mid-Term Review (MTR) has been considered. Thus, area payment of COP crops is reduced to 25% of the current level. The rest is paid as single payment to the producers, following a recently approved national regulation. We also assume the implementation of the Commission's proposal for the reform of the sugar CMO, with a sugar beet price of €32.8/t for 2005/06.

3.6. Models validation

Validation of the models built for each group of farmers is a key aspect to testing the quality of the results. The procedure employed was to compare the real situation (observed) with the data simulated by the models for the current scenario. This type of comparison is the most common method of validating models (Qureshi et al., 1999). Implementing this technique demonstrated that the deviations in the objectives and the decision variable spaces were sufficiently small to permit us to regard the model as a good approximation to the actual decision-making process in all clusters.

4. Results

4.1. Classification of cotton farmers

In order to simulate the behaviour of farmers who face agricultural policy changes, first, due to clear agro-climate differences, we have classified the survey sample into two sub-samples as follows: High Guadalquivir (186 cases) and Low Guadalquivir (430 cases).

The classification variables used to group cotton growers within each group have been the area percentage of each crop on their farms. Since a total of 11 crops exceed the maximum suitable for cluster analysis, we carried out factor analysis (Gorsuch, 1983; Bryant and Yarnold, 1995) to reduce the number of classifying variables. In both groups, the number of cases was more than 10 times the number of variables, as a necessary sample size for factor analysis (Nunnally, 1978; Kass and Tinsley, 1979).

Using SPAD 5.0, two factors with eigenvalues greater than 1 and a cumulative explained variance of 55% were retained following Stevens' rule of sample size and importance of factor loadings (Stevens, 1992). While the first factor explains the farm's cotton specialization, the second refers to irrigation water requirements.

Once the number of decision variables was reduced, the cluster analysis used the two factors as classifying variables. Based on the Euclidean distance among cases and the minimum variance method (Ward method) to aggregate them (Hair et al., 1998), three clusters in each sub-sample were obtained. The table 7 summarizes the characteristics of each cluster.

4.2. Weights of the farmers' objectives

From the observed crop distribution of each group of

Table 8. *Current and theoretical extreme values of farm total gross margin (TGM) and total variable costs (TVC). Weight of each objective of the utility function*

		High Guadalquivir			Low Guadalquivir		
		H1	*H2*	*H3*	*L1*	*L2*	*L3*
Current values (€/ha)	TGM	1,207	1,169	1,572	1,374	1,218	1,548
	TVC	1,538	1,646	2,297	1,859	1,682	2,238
Maximiz. of TGM (€/ha)	TGM	1,365	1,487	1,583	1,468	1,468	1,612
	TVC	1,789	2,232	2,320	2,034	2,088	2,354
Minimiz. of TVC (€/ha)	TGM	390	390	390	390	390	390
	TVC	243	243	243	243	243	243
Weight of the maximization of TGM (w_1)		*84%*	*71%*	*99%*	*90%*	*78%*	*95%*
Weight of the minimization of TVC (w_2)		*16%*	*29%*	*1%*	*10%*	*22%*	*5%*

farmers, six MAUFs were elicited. The following table shows the current total gross margin (TGM) and total variable costs (TVC) of the farm derived from the observed crop distribution, the theoretical maximum TGM and its associated TVC, the theoretical minimum TVC subject to the achievement of a minimum TGM (forcing the model to sow the whole farm) and its associated TGM, and finally, the weight attached to each objective in the utility function using the multicriteria technique described above.

Data in Table 8 suggest that farms in the H3, L1 and L3 groups could be named as true seekers of profit maximization. On the other hand, farms in groups H2 and L2 seem to opt for a more conservative crop distribution, i.e. a higher proportion of COP crops, resulting in a greater weighting being given to minimization of TVC.

4.3. Simulated changes in crop distribution

Optimization of the six utility functions in both policy scenarios through the farm type simulation model led to important changes in crop distribution of the area of study. The following table compares the current crop distribution in each group of farmers with the expected changes in both scenarios.

In Scenario A, without any additional policy measures, most of conventional cotton (93%) is substituted by a cultivation system of semi-abandonment. The remaining 7% is substituted by other crops. Thus, the aggregated impact shows increases in maize (57% higher than the current level), sunflower (42%) and wheat (34%). According to these results, no cotton farmer would harvest the raw cotton. This radical forecast might be less severe during the first season for psycho-sociological reasons, such as the farmer's tendency to continue with the production, even when not economically rational, attempting to justify accepting the subsidies, etc.

In Scenario B, with the additional environmental area payment and the modulation of the area subsidy, 69% of the current hectareage of cotton would

Table 9. *Comparison of current crop distribution and simulated changes in both scenarios (percentages)*

Current crop distribution	H1	H2	H3	L1	L2	L3	Average
Cotton	43.1	28.9	97.4	42.2	39.9	93.6	47.0
Sunflower	2.0	0.9	0.0	1.1	7.2	0.9	3.7
Protein crops	8.6	0.3	0.0	0.0	1.8	0.3	2.2
Vegetables	0.4	14.4	1.0	6.2	0.4	0.1	3.0
Maize	34.0	14.3	1.3	41.1	6.7	3.6	17.8
Potatoes	2.8	0.0	0.0	4.0	1.8	0.5	2.0
Sugar beet	0.5	8.0	0.0	3.7	26.0	1.0	12.3
Wheat	8.6	33.1	0.3	1.7	16.1	0.1	12.1
Scenario A (2006/07 onwards)	H1	H2	H3	L1	L2	L3	Average
Conventional cotton	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cotton: semi-abandonment	39.2	24.3	88.6	38.4	39.1	84.5	43.6
Sunflower	1.2	0.6	0.0	0.7	11.8	0.5	5.2
Protein crops	6.9	0.3	0.0	0.0	1.5	0.2	1.8
Vegetables	0.5	15.9	1.1	6.8	0.4	0.1	3.4
Maize	48.0	36.8	5.1	48.0	13.4	14.1	27.9
Potatoes	3.1	0.0	0.0	4.4	1.7	0.6	2.0
Sugar beet	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wheat	1.2	22.2	5.1	1.7	32.2	0.0	16.2
Scenario B (alternative)	H1	H2	H3	L1	L2	L3	Average
Integrated cotton production	30.2	0.0	77.9	33.8	27.9	74.9	32.6
Cotton: semi-abandonment	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sunflower	1.2	0.6	0.0	0.7	26.1	0.5	11.0
Protein crops	6.9	0.3	0.0	0.0	1.5	0.2	1.8
Vegetables	0.5	15.9	1.1	6.8	0.4	0.1	3.4
Maize	48.0	37.1	12.5	48.0	10.1	16.9	27.1
Potatoes	3.1	0.0	0.0	4.4	1.8	0.6	2.1
Sugar beet	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wheat	10.2	46.2	8.5	6.4	32.2	6.9	22.1

Source: Own simulations from the six elicited MAUFs.

continue under integrated production, finishing the crop season with the harvest of all the raw cotton. Most of the cotton growers who would abandon this crop (31% of the current level) would change to maize and wheat, as is shown in Table 10.

Table 10. *Aggregate crop distribution changes in both policy scenarios (ha)*

Crop / Policy scenario	Current	Scenario A	Scenario B
Cotton	5,979 [a]	0	4,147 [b]
Cotton: semi-abandonment	0	5,546	0
Sunflower	466	661	1,399
Protein crops	283	226	226
Vegetables	388	427	427
Maize	2,262	3,547	3,444
Potatoes	252	258	267
Sugar beet	1,564	0	0
Wheat	1,535	2,063	2,819

[a] Conventional cotton
[b] Integrated production of cotton

4.4. Socio-economic and environmental impact

There are socioeconomic and environmental implications to be derived from the simulated changes in crop distributions in the 2005/06 season due to the recent policy reform (Scenario A) and the alternative scenario (Scenario B).

First, considering the economic impact, Scenario A implies a slightly lower EAGGF expenditure for cotton (93% of the current level) due to the moderate reduction of cotton area. On the other hand, Scenario B increases this expenditure by €12 million as consequence of the additional environmental area payment. However, taking into account the reduction in the cotton hectareage, from some 92,000 to 59,000 ha, there is a saving of €9 million, resulting in a net increase of EAGGF expenditure of 3 millions.

With respect to the cotton gross margin, Scenario A implies a reduction from an average gross margin of €1,579 to approximately 600 €/ha for the semi-abandonment option. The single producer's payment based on 65% of the subsidies received during the reference period is not included since entitlement to it does not depend on the cotton cultivation. In Scenario B the cotton gross margin would be approximately half of the current level. Nevertheless, in spite of the reduction in the gross margin in both scenarios, the total gross margin of the farm, including all the subsidies (single payment plus area payment), would benefit from this reform, with an increase of 14% and 22% of profits in Scenarios A and B, respectively, due mainly to a cotton area payment of 1,039 €/ha instead of the initial figure of 813 €/ha (35% of the payment in the reference period) in Scenario A, and the additional environmental area payment in Scenario B.

From a consumer point of view, the reform will not have any impact, since the Spanish production cannot affect the world price of fibre.

On the social side, the reform (Scenario A) has a markedly negative impact, since farm labour will be reduced by half[2] of the current level due to the substitution of cotton by COP crops and the changeover of the remaining cotton cultivation from conventional to semi-abandonment (80% labour reduction). In Scenario B the reduction in farm labour is less marked, at 24%, since cotton cultivation shifts from conventional to integrated production. In both scenarios the negative impact has been strengthened by the disappearance of sugar beet from the optimum solutions due to the probable implementation of the EU Commission's proposal for sugar CMO reform. Furthermore, the overall impact of the semi-abandonment option will be even greater, given the loss of jobs in the 27 ginneries (251 full-time and 950 part-time) and other input supplier companies.

From an environmental point of view the reform is clearly beneficial since the semi-abandonment option drastically reduces the use of inputs. However, Scenario B also produces this positive effect with an overall reduction in pesticide use of 48% compared to the current level.

5. Conclusions

According to the economic analysis carried out in this study, the reform of the cotton market regulation of April 2004 could mean the complete end of cotton production in Spain. Due to the situation of low world prices far below the variable costs of production, the decoupling of subsidies would probably lead to farmers sowing the current cotton area (some 90,000 ha) but in a semi-abandonment system of cultivation, that is, minimizing the use of inputs and leaving the raw cotton in the field.

The alternative scenario proposed in this study includes an additional area payment of approximately 350 €/ha of environmental nature for shifting from conventional cotton production to integrated production. The approved area payment of 1,039 €/ha is also modulated according to the quality of the raw cotton to a maximum of 50% of that amount. The simulation of this alternative scenario suggest that the current cotton area of Spain, some 90,000 ha, could be reduced up to approximately 59,000 ha, a figure that would mean the continued existence of the cotton sector in Spain.

In general, the net increase in EAGGF expenditure of €3 million resulting from the implementation of these additional measures, the environmental payment plus the modulation of the subsidy, would be offset by the continuation of cotton production under more stringent environmental regulations for more than two thirds of cotton producers (some 9,000 at present). This level of production would ensure the continuation of much of the ancillary industrial sector and would justify subsidies from a social point of view.

[2] On average, cotton labour costs total 350 €/ha, maize 120 €/ha, wheat 10 €/ha, sunflower 11 €/ha and potatoes 1,010 €/ha.

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