JOURNAL OF FARM MANAGEMENT VOL.13. NO. 7. PAGES X

REFEREED ARTICLE

RISK OPTIMAL FARM PLANS IN THE CONTEXT OF DECOUPLED SUBSIDY PAYMENTS: THE CASE OF COTTON PRODUCTION IN THESSALY.

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Partial decoupling earmarked for cotton in the context of the 2003 CAP reform has introduced a risk-free option to the crop mix of cotton farming systems. Portfolio analysis is implemented using a mathematical programming model in order to determine the risk optimal farm plan under the new CAP conditions. Results in Greek representative cotton farms suggest that cotton production will dramatically decrease, replaced mainly by alfalfa and maize rotation, and to a lesser extent by non-harvested cotton and cereals.

Keywords: Cotton, CAP, crop rotation, risk, portfolio analysis

1. Introduction

Traditionally, cotton growing has been a prominent farming activity in Greece, providing the primary input to a major domestic processing industry (cotton ginners). The acreage cultivated with cotton almost doubled during the 1980s, reaching 240 000 ha in 1991, from only 120 000 ha in 1981 (year of Greek admission to the EU) and kept expanding during the 1990s, reaching 430 000 ha in 1996. Within the EU, Greece has thus become the largest cotton producer, accounting for about 70 percent of total cotton production.

Cotton profitability is largely affected by the decisions that were taken during the last reform of the CAP, including the adoption of Regulation 1782/2003, which introduces decoupled payments replacing subsidies related to land or quantity of agricultural production. The Greek government, conscious that the cotton gross margin net of subsidies is negative for the great majority of producers, opted for partial decoupling (65%) according to Regulation 864/2004, with the rest of the quantity dependant payments obtained during the reference period 2000-2002 to be transformed into a subsidy per hectare[1]. Total decoupling is chosen for other agricultural products that are traditionally produced in the region, like durum wheat, maize and tobacco while sugar-beet price decreases by 36% after the sugar Common Market Organization (CMO). Gross margin hereafter net of subsidies modifies the risk and return conditions within which farmers operate, as subsidy buffer notwithstanding, yield and price variability are directly transmitted to gross margins.

The decoupled payment keeps farm income at the previous CAP levels until 2013 while the cotton specific area payment is intended to support cotton cultivation and guarantee supply to the downstream activities. As a matter of fact, producers may receive an area payment if the crop reaches the open capsule stage. This involves minimal input and no harvesting operation, so

1. According to the new regime, the coupled payment for the first 300,000 hectares is €594.00 per hectare, while for the remaining 70,000 hectares it is €342.85 per hectare

corresponds to a shift from current intensive cotton production system to the semi-abandonment of cotton production. This is a risk free activity to consider for the new cropping plan that gives rise to a version of the well known Tobin separation theorem. In fact, up to a certain level of risk-return, the optimal risky portfolio can be determined without any knowledge of the farmer's utility curve. In order to study that, the mean-variance modeling framework has been chosen instead of the expected-utility one. Thus, the frontier of efficient solutions is calculated for cotton growers, and their risk attitude is determined for the 2002 production plan. The analysis was then expanded, by including the new CAP provisions (decoupled payment, risk-free alternative, environmental terms etc) that alter the feasible alternative cropping plans.

Relevant studies evaluating the CAP 2003 reform include welfare analysis based on partial equilibrium approach (Karagiannis, 2004) and bottom-up sector modeling (Rozakis and Tsiboukas, 2006). Neither of them considers alterations to risk and return environment and subsequent reactions by farmers. A recent work that takes this dimension into account (Kotakou and Katranidis, 2008) is operating in the expected-utility framework thus ignoring the risk-free activity emanated by the partial decoupling option.

Portfolio analysis has been used extensively in farm management (Hardaker *et al.*, 2004), in order to define the optimal production plan, for example, the allocation of land to arable crops (Brink and McCarl, 1978) or to aid the design of feeding rations in animal nutrition (Torres-Rojo, 2001). More recently, it was used to discount cereal crop producers' behavior in England and Ireland, in the context of the new CAP decoupled payments (Roche and McQuinn, 2003, 2004). The conclusion was that decoupling will only marginally lead farmers to abandon cultivation (maximum percentage 24% in Ireland and none for England), and for the rest of the cultivated land, to production choices which involve higher risk.

A similar investigation is undertaken in this paper, for selected representative cotton producing farms in Thessaly, the region in which the bulk of Greek cotton production is located; Statistical data indicate that 36% of the farms in Thessaly cultivate cotton, taking up more than 150 000 ha, almost 40% of the total cotton acreage in the country. The farms used in the analysis appear in the Greek Farm Accountancy Data Network (FADN)[2] database of the year 2002 for the region of Thessaly. Cluster analysis provided eight homogeneous farm groups from which representative farms were selected. Data required for the analysis came from the FADN database as well as from personal interviews with farmers.

Extending the stylized wheat and barley system analysed by Roche and McQuinn (2004), detailed farm models, including up to 10 variables and more than 10 constraints, determine the feasible area for representative cotton farmers in Thessaly. On the other hand, the risk free activity emanates from the partial decoupling option exercised by the Greek government that leads to

2. FADN is an EU database with micro-economic accountancy data from a sample of agricultural holdings, collected every year from national surveys. Only 'commercial' farms are included in the surveys. A farm is considered commercial if it exceeds a minimum economic size. This size limit is country specific due to the different farm structures in each Member State. For Greece only farms greater than 2 ESU (Economic Size Unit) are included in the survey.

semi-abandoned cotton, instead of the idle land entitled for the decoupled payment in the case of England and Ireland.

As results show, conventional cotton production is giving way to feedstock crops (alfalfa and maize), while in some cases, semi-abandoned cotton production is undertaken. Thus, the quantity of cotton delivered to the ginning industry may be dramatically decreased, as is confirmed by provisional statistical data after the CAP reform, jeopardizing the whole chain (Ministry of Rural Development and Food, 2007). Similar phenomena have been detected in Spain in the post CAP reform period (Arriaza and Gomez-Limon, 2007).

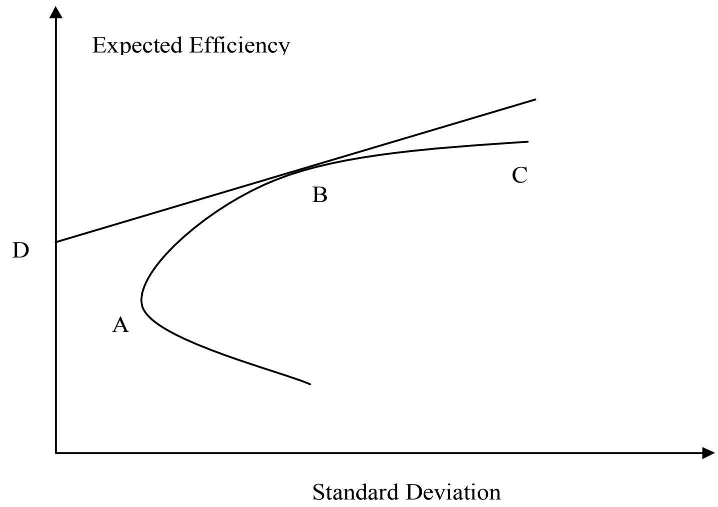
Portfolio analysis is briefly presented in the next section, specified for arable farming using mathematical programming. The third section contains a sample description of cotton growing farms in Thessaly. In the fourth section results of mean-variance optimisation are presented and analysed, followed by discussion and conclusions.

2. Portfolio analysis and mathematical programming

2.1. Portfolio analysis for crop mix selection

The crop mix selection process starts by determining available options in commodity as well as production factor markets. Then decision making units calculate the expected return and its variance of alternative cropping plans subject to resource, market and agronomic constraints. These alternative plans can be plotted on the mean-variance graph forming the E-V curve. Pareto efficient portfolios in mean-variance terms are located in the AC part of the curve (Figure 1). The precise location and shape of the curve is determined by data used for the expected gross margin, variance and covariance values, and, last but not least, by constraints that shape the feasible area of production plans. Preferences and risk attitude determine the efficient frontier point selection by farmers, so that even if two farmers have identical expectations and potential, thus facing the same E-V curve, they will probably select different portfolios because of different risk attitudes (Lumby, 2000).

Figure 1. Portfolio efficiency frontier



If a zero risk option is available among alternative plans (which yield low profits, such as Central Bank bonds) then the line segment that starts from point D (certain value of the risk free option) and is tangent to the curve (point B), replaces part of the efficient frontier, namely the segment AB. Portfolios on the segment DB represent a combination of portfolio B plus variable proportion of the risk free investment that increases when approaching the vertical axis. These portfolios dominate over corresponding points of curve segment AB as for each one there is another on DB that yields higher expected return for the same variance (risk). The typical risk free choice in agriculture is land leasing (Blank, 2001). In presence of a market for land rent, the rental amount represents the risk free yield of land. Consequently some farmers will lease part of their agricultural land, and cultivate the rest according to the crop mix (portfolio) B. In the case of decoupling, the flat fee seems to represent a risk-free option since idle land enjoys a fixed gross margin (decoupled payment minus minimal variable expenses to keep land in acceptable condition). The Tobin separation theorem (Lumby, 2000, pp.214-215) holds for farmers that opt for a cropping plan on the DB segment, stating that portfolio selected is independent to their preferences as it is determined by risk -free yield and the position of E-V curve. The remaining farmers will exhaustively use arable land, selecting a cropping plan that is located on the BC segment, depending on their risk attitude.

2.2. Constructing the mathematical programming model

In the short run, total in-farm operations gross margin is typically the objective to be maximised (equation 1). Decision variables x_i refer to cultivated area by crop i and coefficients gm_i to gross margin of crop i per ha. It has to be noted that inflow or outflow items such as casual labour can be explicitly included for decision variables multiplied by the corresponding coefficient (assuming perfectly elastic hourly wages). A constant term (decheq) denotes the decoupled subsidies enjoyed by the farm after the 2003 CAP reform (this amount is fixed for the period 2006-2013 based on historical data on subsidies received by the farm during the 2000-2002 cultivation period).

$$decheq + \sum_i gm_i \cdot x_i = tot\_gross\_margin \qquad (1)$$

Subject to linear constraints that denote feasible production plans so that:

I The production system is not altered (including for example, total useful land and water resources, irrigation type and system, family labour availability).

II Total variable expenses remain unchanged at the farm level. This constraint limits the farm budget at the base year level. It was introduced because interviews revealed that most of the farmers were in the process of paying back bank loans.

III Fixed and quasi-fixed farm capital is given.

IV New CAP provision: Cross compliance obligation in order to receive the single payment (crop – rotation with legumes in 20% of the eligible land)

V New CAP provision: Actual farm land must be greater than or equal to eligible land.

No matter what the purpose of the crop planning model (three main purposes according to Brink and McCarl (1978): to plan acreages, to budget returns to investment and/or to predict land allocation to crops accurately), introducing risk consideration into the analysis may help to predict farm behaviour. In the context of the mean-variance model, activity plans that are implemented have to minimise risk, in other words, the variance of total gross margin, at the same time keeping the expected total gross margin at a desired level. Total variance is represented in equation 2. The mean-variance is a quadratic model that is parametrically solved for different levels of total gross margin thus plotting the efficient frontier.

$$\sum_{ir} \sigma_{ir}^2 \cdot x_{ir}^2 + \sum_{ir} \sum_{\substack{j \\ ir \neq j}} x_{ir} x_j \sigma_{ir,j} = tot\_variance \quad (2)$$

[3]

An alternative specification of the E-V model that explicits the risk aversion coefficient is the E-σ model. Assuming that the farmer has an expected utility function *E(U) = E – r s* (*s* stands for standard deviation), once the efficient *E-s* (that coincides to *E-V*) frontier is known, then the knowledge of the risk aversion parameter *r* leads to the identification of the optimal plan. As Hazell and Norton suggest (1986, p. 93), imputing values of *r* by solving farm models for their efficient set of plans and selecting the value that leads to the closest fit between the actual and predicted farm plans. The measure used in this exercise is the mean absolute deviation (MAD) of the solution values from the actual mix of cropping activities grown by the sampled farmers in the year of the survey. Following Elamin and Rogers (1992), the single farm plan, identified by *r* is risk optimal while other plans, though risk efficient, are not risk optimal.

3. Case study: Cotton producing farms in Thessaly

3.1 Farm typology

The Greek FADN database of the year 2002 includes 544 farms in Thessaly (representing 79.477 farms in the region), from which we selected the 324 that cultivate more than 0.1 hectares of cotton and represent a total of 24.098 cotton farms in Thessaly. Cluster analysis was implemented to produce a farm typology of representative farms with the use of eighteen FADN

3. Covariance on the second part of the equation (2) equals the product of variances multiplied by the correlation coefficient.

variables (Table 1) that satisfy the criteria of technological and profit homogeneity introduced by Day (1963). Cluster analysis is a widely used grouping method for creating farm and behavioral typologies as a means either to facilitate policy analysis via mathematical programming or econometric models (e.g. Buysse et al, 2007; Gómez-Limón & Riesgo, 2004; Hennesy, 2000), or to identify different marketing strategies and explaining farmer's behaviour. (e.g. McLeay et al, 1996; Tsourgiannis et al, 2006 ; Eboli and Turri, 1988).

The number of variables used, as well as the large number of farms, imposed factor analysis, in order to produce a smaller variable (factor) set that would be used for clustering. The Bartlett's Test of Sphericity as well as the measure of sampling adequacy (MSA) values for each variable (Table 1) show that there is sufficient intercorrelation among them to justify the use of Farctor Analysis (Hair *et al*, 2006, p. 114-115).

Table 1. Variables used in Factor Analysis and results.

			Factor Loadings				
#	**Variable**	**MSA**	**Cotton**	**Tobacco**	**Durum-Wheat**	**Sugar Beet**	**Maize**
1	Total Labor Used (AWU)	.704		.764			
2	Total Farm Land (ha)	.859	.759				
3	Land Irrigated (ha)	.958	.883				
4	Land Rent (ha)	.887	.683				
5	Economic Size (ESU)	.968	.764				
6	Cotton (ha)	.885	.962				
7	Durum Wheat (ha)	.639			.963		
8	Maize (ha)	.529					.991
9	Sugar Beet (ha)	.636				.968	
10	Tobacco (ha)	.658		.966			
11	Cotton Gross Revenue (€)	.822	.961				
12	Durum Wheat Gross Revenue (€)	.781			.960		
13	Maize Gross Revenue (€)	.546					.989
14	Sugar Beet Gross Revenue (€)	.662				.970	
15	Tobacco Gross Revenue (€)	.558		.970			
16	Total Subsidies Received (€)	.832	.931				
17	Farm Income (€)	.796	.732				
18	Farm Gross Revenue (€)	.823	.897				

Bartlett's Test of Sphericity	Sig. 0.00					
		Cotton	**Tobacco**	**Durum-Wheat**	**Sugar Beet**	**Maize**
Initial Eigenvalues	Total	7.612	2.722	2.192	2.087	1.446
	% of Variance	42.290	15.120	12.179	11.594	8.032
	Cumulative %	42.290	57.410	69.589	81.183	89.215

The method used for factor analysis was Principal Component Analysis, which resulted in five factors with eigenvalues greater than 1, explaining 89% of total variance. Varimax rotation revealed that each factor corresponded to a different cropping activity (cotton, sugar beet, maize, tobacco and durum wheat) by showing a strong linear relationship between cultivated land and gross revenue. Table 1 presents the factor loadings for each variable used.

The five factors were then used as variables in hierarchical cluster analysis, which was based on squared Euclidean distance to measure intervals among cases and on Ward's method for aggregation. K-means cluster analysis was also performed as a supplement to the Ward's method and the Kruskal-Wallis nonparametric test was used to identify differences between clusters, as the assumptions of normality and homoscedasticity, required for ANOVA and discriminant analysis, were violated. Solutions containing five to ten clusters were examined but those with more than eight clusters resulted in groups with only one farm in both clustering methods. Single farm groups were also produced via the K-Means analysis in the seven cluster solution, while the five cluster solution failed the Kruskal-Wallis test. All the above clustering results were excluded and finally an eight cluster solution was chosen as it proved to be more easily interpretable than the six cluster solution. The eight groups of farms derived from cluster analysis are presented in Table 2.

Table 2. Groups of cotton producing farms in Thessaly.

Clusters	Number of Farms	Farms represen-ted in Thessaly	Main Crops	Farm Size (ha)	Economic Size (ESU)	Total Labour (AWU)
1	11	809	Cotton, D. Wheat	32.11	43.69	0.82
2	21	843	Cotton, S. Beet	28.26	28	0,36
3	17	665	Cotton, Maize (large farms)	19.26	21.5	0,26
4	111	6540	Cotton, various (large farms)	12.9	20.23	0.12
5	16	744	D.Wheat, Cotton	30.89	24.55	0.31
6	38	2211	Cotton, Maize (small farms)	11.5	19.45	0.52
7	10	460	Cotton, Tobacco	8.93	17.97	1.83
8	100	11826	Cotton, various (small farms)	6.99	11.93	0.12

Supplementary data were collected by personal interviews with the farmers (Petsakos, 2006) in order to estimate variable cost per crop.[4] These supplementary data included detailed information about the value and quantity of agricultural inputs, subsidies per crop, land entitlements for the single payment regime, as well as farm specific information about required human and machinery labor per hectare for each crop and field operation.

4. Variable cost per crop could not be calculated by the FADN data, as it only contains expenses aggregated per field operation (tillage, irrigation, harvesting etc.).

3.2. Farm level model building

According to the methodology presented in section 2.2, decision variables x_i used in the MP model refer to crops (activities) that already exist in the farm sample. These crops are cotton, durum and soft wheat, alfalfa, maize, sugar beet, tomatoes, peppers and Virginia tobacco. Variable expenses were calculated separately by farm and activity (crop), depending on the irrigation system and the horsepower of available equipment. Gross margin is calculated given both previous and current CAP regime, assuming full decoupling for all crops (Ministry of Rural Development and Food, 2005), except for cotton and durum wheat, for which there is a subsidy per hectare of €546.50[5] and €40.00 respectively.

In order to satisfy cross-compliance obligation (new CAP), the common vetch intercropped activity[6] was added, as well as the "idle land" activity so that the model calculates at the optimum the farm land that is not cultivated, but is maintained with the minimal required care in order to receive the decoupled payment[7]. Finally, a variable that concerns the non-harvested cotton was included, as the partial decoupling of cotton always renders a higher gross margin than leaving land idle, even if the cotton is not sold. This kind of cotton cultivation (with low input requirements that amount to €300 per hectare) results in decreased gross margin compared to conventional cotton, but obviously is not subject to risk, neither is the output, since it is not harvested, nor is the price, because it is not sold (average gross margin about €290 per ha, the same for all the producers and null variance).

An additional set of farm specific constraints for cotton, tobacco, sugar beet, industrial tomatoes and peppers was also included for the analysis. More specifically, both cotton and tobacco area for the previous CAP regime are constrained to the cultivated areas observed in the base year. For cotton, this reflects national policy to attenuate co-responsibility charges for exceeding a maximum guaranteed national quantity, while for tobacco it simulates the farm specific quotas that were active during the same period. Sugar beet, tomatoes and pepper were considered only for the farms that cultivated these crops in the base year. The reason for the constraint in sugar beet is none other than the contract character of this particular crop and the ability of the corresponding manufacturing industries to absorb the whole production in a given time period. For tomatoes and pepper, the restriction is due to the estimate for weakness of disposal of additional production.

3.3. Implementation of the Expected Return – Standard Deviation model on cotton producing farms

For the application of the mean-variance model, the median farm regarding crop areas from each cluster was selected. It should be noted that base year

5. The mean of total subsidies as described by the new cotton regime
6. We use this term to explain a short rotation scheme of common vetch (legume crop) with cotton or maize which takes place during the same cropping season: Vetch is sown in winter (November-December) and remains in the field until it is removed by tillage operation in spring (March-April) that also prepares the field for the subsequent sowing of cotton or maize.
7. Any payment entitlement must be accompanied by an eligible hectare, in order for the farmer to receive the payment.

(2002), ante reform cotton prices to the producers enjoyed a subsidy level of roughly twice the world market price. In contrast, the current prices of cotton represent the mere commercial value (new CAP) and so its gross revenue is considerably decreased. Thus, cotton gross margin after the reform is limited to one quarter of what was received before the revision of CAP (433.6 vs. 1611.4 €/ha), while for durum wheat it has decreased by 68% (Table 3). This reduction is compensated for by the decoupled payment, which amounts on average to 60% of net revenue (except for farm 7 which cultivates tobacco and receives a single payment almost twice as its net revenue). Gross margin for wheat (durum and soft), and maize includes the subsidy for the year 2002, which according to data provided by the prefecture of Thessaly, was €155.60/ hectare and €554.20/hectare correspondingly. An additional subsidy was calculated especially for durum wheat, depending on the location of each farm.[8] The two last lines of table 3 present the ratio of standard deviation to gross margin, which is more than doubled for cotton and durum wheat. These high rates of output variance impose the adoption of model of decision-making that takes risk into consideration. On the other hand, the presence of a risk free option imposes the use of mean-variance analysis. The *E-s* model takes into account that the feasible region is delineated by the constraints (I-V) of the farm model in paragraph 2.2. It can show to what degree decoupling subsidies from production will lead the producers to shift to idle land or to cultivate alternative crops.

Table 3. Gross margins and risk dependent on CAP (€/ha).

		Gross margin 2002	**Gross margin 2006**
Cotton	***Average***	***1611.4***	***433.6***
	Maximum	1796.9	619.6
	Minimum	1305.0	127.7
	Std deviation / Gross margin	*9.6%*	*35.8%*
D. Wheat	***Average***	***539.5***	***170.9***
	Maximum	635.5	214.4
	Minimum	441.2	80.3
	Std deviation / Gross margin	*13.5%*	*28.3%*
Single payment / Net revenue	***Average***	***60.4%***	
	Maximum	181% (farm 7)	
	Minimum	45% (farm 2)	

8. This additional subsidy is €192.80/hectare for Karditsa, €305.70/hectare for Larisa, €336.90/hectare for Magnesia and €245.60/hectare for Trikala.

The variance of a portfolio equals the weighed sum of its individual element returns moderated by the correlation factor (from relationship 2, known that $cov_{(x,y)}=\rho_{(x,y)}\sigma_x\sigma_y$). For perfect cross-correlation, the two investments portfolio, one with higher return and risk and another with lower return but also less risk, offers reduction of risk proportional to the return decrease. When the correlation factor is decreased, tending to zero, a larger share of the second investment in the portfolio leads to higher reduction of variance than return reduction. When the correlation coefficient becomes negative any portfolio can make a negative contribution to risk (Lumby, 2000, ch. 9).

In the case of arable crops in Thessaly, correlation factors are presented in Table 4. They were specified from historical data that were assumed common to all farmers (time-series for prices and yields for the decade 1992-2001 adjusted for each one of the selected farms). When extreme values are observed in the yield of certain products in some farms, yield distribution was modified suitably, so that these values constitute the extreme (maximum or minimum) of the distribution. Product prices were deflated, using year 2000 as base. Strong positive correlation is observed between sugar beet versus cotton, tobacco and alfalfa while the others are weakly positive or negative, and no correlation is observed between cotton and wheat, sugar beet and soft wheat, or alfalfa and durum wheat.

Table 4. Gross margin correlation coefficients.

	Cotton	Tobacco	Soft Wheat	Durum wheat	Maize	Sugar beet	Alfalfa	Tomatoes	Pepper
Cotton									
Tobacco	0,85								
Soft Wheat	0,073	0,69							
Durum wheat	0,064	0,60	0,69						
Maize	-0,57	0,69	0,62	0,63					
Sugar beets	0,81	0,95	0,068	0,60	0,62				
Alfalfa	-0,183	0,92	-0,157	0,058	0,63	0,87			
Tomatoes	0,41	0,60	0,36	0,31	0,42	0,51	0,59		
Pepper	0,69	0,84	0,50	0,32	0,47	0,86	0,76	0,62	

4. Results and impact of the new CAP on cotton producers

Complete *E-s* model results, under pre and post 2003 CAP conditions, are presented in figure 2, featuring efficient frontiers for each farm. Two frontiers are generated for post-2003 CAP; the first does not include the risk-free option (semi-abandoned cotton) as variable, but the second one does. Post-2003 CAP frontiers dominate pre-2003 CAP ones for low risk levels in all farms, whereas the inverse is true for farms 1, 4, 5, 6 and 8 for high risk activity plans. It has to be noted that optimal activity plans, corresponding to maximum levels of total gross margin (risk aversion coefficient equal to zero), consist of cotton and wheat in pre-2003 conditions, but corn and alfalfa under the new CAP (table 5).

Table 3. Risk optimal results before and after the CAP reform.

	Risk aversion coefficient	Year	Cotton not harvested (ha)	Cotton (ha)	Tobacco (ha)	Soft wheat (ha)	Durum wheat (ha)	Maize (ha)	Sugar beets (ha)	Alfalfa (ha)	Tomatoes (ha)	Pepper (ha)
Farm 1	0-2,4	2002		22,4			6,5					
		2006	5,9-9,8				0-6,5	0-8,2		4,4-11,8		
Farm 2	0	2002		12,0			12,0		6,0	4,0		
		2006	6,9				12,0			14,7		
Farm 3	0-2	2002		12,3			4,0	6,7		1,4		
		2006	0-6,6				0-9,2	0-7,3		7,9-13,2		
Farm 4	0-1,6	2002		13,9			1,3			2,2		
		2006	5,4-6,8				0-1,3	0-9,4		1,4-8,9		
Farm 5	0-3,6	2002		8,7			15,5					
		2006			0-0,8		18,3-18,5	0-5,4		0,3-3,4		
Farm 6	0-2,8	2002		6,1			0,7	2			2,3	1,7
		2006		0-6,1			0,7-2,7	2-6,1			2,3	1,7
Farm 7	0-4	2002		5,9			2					
		2006	0-7,9		0-0,8					0-3,9		
Farm 8	0-3,6	2002		8			3,5					
		2006	0-3,3		0-0,8		0-3,5	0-4,4		0,4-3,1		
Aggregate results		2002	**0**	**244605**	**0**	**0**	**81927**	**8878**	**5058**	**18691**	**5085**	**3759**
		2006	**59637-91527**	**0-13487**	**0-10352**	**0**	**29754-86650**	**13413-132933**	**0**	**34552-129913**	**5085**	**3759**

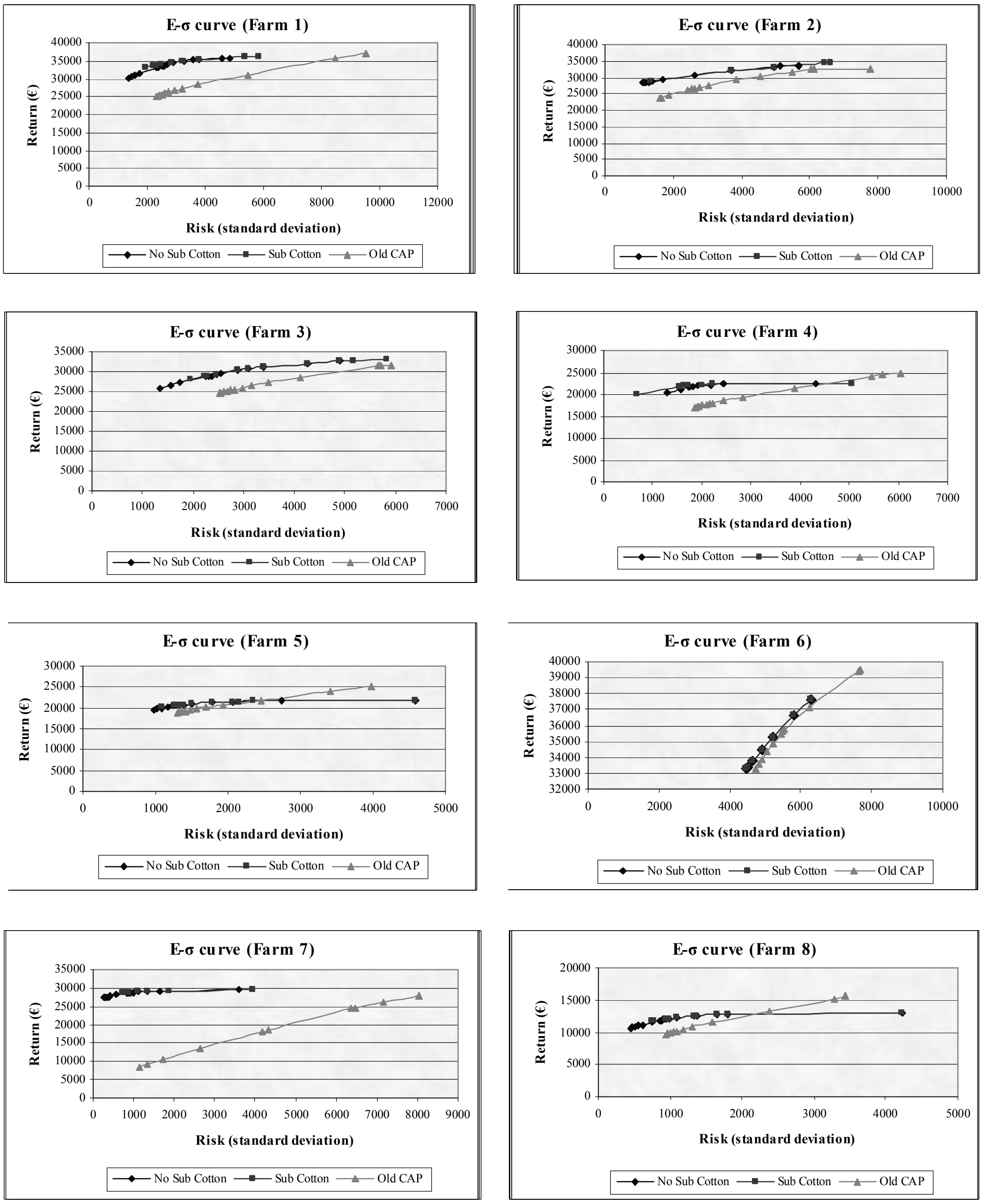
Under the new CAP, due to decoupling, gross margins of cotton and wheat are decreased giving lower value than alfalfa gross margin. Corn gross margin comes just below alfalfa assuming prices maintain 2002 levels. For instance, farm 1 cultivated in 2002 with cotton and durum wheat could introduce corn to mitigate risk levels (table 5). In order to drastically limit risk exposure, gross margin has to be decreased by 25% (figure 2 – farm 1). In the case of new CAP, we observe that the efficient solutions frontier is less steep than before, meaning that if the farmer accepts a moderate gross margin decrease (for instance 10%) risk is almost removed. An activity plan that includes alfalfa and corn maximises gross margin, while in order to further reduce risk subsidy cotton is introduced to the crop mix (table 5). Farm 6 is the exception to the above statement, as the main source of its income is tomatoes and pepper (not affected by the 2003 CAP reform), that amount for almost 61% of its gross margin.

Risk aversion coefficients *r* corresponding to the 2002 activity plan vary between zero (risk neutral behaviour) and 4.[9] Detailed ranges of risk aversion coefficients for the sample farm are presented in table 5. Previous studies mentioned by Hazell and Norton (1986), have shown an average risk aversion coefficient of 1.5 for Mexican irrigated agriculture (Hazell *et al*., 1983), 3.28 for small farms in north Brazil (Goodwin *et al*., 1980), 2.0 for groundnut producers (Nieuweoudt *et al*., 1976), and 0.25 for US cornbelt farmers in Indiana (Brink and McCarl, 1978). More recently Elamin and Rogers (1992) estimated between 1.5 and 2.54 for dry-land agriculture in Sudan, where the larger and mechanized farms proved to be more risk averse. Risk aversion coefficient ranges defined by the basic year model are used in the objective function of the new CAP farm models. Resulting cropping activities are also presented in table 5. In most farms, cotton is cultivated but not harvested, alfalfa and maize are the main crops replacing cotton, durum wheat varies in a range comparable to pre-reform levels, whereas sugar-beet disappears. When results (table 5) are extrapolated by the relative weight of representative farms (table 2) there is a 50% decrease of cotton cultivated area. However, we observe a dramatic fall of quantity delivered, since only 13% of cotton cultivated area is harvested. Aggregate surfaces by crop are presented in the lower part of table 5.

Concerning alfalfa, one should be cautious as market prices change if all farmers switch from cotton and wheat to alfalfa, and secondly corn, in the farms under consideration. This does not hold for corn so much, as its market price is largely linked to the world price. These changes will eventually alter efficient *E-s* frontiers, since expected returns and the variance-covariance matrix will be affected. This topic is beyond the scope of the present work and merits further study and work with partial equilibrium models. In the context of this study, in order to take into account the risk of alfalfa price collapse, we may assume that farmers intuitively discount such possibilities, by choosing activity plans in the efficient frontier with risk aversion at the maximum value

9. Assuming that income is normally distributed, then for $r=2.8$, the expression $E- r\sigma$ identifies the 1% income fractile that is the value of income which, for a given distribution will be exceeded the 99% of the time.

Figure 2. Efficient activity plans



of the range. These plans should be less risky than the optimal ones, thus suggesting a crop mix composed of cotton, wheat, and corn, significantly reducing the alfalfa area.

Conclusions

The current government support for European agriculture (decoupling subsidies from production) modifies the risk environment of arable cropping systems. The fact that alternative activities are offered to the farmer that purport no risk at all such as 'idle land', or in the case of Greek cotton growers 'non harvested cotton', justifies the use of portfolio theory as a tool for analysing farmers' behaviour.

New CAP impacts on typical cotton growers in Thessaly, Greece, are expected to influence crop mix to a large extent, changing the map of arable cropping due to the dramatic decrease in cotton cultivation, in many cases a monoculture in the region for over ten years. CAP impacts are however limited in terms of farm gross margin, as decoupling payment compensates for abolished subsidies previously associated with production. For this reason it is assumed that attitudes toward risk will not change, and the risk aversion exhibited in 2002 would presumably hold today. Thus, risk aversion coefficients estimated for the base year 2002 in eight representative cotton growing farms in Thessaly are used to determine risk optimal plans for the new CAP conditions. The relaxation of the above assumption by taking into account the wealth effect, that could better approximate the reactions of the farmers in the new context, is beyond the scope of the present paper. More detailed information at the farm level is necessary in order to combine the expected utility with the mean-variance framework that can be the focus of a subsequent study.

There is evidence, illustrated by the representative farm models presented in this paper, that farmers, taking into account new CAP conditions, will replace previously cotton cultivated area by corn and alfalfa up to the point where market prices assure satisfactory income, then by wheat to a lesser extent, while a significant percentage of 'non harvested cotton' will cover the rest of irrigated land. The above estimates are valid in the short term. One would expect similar reactions from other cotton producers in the country since cotton farms modelled represent a wide range of cropping systems, from highly specialised to fairly diversified.

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Acknowledgements

The authors wish to thank the participants of the 9nd Congress of the Hellenic Society of Agricultural Economists (ETAGRO), Athens, Greece, November 2006, and the DG Agriculture experts that contributed to the cotton policy informal meeting in Brussels, June 2007 for their helpful comments and suggestions on earlier versions of this paper as well as John Stedman for proofreading the English text. Also we are grateful to the editor and two anonymous referees for valuable comments and remarks. The usual caveats apply.

References

Arriaza, M. and Gomez-Limon, J.A. (2007). Policy implications of the decoupling of the EU cotton subsidies. *Journal of International Agricultural Trade and Development*. Vol. 3(1): 101-127.

Blank, S.C. (2001). Producers get squeezed up the farming food chain: A theory on crop portfolio composition and land use. *Review of Agricultural Economics*. Vol. 23(2): 404-422.

Brink, L., and B. McCarl. (1978). The tradeoff between expected return and risk about corn-belt farmers, *American Journal of Agricultural Economics*. Vol. 60: 259-263.

Buysse, J., Fernagut, B., Harmignie, O., de Frahan, B.H., Lauwers, L., Polomé, P., Van Huylenbroeck, G. and Van Meensel, J. (2007). Farm-based modelling of the EU sugar reform: impact on Belgian sugar beet suppliers. *European Review of Agricultural Economics.* Vol. 34(1): 21 - 52.

Day, R.H. (1963). On aggregating linear programming models of production. *Journal of Farm Economics*. Vol. 45: 797-813.

Eboli, M.G. and Turri, E. (1988). Toward a Behavioral Model of Multiple-Job -Holding Farm Families. *Agricultural Economics*. Vol. 2: 247-258.

Elamin E.M. and Rogers L.F. (1992). Estimation and use of risk aversion coefficient for traditional dryland agriculture in western Sudan. *Agricultural Economics*. Vol. 7: 155-166.

European Commission Directorate – General for Agriculture. (2003). *Mid – term review of the Common Agricultural Policy July 2002 proposals. Impact analyses*, February 2003.

Gómez-Limón, J.A. and Riesgo, L. (2004). Irrigation water pricing: differential impacts on irrigated farms. *Agricultural Economics*. Vol. 31: 47–66.

Goodwin, J.B., Sanders, J.H. and Hollanda A.D. (1980). Ex ante appraisal of new technology: Sorghum in Northeast Brazil. *American Journal of Agricultural Economics*. Vol. 62: 737-741.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E. and Tatham, R. L. (2006). *Multivariate data analysis*. Pearson Prentice Hall Inc, New Jersey.

Hardaker, J. B., Huirne, R. B. M., J. R.Anderson and G.Lien (2004). *Coping with Risk in Agriculture*. CAB International, Wallingford, UK.

Hazell, P.B., Norton R.D., Parthasarathy, M. and Pomareda, C. (1983). The importance of risk in agricultural planning models. In: R.D. Norton and L. Solis (Editors). The Book of CHAC: Programming studies of Mexican Agriculture. John Hopkins University Press, Baltimore, MD.

Hennessy, T. (2000). Modelling Farmer Response to Policy Reform: An Irish Example. In: European Association of Agricultural Economists 65th EAAE Seminar. Bonn, Germany.

Karagiannis, G. (2004). The EU cotton policy regime and the implications of the proposed changes for producer welfare, FAO Commodity and Trade Policy. Research Working Paper 9.

Lumby, S. (2000). *Investment appraisal & financing decisions*. VNR Series in Accounting Finance.

McLeay, F., Martin, S. and Zwart, T. (1996). Farm business marketing behaviour and strategic groups in agriculture. *Agribusiness*. Vol. 12: 339-351.

Ministry of Rural Development and Food. (2005). *Decoupling subsidies from production with the new CAP*. Athens (in Greek).

Ministry of Rural Development and Food. (2007). OPEKEPE, personal communication.

Nieuwoudt, W.L., Bullock, J.B. and Mathia, G.A. (1976). An economic evaluation of alternative peanut policies. *American Journal of Agricultural Economics*. Vol. 53: 485-490

Petsakos, A. (2006). Impacts of the new C.A.P. implementation: Quantitave analysis for cotton cultivating farms in Thessaly region. Master's Thesis in the Graduate programme «Integrated development and management of rural areas». Department of Agricultural Economics and Development, Agricultural University of Athens (in greek).

Roche, M. J. and McQuinn, K. (2003). Efficient allocation of land in a decoupled world, *Economics Department Working paper Series*. National University of Ireland – Maynooth.

Roche, M. J. and McQuinn, K., (2004). Riskier product portfolio under decoupled payments, *European Review of Agricultural Economics*. Vol. 31 (2): 111-123.

Rozakis, S. and Tsiboukas, C. (2006). New CAP impacts to cotton producing farms. In Proceedings of the 8th Greek Agricultural Economics Conference, Athens (in Greek)

Katranidis, S.D. and Kotakou, C.A. (2008). Are CAP Decoupling Policies Really Production Neutral? In 12th Congress of the European Association of Agricultural Economists, Ghent.

Torres-Rojo, J. M. (2001). Risk management in the design of a feeding ration: a portfolio theory approach, *Agricultural Systems*. Vol. 68(1): 1-20.

Tsourgiannis L., Eddison J, M. Warren and Errington A. (2006). Profiles of sheep and goat farmers' marketing strategy in the Region of East Macedonia and Thrace in Greece. *Journal of Farm Management*. Vol. 12 (8): 443-465.