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Στην Οικογένειά μου

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Chapter 1 Introduction

The objective of the present thesis is to examine issues relating with the cotton sector in Greece. In general, the cotton sector is of limited importance to the European Union (EU) as a whole since cotton contributes only 0.5% to the final agricultural output. However, cotton production has strong regional importance to Greece and Spain which are the main EU cotton producers. Greece is the major cotton-producing Member State of the EU given that 76% of the EU's total cotton output is grown in Greece.

In Greece, the share of cotton output to total agricultural output is 9.1 % and there are 79.000 cotton farmers involving in the cotton sector. These farmers are concentrated in Thessaly, Sterea Ellada, Kentriki Makedonia and Anatoliki Makedonia. These areas accounted for 98% of the total cotton area in 2005. In particular, cotton account for 41% of the total arable area in Thessaly region. The corresponding shares in Sterea Ellada, Kentriki Makedonia and Anatoliki Makedonia are 15%, 27% and 15%. Cotton production is characterized by a tendency towards monoculture and the average farm size was 4.5 hectares in 2005.

As for the ginning industry, there are 30 ginning companies in Greece with 65 gins. The majority of the companies (80%) are private and the rest are cooperatives. Additionally, during the period 2000-2006, Greece exported 75% of cotton production and consumed the remainder. Greece's major export partners are Turkey and South Africa.

In the empirical application we use farm level data provided by the Farm Accountancy Data Network (FADN). It should be noted that FADN database does not contain data for half of farms and specifically for farms that lie in the low tail of the size distribution. Thus, the division of farms in small, medium and large corresponds to the half bigger farms in the population and this is a limitation of the data. However, we use these data since the dataset contains many variables, the data are reliable and in a farm level.

The thesis can be divided in three distinct parts, each of which focuses on the analysis of cotton market from a different perspective. Thus, each chapter contains its own introduction, literature review, theoretical framework, estimation results, conclusions and references.

In chapter 2, we examined econometric issues using farm-level data. In recent years, many empirical studies that evaluate the effects of agricultural policies in Europe and United States rely on the estimation of a system of equations and datasets that are balanced or unbalanced panels. However, they do not use panel data estimation methods and therefore the estimation results perhaps are not reliable. In this chapter we estimate a system with equations by applying three different estimation techniques since our objective was twofold: to underline the different results obtained by adopting each method and to examine which of them is the most appropriate. Finally, in this chapter we also examined the relationship between farm size and the elasticity of supply with respect to its own price since there is evidence as the farm size increases the elasticity decreases and vice versa.

In the next chapter, we focus on the agricultural policy analysis. In 2006 a new agricultural policy was introduced in Europe. The main objective of this policy was to shift support from production and prices to direct income support measures. In this way, subsidies are decoupled from the level and/or the kind of production. This assumption makes the evaluation of this new policy a significant research objective. Therefore, in this chapter we examined the effects of the new agricultural policy, past agricultural policy, a fully decoupled policy and the free trade no policy scenario on Greek cotton production. We included the rest policies in the analysis because we also wanted to examine which of them causes the larger production distortion.

Finally, in the last chapter we analyze the effects of Common Agricultural Policy (CAP) reforms on farmers' efficiency and productivity. Up to now, there is evidence that subsidies decrease farmers' efficiency. However, these studies refer to coupled subsidies that producers received till 2005. The main objective of this chapter was to examine if the effect of decoupled subsidies on efficiency is also negative. Additionally, we also evaluate farmers' efficiency and productivity under two alternative policies since the secondary objective of this chapter was to examine if farmers perform better, worse or the same under these two alternative policies.

Chapter 2 Panel Data Estimation Methods on Supply and Demand Elasticities: The Case of Cotton in Greece

2.1 Introduction

In recent years, many empirical studies that evaluate the effects of agricultural policies in Europe and United States rely on datasets that are balanced or unbalanced panels. The use of farm-level data implies that we have to consider the application of proper panel data estimation methods so as to obtain estimates of parameters. The adoption of the appropriate estimation method is crucial since the estimated parameters are used for the policy evaluation. Consequently, the increased reliability of the estimated parameters ensures that the policy evaluation will be more accurate.

Although there is a significant number of empirical papers which rely on the estimation of a system of equations with balanced or unbalanced panel data in order to evaluate agricultural policies, they do not use panel data estimation methods. Serra *et. al.* (2005a) and (2006) examined the effects of agricultural policies in the United States. They have estimated a system of equations using a balanced panel with farm-level data collected in Kansas. As for the unbalanced panel datasets, the most frequently used in agricultural economics in the European Union is the Farm Accountancy Data Network (FADN) which consists of a farm-level data collected every year (Rezitis *et. al.* 2002, Csajbok *et. al.* 2005, Karagiannis and Sarris 2005, Bakucs and Fertõ 2009, Melfou et. al. 2009, Offerman and Nieberg 2009, Reidsma *et. al.* 2009). Many studies which evaluate the effects of Common Agricultural Policy (CAP) estimate a system of equations and make use of the FADN dataset. However, they do not take into account the panel structure of the data (Moro and Sckokai 1999, Sckokai and Moro 2006, Serra *et. al.* 2005b).

In this chapter we focus on the estimation of a Seemingly Unrelated Regression System (SUR) with unbalanced panel data applying three estimation techniques: pooled, random effects (RE) and fixed effects (FE) estimation. We apply these methods to underline the different results obtained by each one. The effects of panel data estimation methods on the estimated parameters have also been examined by Platoni *et. al.* (2008). However, while they apply FE and RE estimation in a single equation, in a system of equations only the RE method is used. In this study, we apply all the different estimation techniques in a system of equations i.e. in the same model. Thus, the difference in the estimated parameters is exclusively attributed to the estimation method.

In terms of economic analysis, the objective of this chapter is to examine the relationship between farm size and the elasticity of cotton supply with respect to its own price. The elasticities we estimate are short-run elasticities which, generally, are smaller than the long-run supply elasticities due to the existence of fixed costs. While producers in the short-run can increase production by increasing variable inputs, in the long-run producers can adjust all input quantities. Small farmers use more variable inputs than medium and large farmers (European Commission, 2007 p. A6-A13). This way, small farmers gain in terms of flexibility and therefore can better accommodate to output variation in the presence of price fluctuations (Mills & Schumann 1985). Therefore, we expect the elasticity of cotton supply to be decreasing with respect to farm size. This result was found by Adesoji (1991), who examined the relation of farm size and supply elasticity for U.S. dairy farms. He found that they move in the opposite direction in the short-run but the reverse holds during the long-run period.

In respect of the chapter’s structure, the following section presents the EU cotton market and the section three the theoretical framework that is used in the present study. In sections four, five and six, we outline the econometric techniques, statistical tests and the data respectively. In the ensuing seventh part, we present the estimation results and a rounded discussion of them. Finally, in the section eight we put forward the main conclusions of our study.

2.2 The EU Cotton Market

The cotton sector is of limited importance to the EU as a whole since cotton contributes only 0.5% to the final agricultural output. However, cotton production has strong regional importance to Greece and Spain which are the main EU cotton producers. Greece is the major cotton-producing Member State of the EU given that 76% of the EU’s total cotton output is grown in Greece. The share of cotton to total agricultural output in Greece is 9.1% and in Spain 1.3% (European Commission, 2007).

In terms of economic size classes, i.e. the classification that is used in the present study, the distribution of small, medium and large sized cotton farms in Greece and Spain is presented in the following table:

Table 2.1: Distribution of farms per size in Greece and Spain

Number of farms per size category				
Greece	**2000**	**2003**	**2005**	**2007**
Small farms	16.600	15.810	15.550	13.200
Medium farms	14.930	10.670	11.980	12.220
Large farms	10.520	5.720	5.980	7.510
Total	***42.050***	***32.200***	***33.510***	***32.930***
Spain	**2000**	**2003**	**2005**	**2007**
Small farms	840	780	490	80
Medium farms	1490	460	1200	200
Large farms	1930	1390	1290	1420
Total	***4260***	***2630***	***2980***	***1700***
Share of farms per size category to total number of farms				
Greece	**2000**	**2003**	**2005**	**2007**
Small farms	39.48%	49.10%	46.40%	40.09%
Medium farms	35.51%	33.14%	35.75%	37.11%
Large farms	25.02%	17.76%	17.85%	22.81%
Spain	**2000**	**2003**	**2005**	**2007**
Small farms	19.72%	29.66%	16.44%	4.71%
Medium farms	34.98%	17.49%	40.27%	11.76%
Large farms	45.31%	52.85%	43.29%	83.53%

Source: FADN

In light of the above results it is quite clear that the number of cotton farmers in Greece is much larger than in Spain. In both countries, the number of farms decreases from 2000 to 2003 but in Greece remains relatively stable after 2003. On the other hand, the number of farms in Spain reduces greatly in 2007. This result can be attributed to the change in cotton policy regime that took place in EU from 2006. In Spain, during the cultivation year 2006/2007, there was a decrease in the area under cotton by 45%. On the contrary, in Greece, the cotton area increased by 4% (European Commission, 2007).

Taking into consideration the share of farms per size it is clear that there is small change from year to year in Greece. However, the situation in Spain is completely different. The share of small and medium farms to total cotton producers’ gradually decreases and the corresponding share of large farms is almost doubled from 2000 to 2007. According to the FADN data the total cost of production is higher in Spain 3.037€/ha than in Greece 2565€/ha. Additionally, the total profit is larger in Spain 745.5€/ha than in Greece 596.8€/ha (European Commission, 2007).

2.3 Theoretical Framework

In this section we present the theoretical framework that we used in this study. In order to compute the supply and the derived demand elasticities, we use duality theory and particularly a flexible functional form for profit function. Flexible functional forms of profit functions have been widely used in agricultural economics research (Sidhu & Baanante 1981, Shumway 1983, Weaver 1983, Villezca –Becerra & Shumway 1994, Abrar *et. al.* 2004, Arnade & Kelch 2007, Pope *et. al.* 2007 e.t.c.). We choose the normalized quadratic profit function which is one of the flexible functional forms.

The normalized quadratic profit function has the following form:

$$\begin{aligned}\Pi / P_m = {} & a_o + \sum_{i=1}^{m-1} a_i \left(P_i / P_m\right) + \sum_{i=m+1}^{n} \beta_i Z_i + \frac{1}{2}\sum_{i=1}^{m-1}\sum_{j=1}^{m-1} a_{ij}\left(P_i / P_m\right)\left(P_j / P_m\right) + \\ & + \frac{1}{2}\sum_{i=m+1}^{n}\sum_{j=m+1}^{n} \beta_{ij} Z_i Z_j + \sum_{i=1}^{m-1}\sum_{j=m+1}^{n} \gamma_{ij}\left(P_i / P_m\right) Z_j + \delta_1 t + \frac{1}{2}\delta_2 t^2 + \\ & + \sum_{i=1}^{m-1} \varepsilon_i \left(P_i / P_m\right) t + \sum_{i=m+1}^{n} \zeta_i Z_i t\end{aligned} \tag{2.1}$$

where *Π* is short-run profit (revenue minus variable costs) divided by the price of netput m (input or output), $P_1 \ldots P_{m-1}$ are the prices of the rest netputs (netputs are measured in negative units if they are inputs and in positive units in case that they refer to outputs) divided by the price of netput m; $Z_{m+1},\ldots,Z_n$ are the quantities of quasi-fixed factors of production; *t* is a time trend and *α, β, γ, δ, ε, ζ* are parameters to be estimated.

Applying Hotelling's lemma to equation (2.1) we obtain the supply of output y_i, and the derived demands for variable inputs of production x_i:

$$\frac{\partial \Pi}{\partial (P_i / P_m)} = y_i = a_i + \sum_{j=1}^{m-1} a_{ij} (P_j / P_m) + \sum_{j=m+1}^{n} \gamma_{ij} Z_j + \varepsilon_i t \qquad (2.2)$$

$$\frac{\partial \Pi}{\partial (P_i / P_m)} = x_i = -(a_i + \sum_{j=1}^{m-1} a_{ij} (P_j / P_m) + \sum_{j=m+1}^{n} \gamma_{ij} Z_j + \varepsilon_i t) \quad (2.3)$$

$$for\ i = 1 \ldots\ldots m-1$$

In order to be consistent with competitive theory, the profit function must satisfy the following properties: linear homogeneity in prices, symmetry i.e. $\alpha_{ij}=\alpha_{ji}$, monotonicity in prices and fixed inputs, convexity in prices and concavity in quantities of fixed inputs. We impose linear homogeneity by dividing the profit function with the price of *m* netput (in our case input)[1] and symmetry before estimation. Convexity and monotonicity were checked after estimation.

---

[1] The derived demand equation for the numeraire input is given by the expression:

$$x_m = \Pi / P_m - \sum_{i=1}^{m-1} P_i \frac{\partial \Pi}{\partial (P_i / P_m)} = a_0 + \sum_{i=m+1}^{n} \beta_i Z_i - \frac{1}{2} \sum_{i=1}^{m-1} \sum_{j=1}^{m-1} a_{ij} (P_i / P_m)(P_j / P_m) +$$
$$+ \frac{1}{2} \sum_{i=m+1}^{n} \sum_{j=m+1}^{n} \beta_{ij} Z_i Z_j + \delta_1 t + \frac{1}{2} \delta_2 t^2 + \sum_{i=m+1}^{n} \zeta_i Z_i t$$

which is a quadratic function of normalized prices, quasi-fixed factors of production and time trend.

2.4 Econometric Techniques

In this section we present the econometric techniques that we applied in order to obtain estimators of the coefficients. As we noted in the introductory comments, we estimate a system of equations using three different econometric techniques. In the first case, we estimate the system without taking into consideration the panel specification of our data i.e. pooled estimation. In the second case, we estimate the system using the one way error components method for unbalanced panel data proposed by Biørn (2004) so as to obtain random effects (RE) estimators. Finally, we use the least-squares dummy-variable approach in order to obtain the fixed effects (FE) estimators[2].

2.4.1 Pooled Data Estimation

It is well-known that the appropriate way to estimate a system of M equations is the Seemingly Unrelated Regressions Method (SUR) proposed by Zellner (1962). In this case, the best linear unbiased estimator is the Generalized Least Squares (GLS). Up to now, this method has been used by various researchers in agricultural economics (Fousekis and Revell 2000, Carlberg 2002, Lee *et. al.* 2006, e.t.c.).

2.4.2 Panel Data Estimation

The panel data estimation relies on the hypothesis that in the estimation procedure we take into account the “heterogeneity” of each cross-sectional unit. As it is well known by previous studies (Baltagi 1985, El-Osta and Mishra 2005, Cai *et.al.* 2008, Kaltsas *et.al.* 2008 and Poudel *et.al.* 2009), the most frequently used

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[2] In order to apply the FE estimation method we had to eliminate all the farms that appeared only once in the samples.

models in panel data are the one way RE and FE models. These models rely on the hypothesis that differences among cross-sectional units can be captured by means of an intercept term which is specific for each cross-sectional unit. This specific intercept term is considered as a random disturbance in the RE model and as a fixed parameter in the FE model.

2.4.2.1 One Way RE Model

Avery (1977) was the first to suggest an appropriate method of estimating a SUR system with error components when the dataset is a balanced panel. However, in most cases we have to deal with unbalanced panels so we have to apply the method proposed by Biørn (2004). The main difficulty in applying both methods is that no econometric software supports the estimation of a SUR system with error components either for a balanced or for unbalanced dataset. In the following analysis we provide the approach suggested by Biørn (2004) which we use in the present study.

Consider a system which consists of M regression equations indexed by $m=1,....,M$. The dataset is an unbalanced panel with N farms indexed by $i=1,....,N$, where each farm is observed in at least two and at most S periods. Let D_s denote the number of farms observed in s periods with $s=2,....S$, and n corresponds to the total number of observations. Then the total number of farms observed up to S periods and the total number of observations are given by $D=\sum_{s=2}^{S} D_s$ and $n=\sum_{s=2}^{S} D_s s$ respectively. The farms are ordered in S groups so as the D_2 farms observed twice come first, the D_3 farms observed three times come second, etc. If the cumulative number of farms observed up to *s* times is K_s, then the index sets of the farms observed *s* times can be written as:

$$\begin{aligned}
&I_2 = 1,.........,K_2 \\
&I_3 = K_2 + 1,.....,K_3 \qquad (2.4) \\
&\vdots \\
&I_S = K_{S-1} + 1,.....,K_S
\end{aligned}$$

where $I_2,...,I_S$ can be considered as balanced sub-panels with 2,….,*S* observations of each farm respectively.

The system of M equations for individual *i*, observation t[3] is written as:

$$\begin{aligned}
&\boldsymbol{y}_{mit} = \boldsymbol{X}_{mit}\boldsymbol{\beta}_m + \boldsymbol{\delta}_{mi} + \boldsymbol{\lambda}_{mit} = \boldsymbol{X}_{mit}\boldsymbol{\beta}_m + \boldsymbol{u}_{mit} \quad (2.5) \\
&m = 1,....M, i \in I_s, t = 1,....S
\end{aligned}$$

The dimensions of the matrices consisting of $\boldsymbol{y}_{mit}$, $\boldsymbol{X}_{mit}$ and $\boldsymbol{\beta}_m$ are Mn x 1, Mnx k and k x 1 respectively.

The usual assumptions made by ECM are:

$$\begin{aligned}
E(\delta_{mi}, \delta_{ji'}) &= \sigma^2_{\delta mj} \qquad i = i' \\
&= 0 \qquad\quad i \neq i' \qquad\qquad (2.6) \\
E(\lambda_{mit}, \lambda_{ji't'}) &= \sigma^2_{\lambda mj} \quad i = i', t = t' \\
&= 0 \qquad i \neq i', t \neq t'
\end{aligned}$$

where *i* is the farm index and *t* is the sequence index which counts the times that each farm is observed.

The variance-covariance matrix of the residuals in this case is equal to:

$$\boldsymbol{\Omega}_{u(s)} = \boldsymbol{C}_s \otimes \boldsymbol{\Sigma}_\lambda + \boldsymbol{F}_s \otimes (\boldsymbol{\Sigma}_\lambda + s\boldsymbol{\Sigma}_\delta) \quad (2.7)$$

where $\boldsymbol{F}_s=(1/s)\boldsymbol{H}_s$ and $\boldsymbol{C}_s=\boldsymbol{I}_s-(1/s)\boldsymbol{H}_s$, $\boldsymbol{I}_s$ is the identity matrix of dimension s and $\boldsymbol{H}_s=\boldsymbol{h}_s\boldsymbol{h}_s'$ is the (sxs) matrix with all elements equal to one.

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[3] In this case *t* is a sequence index, not a time index.

In order to compute the matrices $\boldsymbol{\Sigma}_\lambda$ and $\boldsymbol{\Sigma}_\delta$ we have to calculate the (MxM) matrices of overall within farms and between farms (co)variation in the residuals u of the different equations which can be expressed as:

$$\boldsymbol{W}_{uu} = \sum_{s=2}^{S} \sum_{i \in I_s} \sum_{t=1}^{s} (u_{it} - \bar{u}_i)(u_{it} - \bar{u}_i)' \quad (2.8)$$

$$\boldsymbol{B}_{uu} = \sum_{s=2}^{S} \sum_{i \in I_s} s(\bar{u}_i - \bar{u})(\bar{u}_i - \bar{u})' \qquad (2.9)$$

where $\bar{u}_i = (1/s)\sum_{t=1}^{s} u_{it}$ and $\bar{u} = (1/n)\sum_{s=2}^{S}\sum_{i \in I_s} s\bar{u}_i$.

Biørn (2004) proved that the matrices $\boldsymbol{\Sigma}_\lambda$ and $\boldsymbol{\Sigma}_\delta$ are given by the following expressions:

$$\hat{\boldsymbol{\Sigma}}_\lambda = \frac{\hat{\boldsymbol{W}}_{uu}}{n - N} \qquad (2.10)$$

$$\hat{\boldsymbol{\Sigma}}_\delta = \frac{\hat{\boldsymbol{B}}_{uu} - ((N-1)/(n-N))\hat{\boldsymbol{W}}_{uu}}{n - \left(\sum_{s=2}^{S} D_s s^2\right)/n} \qquad (2.11)$$

Using equations (2.8) and (2.9) to obtain, estimates of the variance-covariance matrices $\hat{\boldsymbol{\Sigma}}_\lambda$ and $\hat{\boldsymbol{\Sigma}}_\delta$, these estimates are then substituted into equation (2.7). After the calculation of the variance-covariance matrix of the residuals, the coefficient's GLS estimators and their variance-covariance matrix can be computed by the following formulas:

$$\hat{\boldsymbol{\beta}}_{GLS} = \left(\sum_{s=2}^{S} \sum_{i \in I_s} \boldsymbol{X}'_{i(s)} \boldsymbol{\Omega}^{-1}_{u(s)} \boldsymbol{X}_{i(s)} \right)^{-1} \left(\sum_{s=2}^{S} \sum_{i \in I_s} \boldsymbol{X}'_{i(s)} \boldsymbol{\Omega}^{-1}_{u(s)} \boldsymbol{y}_{i(s)} \right) \quad (2.12)$$

$$V\left(\hat{\boldsymbol{\beta}}_{GLS}\right) = \left(\sum_{s=2}^{S} \sum_{i \in I_s} \boldsymbol{X}'_{i(s)} \boldsymbol{\Omega}^{-1}_{u(s)} \boldsymbol{X}_{i(s)} \right)^{-1} \qquad (2.13)$$

Once again, as there does not exist any standard econometric software that provide automatic commands to estimate one-way SUR systems, we applied the following stepwise procedure for estimating the matrix $\boldsymbol{\Omega}^{-1}_{u(s)}$, the coefficient's GLS estimators and their variance-covariance matrix:

Step 1: We run an OLS regression separately on all *M* equations for all observations $\boldsymbol{y}_{it}$ and $\boldsymbol{X}_{it}$. Using the estimation results we form the corresponding vectors of residuals $\hat{\boldsymbol{u}}_{it} = \boldsymbol{y}_{it} - \boldsymbol{X}_{it}\hat{\boldsymbol{\beta}}_{OLS}$ for all *i* and *t*.

Step 2: We compute the matrices of overall within and between farms (co)variation that is $\hat{\boldsymbol{W}}_{uu}, \hat{\boldsymbol{B}}_{uu}$, by inserting the residuals $\hat{\boldsymbol{u}}_{it}$ in equations (2.8) and (2.9).

Step 3: We calculate matrices $\hat{\boldsymbol{\Sigma}}_{\lambda}, \hat{\boldsymbol{\Sigma}}_{\delta}$ by inserting the matrices $\hat{\boldsymbol{W}}_{uu}, \hat{\boldsymbol{B}}_{uu}$ in expressions (2.10) and (2.11).

Step 4: Using the results from the previous step and the equation (2.7) We calculate the variance-covariance matrix $\boldsymbol{\Omega}_{u(s)}$.

Step 5: We compute the matrix $\boldsymbol{\Omega}^{-1}_{u(s)}$ which is inserted in equations (2.12) and (2.13) so as to calculate the GLS estimators as well as their variance-covariance matrix.

2.4.2.2 One Way FE Model

To obtain the FE estimators we follow the procedure that is described in the previous section but we modified the variance-covariance matrix of the residuals. It is well known that the GLS estimator is a weighted average of the between and within group estimators (Hsiao, 1986 p. 36). In the case that we exclude the between group variation in the residuals from the variance-covariance matrix we obtain the within group or FE estimators. According to this property of GLS estimator, we modified the variance-covariance matrix described in equation (2.7) as follows:

$$\boldsymbol{\Omega}_{FE} = \boldsymbol{C}_s \otimes \boldsymbol{\Sigma}_\lambda \quad (2.14)$$

The FE estimators and their variance-covariance matrix are given by the following formulas:

$$\hat{\boldsymbol{\beta}}_{FE} = \left(\sum_{s=2}^{S} \sum_{i \in I_s} \boldsymbol{X}_{i(s)}^{'} \boldsymbol{\Omega}_{FE}^{-1} \boldsymbol{X}_{i(s)} \right)^{-1} \left(\sum_{s=2}^{S} \sum_{i \in I_s} \boldsymbol{X}_{i(s)}^{'} \boldsymbol{\Omega}_{FE}^{-1} \boldsymbol{y}_{i(s)} \right) \quad (2.15)$$

$$V\left(\hat{\boldsymbol{\beta}}_{FE}\right) = \left(\sum_{s=2}^{S} \sum_{i \in I_s} \boldsymbol{X}_{i(s)}^{'} \boldsymbol{\Omega}_{FE}^{-1} \boldsymbol{X}_{i(s)} \right)^{-1} \quad (2.16)$$

2.5 Statistical Tests

In our analysis we make the hypothesis that the estimated coefficients vary according with farm size as well as with the estimation method. As a result, it is necessary to examine if our hypotheses are valid by conducting some statistical tests. In order to examine the statistical significance of the differences in the estimated coefficients among the different types of farm size we used the dummy variable approach proposed by Guajarati (1970). According with this approach, suppose that we have a set of $N=N_1+N_2+N_3$ observations of the same variables and there is a source of difference between the observations of sub-samples N_1, N_2 and N_3. Then we run a regression by pooling the set of N observations and we use dummy variables in the coefficients that are affected by this source of difference. Consider, for example, the case that the source of difference affects the constant term and the slope coefficient, then we run a regression as follows:

$$y_{it} = a_1 + a_2 D_1 + a_3 D_2 + \beta_1 X_{it} + \beta_2 D_1 X_{it} + \beta_3 D_2 X_{it} + \varepsilon_{it} \quad (2.17)$$

where D_1=1, if the observation lies in the N_2 set of observations

D_1=0, otherwise

D_2=1, if the observation lies in the N_3 set of observations

D_2=0, otherwise

To test the hypothesis of no parameter change, we have to test the joint hypothesis that $H_0: a_2 = a_3 = \beta_2 = \beta_3 = 0$ against the alternative that at least one of the four hypotheses is not true. This test can be easily conducted by using the χ_J^2 where J is the number of coefficients to be tested.

Additionally, we have to test which is the appropriate specification of our model i.e. the pooled, the RE or the FE. In the beginning, we test the pooled against the one way FE model since the question of whether to pool the data or not naturally arises with panel data. In this case we have to test the hypothesis that constant terms are homogeneous or not (Hsiao, 1986 p. 16). The null and the alternative hypotheses are:

$$H_0: \alpha_1 = \alpha_2 = \text{..........} = \alpha_N$$
$$H_1: \alpha_1 \neq \alpha_2 \neq \text{..........} \neq \alpha_N$$

Under the null hypothesis the constant term is the same for all individuals and the pooled estimators are efficient. The null hypothesis represents a set of linear restrictions on coefficients so we can test the null by using the *F*-statistic written in terms of restricted and unrestricted model sum of squares. In our case, since we have a system of regression equations, we have to use the generalized F test statistic (Zellner 1962, Bun 2004). The F-statistic has the form:

$$F = \frac{(RRSS - URSS)/J}{URSS/(MNT-K)} \sim F_{(J,MNT-K)} \quad (2.18)$$

where *RRSS* = residual sum of squares of the pooled model

URSS= residual sum of squares of the FE model

J = number of linear restrictions equal with *M(N-1)*

M= number of equations

NT= number of observations

K= number of estimated coefficients

Finally, we examine if the appropriate panel model specification is the RE or the FE. The critical assumption in the RE model is that $\mathrm{E}\left(u_{it} / X_{it}\right) = 0$ i.e. there is no correlation between the included variables and the random effect. If there is correlation between the included variables and the random effect, that is $\mathrm{E}\left(u_{it} / X_{it}\right) \neq 0$, the RE estimators become biased and inconsistent (Baltagi, 2005). Hausman (1978) provides a test where we compare these estimators. Under the null hypothesis H_0: $\mathrm{E}\left(u_{it} / X_{it}\right) = 0$ both estimators are consistent and the RE estimator is efficient while under the alternative H_1: $\mathrm{E}\left(u_{it} / X_{it}\right) \neq 0$ the FE estimator is consistent but the RE estimator is not.

The test statistic is given by the expression:

$$h = g^{'} \Psi^{-1} g \quad (2.19)$$

where $g = \hat{\beta}_{FE} - \hat{\beta}_{RE}$ with $\hat{\beta}_{FE}, \hat{\beta}_{RE}$ being the vectors of estimated coefficients without the constant terms and $\Psi = V(\hat{\beta}_{FE}) - V(\hat{\beta}_{RE})$. Under the Ho the test statistic h is asymptotically distributed as χ^2_κ where κ is the dimension of vector $\hat{\beta}$.

2.6 Data

The data we use are from the FADN database, National Statistical Service of Greece and Eurostat during the period 1991-2002. From the entire sample of farms that are characterized as cotton producers, according with the FADN typology, we use the farms that produce only cotton as well as the farms that the proportion of cotton revenue to total revenue is equal or larger than 95%, so they are considered as pure cotton producers. According to standard FADN methodology, there are ten categories of farm size and our sample consists of farms that belong to first nine categories[4]. Details about the way that farms are grouping into nine categories are provided in Table 2.2 in the Appendix. However, due to limitations in the number of observations in each category, we grouped the farms into three size categories. Firstly, the farms that belong to the first three categories are considered as small sized. Secondly, the farms that belong to the next three categories are considered as medium sized and finally the farms of the three last categories as large sized. After this grouping, we obtain three samples of unbalanced panel data. The sample of small sized firms consists of 28 farms, the sample of medium sized farms involves 206 farms and finally the sample of large sized includes 282 agricultural enterprises[5]. The number of observations of each sample is 108, 752 and 986 for small, medium and large farms respectively. The descriptive statistics of the variables are provided in the following table:

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[4] Our sample does not contain farms that belong to the tenth category since there are no so large cotton producers in Greece.

[5] The initial number of farms in each sample was 75 small, 349 medium and 456 large. However, we eliminated the farms that appeared only once in each sample in order to apply the FE estimation method.

Table 2.3: Descriptive statistics of the variables

Variable	**Small Farms**		**Medium farms**		**Large farms**	
	Mean	*St. deviation*	*Mean*	*St. deviation*	*Mean*	*St. deviation*
Profits (€)	1920.1	1486.25	5928.92	4007.19	19812.46	11709.32
Cotton production (kilos)	7063.89	2134.91	17083.51	5810.44	45321.81	20874.37
Cotton price (€/kilo)	0.80	0.06	0.80	0.07	0.81	0.07
Labor (hours)	797.58	236.67	1283.70	579.57	2165.75	1030.54
Labor price (€/hour)	1.99	0.56	1.91	0.46	1.83	0.47
Energy quantity	558.07	385.59	1756.92	1205.87	5061.44	4385.02
Energy price (€)	0.46	0.15	0.46	0.15	0.46	0.15
Fertilizer quantity	1713.66	659.48	4205.70	1811.71	10591.38	5831.47
Fertilizer price (€)	0.18	0.03	0.18	0.03	0.18	0.03
Rest intermediate inputs (€)	1207.79	520.14	2584.96	1140.34	12990.48	6299.23
Rest intermediate inputs price (index)	185.51	30.51	185.51	30.51	185.51	30.51
Capital (€)	5870.54	5126.81	13496.46	9521.70	27764.78	18646.8
Land (ha)	2.5	0.72	5.68	1.61	15.28	6.37

Source: Own computations

Cotton farmers produce cotton using four variable inputs: labor, fertilizer, energy and rest intermediate inputs and two quasi fixed inputs: land and capital. Cotton quantity and revenue are available from FADN data so we obtain farm specific cotton prices by dividing revenue with quantity. As for the variable inputs, the FADN sample contains expenditures and quantity of labor, but only expenditures for fertilizer, energy and the rest intermediate inputs. Labor prices are farm specific and they are computed by dividing labor costs with their quantities. In case a farm hires no labor we use the mean wage and rent that prevail in the village that farm is located.

Prices for energy and fertilizer are provided by Eurostat and the price index for the rest intermediate inputs[6] is provided by the National Statistical Service of Greece. To obtain quantities of energy and fertilizer we divide the expenditures by the corresponding prices. The expenditures of the rest intermediate inputs are divided by their price index so as to obtain their quantity measure. The quantity of land is available from FADN data and the value of capital is deflated by the capital price index to obtain its quantity measure. Finally, we include a time trend to take into account the effect of technology change in the cotton production.

Additionally, the normalized quadratic profit function can be considered as a second-order Taylor series expansion around the point of approximation. This means that all variables should be normalized to one at that point. Therefore, we converted all variables into indices and the basis of normalization was the representative farm in the sample. The point of approximation is defined from the representative farm. The choice of the representative farm was based on the smallest deviation of all variables from the sample means.

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[6] This category includes all other intermediate inputs of production like water, pesticides etc.

For each sample of farms we estimate a system of four equations: cotton supply and the derived demands of fertilizer, energy and the rest intermediate inputs. Labor is the numeraire input. STATA 10 econometrics software is used for the estimations.

2.7 Estimation Results

In this section we present the estimated supply and derived demand functions, which are obtained by applying all estimation techniques, the results which are obtained by the statistical tests as well as the elasticities for small, medium and large sized farms. Initially, we pooled the data for all farms to test if the parameter estimates differ by size. Using the dummy variables approach, under the hypothesis that farm size affects both constant terms and slopes, we found that the differences in parameters are statistically significant. The χ^2_{52} statistic is equal to 965.73 at 5% level of significance with the corresponding critical value to be 69.83. Estimation results for small, medium and large sized farms are reported in Tables 2.4, 2.5 and 2.6 respectively.

Table 2.4: Estimated parameters of supply and demands, small sized farms

Variables	Cotton Supply			Fertilizer Demand			Energy Demand			Rest Intermediate Inputs Demand		
	Pooled	*RE*	*FE*	*Pooled*	*RE*	*FE*	*Pooled*	*RE*	*FE*	*Pooled*	*RE*	*FE*
Constant	0.298 (0.137)	0.174 (0.147)	-	0.512 (0.185)	0.574 (0.114)	-	1.424 (0.379)	1.064 (0.116)	-	1.257 (0.511)	2.655 (0.147)	-
Price of Cotton	0.823 (0.262)	2.105 (0.299)	0.874 (0.306)									
Price of Fertilizer	-0.184 (0.080)	-0.263 (0.070)	-0.416 (0.080)	-1.696 (0.134)	-1.869 (0.068)	-1.919 (0.071)						
Price of Energy	-0.053 (0.040)	-0.154 (0.043)	-0.168 (0.051)	0.208 (0.061)	0.266 (0.035)	0.243 (0.037)	-1.597 (0.126)	-1.591 (0.042)	-1.644 (0.046)			
Price of Rest Intermediate Inputs	-0.643 (0.319)	-2.147 (0.337)	-0.496 (0.328)	1.170 (0.209)	0.808 (0.076)	0.924 (0.081)	0.424 (0.164)	0.126 (0.040)	0.195 (0.042)	-2.773 (0.640)	-2.541 (0.405)	-1.264 (0.404)
Quantity of Capital	0.196 (0.085)	0.381 (0.088)	0.135 (0.107	-0.198 (0.123)	-0.092 (0.072)	-0.132 (0.076)	0.101 (0.215)	0.344 (0.066)	0.325 (0.072)	1.653 (0.342)	1.285 (0.089)	1.167 (0.093)
Quantity of Land	0.314 (0.065)	0.357 (0.074)	0.278 (0.099)	-0.161 (0.101)	-0.040 (0.061)	0.077 (0.059)	0.006 (0.203)	-0.013 (0.062)	0.065 (0.061)	-0.699 (0.259)	-0.565 (0.065)	-0.912 (0.060)
Time trend	0.307 (0.104)	0.575 (0.115)	0.322 (0.125)	-0.227 (0.134)	-0.031 (0.088)	0.119 (0.091)	1.075 (0.282)	0.852 (0.092)	1.044 (0.096)	-1.378 (0.370)	-0.461 (0.118)	-1.020 (0.105)

Source: Own computations

Note: Numbers in parenthesis are standard errors, significant at 0.05 level.

Table 2.5: Estimated parameters of supply and demands, medium sized farms

Variables	Cotton Supply			Fertilizer Demand			Energy Demand			Rest Intermediate Inputs Demand		
	Pooled	*RE*	*FE*	*Pooled*	*RE*	*FE*	*Pooled*	*RE*	*FE*	*Pooled*	*RE*	*FE*
Constant	0.220 (0.043)	0.207 (0.050)	-	0.142 (0.068)	0.192 (0.049)	-	0.549 (0.068)	0.490 (0.048)	-	0.181 (0.098)	0.233 (0.050)	-
Price of Cotton	0.275 (0.067)	0.242 (0.067)	0.258 (0.076)									
Price of Fertilizer	-0.212 (0.027)	-0.408 (0.029)	-0.440 (0.032)	-1.098 (0.045)	-1.248 (0.032)	-1.275 (0.033)						
Price of Energy	-0.007 (0.022)	-0.142 (0.024)	-0.194 (0.027)	0.270 (0.030)	0.240 (0.021)	0.216 (0.021)	-1.485 (0.041)	-1.663 (0.027)	-1.668 (0.029)			
Price of Rest Intermediate Inputs	-0.074 (0.078)	0.168 (0.073)	0.226 (0.080)	0.446 (0.051)	0.276 (0.032)	0.290 (0.033)	0.628 (0.043)	0.522 (0.024)	0.495 (0.026)	-1.298 (0.117)	-0.665 (0.092)	-0.572 (0.100)
Quantity of Capital	0.084 (0.015)	0.042 (0.017)	0.042 (0.020)	-0.043 (0.025)	-0.019 (0.015)	-0.029 (0.016)	-0.025 (0.024)	-0.043 (0.015)	-0.066 (0.016)	0.423 (0.036)	0.340 (0.016)	0.349 (0.017)
Quantity of Land	0.635 (0.034)	0.734 (0.038)	0.788 (0.046)	-0.410 (0.059)	-0.373 (0.034)	-0.385 (0.035)	-0.086 (0.058)	-0.125 (0.035)	-0.145 (0.038)	-0.893 (0.082)	-0.839 (0.035)	-0.789 (0.035)
Time trend	0.248 (0.030)	0.299 (0.036)	0.375 (0.048)	-0.315 (0.044)	-0.238 (0.032)	-0.199 (0.036)	0.181 (0.045)	0.237 (0.033)	0.175 (0.040)	-0.585 (0.037)	-0.558 (0.036)	-0.488 (0.039)

Source: Own computations

Note: Numbers in parenthesis are standard errors, significant at 0.05 level.

Table 2.6: Estimated parameters of supply and demands, large sized farms

Variables	Cotton Supply			Fertilizer Demand			Energy Demand			Rest Intermediate Inputs Demand		
	Pooled	*RE*	*FE*	*Pooled*	*RE*	*FE*	*Pooled*	*RE*	*FE*	*Pooled*	*RE*	*FE*
Constant	0.025	0.016	-	-0.264	-0.117	-	-0.215	0.056	-	-0.175	-0.091	-
	(0.040)	(0.038)		(0.064)	(0.038)		(0.150)	(0.036)		(0.061)	(0.038)	
Price of Cotton	0.145	0.244	0.330									
	(0.032)	(0.035)	(0.040)									
Price of Fertilizer	-0.071	-0.091	-0.128	-0.528	-0.584	-0.596						
	(0.014)	(0.016)	(0.018)	(0.022)	(0.016)	(0.016)						
Price of Energy	-0.071	-0.195	-0.217	0.171	0.256	0.227	-1.107	-1.357	-1.339			
	(0.010)	(0.009)	(0.010)	(0.016)	(0.008)	(0.008)	(0.041)	(0.010)	(0.011)			
Price of Rest Intermediate Inputs	-0.042	-0.121	-0.182	0.163	0.172	0.187	0.188	0.292	0.259	-0.502	-0.588	-0.632
	(0.038)	(0.039)	(0.043)	(0.022)	(0.018)	(0.019)	(0.016)	(0.009)	(0.009)	(0.052)	(0.050)	(0.055)
Quantity of Capital	0.124	0.132	0.107	-0.105	-0.102	-0.104	-0.125	-0.087	-0.022	0.080	0.076	0.088
	(0.009)	(0.008)	(0.010)	(0.015)	(0.008)	(0.008)	(0.036)	(0.008)	(0.009)	(0.014)	(0.008)	(0.009)
Quantity of Land	0.780	0.843	0.859	-0.815	-0.805	-0.798	-0.783	-0.605	-0.463	-0.880	-0.891	-0.874
	(0.026)	(0.023)	(0.027)	(0.044)	(0.021)	(0.021)	(0.109)	(0.022)	(0.024)	(0.040)	(0.023)	(0.024)
Time trend	0.167	0.267	0.257	-0.252	-0.205	-0.105	0.149	0.132	0.090	-0.315	-0.347	-0.327
	(0.021)	(0.022)	(0.038)	(0.033)	(0.021)	(0.026)	(0.078)	(0.020)	(0.029)	(0.032)	(0.022)	(0.028)

Source: Own computations

Note: Numbers in parenthesis are standard errors, significant at 0.05 level.

The absolute value of the estimated coefficients is fairly different when either comparing the coefficients of pooled with the corresponding RE and FE or the coefficients of RE with the FE. For example, the coefficient of cotton supply with respect to cotton price for large sized farms is equal to 0.145, 0.244 and 0.330 when we apply the pooled, RE and FE method respectively. The statistical significance of the estimated parameters is improved when we apply the panel data estimation methods. The standard errors of the RE coefficients are smaller than the standard errors of the pooled coefficients in 59 out of 78 cases. The result is similar when we compare the standard errors of the FE estimators with the corresponding of pooled estimators as they are smaller in 43 out of 66 cases. The obtained results make clear that when we take into account the panel specification of our data, the statistical significance of the estimated parameters is increased.

Additionally, we checked if the properties of the profit function are satisfied. According to the obtained results, the profit function is increasing in the price of output and decreasing in input prices. We also checked the eigenvalues and the determinants of the principal minors of Hessian matrix and we found that the only case that the convexity property is not satisfied is for small farms in the RE model[7]. These results are reported in the Table 2.7 in the Appendix.

Taking into consideration the above analysis about the estimated coefficients in all cases, it is clear that their values are affected by the estimation method. Therefore, the conclusions about cotton supply and input demands depend on the estimation method. In order to examine the appropriate specification of the model and as a result the appropriate estimation method we applied two statistical tests. Firstly, we test the pooled model against the FE model thus we computed the F-

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[7] This result may provide some indication that small farmers are not profit maximizers.

statistic for all samples. The values of F-statistic are reported in the Table 2.8 that follows:

Table 2.8: F test statistic for all samples

Sample	**F-statistic**	**F-critical value**
Small sized farms	2.52	1.27
Medium sized farms	5.72	1.09
Large sized farms	3.79	1.08

Source: Own calculations

In view of the above results it is clear that the null hypothesis about the common constant term for all farms is rejected in all cases. This means that the FE model is preferable than the pooled model so in the estimation procedure we have to take into account the "heterogeneity" of each cross-sectional unit.

Afterwards, the question that arises is which of two panel models is the most appropriate. In this case we have to test the FE model against the RE model using the Hausman test. We computed the *h*-statistic for all samples and we found that the appropriate specification of the model is the FE since the Ho hypothesis is strongly rejected. The values of *h*-statistic are presented in the Table 2.9 that follows.

Table 2.9: Hausman test statistic for all samples

Sample	***h*-statistic**
Small sized farms	337.1
Medium sized farms	376.4
Large sized farms	784.9

Source: Own calculations

Since h is distributed asymptotically as χ^2_{22} which has a critical value of 33.9 at 5% level of significance, it is evident that the random effects model is not appropriate.

In view of the above results we conclude that the right specification of the model is the FE and as a result the FE estimators are consistent. In terms of policy analysis, this implies that we have to use the elasticities based on FE estimators in case we want to make policy simulations.

We now turn the analysis to our estimated elasticities. The elasticities of supply and derived demands for each sample and all estimation methods are reported in Tables 2.10, 2.11 and 2.12 respectively.

Table 2.10: Elasticities of supply and demands, pooled estimation

Small sized farms					
	Cotton	**Fertilizer**	**Energy**	**Rest Intermediate Inputs**	**Labor**
Cotton	0.861	-0.243	-0.082	-0.611	0.076
	(0.274)	(0.106)	(0.062)	(0.304)	(0.104)
Fertilizer	0.149	-1.742	0.247	0.864	0.481
	(0.065)	(0.137)	(0.072)	(0.154)	(0.122)
Energy	0.033	0.161	-1.429	0.236	0.999
	(0.025)	(0.047)	(0.113)	(0.091)	(0.147)
Rest Intermediate Inputs	0.304	0.700	0.293	-1.192	-0.105
	(0.151)	(0.125)	(0.113)	(0.275)	(0.147)
Labor	0.028	0.081	0.642	0.235	-0.985
	(0.053)	(0.092)	(0.147)	(0.201)	(0.479)
Medium sized farms					
	Cotton	**Fertilizer**	**Energy**	**Rest Intermediate Inputs**	**Labor**
Cotton	0.272	-0.204	-0.006	-0.070	0.008
	(0.066)	(0.026)	(0.017)	(0.074)	(0.024)
Fertilizer	0.229	-1.157	0.227	0.464	0.237
	(0.030)	(0.047)	(0.025)	(0.053)	(0.045)
Energy	0.012	0.424	-1.861	0.972	0.454
	(0.036)	(0.047)	(0.051)	(0.067)	(0.065)
Rest Intermediate Inputs	0.060	0.354	0.397	-1.015	0.204
	(0.063)	(0.040)	(0.027)	(0.092)	(0.049)
Labor	0.007	0.065	0.178	0.057	-0.307
	(0.010)	(0.017)	(0.014)	(0.024)	(0.080)
Large sized farms					
	Cotton	**Fertilizer**	**Energy**	**Rest Intermediate Inputs**	**Labor**
Cotton	0.149	-0.071	-0.084	-0.044	0.050
	(0.033)	(0.015)	(0.012)	(0.039)	(0.015)
Fertilizer	0.074	-0.540	0.207	0.171	0.088
	(0.015)	(0.023)	(0.020)	(0.023)	(0.025)
Energy	0.053	0.125	-0.956	0.141	0.638
	(0.007)	(0.012)	(0.035)	(0.012)	(0.039)
Rest Intermediate Inputs	0.046	0.174	0.237	-0.550	0.094
	(0.041)	(0.024)	(0.020)	(0.056)	(0.024)
Labor	0.036	0.113	0.737	0.103	-0.989
	(0.013)	(0.021)	(0.052)	(0.020)	(0.074)

Source: Own computations

Note: Elasticities are computed at the sample mean values, numbers in parenthesis are standard errors.

Table 2.11: Elasticities of supply and demands, RE estimation

Small sized farms					
	Cotton	**Fertilizer**	**Energy**	**Rest Intermediate Inputs**	**Labor**
Cotton	2.202 (0.313)	-0.348 (0.093)	-0.235 (0.066)	-2.043 (0.320)	0.424 (0.109)
Fertilizer	0.213 (0.057)	-1.920 (0.070)	0.316 (0.042)	0.597 (0.056)	0.794 (0.073)
Energy	0.094 (0.026)	0.206 (0.027)	-1.423 (0.037)	0.070 (0.022)	1.052 (0.048)
Rest Intermediate Inputs	1.015 (0.159)	0.483 (0.045)	0.087 (0.028)	-1.092 (0.174)	-0.493 (0.046)
Labor	0.221 (0.054)	0.324 (0.049)	0.736 (0.047)	-0.237 (0.047)	-1.043 (0.148)
Medium sized farms					
	Cotton	**Fertilizer**	**Energy**	**Rest Intermediate Inputs**	**Labor**
Cotton	0.239 (0.066)	-0.393 (0.028)	-0.109 (0.018)	0.160 (0.069)	0.104 (0.028)
Fertilizer	0.441 (0.032)	-1.314 (0.034)	0.202 (0.017)	0.287 (0.033)	0.385 (0.028)
Energy	0.229 (0.038)	0.377 (0.032)	-2.084 (0.034)	0.809 (0.038)	0.670 (0.040)
Rest Intermediate Inputs	-0.137 (0.059)	0.219 (0.025)	0.330 (0.015)	-0.520 (0.072)	0.107 (0.022)
Labor	0.055 (0.012)	0.124 (0.011)	0.233 (0.008)	0.013 (0.011)	-0.426 (0.039)
Large sized farms					
	Cotton	**Fertilizer**	**Energy**	**Rest Intermediate Inputs**	**Labor**
Cotton	0.251 (0.036)	-0.091 (0.016)	-0.232 (0.011)	-0.125 (0.040)	0.198 (0.014)
Fertilizer	0.095 (0.017)	-0.598 (0.016)	0.310 (0.009)	0.181 (0.019)	0.012 (0.013)
Energy	0.145 (0.007)	0.187 (0.006)	-1.172 (0.008)	0.219 (0.006)	0.621 (0.009)
Rest Intermediate Inputs	0.132 (0.042)	0.183 (0.019)	0.368 (0.011)	-0.644 (0.055)	-0.039 (0.014)
Labor	0.152 (0.012)	0.060 (0.011)	0.668 (0.013)	0.003 (0.012)	-0.884 (0.025)

Source: Own computations

Note: Elasticities are computed at the sample mean values, numbers in parenthesis are standard errors.

Table 2.12: Elasticities of supply and demands, FE estimation

Small sized farms					
	Cotton	**Fertilizer**	**Energy**	**Rest Intermediate Inputs**	**Labor**
Cotton	0.914 (0.320)	-0.550 (0.106)	-0.257 (0.077)	-0.472 (0.312)	0.365 (0.143)
Fertilizer	0.337 (0.065)	-1.971 (0.073)	0.288 (0.044)	0.682 (0.060)	0.663 (0.076)
Energy	0.103 (0.031)	0.188 (0.029)	-1.470 (0.041)	0.109 (0.023)	1.071 (0.056)
Rest Intermediate Inputs	0.234 (0.155)	0.553 (0.048)	0.135 (0.029)	-0.543 (0.174)	-0.379 (0.049)
Labor	0.099 (0.071)	0.205 (0.051)	0.730 (0.054)	-0.154 (0.049)	-0.880 (0.170)
Medium sized farms					
	Cotton	**Fertilizer**	**Energy**	**Rest Intermediate Inputs**	**Labor**
Cotton	0.255 (0.075)	-0.424 (0.031)	-0.143 (0.021)	0.215 (0.076)	0.103 (0.033)
Fertilizer	0.475 (0.034)	-1.343 (0.035)	0.182 (0.018)	0.301 (0.034)	0.385 (0.028)
Energy	0.312 (0.043)	0.339 (0.033)	-2.091 (0.036)	0.766 (0.040)	0.674 (0.042)
Rest Intermediate Inputs	-0.184 (0.065)	0.229 (0.026)	0.313 (0.016)	-0.447 (0.078)	0.089 (0.023)
Labor	0.059 (0.014)	0.127 (0.011)	0.235 (0.009)	0.005 (0.012)	-0.426 (0.041)
Large sized farms					
	Cotton	**Fertilizer**	**Energy**	**Rest Intermediate Inputs**	**Labor**
Cotton	0.339 (0.041)	-0.129 (0.018)	-0.259 (0.012)	-0.189 (0.045)	0.237 (0.018)
Fertilizer	0.133 (0.018)	-0.609 (0.017)	0.275 (0.010)	0.196 (0.020)	0.005 (0.013)
Energy	0.162 (0.008)	0.166 (0.006)	-1.156 (0.009)	0.195 (0.007)	0.634 (0.011)
Rest Intermediate Inputs	0.198 (0.047)	0.199 (0.020)	0.327 (0.011)	-0.693 (0.061)	-0.031 (0.015)
Labor	0.185 (0.016)	0.050 (0.011)	0.690 (0.014)	0.004 (0.013)	-0.929 (0.029)

Source: Own computations

Note: Elasticities are computed at the sample mean values, numbers in parenthesis are standard errors.

All own price elasticities have the correct sign, i.e. cotton supply elasticity is positive and input demand elasticities are negative. However, there is a strong variability in the value of the estimated elasticities which depending on the farm size and the estimation method.

Our results indicate that the elasticity of cotton supply with respect to cotton price is larger in value for small farms than for medium and large sized farms. In the case of pooled estimation, the elasticity of cotton supply with respect to cotton price decreases as farm size increases. The calculated cotton supply elasticities for small, medium and large sized farms are 0.861, 0.272 and 0.149 respectively. In the RE and FE models this elasticity is also larger in value for small farms than for medium and large farms, however it is not smaller for large farms relatively to the medium farms. For example, in the RE model the elasticity of the cotton supply with respect to cotton price is equal to 2.202, 0.239 and 0.251 for small, medium and large farms respectively. In the FE model the corresponding values are 0.914, 0.255 and 0.339. Previous studies for Greece (Katranidis & Velentzas 2000, Lianos & Rizopoulos 1988, Zanias 1981) estimated that the elasticity of cotton supply with respect to cotton price varies from 0.41 to 0.70.

The above results are in accordance with the past literature which found an inverse relation between the farm size and the elasticity of supply with respect to price. Mills & Schumann (1985) find that there is an inverse relation between the degree of output variation and capital intensity of a firm, so small firms have the ability to vary production more intensely than large firms. Following this result, short-run supply elasticities are lower for larger farms.

Own price elasticities for inputs are different in three samples and different estimation methods. Specifically, the elasticity of fertilizer with respect to its price range from -0.540 to -1.971, the corresponding elasticity for energy range from -0.956 to -2.091 and the elasticity of rest intermediate inputs with respect to its price varies from -0.447 to -1.192. Additionally, in some cases the demand changes from elastic to inelastic and vice-versa. This change is attributed to the different estimation method. For example, the demand for rest intermediate inputs in medium sized farms is elastic when we apply the pooled estimation method and inelastic in case of RE and FE estimation. This practically means that the adoption of the right estimation method is crucial in order to arrive at a right conclusion about the magnitude of the elasticities.

All in all, considering the aforementioned discussion as well as the results of specifications tests we conclude that the right specification of the model and the data is the FE and as a result the FE estimators are consistent. Consequently, the elasticities based on FE estimators are the accurate policy variables in case we want to make policy simulations.

2.8 Concluding Remarks

In this chapter we have attempted to evaluate the results of three different estimation methods when they are applied in a system of equations and the dataset is an unbalanced panel. These methods are applied in three datasets named small, medium and large sized farms since we also wanted to examine the relation between the own price elasticity of supply and the farm size.

According to the results, the adoption of different estimation techniques leads to quite different results in terms of the absolute value of the estimated parameters as well as in terms of their statistical significance. The absolute value of the estimated parameters is fairly different when either comparing the coefficients of pooled with the corresponding FE and RE or the coefficients of FE with the RE. In view of the fact that the estimated parameters are affected by the estimation method, it was necessary to examine the appropriate specification of our model and as a result the appropriate estimation method. We test the pooled against FE model and we found that the FE model is preferable i.e. in the estimation procedure we have to applied panel data estimation methods. Afterwards, we test the FE against the RE model and we found that the FE estimators are consistent. Therefore, we conclude that the classical regression model with a single constant term is inappropriate for the model and the data since among all estimators, the FE estimators are consistent.

As for the elasticity of cotton with respect to its own price, we found that it varies according to the farm size. The elasticity of cotton supply with respect to cotton price is larger in value for small farms in all cases. In the case that we apply the pooled estimation method, it becomes apparent that as the farm size increases the elasticity of cotton supply decreases. In the FE and RE models the elasticity of cotton supply is larger for small farms than for medium and large farms, however it is not smaller for large farms relatively to the medium farms. As we mentioned earlier, the consistent estimators are the FE, so we come to the conclusion that the elasticity of cotton supply with respect to cotton price is not smaller for large farms relatively to the medium farms. According to this result, it is evident that it is important to apply the appropriate estimation method in order to come to the right conclusions about the key policy parameters.

All in all, the estimation method matters to come to the right conclusions about the estimated coefficients and the estimated elasticities based on them. Moreover, the elasticity of cotton supply with respect to cotton price is larger for small farms relative to their larger ‘counterparts’. In terms of policy this practically means that small farmers will be expected to produce more when, for example, the applied policy tends to increase product price.

Appendix

Each farm in the FADN sample has its own size which is determined by the Standard Gross Margin (SGM) of the output that produces. The SGM is defined as: SGM = value of output from one hectare or animal – cost of variable inputs required producing that output. The SGM is expressed in terms of European Size Units (ESU) which value is expressed as fixed number of euro. One ESU corresponds to 1200 euros. The economic size classes in terms of ESU are presented in the following table:

Table 2.2: Size class per category

Category	Size Classes
1	<2 ESU
2	2-<4 ESU
3	4-<6 ESU
4	6-<8 ESU
5	8-<12 ESU
6	12-<16 ESU
7	16-<40 ESU
8	40-<100 ESU
9	100 -<250 ESU
10	>=250 ESU

Source: European Commission

Table 2.7: Principal minors and eigenvalues of the Hessian determinants

Small sized farms								
	H_1	**H_2**	**H_3**	**H_4**	**eigenvalues**			
Pooled	0.823	1.312	2.130	2.055	3.626	1.780	1.222	0.261
RE	2.105	3.325	5.934	-2.452	4.552	2.137	4.576	-0.160
FE	0.874	1.409	2.334	0.080	2.582	1.717	1.390	0.013
Medium sized farms								
	H_1	**H_2**	**H_3**	**H_4**	**eigenvalues**			
Pooled	0.275	0.409	0.362	0.208	2.037	1.478	0.506	0.137
RE	0.242	0.382	0.157	0.063	1.917	1.510	0.322	0.067
FE	0.258	0.393	0.129	0.039	1.902	1.559	0.263	0.050
Large sized farms								
	H_1	**H_2**	**H_3**	**H_4**	**eigenvalues**			
Pooled	0.145	0.155	0.071	0.024	1.186	0.679	0.325	0.091
RE	0.244	0.293	0.135	0.024	1.510	0.759	0.459	0.045
FE	0.330	0.395	0.184	0.026	1.472	0.807	0.581	0.037

Source: Own computations

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Chapter 3 Are CAP Decoupling Policies Really Production Neutral?

3.1 Introduction

The Common Agricultural Policy (CAP) has been reformed three times over the last fifteen years (McSharry Reform in 1992, AGENDA 2000 in 1999 and Mid Term Review (MTR) in 2003). Concerted efforts to reform the CAP, in turn, have shared a common purpose: to shift support from production and prices to direct income support measures. In particular, under the MTR all compensatory payments given in the context of the first two reform packages were replaced by a Single Farm Payment (SFP) based on historical payments while being entirely decoupled from the kind and/or the level of production (OECD, 2004).

The European Commission aspiring to serve a variety of objectives has reached the decision to adopt the SFP on a significant number of farm products as a means of supporting agricultural income. First and foremost, the MTR regime will help European Union's negotiations in WTO, since SFP is consistent with the 'green box' criteria, mainly because it does not distort production and trade. In addition, it allows European authorities to manage the EU budget more effectively, making expenditure on agricultural support more transparent. Furthermore, fully decoupled policies are friendlier to the environment not only because SFP is directly linked to environmental standards but also because the resulting agricultural prices decreases facilitate a less intensive use of non-renewable resources (OECD, 2004).

According to the concept of SFP, production decisions depend only on market prices. Given that market prices will tend to approximate the actual, nowadays lower, world prices, production is expected to decline. However, this rather straightforward outcome is going to be the case only in a static and certain world. In case that decoupled policies applied, producer prices are determined in the international markets and as a result price uncertainty increases. In the presence of price uncertainty, nevertheless, which, in the absence of intervention mechanisms is expected to grow more intense, the reality may be substantially different.

In fact it is questionable whether SFP is going to be production neutral, namely to leave production decisions unaffected, in a potential uprise of uncertainty and risk. It is thus worth considering the effects of increasing producers' wealth, assuming first that producers are risk averse, and how such rising wealth may in turn increase production by decreasing the relevant farmers' risk attitude. The 'wealth effect', first introduced by Hennessy (1998) is expected to reverse a potential decline in production expected in the face of lower farm prices.

One the other hand, the degree of risk aversion may differ substantially among farmers. In particular, a link there may well be between farm size and risk aversion levels. Risk aversion in fact may be inversely related to the level of wealth, - that is farms with lower income and wealth, are expected to be more risk averse than large farms, with substantially greater resources. Decoupled payments will, in turn, increase farmers' wealth and will subsequently lead to lower levels in risk aversion. The drop in risk aversion is expectedly going to be greater for small farms in relation to what will happen in their "larger" counterparts. In this context, the wealth effect is going to be more intensive for less wealthy farmers.

The objective of this chapter is to evaluate the effect of decoupling policies on Greek cotton production. We have chosen cotton, not only because of its great importance for Greek agriculture, but mainly because, a mix of partial and fully decoupled measures has been adopted after 2005. According to the initial European Commission's regulation, under the MTR regime, 65% of the total amount of subsidies producers' received throughout 2000-2002 (the reference period), would be paid to producers as a fixed payment independent of the level of production. The rest 35% of the total amount of subsidies would be transferred to producers as an area payment (European Commission, 2007). However, in June 2008 European Commission changed the first regulation for cotton sector. In line with the second regulation, 65% of the total amount of subsidies remains the same (i.e. as it was in the initial regulation) but the rest 35% is subject to national base areas, fixed yields and reference amounts. The national base area for Greece is 250.000 ha, fixed yields are 3.2 tonnes/ha and the reference amount per hectare is 251.75€ (European Commission, 2008). This regulation applies from 1st January 2009.

Moreover, it should be pointed out that the total budget available for the area payment is fixed, meaning that if the total cultivated land increases, then the amount of the area payment per unit of land will decrease. On this ground, the area payment relates to fluctuations in world prices since the level of production and as a result cultivated land depend on them.

The above policy mix renders the evaluation as well as the comparison of the effects of various alternative policies on cotton production a significant research objective. In this context, we decided to examine and comparatively review the effects on production of a) the ‘‘Old’’ CAP regime (the policy practiced until 2005), b) the new MTR regime, a combination of partially and fully decoupled measures, c) a full decoupling system which probably could be applied in the next years and d) a free trade scenario, which could also be adopted especially in the period after 2013.

The rest of the chapter is organized as follows. The following section presents an extended literature review on partial and full decoupling practices research that has been implemented in Europe or elsewhere. In section three, we outline the theoretical framework first and then delineate its empirical specification. In the ensuing fourth part we present the estimation and simulation results as well as a rounded discussion of the main results obtained by the statistical analysis. Finally, in the fifth section we put forward the main conclusions of our study.

3.2 Literature Review

Decoupling policies in the farm sector have been thoroughly examined by a significant number of researchers in Europe and elsewhere, especially in the US, over the last 15 years. Although these studies have followed different theoretical approaches and examined different products in several countries and under partly different decoupling regimes they have come to a common conclusion: All different kinds of decoupling policies affect farmers ’production decision.

Although this is an expected result for partly decoupled measures, it is of special interest in the case of fully decoupled policies, since it contradicts their main property, namely their neutrality towards realized production. In the remainder of this section we put forward a short presentation of the main studies on this topic.

Moro and Sckokai (1999) simulated the effects of AGENDA 2000 reform on arable crop farmers in Italy using a profit function approach. They found that this policy package had affected crop production mainly through the mechanism of land allocation. On the basis of their findings, producers were expected to increase the land allocated in wheat production. The increased supply of wheat in turn, had been estimated to affect negatively oilseeds production.

In another paper, Gullstrand (2003), adapting the methodology of Moro and Sckokai (1999), analyzed the effects of AGENDA 2000 on Swedish crop production. In his analysis it was evident that crop production has been affected by changes in the land allocated to various crops among Swedish farmers. In line with the above-mentioned study, Gullstrand (2003) showed that Swedish crop producers have decreased oilseeds production in favor of wheat. Once again, the obtained results have not substantiated this policy's neutrality towards level and output mix.

In a partly different paper, Gohin and Guyomard (2000) analyzed the compensatory payments and set-aside requirements of AGENDA 2000 reform from a different point of view. They launched a comparison between this policy mix and the 'green box' criteria, using data for cereals, oilseeds and protein crops production in France during 1973-1997. Their findings suggest that, even if AGENDA 2000 reform had been more decoupled than McSharry reform, it would not have satisfied many of the 'green-box' criteria, since it would have led to production and trade distortions.

If we turn now to studies focusing into the analysis of full decoupled policies, we see that the bulk of them has been done for the USA and has been almost exclusively oriented towards the analysis of the effects of the Federal Agricultural Improvement and Reform Act (FAIR Act) implemented after 1996. Under the FAIR Act, market price support measures and deficiency payments had been replaced with a fixed payment based on historical data (Andersson, 2004).

There are many studies dealing with the analysis of the direct and indirect effects of the FAIR Act on American Agriculture. In the next lines, we summarize some of the most representative pieces of research on the subject. To begin with, Key *et. al.* (2005) have examined ex-post the direct effects of decoupled payments on farm level production, cultivated land and total sales. Using farm level data they have estimated the effects of participation in the government program on production, cultivated land and total sales and compared those effects with the corresponding of non-participants farmers. On the basis of their findings it became evident that, participants produce 38% more, cultivate 15.8% more land and their sales value is 22.5% greater than that of non-participants farmers. Their results did not lend support to the production neutrality of decoupled payments.

We consider now the indirect effects of the decoupled payments. A fully decoupled policy becomes coupled in the presence of uncertainty and risk. The first study that analyzed the results of a decoupled policy taking into consideration uncertainty and risk was conducted by Hennessy (1998). He suggested a framework where, under the assumption that producers are risk averse, the decoupled payments affect production through two effects: the wealth effect and the insurance effect. The first effect arises when a policy measure affects producers' total wealth: if wealth increases producers become less risk averse and as a consequence they produce more because of price uncertainty. The second effect takes place through the stabilization of farm income, when government increases payments to compensate producers for price reductions. Additionally, Hennessy checked the validation of the proposed model with a simulation analysis using data for corn production in Iowa. The results obtained confirm the existence of both effects.

More recently, Goodwin and Mishra (2006) made an ex-post analysis of fixed payments effects on corn, soybeans and wheat cultivated land under uncertainty. In their analysis decoupled payments have three discernible effects on cultivated land: the first is the direct effect, the second one is the effect on financial leverage and the third is the wealth effect. Their study showed that decoupled payments influence farmers' decision on land allocation since the elasticity of land with respect to payment was found to be positive. As for indirect effects, they were found to be positive but smaller than direct ones.

Similarly, Serra *et.al.* (2005) examined the ex-post effect of the lump-sum payments on agricultural output in Kansas under price uncertainty. They estimated production function alongside utility maximization conditions and having found that the elasticity of production with respect to lump-sum payments was positive, they came to the conclusion that the fully decoupled payments were not really decoupled from farm output.

As for the evaluation of the MTR of CAP very few studies exist. Breen *et. al.* (2005) have analyzed the effects of the MTR regime on dairy, cattle and tillage farmers in Ireland. Their study consists of two parts. In the first part they adopted a profit maximization Linear Programming approach assuming that farmers consider SFP as fully decoupled from production. The analysis showed that under the MTR regime 10% of cattle farmers, 30% of dairy farmers and 6% of tillage farmers would quit production. In the second part, they presented the results from a questionnaire asking producers about their production behavior under the MTR regime. The survey indicated that the majority of farmers in three sectors would follow the same pattern of production. However, it should be pointed out that only 2-3% of the farmers interviewed were familiar with the new policy regime.

Last but not least, in a very interesting paper, Sckokai and Moro (2006) have simulated the effects of AGENDA 2000 and MTR regime on cultivated land of arable crops in Italy under price uncertainty. Using FADN farm level data, they found that the corn and oilseeds acreage would increase, but the area of durum wheat and other cereals would not. Yet, the most interesting finding was that decoupled payments were not production neutral, since the positive wealth and insurance effects would compensate the negative price effect in all cases. Additionally, according to their estimated coefficients of relative risk aversion, as farm size increased the degree of risk aversion decreased, which means wealthier farms were less risk averse.

3.3 Theoretical Framework

In this section we present the model which specifies farmer's risk preferences (Coyle (1999). We assume non-linear mean variance risk preferences which mean that absolute risk aversion is non-constant (Coyle (1999), Sckokai and Moro (2006)). Producers' risk preferences are specified through a mean-variance utility function:

$$U = U(\bar{W}, \sigma_w^2) \quad (3.1)$$

where $\bar{W}$ and σ_w^2 are the mean and variance of final wealth which are uncertain due to price uncertainty that producers face. The certainty equivalent of this type of utility function is

$$U = \bar{W} - \frac{a(\bar{W}, \sigma_w^2)\sigma_w^2}{2} \quad (3.2)$$

where $\bar{W} = W_0 + \bar{\pi}$, expected wealth

$W_0 =$ initial wealth, non-random

$\bar{\pi} =$ market profit, random due to price uncertainty

$\sigma_{\mathrm{w}}^2 =$ wealth variance

$a = -\dfrac{\partial U''(\bar{W})}{\partial U'(\bar{W})}$, Arrow-Pratt measure of absolute risk aversion

Additionally, in line with other studies (Coyle (1999), Sckokai and Moro (2006)), we assume that preferences are specified as Constant Relative Risk Aversion (CRRA) type: that is, the coefficient of absolute risk aversion α depends on the level of wealth and can be specified as follows:

$$a = \frac{a_c}{\bar{W}} \quad (3.3)$$

From the above specification it is clear that as wealth increases the degree of risk aversion decreases. According to the foregoing analysis producers will maximize the expected utility function of the form:

$$U(p^e, w, V_p, z, W_0) = W_0 + p^e y - wx - \frac{a_c}{2(W_0 + p^e y - wx)} y^2 V_p \quad (3.4)$$

where W_0 is initial wealth, y is output quantity, p^e corresponds to expected output price, w and x are prices and quantities of variable inputs respectively, z corresponds to fixed inputs and V_p is the variance of expected output price.

The expected utility function carries the following properties:

a) It is increasing in output price and initial wealth and decreasing in input prices and variance of expected output price.

b) Under CRRA preferences, it is homogeneous of degree one in expected output price, input prices, initial wealth and variance of expected output price.

c) It is continuous and differentiable so we obtain the supply and derived demands as follows (Coyle (1999):

$$y(p^e, w, V_p, z, W_0) = \frac{\partial U / \partial p^e}{\partial U / \partial W_0}$$

$$x_i(p^e, w, V_p, z, W_0) = -\frac{\partial U / \partial w}{\partial U / \partial W_0}$$

$$\partial U / \partial W_0 = 1 + \frac{a_c}{2(\bar{W})^2} y^2 V_P$$

d) Under DARA preferences is quasiconvex in (p^e, w, W_0).

e) The standard symmetry and reciprocity conditions hold.

In order to estimate the coefficients of the supply and derived demand functions we use the normalized quadratic form of the indirect utility which takes the form:

$$\bar{U} = a_0 + \sum_{i=1}^{m-1} a_i \bar{r}_i + \frac{1}{2} \sum_{i=1}^{m-1} \sum_{j=1}^{m-1} a_{ij} \bar{r}_i \bar{r}_j \quad (3.5)$$

where $\bar{U} = U / w_m$ and $\bar{r} = (p^e / w_m, w / w_m, V_p / w_m^2, W_0 / w_m, z)$

Applying the derivative property in equation (3.5) supply and derived demand functions are specified as follows:

$$y = (\alpha_i + \sum_j \alpha_{ij} \bar{r}_j) / (\alpha_i + \sum_j \alpha_{ij} \bar{r}_j) \qquad (3.6)$$

$$x_i = -(\alpha_i + \sum_j \alpha_{ij} \bar{r}_j) / (\alpha_i + \sum_j \alpha_{ij} \bar{r}_j) \quad (3.7)$$

where α_i, α_{ij} are the coefficients to be estimated. The numerator of the equation (3.6) corresponds to the derivative of the normalized quadratic utility function with respect to output price and the denominator to the derivative of the normalized quadratic utility function with respect to initial wealth. In the same way, the numerator and the denominator of equation (3.7) correspond to the derivative of the normalized quadratic utility function with respect to input price and initial wealth respectively.

We model price expectations using the hypothesis that each period producers expect that the price will be equal to the price that they received the previous period that is[8]:

$$E_t(P_t) = P_{t-1} \quad (3.8)$$

As for the computation of expected output price variance, we used the formula that first proposed by Chavas and Holt (1990). According to their formula, variance of expected output price is equal to the weighted sum of squared differences between actual prices and their expected values:

$$Var(P_{i,t}) = \sum_{j=1}^{2} \omega_j \left[P_{i,t-j} - E_{t-j-1}(P_{i,t-j}) \right]^2 \quad (3.9)$$

where weights ω_j are equal to 0.50 and 0.33 respectively[9].

Additionally, since we want to measure the risk attitude of farmers according to their farm size we computed the coefficient of relative risk aversion as follows:

$$a = \frac{a_1 d_1 + a_2 d_2}{\bar{W}} \quad (3.10)$$

where d_1 and d_2 are dummy variables that distinguish two types of farm size: small-medium sized farms which own land smaller or equal to 5 hectares and large sized farms which own land more than 5 hectares.

The data we use are from FADN database and the National Statistical Service of Greece. The data are in a farm level during the period 1994-2002 and our dataset consists of 1342 observations which correspond to 438 farms. The variables are prices and quantities of cotton production and three variable inputs: land, labor and intermediate inputs. In this chapter land is treated as variable input since, as we

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[8] We assume that cotton producers do not adjust their expectations according with the rational expectations model.

[9] In Chavas and Holt (1990) study variance has three years time horizon but given that the weight in third year is small i.e. equal to 0.17 and because we did not want to lose observations we constructed the variance with two years time horizon.

noted in the introductory comments, under the MTR of CAP 35% of subsidies is given to farmers as an area payment. This way, we believe that farmers have an incentive to vary cultivated land so as to receive extra income through subsidies.

Cotton prices are farm specific and we compute them by dividing cotton revenue with cotton production. Land and labor prices are farm specific and they are computed by dividing land and labor costs with their quantities. In case a farm rents no land and hires no labor we use the mean wage and rent that prevail in the village that farm is located. Intermediate inputs prices are national price indices since FADN data does not contain firm specific input prices. The expenditures of the intermediate inputs are divided by their price index so as to obtain their quantity measure.

Initial wealth has been computed as the difference between total assets value and total debts value. Total wealth corresponds to the sum of initial wealth and expected revenue minus the variable cost. The value of capital is deflated by the capital price index to obtain its quantity measure. The quantity of capital is considered as a quasi-fixed input of production and we also include a time trend that captures the effects of technology on cotton production. Summary statistics of the variables are provided in Table 3.1 in the Appendix.

Additionally, the normalized quadratic profit function can be considered as a second-order Taylor series expansion around the point of approximation. This means that all variables should be normalized to one at that point. Therefore, we converted all variables into indices and the basis of normalization was the representative farm in the sample. The point of approximation is defined from the representative farm. The choice of the representative farm was based on the smallest deviation of all variables from the sample means.

We estimated a system of three equations: cotton supply, intermediate inputs derived demand and land derived demand applying the Iterative Nonlinear SURE method in STATA 10 econometric software. To the best of our knowledge, there is no estimation method which supports panel data estimation in the case of nonlinear SURE equations. Therefore, pooled estimation method is used in this chapter. We imposed homogeneity condition using wage as a numeraire and we also imposed the symmetry restriction. However, because of high nonlinearity in parameters of equations (3.6) and (3.7) convergence was not achieved so following Coyle's (1999) suggestion, we divided all equations with the common denominator:

$$\partial U / \partial W_0 = 1 + \frac{a_1 d_1 + a_2 d_2}{2(\bar{W})^2} y^2 V_P \quad (3.11)$$

At this point, we have to mention that elasticities provided in the next section are calculated using the following formulas:

$$\varepsilon_{output} = \frac{\partial y}{\partial p}\frac{p}{y} = \frac{b_i}{1 + \frac{a_1 d_1 + a_2 d_2}{2(\bar{W})^2} y^2 V_P}\frac{p}{y} \quad (3.12)$$

$$\varepsilon_{input} = \frac{\partial x_i}{\partial p_i}\frac{p_i}{x_i} = \frac{b_i}{1 + \frac{a_1 d_1 + a_2 d_2}{2(\bar{W})^2} y^2 V_P}\frac{p_i}{x_i} \quad (3.13)$$

3.4 Estimation and Simulation Results

In this section we present the estimated supply and derived demand functions as well as the simulation results based on them for the evaluation of four alternative cotton policy regimes. As we noted in the introductory comments these regimes refer to: the 'Old' CAP regime that had been in action till 2005, the new MTR regime consisting of a combination of partial and fully decoupled measures, another fully decoupled system seen as an alternative to the MTR regime in the coming years and finally, a completely free trade-no policy scenario, mainly used as a reference system.

Table 3.2 presents the obtained estimation results. It appears that in their vast majority the estimated coefficients are statistically significant, while the own price coefficients have the correct sign. Additionally, quasiconvexity property is satisfied at the point of approximation since the determinants of the principal minors of the Hessian are -1.2212, -0.49217, -0.07039 and -0.145207. Turning to the cotton supply estimated parameters, which are of special interest, we establish that the cotton price coefficient is positive and significant. Input prices coefficients are negative as expected. Moreover, the reported results substantiate the existence of both a positive relationship between initial wealth and cotton supply and a negative relationship between cotton price variance and cotton supply. Finally, the coefficients of constant relative risk aversion confirm the hypothesis of risk averse behavior. The corresponding coefficient for small-medium sized farms, however, is larger and statistically significant while being very close to zero and statistically insignificant for large sized farms (that is, equally, zero)[10]. Such findings confirm that large sized farms are not risk averse. Such findings confirm that wealthier farmers are less risk averse and are in line with results obtained in earlier studies (Sckokai and Moro, 2006).

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[10] These coefficients are in line with those of other studies. The coefficient of relative risk aversion in agriculture varies from 0 to over 7.5 (Chavas and Holt, 1996).

Table 3.2: Estimated parameters of supply and derived demands

Variables	**Cotton Supply**	**Land Derived Demand**	**Intermediate Inputs Derived Demand**
Constant	0.960 (26.54)	0.569 (-25.12)	0.697 (-20.21)
Price of Cotton	0.223 (4.79)	0.069 (-5.36)	0.310 (-7.25)
Price of Land	-0.069 (-5.36)	-0.228 (21.89)	0.097 (-7.48)
Price of Intermediate Inputs	-0.310 (-7.25)	0.097 (-7.48)	-0.429 (10.12)
Cotton Price Variance	-0.0012 (-1.50)	0.001 (-2.03)	0.001 (-1.14)
Initial Wealth	0.203 (10.76)	-0.128 (10.68)	-0.089 (4.91)
Quantity of Capital	0.019 (5.47)	0.017 (-7.61)	0.038 (-11.25)
Time trend	0.081 (3.75)	-0.002 (0.14)	0.017 (0.81)
Risk Aversion Coefficient Small-Medium Farms	2.875 (9.68)	2.875 (9.68)	2.875 (9.68)
Risk Aversion Coefficient Large Farms	0.00000737 (0.18)	0.00000737 (0.18)	0.00000737 (0.18)
R^2	0.88	0.84	0.76

Source: Own computations

Note: Numbers in parenthesis are z-values, significant at 0.05 level

In Table 3.3 the elasticities of cotton supply and derived demands in relation to cotton price, initial wealth, cotton price variance and input prices are presented. All computed elasticities are consistent with economic theory, since they exhibit the correct sign. Additionally, it is evident they are much different from the elasticities presented in the previous chapter because of the different formula used to calculate them.

Table 3.3: Elasticities of supply and demands

	Cotton	Land	Intermediate Inputs	Wage	Initial Wealth	Cotton Price Variance
Cotton	0.045	-0.008	-0.068	-0.093	0.030	-0.0003
	(0.010)	(0.002)	(0.011)	(0.024)	(0.004)	(0.0002)
Land	0.028	-0.053	0.043	-0.142	-0.038	0.0006
	(0.006)	(0.005)	(0.007)	(0.015)	(0.005)	(0.0003)
Intermediate Inputs	0.099	0.018	-0.148	-0.066	-0.021	0.0004
	(0.016)	(0.003)	(0.019)	(0.021)	(0.005)	(0.0003)

Source: Own computations
Note: Elasticities are computed at the corresponding mean values, number in parenthesis are standard errors.

We now turn to our simulation exercise. Using the estimated cotton supply function, the Food and Agricultural Policy Research Institute (FAPRI) projections on cotton world prices until 2013 (FAPRI, 2007) and the United States Department of Agriculture (USDA) projections on Consumer Price Index (CPI) in EU15 until 2013[11] (USDA 2007), we have simulated the effects of the four alternative policy scenarios presented earlier on. In order to evaluate the 'Old' CAP regime, we increased the cotton world price by the amount of mean subsidy per kilogram that producers received during the period 2000-2002 (the reference period for MTR reform). Obviously, in this case the wealth effect on cotton production has been zero.

Furthermore, we have assessed the MTR reform (a combination of fully and partially decoupled policy regime) through changes in prices and initial wealth. We increase initial wealth by 65% of the total subsidies producers received during the reference period (2000-2002). We also, increased world price projections by the remaining 35% of total subsidies per kilogram of production[12]. In the full decoupling policy scenario (third scenario) we assume that producers receive the

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[11] We used CPI projections in order to deflate subsidies from 2006 to 2013, taking 2006 as a base year.

[12] In order to evaluate MTR regime we take into account the provisions of the first European Commission's regulation during the period 2006-2008 as well as the corresponding provisions of the second regulation during the period 2009-2013.

world price and their initial wealth is increased by the full amount of subsidies that they received during the reference period (2000-2002). Moreover, in the free trade scenario we assumed that production depends only on expected world prices. We recomputed the cotton price variance for all these cases in order to consider its effect on cotton production. Finally, we assume that input prices increase due to inflation and we use USDA projections on CPI Greece until 2013 to compute these increments.

Table 3.4 summarizes the percentage changes in cotton production under the three alternative regimes (‘Old CAP regime, MTR regime, full decoupling regime) taking as a reference the free trade-no policy scenario. The obtained results make clear that in all cases cotton production exceeds the volume that would be produced in the case of free trade-no policy scenario. Elaborating on the results of each individual scenario, we come to realise that the ‘Old’ CAP regime distorts production more than any other alternative when farmers are less risk averse i.e. large farms. Under this regime, production is on average, compared with the fourth-no policy scenario, higher by 9.93% for large farms. In the case of a more decoupled policy, as under the MTR regime, the corresponding increase is 4.54% for large farms. Finally, in the presence of a fully decoupled policy regime the distortions to production are smaller than in any other case since the corresponding increase in production 2.04% for large sized farms.

Turn now the analysis to small-medium sized farms. Elaborating on the results of each individual scenario, we come to realise that the full decoupling regime distorts production more than any other alternative when farmers are more risk averse i.e. small - medium sized farms. When the full decoupling policy is applied, farmers produce 20.85% relative to no policy scenario. The corresponding increases for MTR and ‘Old’ CAP regimes are 17.06% and 11.91% respectively.

Table 3.4: Percentage changes in cotton production in relation to free trade-no policy scenario

Small-Medium Sized Farms			
Year	‘Old’ CAP Regime	MTR Regime	Full Decoupling Regime
2006	12.85%	19.55%	22.44%
2007	12.68%	19.17%	21.96%
2008	12.38%	18.76%	21.52%
2009	12.12%	18.36%	21.07%
2010	11.79%	15.65%	20.63%
2011	11.47%	15.31%	20.18%
2012	11.16%	15.00%	19.73%
2013	10.84%	14.65%	19.28%
Large Sized Farms			
Year	‘Old’ CAP Regime	MTR Regime	Full Decoupling Regime
2006	10.68%	5.19%	2.24%
2007	10.56%	5.18%	2.17%
2008	10.31%	5.14%	2.12%
2009	10.10%	5.12%	2.07%
2010	9.84%	5.08%	2.02%
2011	9.58%	3.51%	1.96%
2012	9.32%	3.53%	1.91%
2013	9.07%	3.56%	1.86%

Source: Own computations

Taking into consideration the aforementioned results, we first conclude that when support to producers is connected to prices, large farms produce more than small and medium sized. Secondly, it becomes apparent that if farmers are less risk averse the closer we move to a more decoupled policy the smaller the distortion to production becomes. However, the reverse holds in case of small- medium sized farmers who they are more risk averse. The most interesting result, nevertheless, is that even in the case of adopting a fully decoupled policy; producers' decisions are indirectly affected through the wealth effect. In particular, production appears to be higher than in the free trade scenario, and this difference is exclusively attributed to the fully decoupled payments received by farmers. This means that, in the real world there is no fully decoupled policy, and any type of support to producers' income affects production decisions even indirectly.

Up to now, our analysis of the four policy scenarios has been based on farm-level data derived from the FADN database and is thus representative of the corresponding sample of farmers. We wanted, however, to estimate the level of overall cotton production in Greece under these four alternative policy scenarios so as to provide a more complete picture. Using our previous results, we made projections of overall cotton production of small-medium sized and large farmers respectively. In order to effectuate these projections, we used the distribution of Greek cotton producers by farm size. According to this distribution, 30% of overall production is supplied by small and medium sized farmers and the remaining 70% by large sized farmers. In fact, overall cotton production is equal to the sum of the produced quantity that is supplied by these two groups of producers.

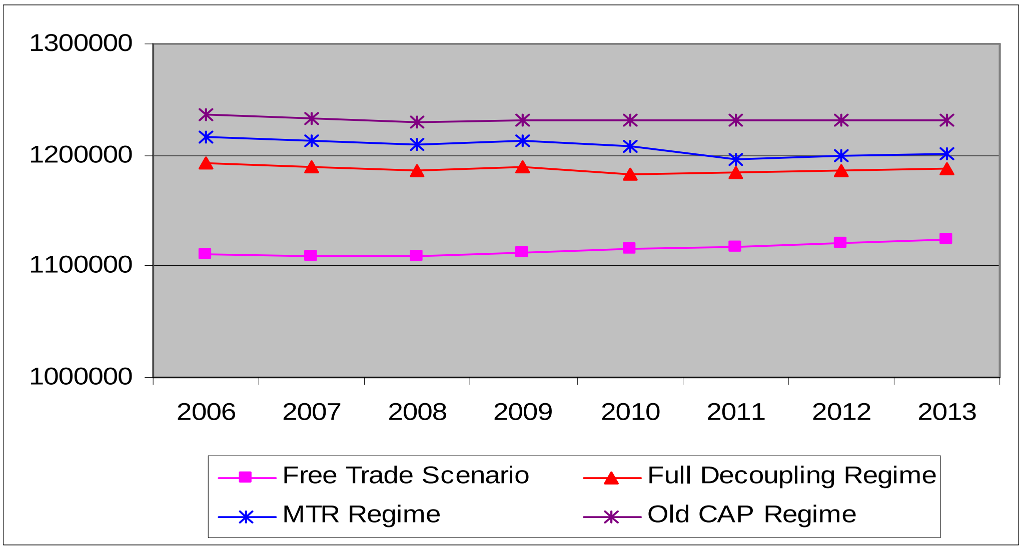
In Table 3.5, estimates of overall cotton production under these four policies until 2013 are presented. If we take again, the free trade-no policy scenario as a point of reference, we see that the overall cotton production under the 'Old' CAP regime is greater by 11% on average, with an increase by 8% under the MTR regime and only by 6% in case a fully decoupled policy is adopted. These differences in production trends become more obvious if we take a look in Figure 3.1.

Table 3.5: Overall cotton production (tonnes) in Greece under four alternative policies

Overall Cotton Production in Greece				
year	Free Trade Scenario	Full Decoupling Regime	MTR Regime	'Old' CAP Regime
2006	1110737	1192466	1215571	1236451
2007	1109431	1189289	1212843	1233522
2008	1108358	1186463	1210055	1229393
2009	1111982	1188672	1212536	1230956
2010	1115622	1183191	1207188	1231815
2011	1118155	1184349	1196542	1231520
2012	1121191	1186125	1198880	1231813
2013	1123691	1187180	1200590	1231509

Source: Own Computations

Figure 3.1: Overall cotton production (tonnes) in Greece under four alternative policies



3.5 Concluding Remarks

All in all, in this chapter we have attempted to evaluate the effects of four alternative policy scenarios on Greek cotton production: the ‘Old’ CAP regime i.e. the policy in action until 2005, the new MTR regime adopted after 2005, a fully decoupled policy and a free trade-no policy scenario mainly used as a system of reference. In the analysis, we assumed that cotton producers face uncertainty over prices and we used the mean-variance utility function approach, proposed by Coyle (1999).

Estimation results indicate that cotton producers are risk averse and their risk attitude is greatly influenced by farm size. In particular, small-medium sized farmers appear to be more risk averse than large sized farms.

According to the obtained simulation results and in line with our expectations when farmers are less risk averse production gradually decreases as farmers’ support becomes decoupled to production. On the other hand, when farmers are more risk averse the opposite holds. However, although the fixed payment that is given to producers is supposed to be production neutral, this seems not to be valid in real world. On the basis of these results it becomes apparent that even decoupled payments affect the volume of production. Our analysis makes this evident by comparing the level of cotton production obtained under the free trade-no policy scenario with that achieved after the full decoupling policy scenario. Cotton production in the second case is greater than in the first one. This practically implies that as long as farmers receive an extra income through supporting measures their production behaviour is affected and the supplied quantity in turn does not unilaterally depend on market conditions.

Appendix

Table 3.1: Descriptive statistics of the variables

Variable	**Mean**	**Standard Deviation**
Cotton Production (kilos)	24711.03	12487.29
Cotton Price (drachmas/kilo)	275.06	23.24
Cotton Price Variance	673.03	1701.27
Labor (hours)	1539.92	774.8
Labor Price (drachmas/hour)	671.2	156.8
Land (stremmas)	83.96	43.3
Land Price (drachmas/stremma)	20068.64	6133.11
Intermediate Inputs (thousand drachmas)	2684.17	1365.56
Intermediate Inputs Price[a] (Index)	0.98	0.08
Capital (thousand drachmas)	6530.44	5071.29
Initial Wealth (thousand drachmas)	27200	17800
Total Wealth (thousand drachmas)	28600	18500

Source: Own Computations

a: Intermediate Inputs Price Index provided by National Statistical Service of Greece

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Chapter 4: The Effects of CAP Reforms on Efficiency and Productivity: the Case of Cotton in Greece

4.1. Introduction

The Common Agricultural Policy (CAP) has been reformed three times over the last fifteen years (McSharry Reform in 1992, AGENDA 2000 in 1999 and Mid Term Review (MTR) in 2003). Since 1992 the various CAP reforms have shared a common purpose: to shift support from production and prices to direct income support measures. In particular, under the MTR of CAP coupled support has been replaced by decoupled support which is given to farmers independently from the kind and/or the level of production. In order to design future agricultural policies, policy makers need to be aware of the effects of CAP reforms on farmers' decisions. Thus, in terms of policy analysis it is interesting to examine the effects of CAP reforms on farmers' economic performance - that is efficiency and productivity.

Theoretically, subsidies can increase or decrease the technical efficiency. Subsidies can increase technical efficiency if farmers use this extra income for investments and technology improvements. On the other hand, subsidies can decrease technical efficiency if farmers are less motivated to perform well because of the increased income that they receive through subsidies. Taking into consideration these two contradictory effects of subsidies, it is very interesting to evaluate the actual impact of subsidies on farmers' performance.

The objective of this chapter is to evaluate the performance of Greek cotton producers under the 'Old' CAP (the policy practiced until 2005) and the MTR review of CAP. We have chosen cotton for two reasons. First, under the MTR of CAP a mix of partial and fully decoupled measures has been adopted. According to the initial European Commission's regulation, under the MTR regime, 65% of the total amount of subsidies producers' received throughout 2000-2002 (i.e. the reference period), will be paid to producers as a fixed payment independent of the level of production. The rest 35% is subject to national base areas, fixed yields and reference amounts. The national base area for Greece is 250.000 ha, fixed yields are 3.2 tonnes/ha and the reference amount per hectare is 251.75€ (European Commission, 2008). Thus, it is very interesting to examine if decoupled and coupled payments have the same or different effect on farmers' efficiency.

Second, cotton production has strong regional importance to Greece. Greece is the major cotton-producing Member State of the EU given that 76% of the EU's total cotton output is grown in Greece. The share of cotton to total agricultural output in Greece is 9.1% (European Commission, 2007).

To the best of our knowledge, there is no study that examines cotton producers' performance under the MTR of CAP. Thus, the main objective of this chapter is to evaluate the effects of the policy applied from 2006 on farmers' efficiency and productivity. However, we also evaluate cotton farmers' performance under the 'Old' CAP regime since the secondary objective of this chapter is to examine if farmers perform better, worse or the same under these two alternative policies.

The rest of the chapter is organized as follows. The following section presents a literature review on studies that examine the performance of farmers in Europe. In section three, we outline the theoretical frameworks used to estimate technical efficiency and productivity. In the ensuing fourth part we present the estimation results as well as a rounded discussion of the main results obtained by the statistical analysis. Finally, in the fifth section we put forward the main conclusions of our study.

4.2 Literature Review

The effect of subsidies that farmers receive through CAP on technical efficiency has been examined by a significant number of researchers in Europe over the last 10 years. Although these studies have followed different theoretical approaches and examined different products in several countries they have come to a common conclusion: subsidies affect technical efficiency of farmers. In the following analysis we put forward a short presentation of the main studies on this topic.

Iraizoz *et. al* (2005) examined the factors that affect technical efficiency in the Spanish beef sector. Using the production frontier approach, he found that there was a negative relationship between subsidies and technical efficiency. Similarly, Karagiannis and Sarris (2002) analyzed the factors that affect technical efficiency in the Greek agriculture. They examined various products and they found that the relationship between subsidies and technical efficiency was statistically insignificant for vegetables and negative for tobacco, cotton, fruits, wheat, other arable crops, and olive farms in Greece.

In a highly interesting paper, Hadley (2006) examined the patterns in technical efficiency and technical change in England and Wales during the period 1982-2002. Their results about the relationship between subsidies and technical efficiency were mixed. They found that subsidies increased efficiency of beef and dairy farms and decrease efficiency of pig, poultry, cereals, sheep, general cropping and mixed farms in the UK.

Zhu and Oude Lansink (2010) made an analysis of the impact of subsidies on technical efficiency of crop farms in Germany, the Netherlands and Sweden. They used two subsidy related variables: the first was the share of total subsidies in total farm revenue and the second was the share of crop subsidies in total subsidies. Their results confirmed there was a negative relationship between the share of total subsidies in total farm income and technical efficiency. Additionally, they found that relationship between the share of crop subsidies in total subsidies and technical efficiency was negative in Germany, positive but statistically insignificant in the Netherlands and positive and statistically significant in Sweden.

In a very interested paper, Zhu *et. al.* (2010) analyzed the impact of direct income transfers on Greek olive farms performance. Their results indicated that as the direct income transfers increase the technical efficiency of Greek olive farms decreases. More specifically, they found that if the share of direct income transfers in total revenue increases by 1% then the technical efficiency decreases by 1.6%.

Although the main objective of this chapter is to examine the effect of subsidies on technical efficiency, in our model we also include some firm specific explanatory variables in order to examine their effect on technical efficiency. The firm specific explanatory variables are: farm size, farmer's age, the percentage of rented land to total cultivated land, the percentage of family labor to total labor, the degree of specialization and a dummy variable, which identifies if a farm is located in a Less Favored Area. In the remainder of this section, we present the findings of other researchers regarding the effects of the above factors on technical efficiency.

First, the effect of farm size on technical efficiency is controversial. Some authors (Coelli and Battese, 1996) suggest that small farms are less efficient since they may have alternative income sources and therefore put less effort into farming compared with larger farms. On the other hand, large farms tend to be more technically efficient than small farms because of the economies of scale (Hallam and Machado, 1996). The empirical findings with respect to the effect of farm size to technical efficiency are mixed since some authors found that there is positive relationship between them (Iraizoz *et.al.* 2005; Karagiannis and Sarris, 2002; Rezitis *et.al.*, 2003; Zhu and Oude Lansink, 2010) and others found this relationship is negative (Amara *et. al.* 1999;Zhu and Oude Lansink, 2010).

Second the effect of farmer's age on technical efficiency is also debatable. On the one hand, older farmers tend likely to be more experienced and therefore more technically efficient (Coelli and Battese, 1996). One the other hand, older farmers are less willing to adopt new practices because they are more conservative and hence they tend to be more inefficient. On the contrary, younger farmers are more willing to adopt new production practices and hence they tend to be more efficient (Weersink *et.al.*, 1990). Once more, the empirical findings, regarding the effect of farmer's age on technical efficiency, are mixed. Karagiannis and Sarris (2002) found that farmer's age had a positive impact on efficiency of mixed arable crops, cotton and olive oil farms in Greece, and a negative impact on efficiency of fruits farms. Additionally, they found that the relationship between these two variables was statistically insignificant for wheat, tobacco and greenhouse horticulture farms. The negative relationship between farmer's age and efficiency has also confirmed by Handley (2006), who found that this relationship was true for cereal, dairy, sheep, beef and mixed farms in the UK.

Third, the share of rented land to total cultivated land has a negative impact on technical efficiency since farmers who rent land tend to be less efficient than farmers who own the land. This result holds because in general it is cheaper to rent the land than to buy the land. The negative effect of rented land to technical efficiency has been confirmed by Zhu and Oude Lansink (2010).

Fourth, the share of family labor to total labor is expected to have a positive effect on technical efficiency because family has the incentive for more efficient production. However, the empirical findings do not confirm this relationship since they found that there is a negative relationship between these two variables (Karagiannis and Sarris, 2002, 2005). This means that hired labor is more productive than family labor.

Fifth, farmers who produce only one product may be more efficient than farmers who produce more products (Llewelyn and Williams, 1996). This may be reasonable since farmers who are highly specialized acquire high skills in the production of this product. In contrast, farmers who are more diversified may be more efficient because of the economies of scope (Featherstone, *et. al.* 1997). The empirical findings regarding the effect of specialization on technical efficiency are mixed given that some researchers found that specialization increases technical efficiency (Llewelyn and Williams, 1996; Karagiannis and Sarris, 2002, 2005; Zhu and Oude Lansink, 2010) and others that higher specialization is related with lower efficiency (Karagiannis and Sarris, 2002; Iraizoz *et. al.*, 2005; Handley, 2006; Zhu and Oude Lansink, 2010).

Finally, farms located in less-favored areas tend to be less efficient than farms located in normal areas. This is because usually farms located in less-favored areas are poorly-endowed in terms of infrastructure and extension services. This negative effect of farms’ location to technical efficiency has been confirmed by various studies (Iraizoz *et. al.* 2005, Karagiannis and Sarris, 2005).

4.3 Theoretical Framework

4.3.1 The Data Envelopment Analysis

Efficiency is the relationship between the actual production and the feasible production of a firm, under the assumption of full utilization of the available resources. Farrel (1957) proposed an empirical method to estimate efficiency by comparing the output in a production frontier of a firm and its effective output. The production frontier can be estimated either non-parametrically using data envelopment analysis (DEA) or parametrically using stochastic frontier methods.

DEA is a non-parametric approach to estimate efficiency originally proposed by Charnes *et.al.* (1978). The method involves the use of a linear programming problem to calculate efficiency by comparing each of Decision Making Unit (DMU) against all other DMUs. Solving the linear programming problem, a piece-wise linear envelopment frontier over the data points is constructed where all observed points lie on or below the production frontier. Therefore technical efficiency scores obtained through comparisons among an observation and each others.

Charnes *et.al.* (1978) proposed an input orientated model and assumed constant returns to scale (CRS). However, this assumption was too restrictive thus Banker *et. al.* (1984) proposed a variable returns to scale (VRS) model. In the present study we use the output orientated VRS model where DMUs have to produce as much as possible output given the available quantities of inputs.

Let first define the notation of the analysis. Assume that there are N firms which produce *1* output using K inputs. Input vectors x_i construct the $K \times N$ input matrix

X and output vector y_i constructs the $1 \times N$ output matrix *Y*. The output-orientated VRS DEA frontier is defined by the solution of *N* linear programs as follows:

$$\begin{aligned} \max_{\theta,\lambda} \quad & \theta \\ s.t. \quad & -\theta y_i + Y\lambda \geq 0 \\ & x_i - X\lambda \geq 0 \qquad (4.1) \\ & N1'\lambda = 1 \\ & \lambda \geq 0 \end{aligned}$$

where *N1* is a $N \times 1$ vector of 1*s* and λ represents a $N \times 1$ vector of weights. Additionally, $1 \leq \theta \prec \infty$ and $\theta - 1$ corresponds to the proportional increase in output that each firm could achieve assuming that input quantities remain constant (Coelli *et.al.* 1998). In order to run the DEA analysis we use the DEAP 1.2 statistical software proposed by Coelli (1996).

4.3.2 Model to evaluate the impact of contextual variables on farm efficiency

In the present section we provide the method we use to evaluate the effect of firm specific factors on efficiency using a two-stage DEA approach. In the first stage we use DEA method to calculate efficiency or productivity scores and in the second stage we regress these scores on contextual variables to evaluate their effect on efficiency. Typical two-stage DEA statistical approaches can be seen in Simar and Wilson (2007), Souza and Staub (2007) and Banker and Natarajan (2009).

In this study we use the method proposed by Banker and Natarajan (2009). In the analysis we use observations on *j=1,…..,N* farms, which produce one output $Y_j = (y_1, ..., y_N)$ by using a vector of inputs $X_j = (x_{1j}, ..., x_{Rj})$. Additionally, a vector of contextual variables $Z_j = (z_{1j}, ..., z_{Sj})$ is available which may influence the farm efficiency. The output, input and contextual variables vectors are strictly positive in at least one dimension. The model suggests that the data on the *N* farms are generated by the true production function $\phi(X)$ and an error term ε. The production function $\phi(X)$ follows the standard properties i.e. is monotone, increasing and concave in *X*. Equation that follows specifies the production function:

$$y = \phi(X) * e^{\varepsilon *} \quad (4.2)$$

The error term ε^* is generated by the following process:

$$\varepsilon^* = v - u - \sum_{s=1}^{S} \beta_s z_s \quad (4.3)$$

where *v* corresponds to random noise which has a two-sided distribution, *u* is the technical inefficiency and has a one-sided distribution and *z* corresponds to contextual variables which are all positive. The contextual variables are measured so as the weights β_s, *s=1,….S,* are all nonnegative which means that as the value of contextual variables increases the inefficiency of the farm also increases. The error $\varepsilon = v - u$ is attributed only to noise and technical inefficiency.

Probability density functions that generate the various variables are as follows:

$$f_{xi}(x_i) = 0 \text{ for all } x_i < 0 \quad (4.4)$$
$$f_{zs}(z_s) = 0 \text{ for all } z_s < 0 \quad (4.5)$$
$$f_u(u) = 0 \text{ for all } u < 0 \quad (4.6)$$
$$f_u(v) = 0 \text{ for all } |v| > V^M \quad (4.7)$$

Moreover, we assume that the input variable vector *X,* the contextual variables vector *Z,* the noise *v* and the inefficiency term *u* are independently distributed. The input variables may be correlated each other as well as the contextual variables since there are not imposed any restrictions on the joint distributions of them.

Banker and Natarajan (2009) proved that a two stage procedure which involves a DEA model in the first stage followed by an ordinary least squares (OLS) or maximum likelihood (ML) or even a Tobit regression in the second stage outperform the parametric method. In our analysis we use an OLS regression in the second stage. Consider that $\theta \leq 1$ corresponds to efficiency score. The model we use is specified by the following equation:

$$\ln\theta = \beta_0 - \sum_{i=1}^{S} \beta_i z_i + \delta \quad (4.8)$$

The error term δ has a zero mean and a finite variance. Because the dependent variable $\ln\theta$ is not known, we replace it with the efficiency DEA estimator $\ln\tilde{\theta}$. Banker and Natarajan (2009) proved that it is consistent to use $\ln\tilde{\theta}$ in the second stage regression.

4.3.3 The Malmquist Productivity Change Index

The Malmquist productivity change index suggested by Malmquist (1953) is used for the measurement of productivity change. The Malmquist productivity index measures the TFP change between two data points by calculating the ratio of the distances of each data point relative to a common production technology (Fare *et.al.* 1994). In our case each firm produces one output with the use of *K* inputs. Productivity change can be estimated by using period *t* or *t+1*technology as the reference technology. The Malmquist productivity index relative to period *t* or *t+1* technology is defined by the following equations:

$$M_o^t = \left(\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \right) \qquad (4.4)$$

$$M_o^{t+1} = \left(\frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)} \right) \quad (4.5)$$

where *o* denotes the output orientation, *y* is the output and *x* is the $(K \times 1)$ vector of inputs in period *t* and *t+1*; $D_o^t(x^{t+1}, y^{t+1})$ is the distance from the period *t+1* to the period *t* technology, and $D_o^{t+1}(x^t, y^t)$ is the distance from the period *t* to the period *t*+1 technology.

The Malmquist productivity change index is defined as the geometric mean of these two indices:

$$M_o(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\left(\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \right) \left(\frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)} \right) \right]^{1/2} \quad (4.6)$$

This index takes values between zero and one. If its value is greater than one then productivity from year *t* to *t+1* has been increased, the reverse holds when the index takes values less than one. Additionally, the index can also be written as:

$$M_o(x^{t+1}, y^{t+1}, x^t, y^t) = E \times T = \left(\frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \right) \left[\left(\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \right) \left(\frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)} \right) \right]^{1/2} \quad (4.7)$$

where the first component *E* and the second component *T* measure the technical efficiency change and the technology change over the two periods respectively.

In the present study we measure the four distance measures in equation (4.6) using DEA method (Fare *et. al.* 1994). This requires the solving of four linear programming (LP) problems. The required LPs are:

$$\begin{aligned}
&\left[D_o^t(x_t, y_t) \right]^{-1} = \max_{\varphi,\lambda} \varphi, \\
&st \qquad \text{-}\phi y_{it} + Y_t \lambda \geq 0, \\
&\qquad\quad x_{it} - X_t \lambda \geq 0, \\
&\qquad\quad \lambda \geq 0, \qquad\qquad\qquad (4.8)
\end{aligned}$$

$$
\begin{aligned}
&\left[D_o^{t+1}(x_{t+1}, y_{t+1})\right]^{-1} = \max_{\varphi,\lambda} \varphi, \\
st \qquad & \text{-}\phi y_{i,t+1} + Y_{t+1}\lambda \geq 0, \\
& x_{i,t+1} - X_{t+1}\lambda \geq 0, \\
& \lambda \geq 0, \qquad\qquad\qquad\qquad (4.9)
\end{aligned}
$$

$$
\begin{aligned}
&\left[D_o^{t}(x_{t+1}, y_{t+1})\right]^{-1} = \max_{\varphi,\lambda} \varphi, \\
st \qquad & \text{-}\phi y_{i,t+1} + Y_{t}\lambda \geq 0, \\
& x_{i,t+1} - X_{t}\lambda \geq 0, \\
& \lambda \geq 0, \qquad\qquad\qquad\qquad (4.10)
\end{aligned}
$$

$$
\begin{aligned}
&\left[D_o^{t+1}(x_{t}, y_{t})\right]^{-1} = \max_{\varphi,\lambda} \varphi, \\
st \qquad & \text{-}\phi y_{it} + Y_{t+1}\lambda \geq 0, \\
& x_{it} - X_{t+1}\lambda \geq 0, \\
& \lambda \geq 0, \qquad\qquad\qquad\qquad (4.11)
\end{aligned}
$$

where *i* denotes the i^{th} firm, Q_t and Q_{t+1} are $(1 \times N)$ matrices containing the output for all firms in periods *t* and *t+1* respectively, X_t and X_{t+1} are $(K \times N)$ matrices containing the input vectors for all firms in both periods, λ is $(N \times 1)$ vector of weights (one for each firm) and φ is a scalar. The Malmquist productivity change index is calculated with the use of DEAP 1.2 statistical software proposed by Coelli (1996).

4.4 Data

The data we use are from the FADN database and the National Statistical Service of Greece during the period 2003-2007. In the estimation procedure we use two datasets, one for the period 2003-2005 which corresponds to ‘Old’ CAP regime and one for the period 2006-2007 which refers to the MTR of CAP. In order to run the DEA analysis, given the nature of the model, we had to construct our datasets as balanced panels. As a result, we deleted 467 observations of the first sample and we have 624 observations which correspond to 208 firms. The initial number of observations in the second file was 712 and the final is 436 which represent 218 firms.

Cotton farmers produce cotton using four inputs: labor, capital, land and intermediate inputs. Output is measured in terms of total gross revenue, measured in thousands of euro. Land measured in hectares (ha), labor is measured in annual working hours, capital and intermediate inputs are measured in thousands of euro. In the present analysis we deflate all the monetary values i.e. output, capital, intermediate inputs, with the price indices provided by the National Statistical Service of Greece in Agriculture Statistics.

A number of variables have been included in the second stage model. First, we use two subsidy related variables, the coupled subsidy measured as the share of cotton subsidies in total farm income and the decoupled subsidy[13] measured as the share of SFP in total farm income. Second, we use farmers' age, measured in years, to account the effect of entrepreneurial skills, learning by doing and experience. Additionally, we include the percentage of rented land to total cultivated land and the percentage of family labor to total labor which is used in production. The degree of specialization is also used, which is measured as the share of cotton revenue in total farm revenue. Moreover, we use the farm size measured in terms of European Size Units (ESU) to examine its effect on efficiency and productivity. Finally, we include a dummy variable, which identifies if a farm is located in a

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[13] This variable included only in the dataset which refers to the MTR of CAP, since under the Old CAP policy farmers did not receive decoupled payments.

Less Favored Area. The descriptive statistics of the variables are provided in Table 4.1.

Table 4.1: Descriptive statistics of the variables

Variable	**2003**	**2004**	**2005**	**2006**	**2007**
Gross revenue (€)	32432.32	31893.05	34382.23	13263.4	19032.2
Labor (hours)	2144.25	2098.13	2129.44	1841.17	1820.84
Capital (€)	28962.55	28836.28	30036.03	37698.13	35386.33
Land (ha)	13.53	13.36	13.23	15.49	15.69
Intermediate inputs (€)	13337.26	13689.16	13689.5	13520.28	13718.78
Coupled subsidy	0.56	0.58	0.57	0.19	0.17
Decoupled subsidy	-	-	-	0.39	0.34
Age of farm owner	60	56	55	55	54
Share of rented land to total land	0.51	0.50	0.51	0.52	0.52
Share of family labor to total labor	0.90	0.90	0.90	0.87	0.88
Degree of specialization	0.90	0.90	0.90	0.77	0.78

Source: Own computations

4.5 Estimation Results

4.5.1 Technical Efficiency

In this section we present the efficiency estimation results as well as the results of the second stage DEA analysis where we evaluate the effect of contextual variables on technical efficiency of the farms. The estimated mean technical efficiency scores along with the standard deviation and range per year are presented in the Table 4.2 that follows.

Table 4.2: Mean efficiency scores and range of efficiency scores per year

	2003	**2004**	**2005**	**2006**	**2007**
Mean efficiency	0.65	0.76	0.74	0.53	0.72
Standard deviation	0.21	0.14	0.17	0.24	0.20
Minimum	0.06	0.44	0.24	0.04	0.14
Maximum	1	1	1	1	1

Source: Own computations

The above results make clear that technical efficiency is 0.65 in 2003 and increases to 0.76 and 0.74 in 2004 and 2005 respectively. Additionally, the first year that the MTR applies technical efficiency decreases to 0.53. However, technical efficiency increases again in 2007 and it is equal to 0.72. The average technical efficiency during the period 2003-2005 was 0.72 which means that cotton farmers could have on average increased their output by 28% if they had used existing technology more efficiently. On the other hand, the average technical efficiency during the period 2006-2007 was 0.62. This result indicates that cotton farmers could have on average increased their output by 38% if they had used existing technology more efficiently. Taking into consideration the above results, it is clear that the technical efficiency has dropped by 0.10 after the application of the MTR of CAP.

Let now turn the analysis to the second stage regression. The estimated coefficients are presented in the Table 4.3 that follows. Most of them are statistically significant at the 5% level of significance.

Table 4.3: Parameter estimates of relating the logarithm of efficiency scores to contextual variables

	'Old' CAP	*MTR of CAP*
Variable	Estimated value	Estimated value
Constant	-0.442 (-2.71)	0.113 (0.55)
Size	-0.023 (-2.74)	0.013 (0.94)
Specialization	0.977 (7.76)	-0.060 (-0.71)
Family labor	-0.118 (-1.42)	-0.254 (-1.78)
Rented land	0.017 (0.43)	0.005 (0.07)
Age	0.001 (0.57)	-0.003 (-1.76)
Lfa	-0.172 (-6.29)	-0.162 (-3.72)
Coupling subsidy	-1.032 (-9.09)	-0.340 (-7.25)
Decoupling subsidy	-	-0.139 (-7.47)

Source: Own estimations

Note: Numbers in parenthesis are t-statistics, significant at 0.05 level.

Firstly, it is clear from the above results that the effects are different in magnitude and sign for different policy. Farm size has no effect on technical efficiency under the MTR of CAP regime but large farms are less efficient in case the ‘Old’ CAP is applied. Specialization increases the efficiency of cotton farmers under the ‘Old’ CAP regime but does not affect farm efficiency in case the new policy is applied. Additionally, as the percentage of family labor increases cotton farmers become neither less nor more efficient since the estimated coefficient of this factor is statistically insignificant under both policies.

The percentage of rented land to total land does not affect technical efficiency since this coefficient is not statistically significant under both policies. Similarly, farmer age does not affect technical efficiency under both policies. Cotton farms that located in less favoured areas tend to be less technically efficient than farms located in normal areas regardless of the policy applied.

Finally, as the share of subsidies to total farm income increases the technical efficiency decreases and vice versa. The effect of coupled subsidies to technical efficiency is negative in both policies. However, when the ‘Old’ CAP applied this effect is much larger, the coefficient is -1.032, relative to the corresponding effect under the MTR of CAP. This result is reasonable since under the ‘Old’ CAP regime all the subsidies were coupled to production and farmers’ income did not affected so much by the price fluctuations. Moreover, the larger the share of decoupled payments to total farm income the less efficient farmers become. On the whole, our results indicate that regardless of the type of subsidies, farmers become more inefficient when they receive them. Farmers tend to put less effort into their farm activities because they receive a certain amount of income irrespective of their effort.

4.5.2 Productivity analysis

In this section we present the productivity estimation results for 'Old' CAP and MTR regimes. First, we present the results for Malqmuist TFP change index and its decompositions. Second, we analyze the Malqmuist TFP change index per farm size.

Table 4.4: Malqmuist index and its decompositions

	2003/4	2004/2005	2006/2007
Malmquist index	1,17	1,11	1,06
Technical efficiency change	1,21	0,96	1,68
Technical change	0,97	1,16	0,63

Source: Own estimations

The results in Table 4.4 show that the TFP increased 17% from 2003 to 2004, 11% from 2004 to 2005 and 6% from 2006 to 2007[14]. Taking into consideration these results, there is evidence that cotton producers become less productive when the MTR regime applied. In terms of the efficiency change component, the average value is 1.28 which indicates that the gap between farms' actual production and the production frontier decreased during the relevant period. On the other hand, the average value of technical change is 0.92, which indicates a downward shift in the production frontier.

In Table 4.5 the results for Malqmuist index per farm size are presented. We consider three size categories small, medium and large farms[15]. According to our results, the TFP growth for small farms increased 19% from 2003 to 2004 and 7% from 2004 to 2005 but decreased 1% from 2006 to 2007. On average the small

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[14] We do not have the TFP change from 2005 to 2006 since we use the two separate data files to calculate the Malmquist index.

[15] The farm size is expressed in terms of European Size Units (ESU). First, the farms that belong to the first three categories are considered small-sized. Second, the farms that belong to the next three categories are considered as medium-sized and finally the farms of the three last categories as large-sized.

farms' TFP growth is 8% during 2003-2007 but it is clear the productivity of small farms reduced when the MTR regime applied. The TFP growth for medium-sized farms is on average 22% and increased 37% from 2003 to 2004, 12% from 2004 to 2005 and 17% from 2006 to 2007. The TFP growth for large farms is on average 17% during this period and increased 26% from 2003 to 2004, 14% from 2004 to 2005 and 10% from 2006 to 2007.

Table 4.5: Malqmuist index per farm size

Mean productivity per farm size			
Farm size	2003/4	2004/2005	2006/2007
Small	1,19	1,07	0,99
Medium	1,37	1,12	1,17
Large	1,26	1,14	1,10

Source: Own estimations

In terms of policy analysis, under the 'Old' CAP regime, i.e. the period 2003-2005, the TFP growth is on average 13%, 24% and 20% for small, medium and large farms respectively. Taking into consideration these results it is clear that the introduction of MTR regime did not make cotton farmers more productive relative to the 'Old' CAP regime.

4.6 Concluding Remarks

In this chapter we have attempted to evaluate the efficiency and productivity of cotton farmers under two policy regimes: the 'Old' CAP and the MTR of CAP. The technical efficiency was found to be on average larger under the 'Old' CAP regime than under the MTR of CAP. As for the productivity, our results indicate that the TFP growth from year to year is also larger under the 'Old' CAP regime than under the MTR of CAP. Therefore, cotton farmers are neither more efficient nor more productive when they received the decoupled payments.

As far as the factors influencing efficiency are concerned, we found that when the ‘Old’ CAP policy regime was applied more specialized farms tend to be more efficient and larger farms tend to be less efficient. On the other hand, as the share of the share of coupled subsidies to total subsidies increases farms become less technically efficient. Taking into account the effects of the relative factors on technical efficiency under the MTR of CAP, we found that as the share of coupled and decoupled payments to total revenue increases farmers become less technically efficient. Finally, farms located in less favored areas are relatively less efficient than farms located in normal areas under both policy regimes.

In terms of policy analysis, it is clear that after the policy change, that is, when the MTR of CAP applied, cotton farmers become neither more efficient nor more productive. Looking towards the future and the CAP reform in 2013, policy makers have to consider this fact in order to improve further the new policy reform.

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Chapter 5 Conclusions

The aim of this thesis was to highlight aspects of cotton sector in Greece. In the second chapter, using data from agricultural enterprises we evaluated different panel data estimation techniques in order to find out which of them is more appropriate. In chapters 3 and 4 we analyzed the effects of past and new agricultural policies in Europe since this is a highly debatable issue in agricultural economics.

In Chapter 2, we examined some econometric aspects by using agricultural farm- level data. We found that the estimation method matters to come to the right conclusions about the estimated coefficients and the estimated elasticities based on them. Consequently, the more reliable the estimated elasticities are the more reliable will be the policy simulations which are based on estimated elasticities. The conclusion is that the adoption of different estimation techniques leads to quite different results in terms of the absolute value of the estimated parameters as well as in terms of their statistical significance. Additionally, the elasticity of cotton with respect to its own price varies according to the farm size.

Chapter 3 focused on the effects of decoupling policies on Greek cotton production. Even though the fixed payment given to producers is supposed to be production neutral this seems not to be valid in real world since decoupled payment affect the volume of production. This practically means that as long as farmers receive an extra income through supporting measures their production behaviour is affected and the supplied quantity in turn does not unilaterally depend on market conditions. Thus the debate about production neutral support policies is meaningless since whatever the policy, producers’ behaviour with respect to the level of production is affected.

Finally, last chapter focused on the analysis of cotton producers’ performance under the previous and current agricultural policy. According to the results, the introduction of the new partial decoupled policy did not improve cotton farmers’ performance. They become neither more efficient nor more productive. This result indicates that farmers tend to put less effort into their farm activities because they receive a certain amount of income irrespective of their effort. Taking into consideration this fact, policy makers have to redesign the policy in a more effective way.